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Design and Implementation of an IoT-Based Smart Office Automation System

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Abstract: The "Smart Office Using IoT" focuses on creating a smart and energy-efficient workplace by integrating modern IoT technology into daily office work.It automatically controls lights, fans, window curtains and other electrical devices using sensors and actuators that react to hu- man presence and environmental conditions. For example, when someone enters the office, lights and fans automatically turn on and if the office is empty, they turn off to save energy. This system also monitors temperature, humidity, light and oxygen levels to maintain a comfortable working office environment. A biometric sensor ensures only authorized access while a dig- ital display at the door shows whether the user is available, or not available and it improves communication without disturbance. The entire setup is managed by an ESP32 microcontroller programmed using Arduino IDE, which collects sensor data and executes automation com- mands through Wi-Fi connectivity. This project aims to reduce manual work, reduce energy west and enhance convenience and security within the office. In the future, the system can be upgraded with voice control, AI-based predictions and cloud integration for smart campus or enterprise-level applications.

Keywords: IoT, Smart Office, Automation, Energy Efficiency, Sensors, ESP32, Biometric, Actuators, IR, Environment Monitoring.

INTRODUCTION

The Internet of Things (IoT) is a technology that allows devices to connect and work automatically and smartly without any human interaction . A Smart Office uses internet connected devices and sensors to make the workplace elegant. These devices help to improve work efficiency, keep the office secure and save energy. A smart office system can control environmental parameters such as temperature, humidity, and light intensity while intelligently controlling appliances like fans, lights, and curtains without human interaction . This technology not only reduces energy waste but also improves the overall performance and convenience of the workplace. Smart Office Using IoT, more focuses on automatically the office cabin by managing sensors, actuators, and wireless communication modules. The system detects the presence of people using motion and fingerprint sensors, automatically turning on or off electrical devices such as lights and fans. It also controls the air quality, humidity, and temperature us- ing suitable sensors, and displays real-time data on an LCD screen. One more thing added here , the system shows an occupancy status indicator that displays whether the user is "Available" or "Not Available," helping visitors avoid unnec- essary interruptions. This project's main motive is to create a suitable and intelligent office environment that demonstrates the practical use of IoT in the real-world. By combination of the automation, energy efficiency, and user convenience, the Smart Office Using IoT system represents a smart campus infrastructure. The implementation of this project can be fur- ther expanded to other departments and administrative areas, promoting a culture of digital transformation, operational efficiency and environmental responsibility within educational organizations. In the future, the system can be upgraded with voice control, AI-based predictions and cloud integration for smart campus or enterprise-level applications.

PROBLEM STATEMENT

Energy wastage and manual systems are major problems in the existing office environment. In many office electrical appliances such as lights, fans, and curtains left on without need and Additionally, the absence of real-time information about staff availability, particularly in office, leads to inconvenience for visitors and inefficient communication and security is limited. To overcome these challenges, the system uses the ESP32 microcontroller as the central unit, integrating various sensors such as IR sensors for motion detection, LDR for light intensity monitoring, DHT11 for temperature and humidity sensing, and a gas sensor for air quality measurement. A fingerprint sensor (R307) ensures biometric authentication for secure access, while the system automatically controls electrical devices based on sensor inputs. Real-time environment data status are displayed on an LCD display and availability status show placed at the office entrance wi-fi display, creating a smart, secure, and energy-optimized workspace.

GOALS AND OBJECTIVES

Goals

The main goal of the Smart Office Using IoT project is to create an intelligent and automated office environment that improves energy efficiency, security and convenience. The main goal of the system is to reduce human effort by auto- matically controlling electrical devices and monitoring office conditions in real time. It aims to change a traditional office into a smart office.

Objectives

1. To automatically control electrical devices like lights, fans, and curtains.
2. To monitor temperature, humidity and air quality using IoT sensors to keep the office comfortable.
3. To provide the security to the office using a fingerprint sensor (R307).
4. To provide real-time data visualization of environmental parameters and availability status through an LCD display.
5. To minimize energy wastage and operational costs by using smart sensing and automated control mechanisms.
6. To promote a sustainable and smart workspace model that can be expanded to other offices or departments.

PROPOSED METHODOLOGY

The proposed Smart Office system uses IoT technology to automate office tasks, save energy and improve security. The system is divided into different functional parts that work to- gether to monitor the environment, detect people's presence and control electrical devices in a smart way.

Step 1: Input Sensor Module

To get the room to respond to people, we've packed it with a few key sensors. First an IR sensor handles presence detection so the room knows when someone walks in. For security purposes, we are using an R307 fingerprint scanner to make sure only authorized people can get in.The DHT11 checks the temperature and humidity, the LDR checks the light level, and the MQ-2 checks the air quality to keep the room comfortable. All of these units feed live data back to the central controller, which makes the actual decisions for the office.

Step 2: ESP32 Controller Module

The ESP32 microcontroller is the main control unit of the system. It receives data from all sensors and then processes it using predefined decision logic and determines relevant actions. Based on sensor inputs Lights and fans are turned ON/OFF automatically.Access is granted or denied using fingerprint verification. Environmental parameters are evaluated for comfort and safety. ESP32 is selected because of its low power use , high processing speed and built-in Wi-Fi capability.

Step 3: Decision & Control Logic

The controller executes conditional logic such as:

- If human presence is detected, electrical appliances are activated.
- If no presence is detected, devices are turned OFF to save energy.
- If fingerprint authentication fails, access is denied.
- Environmental data is compared with threshold values to control appliances.

Step 4: Actuator Module

The actuator module includes: Relay Module to control lights, fans and Motor Driver control window curtain motor.

Step 5: Display Module

A 16×2 LCD display is used to show real-time system status, like following :

- Temperature and humidity
- Oxygen level
- Light intensity window status
- Office availability status (YES / NO)

Step 6: Wi-Fi Display / Communication Module

Using ESP-NOW / Wi-Fi communication, the system sends availability status and sensor data to a remote dis- play module placed outside the office. This helps the visitors see whether the staff member is available without disturbing them.

Step 7: System Integration & Automation

All modules are combined to form a fully automated smart office system. The system works continuously, monitors conditions in real time and responds intelligently to changes, ensuring security, comfort and energy efficiency.

SYSTEM ARCHITECTURE

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- **Block Diagram:**

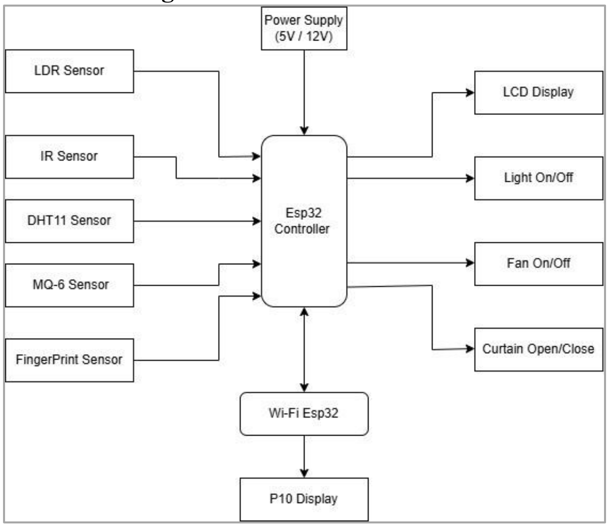

Fig. 1. Block Diagram

- **Circuit Diagram:**

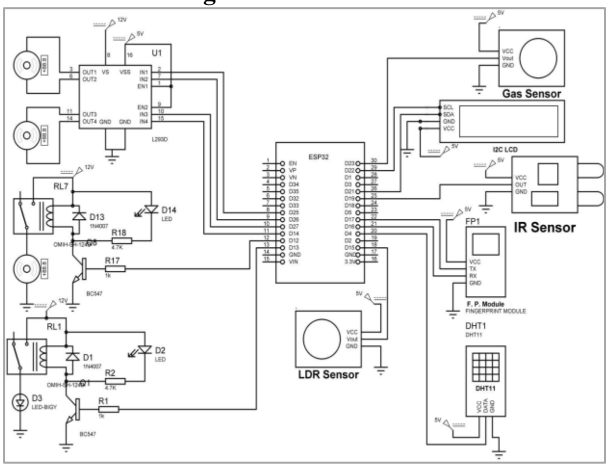

Fig. 2. Circuit Diagram

ALGORITHM

- **Start**
  - **Initialize Components:**
    - Firstly, set the GPIO pins for relays and motor drivers as output and turn them off .
    - Second, set the sensor pins (IR, LDR, MQ-2, Fingerprint, DHT11) as input.
- **Initialize Displays and Communication:**
  - Start I2C LCD and display System Starting
  - Initialize P10 LED display.
  - Initialize DHT11 sensor for temperature and humidity measurement.
  - Initialize UART communication for R307 finger-print sensor.
  - Initialize Wi-Fi and ESP-NOW communication.
  - **Set Initial Conditions:**
    - CurtainStatus ← CLOSED
    - UserStatus ← UNAVAILABLE
- **Repeat Continuously (Main Loop)**
  - Read Sensors:
    - * Read temperature and humidity from the DHT11 sensor.
    - * Read motion status from the IR sensor.
    - * Read light/dark conditions from the LDR sensor.
    - * Read oxygen level from MQ-2 sensor.
  - Fingerprint Authentication:
    - * If a valid fingerprint is detected, set UserStatus ← AVAILABLE.
    - * Else, set UserStatus ← UNAVAILABLE
  - Update LCD Display:
    - * Display temperature, humidity, light status, User status, and air quality.
  - If Motion is Detected:
    - * If the (Temperature > 20°C) then turn ON Fan; otherwise turn OFF Fan.
    - * If Day (Bright condition):
      - · Turn OFF Lights.
      - · If the curtain is OPEN, open the curtain (Motor ON → Delay 30 seconds → Mo-tor OFF).
    - * Else (Night/Dark condition):
      - · Turn ON Lights.
      - · If the curtain is CLOSE, close curtain (Mo- tor ON → Delay 15 seconds → Motor OFF).
  - If No Motion is Detected:
    - * Turn OFF Fan after a short delay.
    - * Turn OFF Lights after a short delay.
  - Update Wi-Fi Display:
    - * Send system data (Wi-Fi status, air quality, User status) via ESP-NOW.
    - * Remote ESP32 receives data and updates the P10 LED display.
- **End**

IMPLEMENTATION

Sensors Integration

In our project, the ESP32 microcontroller is used as the main controller unit to combine all hardware components. The IR sensor used to detects human availability. The DHT11 used to measures temperature and humidity. The LDR sensor is de- tects light intensity and the MQ-2 monitors air quality.These all sensors send data to the ESP32 through digital and analog pins. The R307 fingerprint sensor is connected using UART communication to provide secure biometric authentication. Relay modules are used to control lights and fans, while an L298N motor driver controls the DC motor for curtain operation. A 16×2 LCD displays real-time sensor data using I2C communication.

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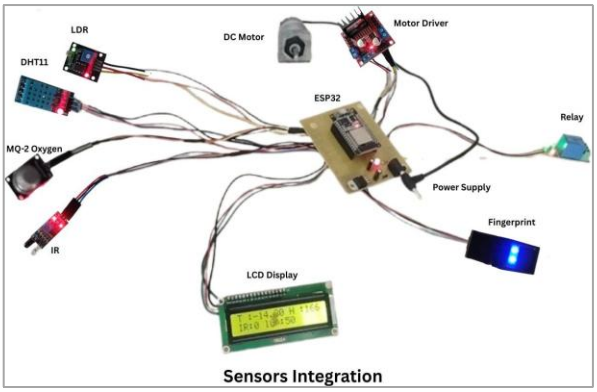
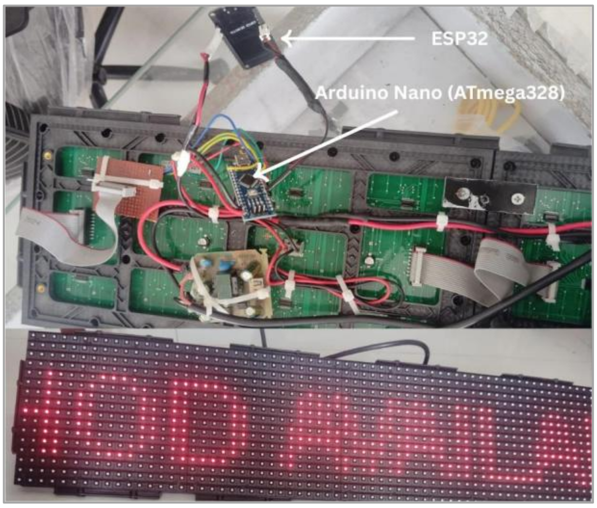


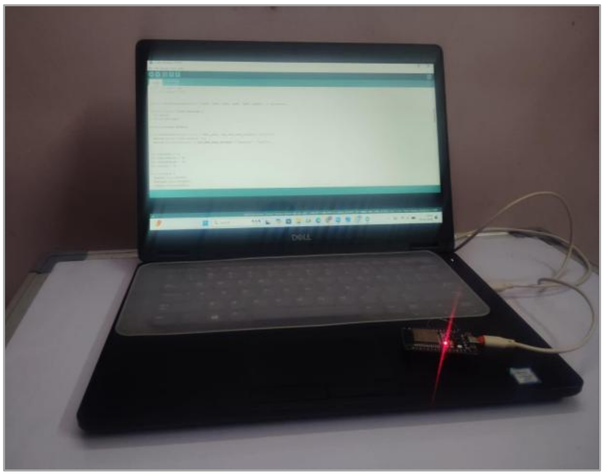
P10 LED Display

A P10 LED display receives user availability status wirelessly through Wi-Fi/ESP-NOW from the main Eps32 controller.



Microcontroller Programming

The ESP32 microcontroller is programmed using the Arduino IDE software in c++ language. Required libraries are added to read sensor data and control devices.

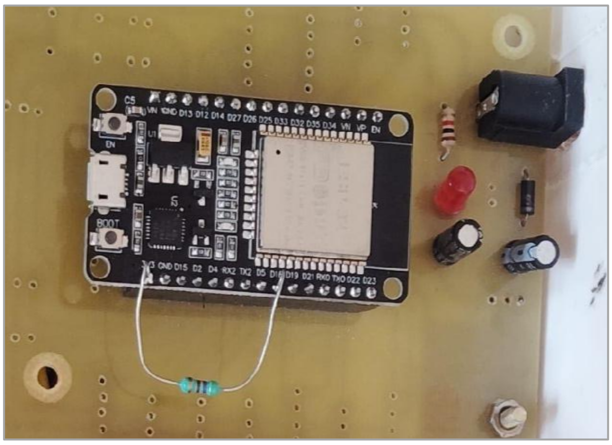


HARDWARE REQUIREMENTS

Microcontroller:

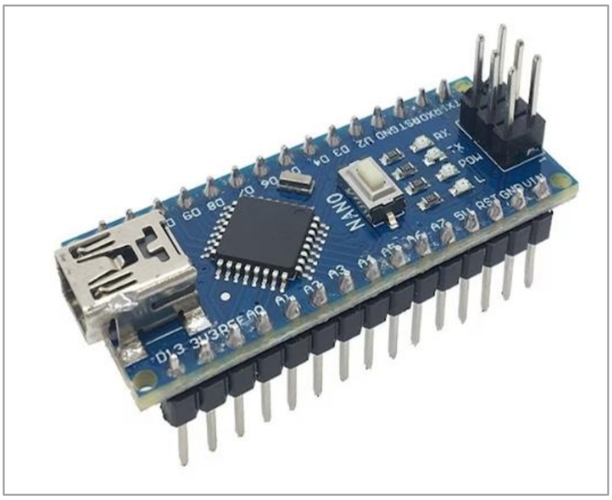
a. ESP32

The ESP32 is the main microcontroller of the project. So it has dual-core processors , built-in Wi-Fi and Bluetooth connectivity. Also It collects data from sensors such as IR, LDR, DHT11 and MQ-2 then processes the information and sends commands to actuators like relays and motors. The Wi-Fi module allows wireless TCP connectivity.



b. Arduino Nano (ATmega328)

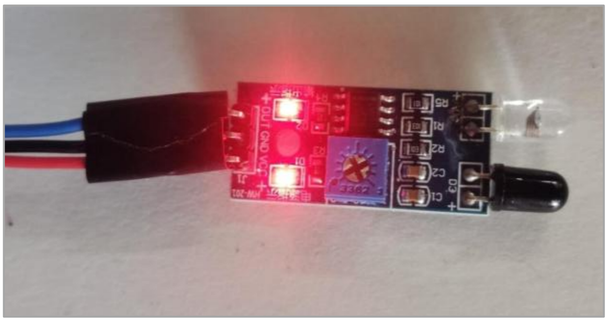
The Arduino Nano is a small microcontroller board and uses AImega328 as the main processor. It works at 5 volts and provides digital and analog input/output pins to connect with sensors and actuators.The Arduino Nano is used to handle smaller tasks such as running P10 display automation after connecting esp32 now through the wifi from the main controller and sending status to esp32-now and then displaying the status.



Sensors:

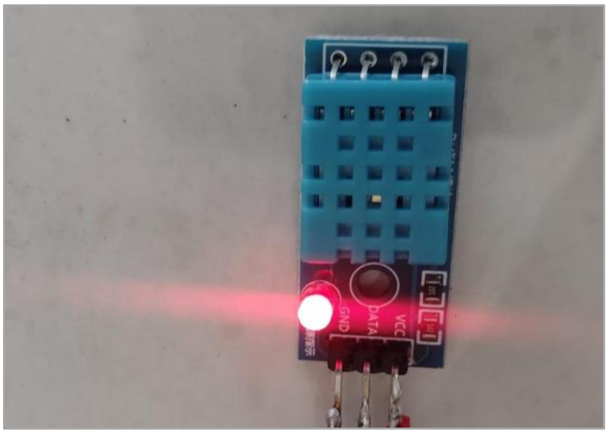
a. IR Sensor

IR sensor detects object presence and this Sensor is used for detecting the user and sending signal To esp32 controller.



b. DHT11 Sensor

The DHT11 sensor is the measured temperature (T) and humidity (H). It uses a humidity sensor to sense the surrounding air after that the sensor sends digital data to the microcontroller.

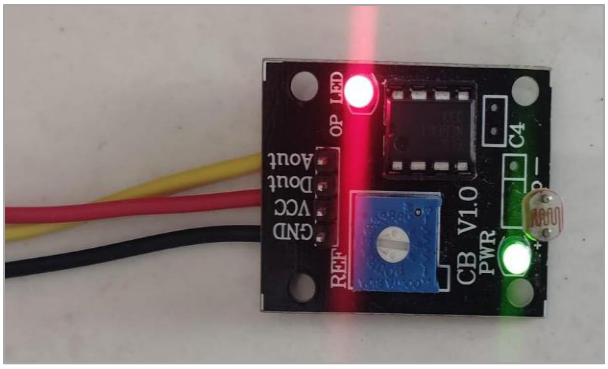


c. MQ-2 Sensor (Gas/Smoke/Oxygen)

The MQ-2 sensor detects gases such as LPG, smoke and oxygen levels in the environment. It contains a heating element and a sensitive layer whose resistance changes in the presence of gas. The microcontroller reads the analog output to manage air quality.

d. LDR (Light Dependent Resistor)

The LDR sensor is used to measure light intensity. Its resistance decreases when light intensity increases, producing a varying voltage signal. The microcontroller reads this signal to adjust lighting conditions automatically.



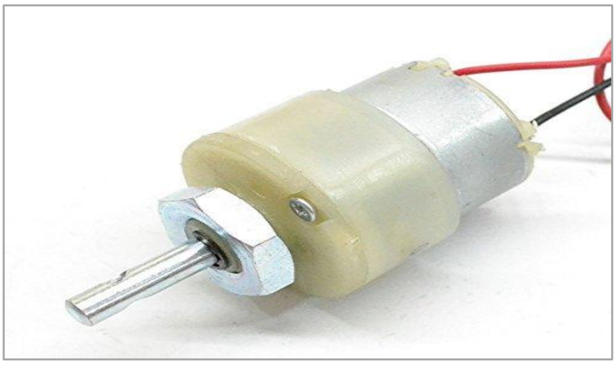
e. Fingerprint Module (R307)

A fingerprint-based sensor used for authentication and security.

Actuators:

a. DC Motor

It can be used to automatically open or close office windows based on sensor signals. When the ESP32 detects changes in light intensity or user input, it sends signals to the motor driver, which drives the motor to open or close curtains and maintain optimal light levels in the office.

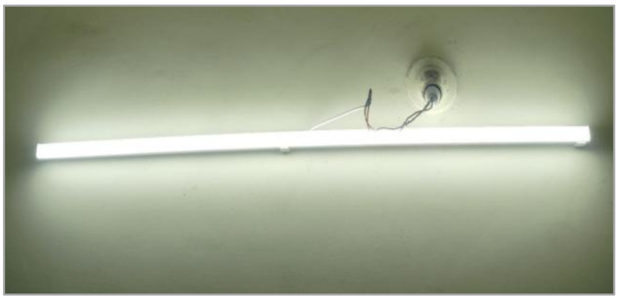


b. Fan

Fan acts as an actuator that controls air circulation and room comfort. The fan is connected to the microcontroller through a relay module. If an IR sensor detects a person then check temperature condition if temperature is greater than predefined condition then fan ON otherwise fan OFF.

c. Light

The light is an electrical actuator used to provide automatic lighting in the smart office. It is connected to the microcontroller via a relay module. If IR sensors detect a person or LDR sensor detects room light intensity. When a person is detected or the surrounding light is low, the microcontroller activates the relay and turns the light ON then closes curtains. If no movement is detected or sufficient daylight is available, the light is turned OFF then open curtains automatically.



Display:

a. P10 Display

A small digital screen that shows important informa- tion. It can display “User Available/Not Available,” Connected to ESP32, it updates information in real- time.

b. LCD Display

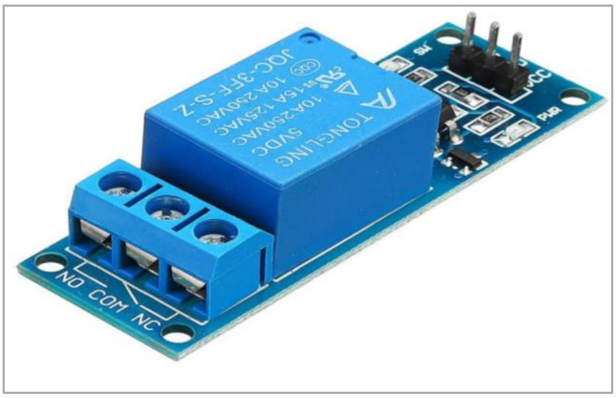
The LCD display is used to show output such as temperature,humidity, air quality and occupancy status.

Voltage Regulator IC (LM2596)

The LM2596 is a step-down voltage regulator IC used to con- vert higher voltage to a stable lower voltage that is suitable for microcontrollers and sensors. It ensures that the components work within their safe voltage range and protects them from damage due to voltage fluctuations.

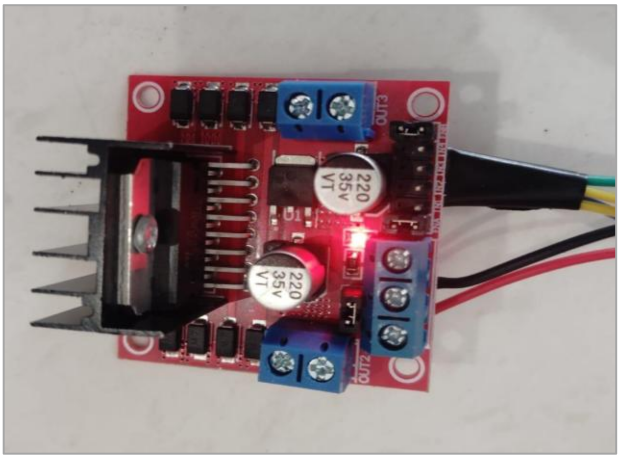
Relay Module

The relay module acts as an electronic switch to control high- power devices like lights, fans.



Motor Driver (L298N)

The L298N is a motor driver used to control DC motors. It has H-bridge circuits which means it can control the direction and speed of motors.



SOFTWARE REQUIREMENTS

- Arduino IDE (Programming Microcontroller)
- Programming Language: C++

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RESULT

ADVANTAGES

- Automated Office Control
- Energy Efficiency
- Improved security
- Real-Time Monitoring
- Save Energy & Time

DISADVANTAGES

- Power Supply Requirements
- Sensor Sensitivity
- Limited Range of Wi-Fi
- Hardware failure
- Initial Cost is High

FUTURE SCOPE

The purpose of the system can be used in offices, classrooms, laboratories and institutional buildings. It automati- cally controls lighting, fan and environmental monitoring. The system can be expanded for smart campuses by integrating cloud platforms, AI-based energy prediction, voice control and mobile applications. Future improvements may include data analytics.

APPLICATION

- **Educational Institutions:**

We can control Automating offices, classrooms and laboratories to save energy and improve efficiency.

- **Corporate Offices:**

boost office productivity and energy management through automated systems.

- **Government Offices:**

In this section we can improv- ing operational control and monitoring for administrative efficiency.

- **Smart Buildings:**

Integrating IoT automation across multiple office spaces for centralized monitoring.

- **Research and Development Labs:**

Providing a base model for IoT-based automation and energy conserva- tion research.

CONCLUSION

The Smart Office using IoT develops workplaces more efficiently, securely and eco-friendly by using IoT technology to au- tomating daily tasks such as controlling lights, fans and other devices. It helps save energy, improves comfort and provides real-time information about occupancy and environment conditions. With features like motion detection, biometric security and digital displays the system reduces manual effort and enhances office management.

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