IOT Based Home Automation

1. Introduction

This project presents a smart home automation system designed using NodeMCU ESP8266, incorporating features such as OTP-based lock/unlock via Telegram, temperature-based fan control, object detection, motion sensing, and real-time remote notifications. The system integrates multiple sensors and actuators with cloud-based interaction to enhance security and energy efficiency. It serves as a compact, scalable, and cost-effective solution for modern smart environments.

2. Components Description

Component	Functionality
NodeMCU ESP8266	Core microcontroller with Wi-Fi capability for controlling and communication
DHT11 Sensor	Measures ambient temperature and humidity
Servo Motor	Simulates lock/unlock action via rotation
Ultrasonic Sensor	Detects presence of objects based on distance measurement
PIR Sensor	Detects human motion in its proximity
Relay Module	Enables switching of external AC/DC devices
LED Indicators	Display fan and object detection status
Buzzer	Provides audible feedback for access control
Telegram Bot API	Facilitates secure communication between user and system
Power Supply (5V)	Powers the NodeMCU and connected components

3. Working Principle

The system is designed around the following high-level operations:

- Lock/unlock access is controlled via a Telegram-delivered OTP.
- Environmental conditions are monitored using temperature and distance sensors.
- Actuators such as servo, relay, LEDs, and buzzer respond to sensor inputs and user commands.
- Telegram notifications are used for remote alerts and monitoring.

All modules operate concurrently to ensure continuous automation and responsiveness.

4. Algorithm Implementation

System Flow is as follows:

(I) Initialization:

a. Establish Wi-Fi and Telegram bot connection.
b. Initialize all sensors and actuators.

(II) Access Control:

a. Wait for user input (lock/unlock request).
b. Generate and send OTP via Telegram.
c. Verify user-input OTP from Serial.
d. On correct entry, rotate servo and notify user.
e. On incorrect entry, activate buzzer and notify user.

(III) Environmental Monitoring:

a. Continuously read temperature and humidity.
b. Activate fan (relay/LED) above threshold; deactivate when cooled.
c. Detect object distance and toggle object indicator LED.

(IV) Motion Detection:

a. Monitor PIR sensor to detect motion.
b. Toggle relay-controlled device accordingly (with delay).

(V) Notification & Feedback:

a. Send real-time updates via Telegram on environmental changes or system actions.

5. Advantages

- Low-cost, compact, and Wi-Fi-enabled solution
- Remote control and monitoring using Telegram
- Secure access via OTP authentication
- Energy efficiency through automated fan/light control
- Modular design suitable for future expansion

6. Future Advancements

To enhance functionality, reliability, and user experience, the following future developments are proposed:

(I) Hardware Enhancements

- **Real Fan/Light Control:**
  - Integrate actual appliances via relay modules for practical automation.
- **Battery Backup:**
  - Add a rechargeable battery unit for uninterrupted operation during power failure.
- **Biometric/RFID Integration:**
  - Add fingerprint scanner or RFID reader for alternate access methods.
- **OLED Display:**
  - Real-time display of system status, temperature, and distance on a screen.
- **ESP32 Upgrade:**
  - Transition to ESP32 for camera support and dual-core processing.

(II) Software and Connectivity Improvements

- **Web Dashboard:**
  - Real-time system monitoring and control via browser interface.
- **Telegram Reply-Based OTP Input:**
  - Allow user to enter OTP directly in Telegram chat for better security.
- **Mobile App:**
  - Develop a custom Android/iOS app using MIT App Inventor or Flutter.

- **IFTTT and Voice Assistant Integration:**
  - Control system via Google Assistant, Alexa, or Siri using IFTTT.
- **Data Logging and Analytics:**
  - Store historical temperature/motion data and visualize trends.
- **Face Detection (ESP32-CAM):**
  - Implement AI-based recognition to replace or supplement OTP access.
- **Multi-User and Role-Based Access Control:**
  - Allow different access levels for different users (admin, guest, etc.)

7. Conclusion

This project successfully demonstrates a functional IoT-based security and environmental monitoring system. It highlights the potential of integrating microcontrollers with cloud services and real-time sensing for smart automation. With the outlined future advancements, this system can be further extended to support a comprehensive, scalable, and user-friendly smart home solution.