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# DEVELOPMENT OF A WEB-BASED APPLICATION FOR SMART CURTAIN CONTROL

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**Abstract.** This paper presents the development of a web-based application for controlling smart curtains using IoT technology. The system is designed to provide a secure and efficient method for managing curtain movements remotely via a web interface. The core hardware components include an Arduino Uno, a Wi-Fi module ESP8266, a light sensor LM393, a DHT11 temperature and humidity sensor, a BTS7960 motor driver, and a 775 24VDC motor.

A key feature of the system is its enhanced security, achieved through the HTTPS (SSL/TLS) protocol, which encrypts data transmission between the ESP8266 module and the server. Additionally, user authentication is implemented, requiring a unique password verification, with the option for two-factor authentication (2FA) via SMS or a mobile app.

Data transmission to the server is performed using the SFTP (Secure File Transfer Protocol), ensuring secure communication. The system allows users to log in once and remain authenticated for future sessions without repeated password entry. This project aims to provide an intuitive and safe smart home automation solution, improving energy efficiency and user convenience.

**Keywords:** Smart curtains, web-based application, IoT, Arduino Uno, ESP8266, HTTPS encryption, SFTP, home automation, remote curtain control.

## Introduction

With the growing demand for smart home automation, IoT-based solutions have become a crucial component in enhancing user convenience, energy efficiency, and security. One such application is the automation of window coverings, where smart curtain systems can optimize indoor lighting conditions, regulate temperature, and provide seamless remote control functionality.

Traditional curtain systems require manual operation, which may be inconvenient, especially in large homes or offices. The integration of IoT technology allows users to control their curtains remotely via a web-based interface, adjusting them based on real-time environmental data. This not only improves energy efficiency by reducing reliance on artificial lighting but also enhances security and comfort.

This project focuses on developing a secure web application for smart curtain control, utilizing an Arduino Uno and an ESP8266 Wi-Fi module for connectivity. The system processes data from LM393 light and DHT11 temperature/humidity sensors to adjust curtain positions automatically. The curtain movement is powered by a 775 24VDC motor, controlled by a BTS7960 motor driver.

Security is a crucial aspect of this project. To protect data transmission between the ESP8266 and

the server, the HTTPS (SSL/TLS) protocol is used. Additionally, user authentication mechanisms ensure secure access, with optional two-factor authentication (2FA). Data transfer to the server is handled using SFTP (port 22) via WinSCP, ensuring encrypted communication.

The proposed system enhances smart home automation by integrating secure remote access, real-time environmental monitoring, and intelligent curtain control into a single, user-friendly platform.

## Problem Statement

As smart home automation continues to evolve, the need for secure and efficient remote control systems has become increasingly important. Traditional curtain systems require manual operation, which can be inconvenient, especially in large homes or offices. Additionally, improper light management leads to unnecessary energy consumption, increasing electricity costs and reducing overall efficiency.

Existing smart curtain solutions often lack robust security features, exposing users to potential data breaches and unauthorized access. Many systems rely on unencrypted communication protocols, making them vulnerable to cyberattacks. Furthermore, some IoT curtain control systems require complex installation processes or are limited in remote access functionality, reducing user convenience.

This project aims to address these challenges by developing a secure web-based application for smart curtain control, leveraging the power of Arduino Uno and ESP8266. The system integrates HTTPS (SSL/TLS) encryption to secure communication between the curtain control unit and the server. Additionally, user authentication with optional two-factor authentication (2FA) ensures that only authorized users can access and manage the system.

To further enhance security, SFTP (port 22) is implemented for encrypted data transmission between the ESP8266 module and the server. The system also provides an intuitive and user-friendly web interface, allowing users to remotely control curtains based on real-time light and climate data collected by the LM393 light sensor and DHT11 temperature/humidity sensor. The BTS7960 motor driver and 775 24VDC motor ensure smooth and precise curtain movement, adapting to environmental conditions.

By combining IoT technology with cybersecurity measures, this project aims to provide a practical, secure, and scalable smart home automation solution, improving both energy efficiency and user convenience.

## Review of Modern Information Sources on the Subject of the Paper

The development of web applications for controlling IoT systems is an important step in the introduction of intelligent technologies into everyday life. In this context, there is a need to analyze existing approaches and technologies used in the development of web applications for controlling smart curtains. In this paper [1], IoT-based smart homes are explored for their ability to enhance convenience and automation. The study presents smart curtains equipped with embedded LEDs, sensors, and smartphone control. These curtains adjust lighting, regulate temperature, and improve security by detecting fire or intrusions. A prototype was tested for performance, demonstrating the potential of IoT systems in home automation.

This study [2] introduces an IoT-based framework designed for controlling lights, window decorations, and air conditioning through a private cloud. The framework employs a Raspberry Pi 3 server and an Android app, although performance tests showed reaction delays of up to 2.1 seconds, which indicates potential areas for improvement in the system's responsiveness. In this research [3], an automated air curtain system is examined for optimizing the microclimate in livestock buildings. The system is designed to improve temperature and humidity control, leading to a 10–15% reduction in thermal energy consumption. Tested in a pigsty, the system enhanced environmental conditions while reducing energy costs. Future developments include the integration of IoT-based remote control features.

This work [4] presents a smart home model that integrates IoT, ambient intelligence, and user profiling to personalize multimedia content and automatically regulate environmental factors such as lighting, curtains, and temperature. Evaluations highlight the system's effectiveness in improving smart

environments and enhancing daily living by providing personalized comfort. In this paper [5], an IoT-based smart blackout curtain is introduced. The curtain automates its opening and closing based on various factors such as temperature, light, voice commands, and air quality. Voice recognition features further enhance the system's convenience, allowing for remote operation to improve sleep quality and daily comfort. This study [6] explores various IoT applications in both industrial and household sectors, emphasizing how automation can enhance efficiency. Examples include smart curtains, water faucets, and parking sensors. The findings underline the impact of IoT on supply chains, work effectiveness, and individual behaviors, illustrating its broad potential across different sectors.

In this research [7], an IoT-based winch curtain system is examined for its use in livestock barns. The system helps improve climate control and safety, with performance tests confirming its effectiveness in enhancing animal health and productivity. The findings suggest the system could have significant benefits for agricultural environments. This study [8] introduces an IoT-based smart curtain system that integrates voice control, artificial intelligence (AI), and solar energy to promote energy efficiency and sustainability. The system's performance was tested, and it was confirmed to be reliable, featuring dual control modes and the ability to power other devices, making it a valuable addition to modern smart homes.

In this paper [9], a web-based IoT crop monitoring system is presented. The system regulates environmental factors such as temperature, humidity, sunlight, and soil moisture. It automates the operation of curtains, fans, and water sprayers based on preset values or manual control, offering efficient remote management of greenhouses. The system uses NodeMcu, C#, and JavaScript for its implementation.

This study [10] introduces an IoT-based air purifier that uses a water curtain to reduce pollution from waste burning. The system sprays water to capture pollutants, which are then recirculated through a pump. Remote monitoring capabilities enhance control, and the system has been shown to achieve a 10–15% reduction in carbon emissions. In this research [11], an IoT-based system is proposed to reduce sleep inertia by simulating sunrise, regulating natural light, and controlling temperature. The system integrates smartphone control, stepper motors for curtains, and infrared technology for adjusting air conditioning. Experiments have shown that it is effective in providing a gradual, pleasant awakening. This study [12] develops an IoT-based smart home system that utilizes the ESP8266 module and ESP-mesh for scalability and reliability. The system integrates mechanical, electrical, and sensor-based nodes, enabling smartphone control. Its performance was evaluated with respect to functionality, power consumption, and connectivity, highlighting its potential for widespread use in smart homes.

## Main Material Presentation

The data processing workflow in the curtain control system consists of several stages, starting from sensor data acquisition to decision-making, information transmission to the server, and user interaction via the web interface. Each step plays a crucial role in ensuring seamless automation and responsiveness. The collected data is analyzed in real-time to determine optimal curtain operation based on environmental conditions. The system then processes this information and transmits the corresponding commands, allowing users to monitor and adjust settings remotely. The following section presents the results of the system's performance evaluation and discusses its effectiveness in smart home automation.

The Authorization Page serves as the entry point for users to access the smart curtain control system. It ensures secure authentication and user verification before granting access to system functionalities.

**Key Features:**

User Login (Fig. 1): Users enter their credentials (email/username and password) to access the system. Registration Option (Fig. 2): New users can create an account by providing necessary details such as username, email, password. Password Recovery (Fig. 3): A "Forgot Password" option allows users to reset their credentials via email authentication. Once successfully authenticated, users are redirected to the main page (Fig. 4), where they can monitor and control smart curtains remotely.

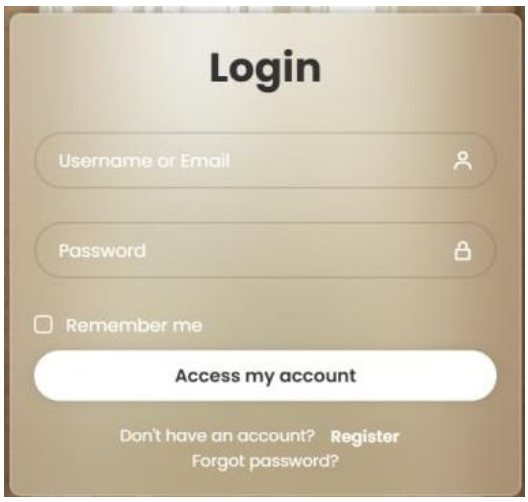


**Fig. 1.** Authorization page


**Fig. 2.** Registration page

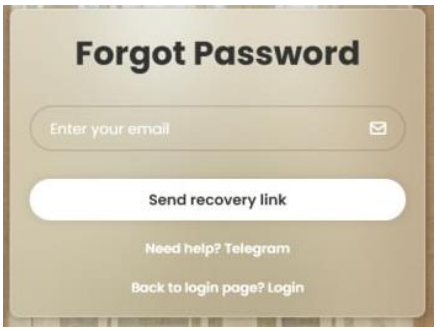


**Fig. 3.** Forgot password page

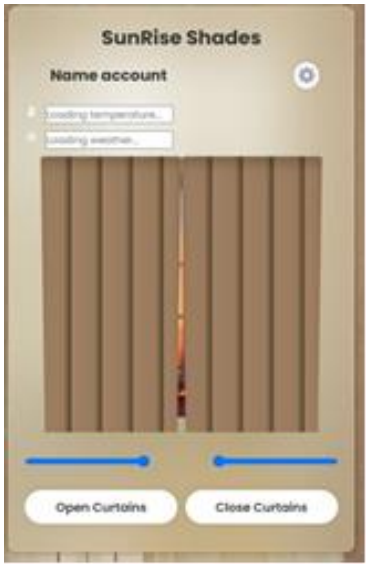


**Fig. 4.** Main app page with controls

System provides an intuitive interface for remotely managing smart curtains through a web-based application. The functionality includes:

1. **User Authentication & Personalization**

- Displays the user's account name, ensuring a personalized experience.
- Supports potential multi-user access with individual settings.

**2. Real-Time Environmental Data Integration**

- Retrieves and displays temperature and weather conditions, which can influence curtain automation settings.
- Ensures dynamic adjustments based on external environmental factors.

**3. Curtain Control & Automation**

- Provides manual controls with two buttons: “Open Curtains” and “Close Curtains” for instant operation.
- Includes a slider control for adjusting curtain position with precision.
- Displays an animated curtain visual that dynamically updates according to user input.

**4. Responsive & Interactive User Interface**

- The application overlays a real-world background to enhance visual realism.

- Ensures seamless interaction through a web-based or mobile-friendly design.

This system is designed to enhance user convenience, energy efficiency, and home automation, making curtain control seamless and adaptive to environmental conditions.

System includes an advanced Settings Panel (Fig. 5) that allows users to configure and automate their curtain operation. Key functionalities include:

1. **Automated Opening and Closing Modes**

o A toggle switch for enabling automatic curtain control, allowing the system to operate based on predefined conditions.

2. **Scheduled Curtain Control**

o Users can set specific opening and closing times using a time picker, ensuring curtains adjust automatically at preferred times.

3. **Environmental Condition-Based Control**

o Additional toggle switches allow users to automate curtain movement based on:

- Light levels
- Temperature
- Weather conditions

o This ensures an adaptive system that optimizes energy efficiency and indoor comfort.

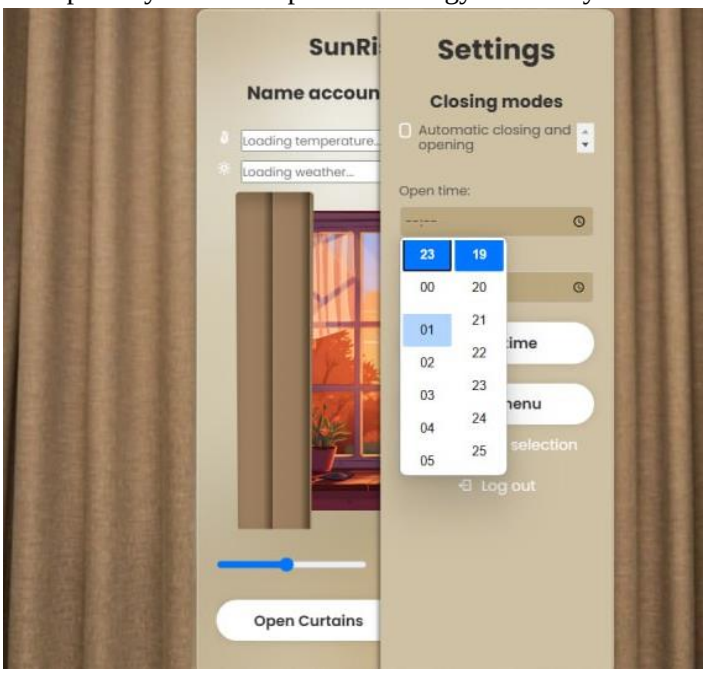


**Fig. 5.** Automatic settings

4. **User Account & Security Features**

• A "Log out" button enables secure user session management.The table [Fig.6, Fig.7] contains multiple rows with recorded data regarding curtain position control. The structure of the curtain_control table includes the following columns:

• id: Unique identifier for each record.
• position_percentage: The position of the curtain as a percentage (e.g., 81, 83, 97, etc.).
• open_hour, open_minute: Scheduled opening time of the curtain (all values are currently set to 0).
• close_hour, close_minute: Scheduled closing time of the curtain (all values are also 0).
• device_id: Identifier for the associated device.
• created_at: Timestamp of when the record was inserted (format: YYYY-MM-DD HH:MM:SS).

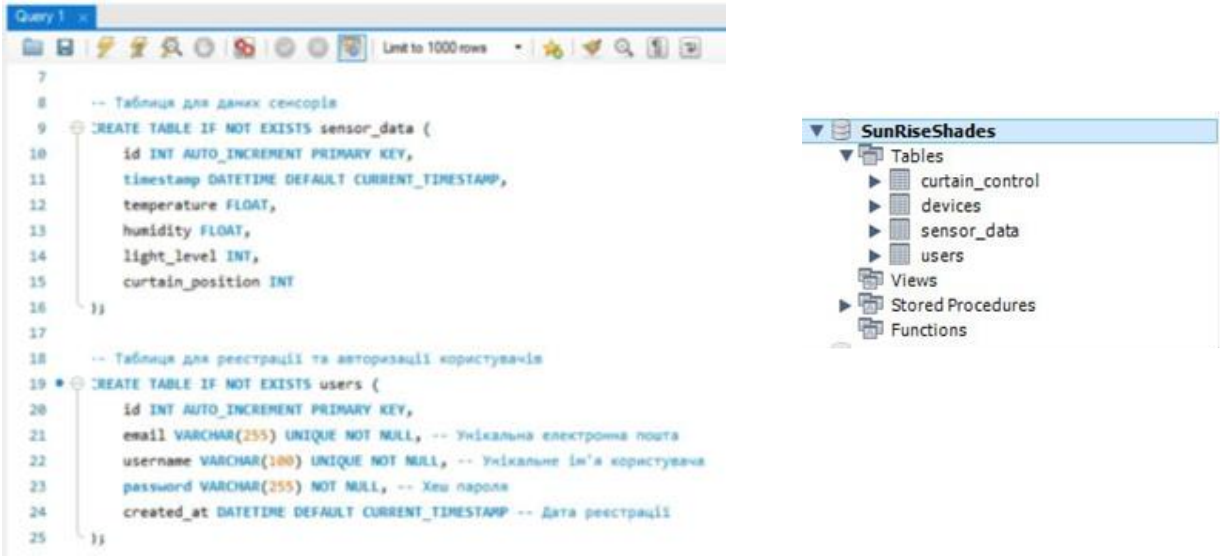


**Fig. 6.** Table data

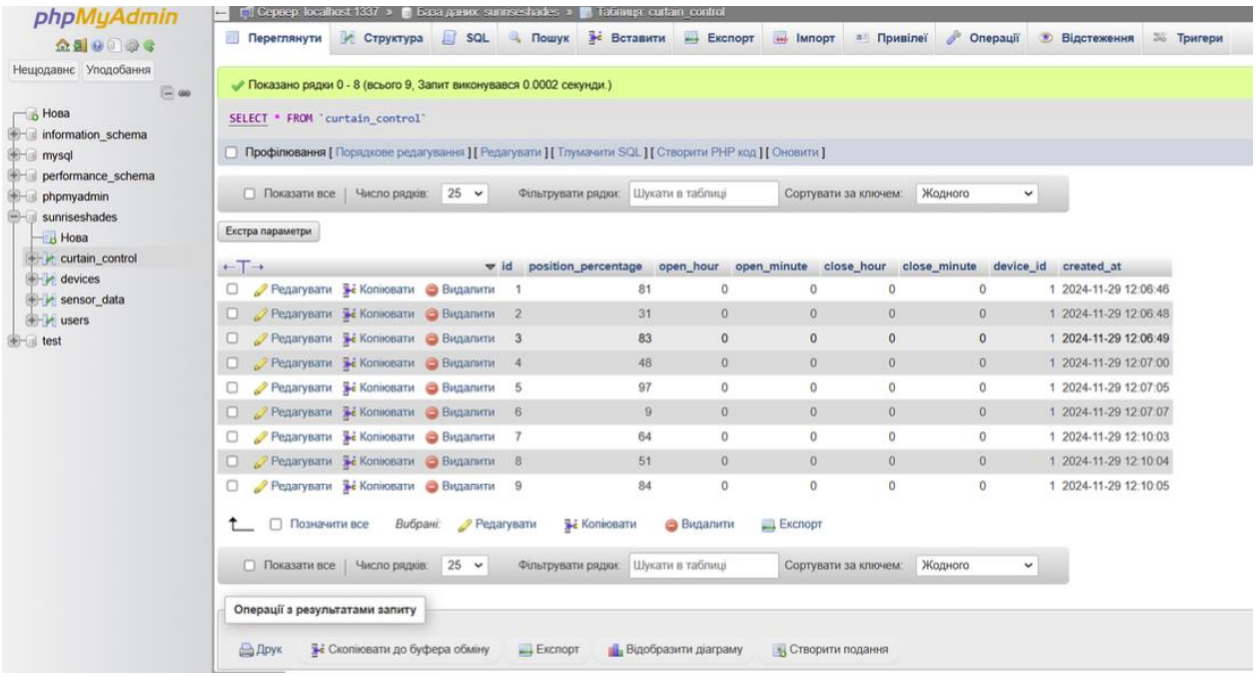


**Fig. 7.** PHP MyAdmin setup

## Conclusions

The development of a web-based smart curtain control system demonstrates how IoT technology can enhance home automation by providing a secure, remote-controlled, and efficient solution. The integration of an ESP8266 Wi-Fi module with HTTPS encryption ensures data security, while the SFTP protocol further protects transmitted information. The system's user authentication process, including two-factor authentication, enhances safety and prevents unauthorized access.

By utilizing light and climate sensors, the system can intelligently adjust curtains to optimize natural lighting and indoor climate conditions, reducing energy consumption. The web application allows seamless control from anywhere, ensuring user convenience and flexibility.

Future enhancements may include voice assistant integration, AI-based predictive adjustments, and mobile app support to further improve usability. Overall, this project highlights the importance of secure, scalable, and efficient IoT solutions in modern smart home automation.

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**РОЗРОБЛЕННЯ ВЕБЗАСТОСУНКУ ДЛЯ КЕРУВАННЯ РОЗУМНИМИ ШТОРАМИ**

Отримано: Лютий 04, 2025 / Переглянуто: Лютий 18, 2025 / Прийнято: Лютий 25, 2025

**Анотація.** У статті представлено розробку вебзастосунку для керування розумними шторами із використанням технології IoT. Система призначена для забезпечення безпечного та ефективного способу дистанційного керування рухом штор через вебінтерфейс. Основні апаратні компоненти включають Arduino Uno, Wi-Fi модуль ESP8266, датчик освітленості LM393, датчик температури та вологості DHT11, драйвер двигуна BTS7960 і двигун 775 24VDC.

Ключовою особливістю системи є підвищена безпека, що досягається за допомогою протоколу HTTPS (SSL/TLS), який шифрує передачу даних між модулем ESP8266 і сервером. Додатково реалізовано автентифікацію користувачів, яка передбачає перевірку унікального пароля з можливістю двофакторної автентифікації (2FA) через SMS або мобільний застосунок.

Передача даних на сервер виконується через SFTP (Secure File Transfer Protocol), що забезпечує безпечний обмін інформацією. Система дозволяє користувачам входити один раз і залишатися автентифікованими для майбутніх сеансів без повторного введення пароля. Даний проєкт спрямований на створення інтуїтивно зрозумілого та безпечного рішення для автоматизації розумного будинку, покращуючи енергоефективність і зручність для користувачів.

**Ключові слова:** розумні штори, вебзастосунок, IoT, Arduino Uno, ESP8266, шифрування HTTPS, SFTP, автоматизація будинку, дистанційне керування шторами.