International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 01 | Jan - 2026 SJIF Rating: 8.586 ISSN: 2582-3930

Integrated Air Purification System in Two-Wheeler Helmets

Sarah Firdouse[1], Dr.Malatesh S H[2], Mohammed Suhail S[3] , Mohammed Talib[4] , Mahamad Vaseem M S[5]

[1]Sarah Firdouse ,CSE Department & M S Engineering College
[2]Dr.Malatesh S H ,HOD & Prof. CSE Department & College
[3]Mohammed Suhail S ,CSE Department & M S Engineering College
[4]Mohammed Talib ,CSE Department & M S Engineering College
[5]Mahamad Vaseem ,CSE Department & M S Engineering College

---***---

Abstract - Air pollution is a major menace to riders of two-wheeled vehicles due to its hazardous effects on their health. In most cases, this is evident in urban areas characterized by constant traffic. Helmets offer riders with physical protection without considering the type and quality of air that the rider inhales. The major contributors to decreased air quality include vehicle emissions and dust. This article proposes and discusses IoT-based Integrated Air Purification System in Two-Wheeler Helmets that have the ability to detect environmental changes and offer clean air instantly. The system uses an MQ135 gas sensor and a DHT11 sensor that detects environmental changes such as temperature and humidity. The ESP32 microcontroller is responsible for processing these data and automatically turning on the fan and filter system whenever environmental changes go beyond specified limits. This system also uses an OLED display that offers instant data and is connected to a mobile application through Blynk IoT technology. Experiments contributed significantly towards proving that this technology is effective in improving air quality within a two-wheeled vehicle helmet and also offers significant comfort to riders as well as reduces risks associated with riders inhaling large amounts of polluted air..

Key Words: IoT, Smart Helmet,Air Pollution, MQ135 Sensor, DHT11, ESP32, Blynk App, Wearable Technology

1.INTRODUCTION

The main reasons for air contamination in this area are fast urbanization and increased traffic, which make two-wheeler users one of the substantially vulnerable groups. Prolonged exposure to air pollutants like carbon monoxide, nitrogen oxides, smoke, and dust particles can cause respiratory problems and other health ailments.Although helmets are a must for their safety, they do not protect two-wheel users from air contamination. External masks can sometimes cause irritation and inflammation in their noses and do not work well during long rides.Advances in Internet of Things (IoT) technology make it feasible to create a smart wearable system that can monitor the environment in real-time and respond accordingly. The idea of incorporating air purification systems in helmets would provide a valuable solution to make riders' health and safety better. This paper presents a smart helmet system that will continuously monitor air quality and provide purified air to the wearer without any human intervention.

2. Methodology

The integrated air purification system in two-wheeler helmets works on a structured real-time environmental data that integrates several environmental sensors on the helmet. For harmful gases and pollution levels, the MQ135 gas sensor continuously monitors, while the DHT11 sensor measures the ambient temperature and humidity. These sensors provide real time, continuous data to the microcontroller regarding the air conditions around the rider at all instances.

Data Processing and Threshold Analysis:

The microcontroller analyses input data received from the sensors and compares them with predetermined safety limits. Fluctuations or high concentrations of air pollutants, or inappropriate levels of temperature and humidity, are detected by threshold analysis. The process is performed in real time to promptly identify harmful breathing conditions.

Air Quality Detection and Decision Mechanism:

Once the readings go beyond the safe levels, the decision-making algorithm is invoked automatically. It uses rule-based logic to check if the quality of the air is hazardous, thus preventing unwanted triggering and resulting in fewer false outputs. It is also a mechanism responsible for accurate detection of air pollution while riding dynamically.

Air Purification Control

Upon sensing low-quality air, the acquisition, processing, decision-making, and automated air purification process to ensure rider safety and respiratory comfort. The methodology adopted for the development of the system will be outlined as follows:

Requirement Analysis

The first stage identifies the system requirements in terms of air quality monitoring, purification efficiency, portability, and power management. It selects the key components based on accuracy, energy efficiency, and wearability: the ESP32 microcontroller, air quality sensors (MQ135), temperature and humidity sensors (DHT11), filtration unit, fan mechanism, display module, and IoT communication platform.

Sensor Integration and Data Acquisition

This system microcontroller activates the relay-operated fan and filter system automatically. Air with impurities is passed through HEPA or activated filters, and clean air is circulated inside the helmet. Activation of the fan is automatically discontinued as soon as the purity level increases to safe levels.

Display and IoT Communication

The actual parameters of air quality, temperature, humidity, and system status can be viewed using an OLED display incorporated into the helmet. At the same time, the processed data can be sent to a mobile application via IoT technology (Wi-Fi/Blynk platform), using which remote monitoring and manual control of the fan are possible.

Development of a prototype and testing

The functional prototype is achieved by incorporating each and every hardware component into a conventional two-wheeler helmet. The system is tested in different levels of pollution to analyze the accuracy of the sensor, response time, purification rate, power consumption, and communication range. The system undergoes calibration and tuning to improve stability and performance.

3. Requirements

3.1 Functional Requirement

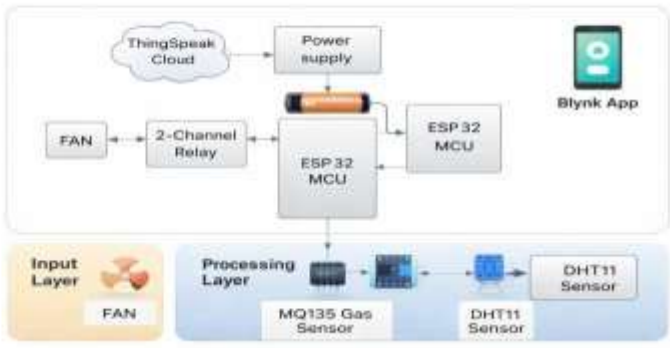
The IoT Based Integrated Air Purification System for Two-Wheeler Helmets will ensure that the air the bikers breathe is clean and fresh. This will inevitably require the system to monitor air, temperature, and humidity levels on a continuous basis through the use of proper sensors such as the MQ135 Gas Sensor and the DHT11 Sensor.The system will be capable of processing the real-time sensor data with the microcontroller and comparing the data with the prescribed safety thresholds to ascertain the unsafe air conditions. As soon as the rider detects the poor quality of the air or uncomfortable environmental conditions, the system will automatically turn on the fan and the filtration system in order to provide the rider with the purified air within the helmet. The system should display air quality, temperature, humidity, and fan status values in real time on an OLED/LCD display mounted inside the helmet for immediate user awareness. The system shall support IoT connectivity via WiFi to transfer sensor data to either a mobile app or cloud, allowing for remote monitoring and optional manual fan control. The system should provide for manual override through the mobile application, where the rider can control airflow by comfort.

3.2 Non-Functional Requirement

provide real-time response capabilities to update the sensor and turn on the fan.It should be compact, lightweight, and ergonomically designed, enabling wearer comfort during prolonged usage. It should work with a high level of availability in different environments, including dust, moisture, and temperature variations, while sustaining less downtime. Data security should be incorporated to prevent unauthorized access to communication via Internet of Things components. It should be scalable for future sensor incorporation and filtration techniques, with power efficiency for better battery life. The user interface should be simple and legible, and the design should be maintainable for The air purification helmet system should provide high reliability, ensuring reliable operations with exact readings from the sensor, dependable detection of air quality, and activation of the air purification system. The system should replacement of parts.

4 .System Architecture

The Integrated Air Purification System for Two-Wheeler Helmets is envisioned as a plug-and-play IoT-based wearable device, wherein the system monitors air quality continuously and automatically supplies purified air to the rider. The system is composed of layers, namely sensing, processing, purification, communication, and power.Data obtained from the MQ135 air quality detector and the DHT11 temperature and humidity sensor is interpreted by an ESP32 microcontroller and measured against set levels. In situations where hazardous levels of air are sensed, a relay-controlled fan and filter system is triggered to circulate filtered air. Real-time data is shown on an OLED display and transmitted to an application on a mobile device over Wi-Fi connections.

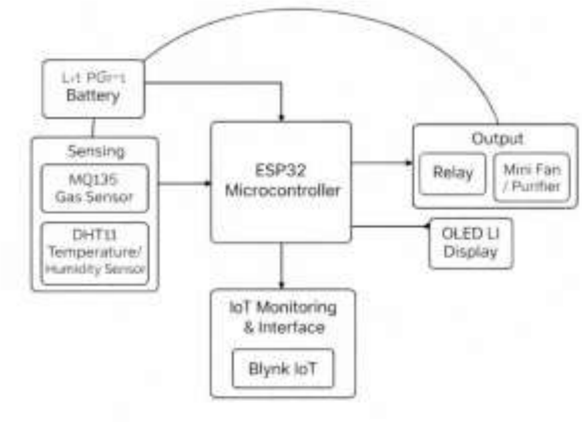


System Architecture

5. Data Flow Diagram

A data flow diagram (DFD) is a graphical representation of the flow of data within a system.

It's a powerful tool used in system analysis and design to illustrate how data moves through different processes and interactions in a system.



Data Flow Diagram6.

SSequence Diagram

A sequence diagram in Unified Modelling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.

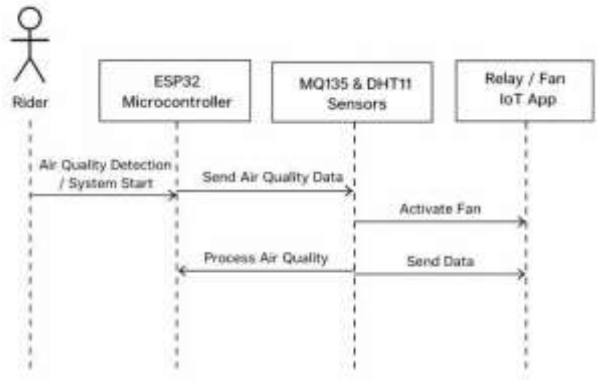


Fig 4.3 - Sequence Diagram

Sequence Diagram

7. Workflow

Workflow of Integrated Air Purification System in Two Wheeler Helmets.

System Start / Power ON

The helmet system is powered ON with a rechargeable battery. The ESP32 microcontroller initializes all connected components such as MQ135 Air Quality

Sensor, DHT11 Temperature & Humidity Sensor, OLED Display, Fan, Relay Module, and IoT Communication Interface.

Standby Monitoring Mode

The system now goes into the continuous monitoring mode. Environmental factors such as the quality of the air, the temperature, and the humidity are monitored in real time, and the readings are shown on the OLED display.

Sensor Data Acquisition.

The MQ-135 sensor is used to measure the concentration of pollutants, and the DHT11 sensor measures the temperatures and humidity levels in the helmet. The data is sent to the microcontroller continuously.

Data Processing and Threshold Check

The ESP32 analyzes data from sensors and compares it with preset safe threshold values. In case all parameters fall within safe ranges, it goes ahead with the monitoring process.

Air Quality Detection

If the quality level of the air exceeds the permissible limits or if the weather becomes too uncomfortable, the system recognizes that it is unsafe.

Purification System Activation

Upon recognition of the unsafe condition of the air quality, the microcontroller turns on the relay-controlled fan and filtering system. Polluted air is sucked through the filter, and the clean air is circulated within the helmet.

Display and IoT Update

Data regarding the air quality, temperature, humidity, and status of fans is displayed using the OLED display. This is while the data is also sent to the IoT platform for remote observation and manual control.

System Reset / Continuous Operation

After regaining healthy levels of air quality, the fan is automatically turned OFF. This continues as long as the helmet is turned on.

Power Management

The rechargeable battery provides constant power to all features. The battery is well-relaed for efficient power management.

8. Performance Evaluation

Accuracy vs. Number of Trials for the Proposed Safety System

Accuracy vs. Number of Trials for the Integrated Air Purification System

9. Screenshots

Hardware Prototype of the Integrated Air Purification System

The following figure represents the IoT-Based Air Purification System in Helmet Hardware Prototype, which consists of an ESP32/Arduino, MQ135 sensor (DHT11), relay module, mini DC fan, air filter, OLED/LCD display, and a Li-ion battery. All these parts are connected via jumper wires. It showcases real-time environmental data on a display and automatically turns on the relay-controlled fan to feed purified air when pollution levels exceed the threshold. Real-time data is monitored via a mobile application.

Hardware Prototype of the Integrated Air Purification System

IoT Monitoring Application Screenshot

Iot Monitoring Application Screenshot

10. Results

The design and development of IoT-Based Air Purification System in Helmet has been successfully carried out and tested in the form of a hardware prototype of the smart helmet system. The effectiveness and accuracy of the smart helmet system have been proven using several test scenarios with satisfactory results regarding rider respiration protection.

Sensor ResponseTesting

All sensors were tested individually and together:

- **MQ-135 Air Quality Sensor:** It successfully identified changes in the level of air quality with varying environmental conditions.
- **DHT11 Sensor:** It provided data on the temperature and humidity.
- The sensor outputs were very consistent with less noise and latency.

Air Quality Monitoring and Purification

- It is able to classify air quality correctly into Good or Bad based on the threshold value set.
- When the level of air pollution surpassed the safe level, the fan and filter system was activated automatically to provide cleaned air within the helmet.

Automatic Fan Control Performance

- The activation response time of the fans is found to lie within 2-4 seconds of approaching the threshold value.
- The fan shutdown occurred seamlessly after air quality was within safe levels through hysteresis control action.

IoT Communication Performance

- There was successful transfer of the real-time sensor data to the mobile application (Blynk/ThingSpeak).
- The updates in the data occurred in a stable and consistent manner under optimal network conditions.

Display Output

- The display of temperature, humidity, air quality,and fan status on the OLED/LCD display was correct.

Performance Evaluation

- On the basis of several test attempts under varied levels of pollution:
- System accuracy: 85% to 90%
- Response time: Less than 5 seconds
- Air Quality Detection Reliability: High

Power Consumption

It could run for a period of 6–8 hours with art mobile applications for Android as well as iOS devices to perform real-time analysis, exposure analysis over time, health status of filtered values, as well as notifications. Cloud analytics can also enable the monitoring of pollution levels over a period of time.Miniaturization of hardware, combined with high-efficiency filters, quiet fans, and long-life batteries, may improve user experience. Incorporating extra sensors such as PM2.5, PM10, CO, and NO2 levels will enable a broader analysis of the air quality. Latest connectivity technologies of 4G/5G networks, NB-IoT, and LoRaWAN will provide seamless connectivity features. On the whole, the system can develop into a scalable smart wearable system for enhancing respiratory health, not only for motorcyclists but for industrial workers and people who find themselves in a polluted environment.

11. Conclusion

This proposed work entailed the design and development of an IoT-Based Integrated Air Purification System in Two-Wheeler Helmets with the sole objective of enhancing the respiratory safety and comfort of two-wheeler riders when airborne in a polluted environment. The proposed design integrates air quality and environmental sensors, an ESP32 Li-ion battery. Effective power consumption allowed for reliable with long-term use.

12. Future Scope

The Internet of Things-Based Integrated Air Purification System in Two-Wheeler Helmets also holds immense potential in being upgraded in the future using new advancements in cutting-edge technology such as artificial intelligence, edge computing, and sensors. Integration of machine learning techniques will allow intelligent processing of air quality patterns, exposure, and changes in order to enhance accuracy of detection, predict dangerous situations, minimize false alarms, as well as energy efficiency.Future work can also include enhancements to microcontroller, an automatic fan-filter purification system, functioning even and an IoT-based monitoring system for air quality analysis and the delivery of purified air.The system is able to monitor the levels of pollution, temperature, and humidity, enabling the purification unit to be turned on whenever there are harmful air conditions detected. This is done using an OLED screen and an application on the phone, allowing monitoring to take place locally or from a distance. The system was tested, showing a high level of accuracy of 85%-90% within a time of below 5 seconds.The prototype is compact in nature and energy efficient. Thus, it is ideal for riding for a longer period of time. Through the integration of IoT and embedded technologies, the project illustrates a feasible method that can be adopted to solve the environmental issues concerning two-wheeler riders. The proposed method does not remove the external pollutants but makes breathing a comfortable experience for the rider.In sum, the proposed solution effectively reaches its goal with a practical, intelligent, and scalable air purification helmet system with tremendous future upgrade potentials with more advanced sensors and analytics.

13. Reference

1. Arduino Documentation, Arduino UNO and ESP32 Technical Specifications, may be downloaded from the official Arduino website.

2. Espressif Systems, ESP32 Series Datasheet, Espressif Systems

3. Hanwei Electronics, Datasheet for MQ135 Gas Sensor, Technical Manual for Air Quality Sensor.

4. Aosong Electronics Datasheet for DHT11 Temperature and Humidity Sensor

5. Gupta, M. K., Sharma, S., & Verma, P. (2021). "IoT-Based Air Quality Monitoring System Using MQ Sensors," IEEE International Conference on Smart Technologies.

6. Patil, R. D., and Sawant, S. D. (2020). "Air Pollution Detection and Control Using IoT," IEEE Global Humanitarian Technology Conference.

7. Kumar, A., Tiwari, R., & Jain, N. (2022). "Smart Helmet Using IoT for Air Quality & Safety Monitoring," in *2022 IEEE International Conference on Communication and Electronics Systems*.

8. Borkar, P. S., & Bhandarkar, R. G. (2021). "Air Quality Measurement Using Low Cost Sensors and IoT Platforms," IEEE International Conference on Computational Intelligence and Communication Networks.

9. Singh, N., and Mehta, K. (2022). "Development of Smart Helmet with Health and Environmental Monitoring," IEEE Conference on IoT Applications.

10. Embedded C Programming Tutorials, TutorialsPoint and Microcontroller Tutorials.

- IoT and Air Quality Monitoring Research Papers, IEEE Xplore Digital Library. KSCST Project Reference Manuals, Karnataka State Council for Science and Technology.

11. **Dr. Malatesh S. H.**,Bikash kumar singh,

Braham kumar sha,Shubham kumar, and Shiv kumar yadav, **"Iot device for detecting leaves diseases in plants by image processing,"** International Journal of Innovative Research in Technology (IJIRT), vol. 11, no. 12, May 2025, 2349-6002.

12. **Dr. Malatesh S. H** , Shreenidhi Kattimani, Pragati Palabhavi, Vaishnavi A P,and Dikshita M G, "**Intruder Detection and Protection System**," International Journal of Innovative Research in Technology (IJIRT), vol. 11, no. 12, May 2025, ISSN: 6002.

13. **Dr. Malatesh S. H** , Arvind G, Chandan B M, Komal A, Manish M N, " **A ML Framework for Predicting and Enhancing Students**" Emotion and Satisfaction in online Education," International Journal of Innovative Research in Technology (IJIRT), vol. 11, no. 12, May 2025, e-ISSN: 2359-6002,p-ISSN: 2395-0072.

14. **Dr. Malatesh S. H** , Jyothi Patil, Ganavi C Kavana S, L G Srusti**, " Coin and RFID-Based Medicine Vending Machine,"** International Journal of Innovative Research in Technology (IJIRT), vol. 11, no. 12, May 2025, ISSN: 2349-6002.

15. **Dr. Malatesh S. H** , Supriya S,Ramya B,Parvathi BV**, "IoT-Enabled Multi-Sensor Healthcare System with ML- Driven Predictive Analytics and Emergency Response,"** International Journal of Innovative Research in Technology (IJIRT), vol. 6, no. 12, May 2025, ISSN: 2349-6002.

16. **Dr. Malatesh S. H**, Puneethraj M R, Shreya V karadi, Akhila S, 'Devika HD, **"Autonomous Sensor Technology in Hydroponics for Monitoring and Controlling Plant Growth,"**International Journal of Innovative