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Automatic Tunnel Ventilation and Lightning System and Tunnel Monitoring System for Railways

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Abstract: ***The current lightning system as well as the ventilation system in the Railway tunnels are not as efficient. The lights as well as fans remain operational even when they are not required i.e. even when the train is not passing through the tunnel. The objective of automatic tunnel ventilation and lighting systems and tunnel monitoring system for railways is to enhance safety, energy efficiency, and operational reliability.***

I. INTRODUCTION

The integration of automatic tunnel ventilation and lighting systems is a critical component in modern railway infrastructure, ensuring safety, operational efficiency, and energy conservation. These systems are designed to enhance the environmental conditions within railway tunnels by automatically controlling air quality, temperature, and lighting based on real-time data.

The primary objective of the automatic ventilation system is to maintain safe and breathable air conditions, removing harmful gases and smoke, particularly in emergency situations such as fires. In such events, the system is programmed to contain smoke, maintain visibility, and provide safe evacuation routes. On a day-to-day basis, the system adjusts ventilation based on train schedules, traffic intensity, and environmental factors, optimizing energy usage by running only when necessary.

Automatic lighting systems aim to ensure consistent and sufficient illumination within tunnels, contributing to both safety and comfort. Lighting is typically adjusted based on the presence of trains and maintenance personnel, ensuring energy is not wasted during inactive periods. These systems also play a key role in emergency scenarios, providing visibility for safe evacuations and rescue operations

II. PROBLEM DEFINATION

The lack of real-time adaptability in conventional tunnel ventilation and lighting systems presents challenges for maintaining air quality, visibility, and energy efficiency. Inadequate ventilation can result in poor air quality, posing health risks to passengers and maintenance crews, while inefficient lighting can impair visibility, potentially compromising safety. Moreover, manually operated or scheduled systems often waste energy by operating at full capacity regardless of actual conditions within the tunnel. An automatic system capable of real-time adjustment based on environmental and operational parameters is necessary to address these limitations effectively. With Remote monitoring feature.

III.LITERATURE REVIEW

1) Current Systems: Overview of traditional methods used in tunnel ventilation and lighting in railways.
2) Technological Advancements**:** Discuss recent advancements in IoT, sensor technology, and automation that enable efficient monitoring and control systems.

IV.OBJECTIVE

The primary objective of this project is to design and implement an automated tunnel ventilation and lighting system and tunnel monitoring system for railways. This system will monitor environmental parameters such as air quality, temperature, and light levels in real-time, and make adjustments to ventilation and lighting based on current needs. By employing sensors and a control algorithm, the system aims to ensure optimal air quality, energy-efficient lighting, and enhanced safety for railway tunnels.

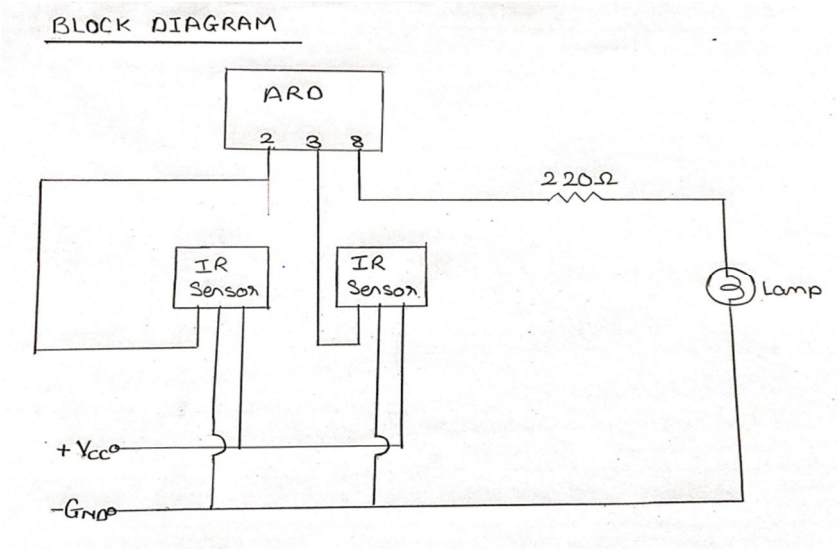
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V. WORKING

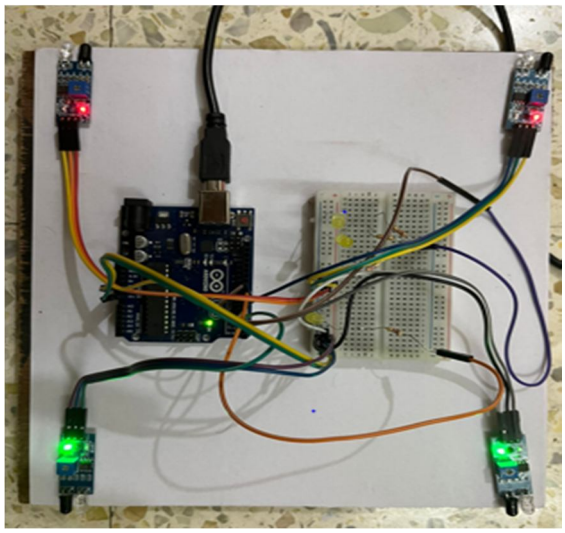
We have 2 sources of the supply the first one is Grid supply & second one supply is from solar panel converter Solar energy into electrical energy. This electrical energy is given to battery which stores the energy & act as backup. This energy by solar panel can also be used as primary energy during summer season. In case of Grid supply, The supply is given to transformer to step down the voltage to the required value . This stepped down voltage is then given to a rectifier which converts AC voltage to DC voltage which is required by the circuit. This Supply is feed to or supply to the microcontroller circuit We have used 2 IR sensors in our project, one placed at entrance side & another is on exit side of tunnel, So when the train arrives at the entrance of tunnel, The IR sensor at the entrance detected. The IR sensor detects the train and gives signal to the microcontroller. Then the microcontroller gives signal to turn on the lights and fans. Similarly, when train leaves the tunnel the IR sensor placed at exit senses this & give signal to microcontroller to turn off the lights & fans. Even if the train comes from the opposite direction the working of the project is same. Including this we will also have an user dashboard that will present all the key parameters to the user it will have an auth key, for security purpose. Hence the tunnel can be operated remotely. It will work on am microcontroller, ESP32 and some sensors such as MQ7 and DHT 11, which will monitor key parameters. Such as temp and smoke inside tunnel.

VI. TECHNICAL APPROACH

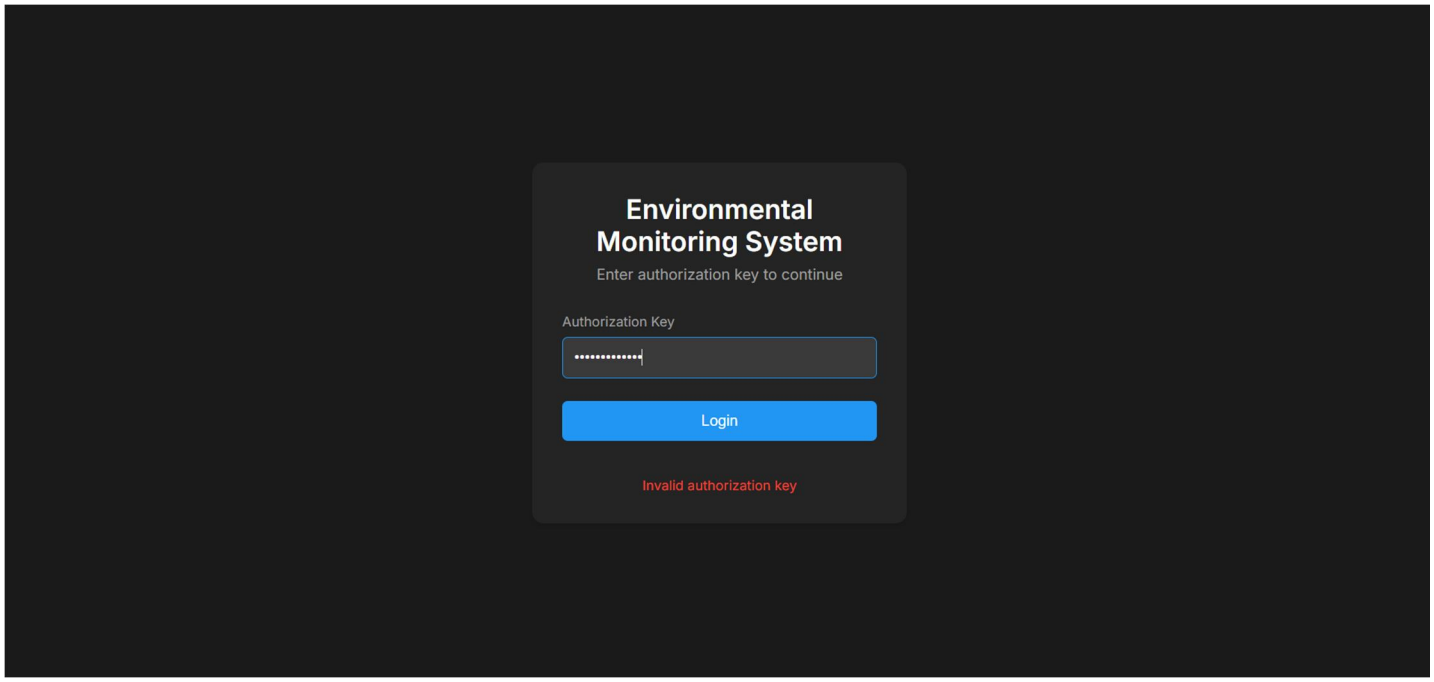
A. Block Diagram



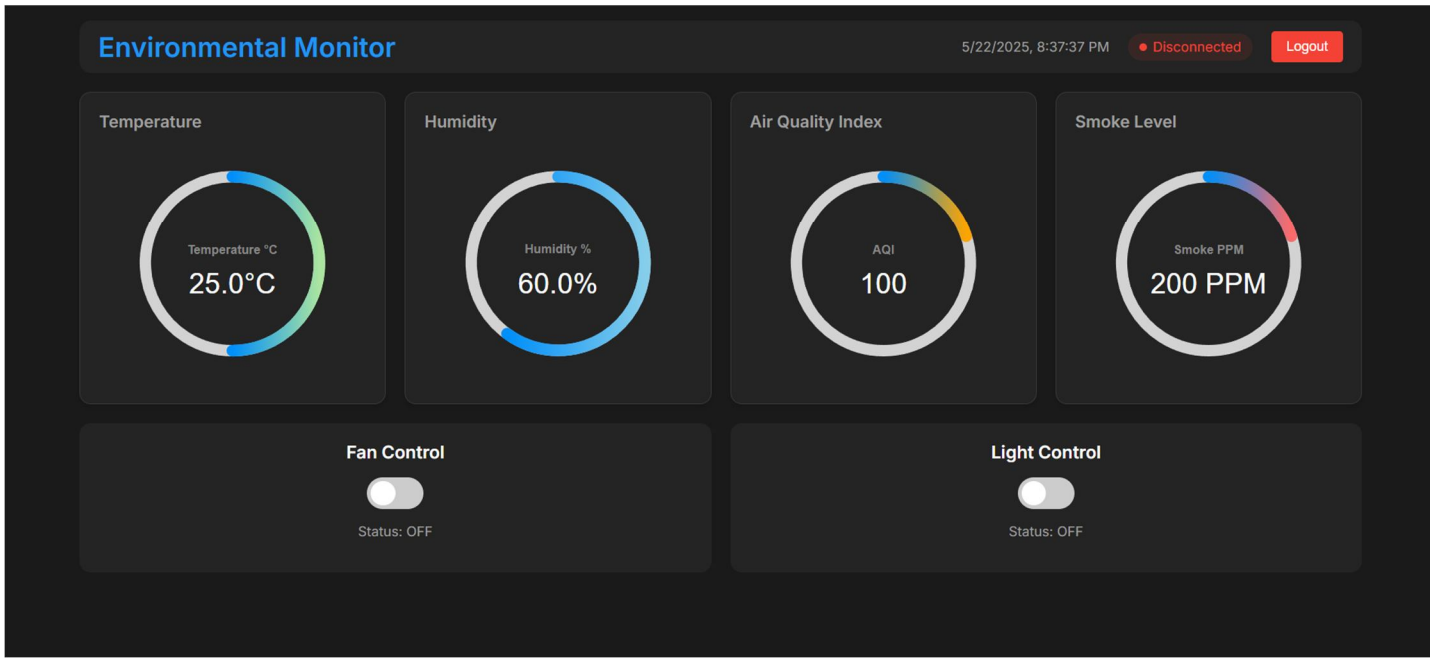
B. Hardware



C. Login Page



D. Dashboard



VII. FUTURE SCOPE

A. Sustainable and Energy-Efficient Technologies

1) Renewable Energy Integration

- Integrating renewable energy sources, such as solar or wind power, into tunnel lighting and ventilation systems can reduce reliance on grid electricity and lower the environmental impact. For instance, solar panels could power lighting systems during the day.

2) LED Lighting with Adaptive Brightness Control

- Energy-efficient LED lighting can be further optimized with adaptive brightness control, which adjusts lighting based on train schedules, time of day, and ambient light levels. This approach would reduce electricity consumption without compromising visibility and safety.

VIII. CONCLUSION

In conclusion , The implementation of an Automatic Tunnel Ventilation and Lighting System, integrated with a comprehensive Tunnel Monitoring System, marks a significant advancement in ensuring safety, efficiency, and sustainability within railway tunnel operations. By leveraging IoT technologies and real-time data acquisition, the system enhances air quality control, visibility, and structural monitoring, thereby reducing human intervention and response time during emergencies.

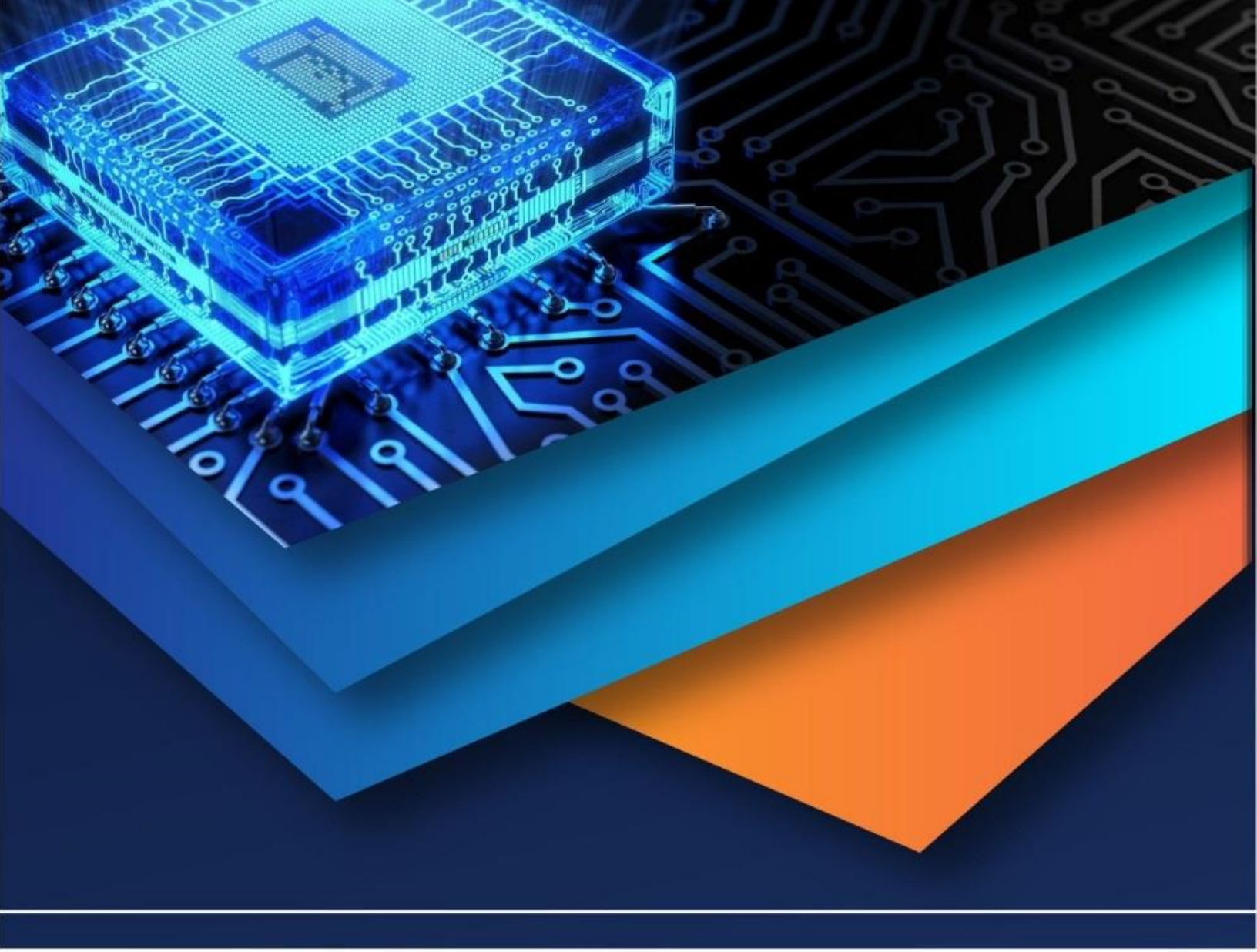
The smart integration of sensors, actuators, and communication modules enables automated regulation of ventilation and lighting based on environmental conditions and train movements. Simultaneously, the tunnel monitoring system provides critical insights into tunnel integrity, fire risks, and other operational parameters, allowing proactive maintenance and risk mitigation.

Overall, this system offers a cost-effective, scalable, and reliable solution for modern railway infrastructure, contributing to safer journeys, reduced energy consumption, and more intelligent transportation networks.

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