Automatic Electrical Appliances Monitoring System

Dr. Ramanna Havinal, Navyashree M P, Rakshitha H N,Sushmitha K B, Nisha G R
Department of Electronics and Communication Engineering, Maharaja Institute of Technology Mysore

Abstract: This project presents an automatic classroom light and fan control system using an ESP32 and PIR sensors to improve energy efficiency and classroom management. The system detects human presence through motion sensing and automatically switches electrical appliances ON or OFF accordingly. By eliminating manual operation, it reduces energy wastage when classrooms are unoccupied. The proposed solution offers a low-cost, reliable, and smart approach for modern classroom automation.

Index Terms: Automation, Energy efficiency, ESP32, Internet of Things (IoT), PIR sensor, Smart classroom.

I. INTRODUCTION

Educational institutions are increasingly adopting Internet of Things (IoT) technologies to develop smart campuses that improve operational efficiency and optimize resource utilization. In traditional classrooms, lights and fans are operated manually, requiring constant attention from teachers or staff, which often results in appliances remaining switched ON even when classrooms are partially occupied or empty. This leads to significant energy wastage, higher operational costs, and inefficient use of non-renewable energy resources, highlighting the need for intelligent and automated classroom management systems.

Automatic room light and fan controller using Arduino and PIR sensors can be used to turn on and off by sensing the presence of human in the room by detecting motion.

The rapid advancement of digital technologies has significantly transformed various sectors, including healthcare, transportation, industries, and education. Among these advancements, the Internet of Things (IoT) and cloud computing have emerged as powerful technologies that enable intelligent automation, real-time monitoring, and efficient resource management. Educational institutions around the world are increasingly adopting these technologies to develop smart campuses, which aim to enhance operational efficiency, improve learning environments, and ensure optimal utilization of resources such as electricity, water, manpower, and infrastructure.

The inefficient use of electricity not only leads to higher operational costs but also poses serious environmental concerns. A major portion of electrical energy is generated from non-renewable fossil fuels such as coal, oil, and natural gas. Excessive consumption of electricity accelerates the depletion of these limited resources and increases the emission of greenhouse gases, which contribute to global warming and climate change. Moreover, waste generated by power plants pollutes air, water, and soil, adversely affecting human health and ecological balance. Therefore, adopting energy-efficient solutions has become an urgent necessity rather than a mere option.

The Internet of Things provides a practical and effective approach to addressing these challenges. IoT refers to a network of interconnected devices embedded with sensors, software, and communication technologies that enable them to collect and exchange data over the internet without human intervention. In the context of smart classrooms, IoT devices can continuously monitor environmental parameters such as occupancy, light intensity, and temperature, and automatically control electrical appliances based on real-time conditions. This intelligent automation eliminates the need for constant manual supervision and ensures optimal energy usage.

Cloud computing further enhances the capabilities of IoT-based systems by providing scalable storage, data processing, and remote accessibility. Through cloud platforms, data collected from multiple classrooms can be stored securely and analyzed to identify usage patterns and inefficiencies. Administrators and facility managers can monitor classroom conditions in real time and make informed decisions to improve energy management. Additionally, cloud integration allows the development of mobile or web applications that provide remote control and visualization of system performance

This paper proposes an IoT-based Automated Classroom Monitoring System using an ESP32 microcontroller and PIR sensors to automatically control classroom lights and fans based on human presence. The system provides real-time status through an OLED display and enables remote monitoring and control via a mobile application. The primary objective is to reduce electricity wastage, minimize manual intervention, and create an energy-efficient and comfortable learning environment, making the proposed solution a low-cost and scalable approach for smart classrooms.

Objectives of the proposed system are

1. To reduce energy consumption by preventing unnecessary electricity usage when rooms are unoccupied. This system is designed to reduce energy consumption by automatically detecting when a room is unoccupied and turning off electrical appliances or lights accordingly. Utilizing motion sensors, infrared detectors, or camera-based presence recognition, the system ensures that electricity is only used when needed, thereby minimizing wastage and promoting energy efficiency in homes, offices, or public buildings.
2. To implement cost-effective system by reducing resource usage. This system is designed to minimize operational costs by efficiently managing and reducing the usage of key resources such as electricity, water, or raw materials. By leveraging smart sensors, data analytics, and automated controls, the system ensures optimal resource utilization without compromising functionality or performance. Its primary goal is to support sustainability while offering a cost-efficient solution for residential, commercial, or industrial environments.

II. BACK GROUND

With the rapid expansion of educational institutions and the increasing integration of electrical appliances into daily classroom activities, energy consumption in classrooms has become a major concern. Traditional classroom setups often rely on manual operation of lighting systems, fans, and other electrical equipment, requiring constant attention from teachers or staff. This approach is highly inefficient, as lights and fans are frequently left on even when classrooms are unoccupied. Such unnecessary energy usage not only leads to higher electricity bills but also places an additional burden on the electrical infrastructure. Moreover, the majority of electricity in many regions is generated from non-renewable energy sources, meaning that inefficient usage contributes to environmental pollution and accelerates the depletion of fossil fuels. The cumulative impact of energy wastage in multiple classrooms across large campuses is therefore both economically and environmentally significant.

To address these challenges, Internet of Things (IoT) and cloud computing technologies are used to develop smart campus solutions. A smart campus integrates various devices, infrastructure, and facilities, enabling intelligent monitoring and control of resources such as lighting, fans, water, manpower, and security systems. By connecting classroom equipment to a centralized system via IoT, it becomes possible to automate routine tasks, such as switching devices on or off based on real-time conditions. This reduces the need for manual intervention, minimizes human error, and ensures that energy is used only when necessary.

This paper focuses on the design and implementation of a smart classroom system that automates the control of lights and fans based on ambient conditions and human presence. The system incorporates multiple sensors: PIR sensors for detecting motion and human occupancy, LDR sensors for measuring sunlight intensity, and temperature sensors to regulate fan speed according to room temperature. By intelligently responding to these environmental factors, the system ensures that electrical devices operate efficiently, reducing energy wastage and lowering operational costs. Additionally, this automation allows teachers to focus more on teaching and student engagement rather than manually managing classroom equipment.

The adoption of IoT-based energy management in educational settings aligns with broader goals of sustainable development and resource conservation.

By integrating automation and intelligent monitoring, institutions can significantly improve energy efficiency, reduce environmental impact, and foster a culture of sustainability among students and staff. This project demonstrates a practical approach to implementing smart classroom solutions, combining cloud computing, IoT, and sensor

III. LITERATURE SURVEY

[1] Niveditha S et.al developed IOT-based Cloud Integrated Smart Classroom for Smart and a Sustainable Campus. The goal is to automate and develop a system can be used to collect attendance in workplaces. This approach is workable, dependable, and sufficiently safe. Without the need for specialised hardware, the system can be implemented in the office. It can be made with a camera and computer. It may be said that a manual and unreliable method for managing class attendance has been replaced by one that is dependable, secure, quick, and efficient. Time will be saved, less work will need to be done

[2] Harshitha Sindhe et.al designed automatic lighting and control system where IR sensor is placed at entry and exit doors of the classroom to capture the entrance of human inside class room and accordingly lights turn on or off in there presence by sending signal to relay. The room temperature is detected by the temperature sensor and immediately the fan is turned on when the temperature is high.

[3]Nasruddin et.al introduced an saving-electricity through sensors and IoT to make human life easier by designing an automated power controlling system for smart classrooms. They built an application that can transmit and receive signals using IoT. The results show that IoT technology can be used to bring improvements to classrooms appliances. Here are some extracted points for advantages that have been achieved based on the objectives of this work. The first point is, save energy and save the environment. Secondly, automated smart classroom system to count the number of students entering and exiting the classroom using sensors. Lastly, a user-friendly system to monitor and control the classroom are easily done through mobile apps.

[4] Harshwardhan Khare et al developed an automatic room light controller using Arduino and PIR Sensor can be used to turn ON and OFF the illumination system of home / office routinely by sensing the presence of a human in the room by detecting motion. This paper focuses on interfacing of different elements to create a home automation system using Arduino. Proposed system will help reduce consumption of electricity and automate the existing system making it efficient

III. METHODOLOGY

This section describes the design and working methodology of the IoT-based Automated Classroom Monitoring System. The system is developed to automatically control classroom electrical appliances such as lights and fans based on human presence and environmental conditions, thereby reducing energy wastage and improving efficiency.

A. System Overview:

The proposed system uses an ESP32 microcontroller as the core processing unit. PIR sensors are employed to detect human presence inside the classroom. Based on the sensor output, the ESP32 controls relays to switch lights and fans ON or OFF automatically. An OLED display shows real-time system status, while IoT connectivity enables remote monitoring and control through a mobile application. The system operates in automatic and manual (IoT) modes.

B. System Architecture:

The system architecture consists of input units (PIR sensors), a processing unit (ESP32), output units (relay module and OLED display), a communication unit (Wi-Fi connectivity), and a power unit supplying regulated DC and AC power to system components and appliances.

C. Hardware Components:

The major hardware components include ESP32 microcontroller, PIR sensors, relay module, OLED display, DHT11 temperature and humidity sensor, power supply unit, and classroom appliances such as fan and light.

D. Software Components:

Arduino IDE is used for firmware development, while the Blynk IoT platform enables cloud connectivity for real-time monitoring and remote control using a mobile application.

E. Working Methodology:

The PIR sensor continuously monitors human motion. When motion is detected, the ESP32 processes the signal and activates the relay to turn ON the fan and light. If no motion is detected for a predefined time, appliances are turned OFF automatically. The OLED display shows occupancy status, and system data is transmitted to the IoT cloud for remote monitoring and control.

PROPOSED SYSTEM

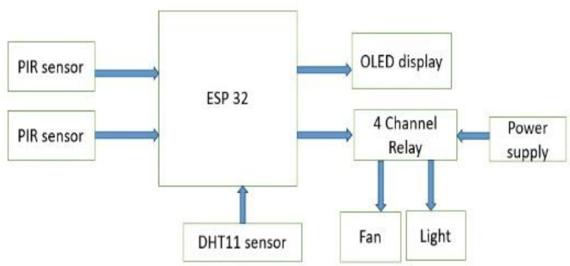

Fig. 1. Block diagram of the proposed automated classroom monitoring system

The IoT-based Automated Classroom Monitoring System is designed to enhance classroom efficiency and safety through real-time monitoring and automation .The proposed system detects human presence using PIR sensors and automatically controls classroom appliances such as fans and lights. An ESP32 processes sensor inputs and activates relays accordingly. The system also integrates the Arduino IDE platform to allow remote access and monitoring.

Key features include:

- Automatic ON/OFF of light and fan
- Real-time occupancy detection
- OLED display for classroom status
- Energy-efficient operation

System Architecture

1. Input Unit
    - PIR Sensors : Detect human presence
    - LDR (if used) : Detects light intensity
2. Processing Unit
    - Esp32 microcontroller
    - Handles sensor signals
    - Processes ON/OFF logic
    - Communicates with Arduino IDE platform
3. Output Unit
    - Relay module
    - Fan and light control
    - OLED display for live status
4. Communication Unit
    - Sends device status to Arduino IDE
    - Allows remote user control
5. Power Unit
    - 5V DC for ESP32 & sensors
    - AC supply for appliances

Fig. 2. Experimental setup of the proposed system

Hardware requirements
ESP32 Microcontroller

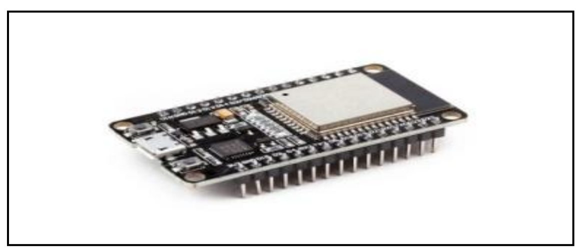

Fig. 3. ESP32 development board used in the system

PIR Sensor Module

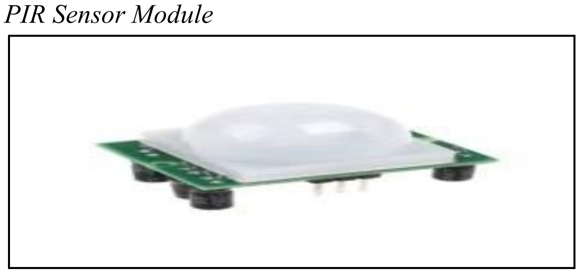

Fig. 4. PIR sensor for human presence detection

OLED Display

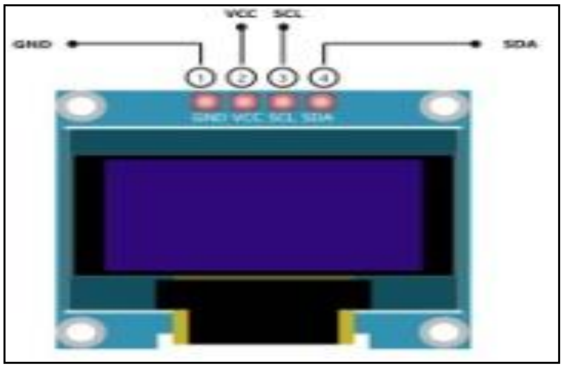

Fig. 5. OLED display showing classroom status

Arduino IDE:

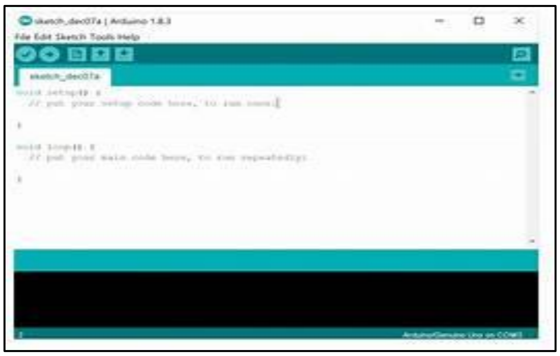

Fig. 6. IoT dashboard for remote monitoring and control

Four channel relay:

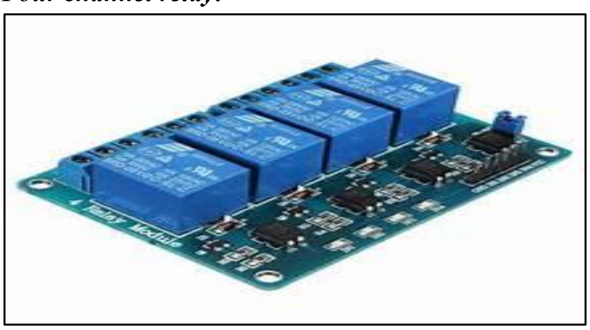

Fig. 7. Four channel relay

Fan:

Fig. 8.Fan

Light:

Fig.9.light

DHT11 sensor:

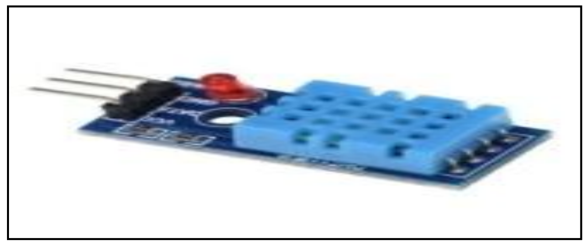

Fig. 10. DHT11 Sensor

Power supply:

Fig. 11.Power Supply

METHODOLOGY

The experimentation phase was carried out to validate the functionality, accuracy, and reliability of the Automated Classroom Monitoring System. This section explains the step-by-step procedure followed during testing, the test environment used, and the observations recorded. The experiments were performed in a controlled classroom-like setup to ensure realistic behavior of sensors, relays, and IoT communication.

The experimentation was conducted in four different stages, ensuring that each functional block of the system was individually verified and validated after integration.

Stage 1: Sensor Testing

1. PIR Sensor Testing

- The PIR sensor was placed at a height of approximately 1 meter.
- Motion was introduced in front of the sensor at different distances (1m to 7m).
- The output signal from the sensor was monitored using the Arduino Serial Monitor.

Observation:

The sensor produced HIGH output when motion was detected and LOW when no movement was observed. Detection accuracy was highest within 0–5 meters.

Stage 2: Relay & Load Testing

1. Relay Switching Test

- The relay module was connected to Arduino digital pins.
- Test code was uploaded to turn the relay ON and OFF at intervals of 3 seconds.
- A lamp / fan model were connected as load.

Observation:

The relay switched appliances smoothly with no mechanical lag. No false triggering occurred during a 10-minute continuous test.

Stage 3: System Integration Testing

This stage verified the combined operation of sensors, Arduino, relays, LCD, and IoT platform.

1. Automation Testing

- PIR sensor was connected to the system.
- When motion was detected → Arduino activated the relay → Fan and light turned ON.
- When no motion was detected → Appliances turned OFF automatically after timeout.
- LCD displayed “Occupied” or “Empty” based on status.

Observation:

- The system responded within 1–2 seconds after motion was detected.
- LCD updated the status instantly.

Stage 4: IoT Connectivity Testing

1. Blynk Cloud Testing

- Arduino was connected to Wi-Fi.
- Device status (ON/OFF) was sent to Blynk dashboard.
- Virtual switch in Blynk app was used to manually override appliance states.

Observation:

- Data is uploaded to cloud every 2–3 seconds.
- Manual control via mobile app worked without delay.
- System maintained stable connection for 20+ minutes of continuous testing.

Experimental Analysis

a. The PIR sensor showed high accuracy in motion detection.
b. The automated switching reduced appliance runtime significantly.
c. IoT monitoring improved system flexibility and allowed users to check classroom status remotely.
d. The LCD provided real-time visibility of system operation.
e. The system is reliable, responsive, and capable of operating in real classroom conditions.

III. VII. CONCLUSION

This paper presented an IoT-based Automated Classroom Monitoring System using an ESP32 microcontroller and PIR sensors to control classroom lights and fans based on human presence. The proposed system effectively eliminates the need for manual operation and significantly reduces unnecessary energy consumption in classrooms. By integrating real-time occupancy detection, relay-based appliance control, OLED status display, and cloud connectivity, the system ensures reliable and efficient management of classroom environments.

Experimental implementation demonstrates that the system provides fast response, accurate detection, and stable operation, making it suitable for practical deployment in educational institutions. The low-cost design and simple architecture enable easy scalability and adoption in schools and colleges. Future enhancements may include integration of additional environmental sensors, machine learning-based occupancy prediction, and centralized monitoring for multiple classrooms to further improve energy efficiency and smart campus development.

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