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IoT based Smart Lighting System in an Auditorium

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Abstract: The overall purpose of this project is to establish Wi-Fi based communication between electronic components to control the output of the selected devices. Another major aim is to implement IoT based technologies in public facilities to reduce manual labour operation. Based on the research that I have studied; previous projects did not utilize any apps while controlling the microcontrollers. Therefore, I have decided to use Blynk app which is a new platform that allows user to quickly build interfaces for controlling and monitoring the hardware projects using mobile devices. The general design of the study primarily focusses on the experimental development of software and the hardware. This project targets on Arduino Uno and ESP8266 connected to WS2812B LED strip, 30 pieces of 5mm white LEDs and two servo motors. NodeMCU paired up with Blynk server, transmits data to Arduino Uno. The incoming serial data is interpreted correspondingly to the connected pins. Thus, producing output for the external device to operate. A major outcome from the result achieved suggests this lighting system is applicable in real life applications majorly found in buildings. To sum up, I believe that designing a user-friendly device without a control booth to track a smart lighting system will save time and can be easily personalized to suit the mood of occasions.

Keywords: IoT, Smart Lighting System, Wi-Fi, User-Friendly

Introduction

The IoT is regarded as one of the most important areas of emerging technology and is attracting significant interest from a wide variety of sectors. The true benefit of IoT for businesses can be completely realized if connected devices can interact and integrate with vendor-managed distribution systems, customer service systems and business intelligence applications [1].

IoT continues to grow and is a prominent subject of study where prospects are limitless. Imaginations are boundless that have placed it on the verge of turning the existing internet type into a transformed, integrated version. The number of devices accessing internet services is rising daily and

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getting all of them connected by wire or wireless would place a powerful source of knowledge at our disposal. The idea of allowing interaction between smart machines is a cutting-edge technology but it is not anything new for us [2] that are sensed by sensor devices and further processed for decision taking, based on which an automated action is carried out [3].

The increase in IoT 's popularity has spread widely to basic in-home applications and daily activities. IoT's use in homes is for energy management and saving purposes, thus attaining and preserving a certain degree of comfort. Home automation systems that use IoT are composed of three main parts. The first part is sensing and acquiring data. This is achieved by placing sensors or tools, at multiple locations throughout the house to measure and gather desired information such as temperature or humidity [4].

The second part of the method is processing of the data. Sensors have raw data. These data are sent to the processor via a transmission mode, wired link or wireless connection. Then, the processor transforms the data into understandable values [6]. These values are transmitted to a computer to be automatically monitored to a user interface. The internet is the last piece of IoT automation. Most systems can use a server to upload data after processing, so the user can access it.

1.1 Problem Statement

An established IoT platform-based lighting system is extremely useful for navigating lights without needing a technician. In addition, with a mobile phone, IoT app allows human to device interactions at ease. Alternatively, it can be done without much effort to configure the light patterns, colour and brightness, thus saving time and energy. Selecting lights that contain good Colour Rendering Index (CRI) is also important for the space. Improper selection can cause the light to interfere with the finishing colour which creates a room that is not very welcoming visually. Due to the need for a device that can be easily managed and modified to match the auditorium needs, it is very vital to choose the proper control simulation.

1. Materials and Methods

Knowing the extent of the electrical and programming areas in this project is significant. The creation of a prototype for the IoT monitoring system is critical to this project. Even if it's just a prototype, the computer has to be run to work as needed for this project's intention.

Two main elements required to control the lighting system is ESP8266 Wi-Fi module and Arduino Uno, by giving command on how it should operate. Mechanical and electrical components are incorporated into the hardware. Figure 1 below displays the overall process taken into account for designing and developing the project step by step.

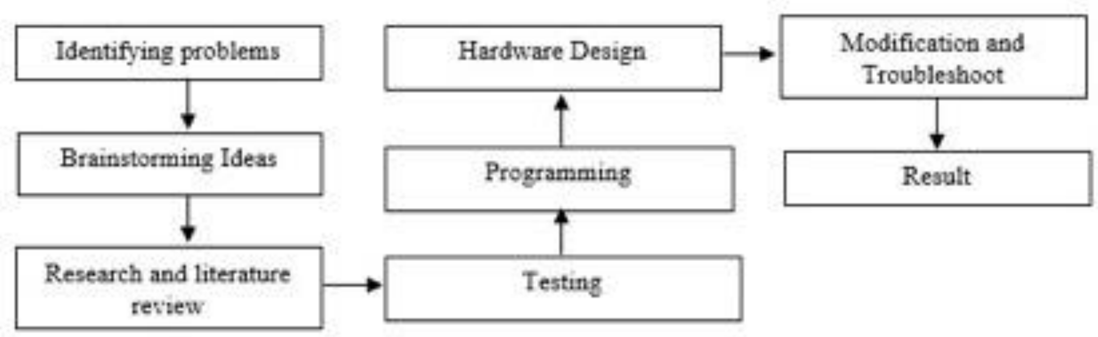


Figure 1: Overall Idea

2.1 Materials

Figure 2: Main electrical components of the prototype

Components for Smart Lighting System:

- Arduino Uno
- WS2812B LEDs
- 5mm White LEDs
- SG90 Servo Motors
- Relay switch

Components for Wi-Fi connection with Blynk:

- ESP8266

Software:

- Arduino IDE
- Blynk
- Fritzing

2.2 Methods

The block diagram for the lighting system proposed is shown in Figure 3 below. It is a smart lighting system that includes WS2812B LEDs, 5mm LEDs and servo motors. In the first portion, a moving stage light is equipped with two 9G servo motors and neopixel light strip. Once the programmed codes are uploaded to Arduino Uno, the Blynk server will be configured, and the internet connection is established. Blynk software offers the virtual setup for controlling stage light's colour, pattern and intensity. There are two servo motors, each resembling the x-axis and y-axis motions for the system to travel around the stage and reach the desired spot. Meanwhile, 5mm LEDs are used to recreate the light for audience and set the tone for an auditorium. These LEDs illuminates at full brightness and requires almost no thermal management. Serial communication between Arduino Uno and ESP8266 Wi-Fi module was formed for data transmission of the circuit.

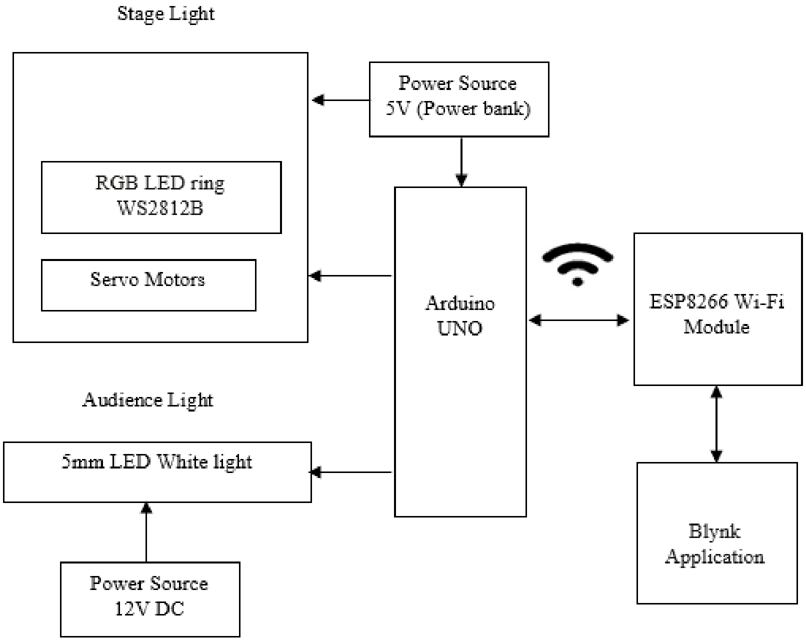


Figure 3: Block diagram of the prototype

Schematic diagram referred in Figure 4 below, offers a clearer picture on the connection between each component to run the circuit.

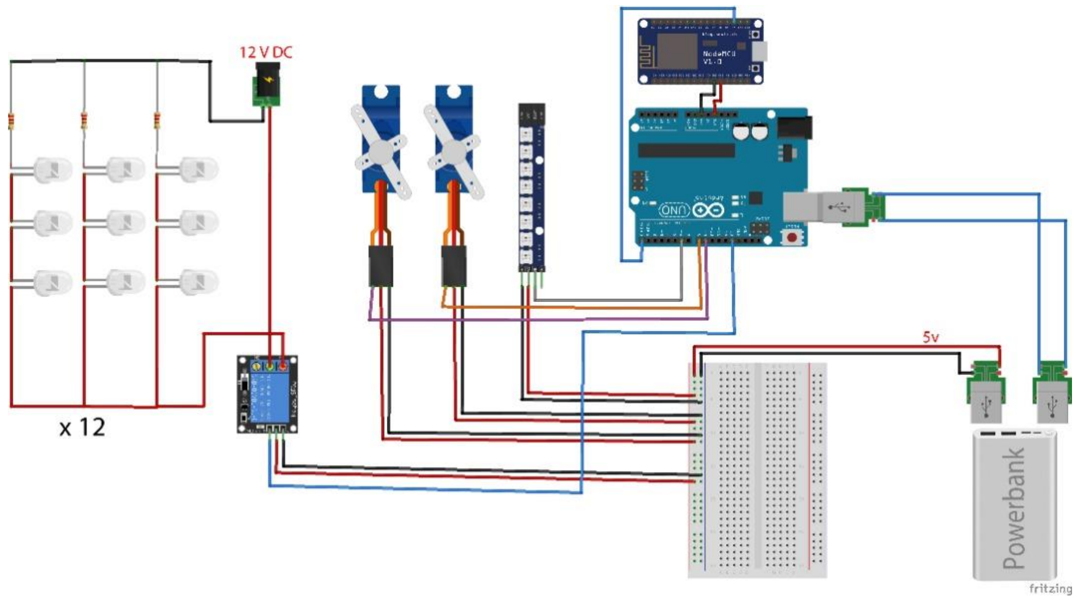


Figure 4: Schematic diagram of the prototype

Figure 5 below shows the overall design of the Smart Lighting system built using acrylic sheets to display a clear prototype.

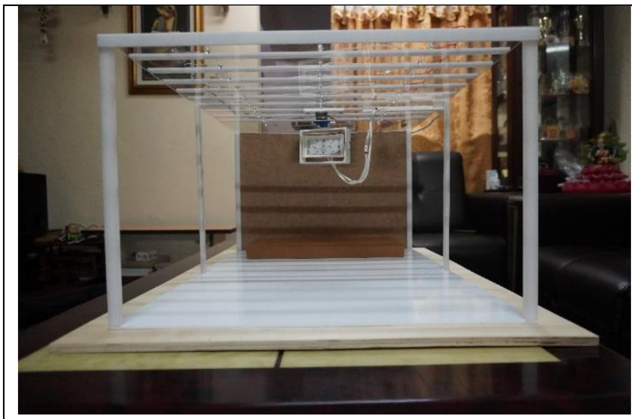
	
Front view	Side view

Figure 5: Overall design of the prototype

2. Results and Discussion

The workflow of each circuit is explained further which results in the desired output. There's a total of 4 part which one must take note for overall setting.

3.1 Bridging ESP8266 to an Arduino Uno

I decided to use two microcontrollers in my project for a particular reason. Despite having the capability of replacing the Arduino's operation in the circuit, it could not carry out multiple commands of execution without having a delay due to having either only 1 or 2 analog input pins compared to the Arduino's boards which has a good amount of analog input pins between 5 and 15. Therefore, I utilised ESP8266 as a WIFI module in transmitting the inputs for Arduino Uno to store and execute the commands. Figure 6 shows the connections made between TX pin of the ESP8266 to RX pin of Arduino to serve as the input pins.

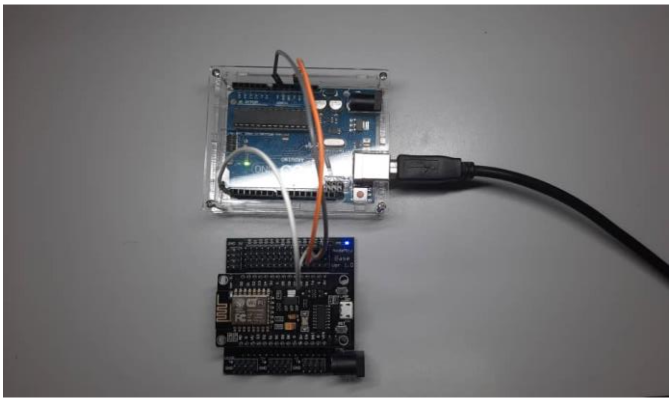
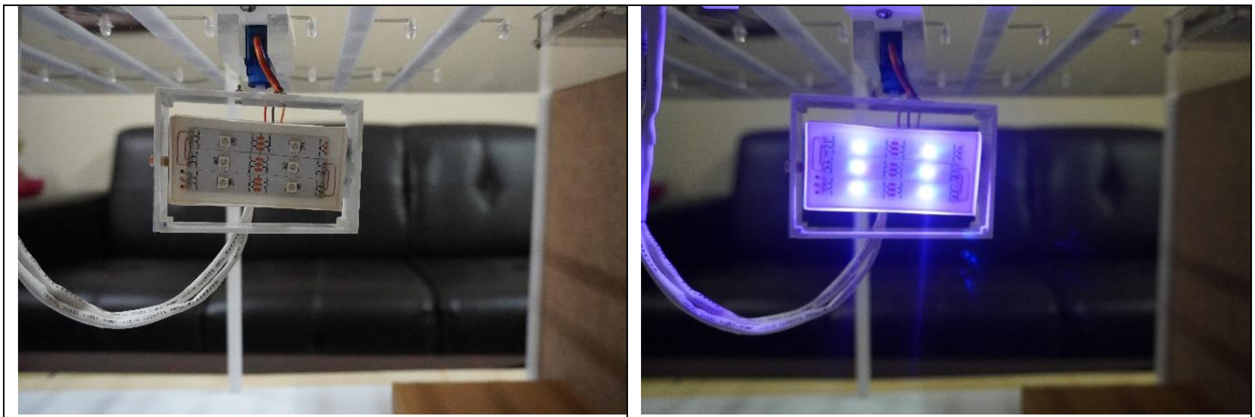


Figure 6: Connection between Arduino Uno and NodeMCU

3.2 Illumination of WS2812B

I have used WS2812B neopixel LED strip to function as the colourful stage light controlled through Blynk app. WS2812B have an IC built into the LED, which enables communication via a one-wire interface. These strips have 3 pins which are, the power pin (+5V), the ground pin (gnd) and the data pin. This LEDs input are controlled through digital pin 6 of Arduino. The power and ground pins used to apply power to strip. This RGB strip requires a power of 5 V, which is obtained from the 5 V output in Arduino.

I have used zebra (zeRGBa) widget to control the colour of the LEDs because it can output three values directly to PWM capable pins on an Arduino. I have merged virtual pin 6 on the blynk server which corresponds with the input pin of the strip. Once the connection is formed successfully, you can quickly see a physical manifestation of that colour from the Blynk Board displayed on the LEDs. Figure 7 displays light being emitted through the LEDs when switched on.



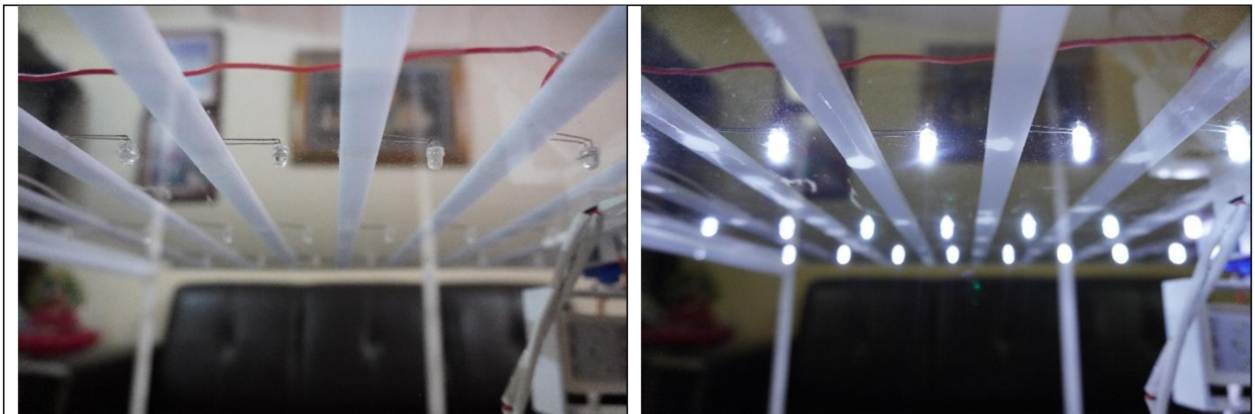
Before switching ON	After switching ON

Figure 7: Output of the WS2812B LEDs

3.3 Relay controlled LEDs

I have used 5 mm white LEDs which acts as the audience lights in the auditorium. Due to the number of LEDs used is relatively high, a relay was used as an electric operated switch to control the high-power circuit. Output pin 13 from Arduino was used to switch on and off the relay when it is provided with 5 V.

I have designed the circuit in a parallel-series combination, so each string of LEDs equally acquires 12 V. If I were to plainly use a series circuit, the LED's brightness would be dimmer due to the current going through them is smaller because 3 bulbs in series have a higher resistance than a single bulb. Meanwhile, in a parallel circuit, it would be chaotic as it requires more wires. This combination of series-parallel saves the usage of wire resulting a less complicated circuit besides providing equal voltage across each line. This circuit design is inspired from the real-life applications used commercially in an auditorium or hall. Figure 8 below shows the illumination of white LEDs.

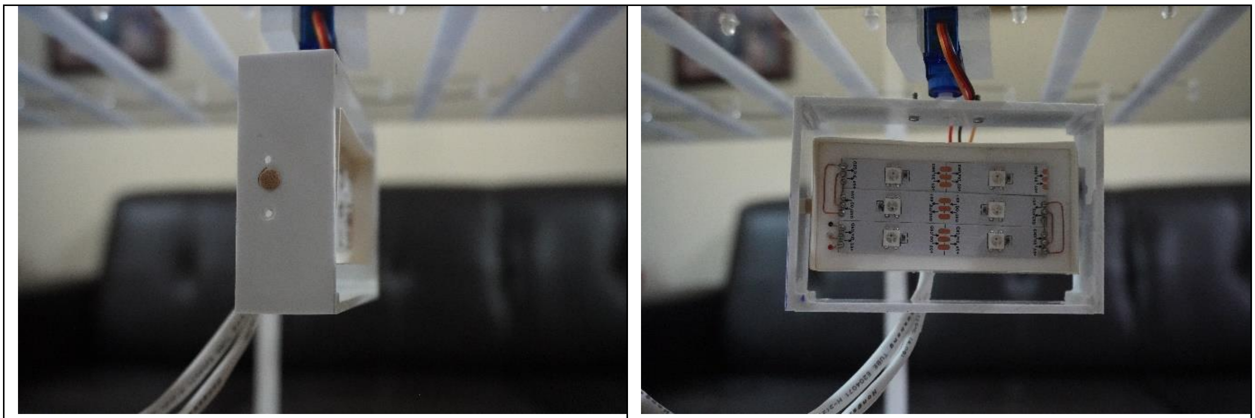


Before switching ON	After switching ON

Figure 8: Output of the white LEDs

3.4 Movements of Servo Motors

To move my stage light, I have decided to use 9g servo motors which assists in the positions of the LEDs. Two servo motors were used for horizontal and vertical direction. The servo arm attached can turn 180 degrees in angle. Using the NodeMCU and Arduino, I can control a servo to turn over a specified angle via Blynk app. Servo motors comes with 3 pins where the orange wire connects to a digital pin of Arduino Uno, brown wire connects to gnd pin and the red wire connects to the power source. Pin 8 and 9 were occupied for PWM signal line. I have set up similar virtual pins which controls the motors on the online server. Figure 9 below displays the movements of the servo motors.



Before sliding the motor	After sliding the motor

Figure 9: Output of the servo motor's movement

3.5 Discussion

The development of this project entitled 'IoT based Smart Lighting System in an Auditorium' is divided by two parts which is software and hardware. First and foremost, I had to go through a series of conversations with my supervisor to build ideas about what my project goals would be. Before preparing the outline, the purpose of this project should be clearly defined as a foundational move.

For the software development, a lot of research has been done to establish a stable connection between Arduino Uno and ESP8266. The initial coding had many errors which had to be corrected for the desired output. The Blynk app had plenty of widgets to explore for creating the suitable control panel layout. Besides, the open-source Arduino software (IDE) has readily available sketch to edit and upload This allows the user to learn additionally.

The Blynk app offers multitude of interfaces with different widgets. The server saves the desired panel layout for the mobile device and hardware's interaction. I have used Pin 6 from Arduino Uno for zebra widget. Whereas sliders 1 and 2 are assigned to pin 8 and 9. The NodeMCU serves as a means for Arduino to be linked to the server. All inputs from the app are forwarded by ESP8266 to Arduino Vin pin TX.

By moving the circle selector, the zebra widget allows users to choose a range of tones. For instance, the selected colour was purple and the intensity of the RGB variable is valued as R: 100, G: 0 and B: 200. This pulse will be forwarded to NodeMCU by the server Blynk. Red, green and blue channels (RGB) would be the basic form, allowing one to dynamically combine the different colour components to achieve virtually any colour. There is an intensity of 0 to 255 for each variable. WS2812B LEDs can create up to 16 million color schemes by combining all three channels. The slider interface with Blynk works on similar principle as well. The slider is marked from 0 to 180 on the widget and the last position of the slider is forwarded to NodeMCU by the Blynk server and servo motors moves accordingly

Prior to constructing and developing the hardware physically, I had studied how real auditorium lighting system works for innovative ideas. Apart from that, I also wanted to design a realistic auditorium using acrylic sheets for display purposes. Two different types of LEDs were used for the functionality of lights. Moreover, the arrangement of power supply went through some changes throughout the project to fit the circuit. Some calculations were done for inspecting the values of electronic components in circuits before proceeding with the design.

Finally, the time management that one takes into account to finish the thesis and the hardware is a notable factor that has been learned in this Final Year Project. To complete this project successfully, the timeframe given to students is a little limited, therefore students need to learn to organise their timetables properly.

3. Conclusion

In short, this project has achieved the given objectives while fulfilling the concept and the principle of smart lighting system. The purpose of this project is rather simple to understand. I wanted to build a lighting system which solely operates via Internet. Smart lighting system can operate without the need for a control booth thereby minimizing labour work and monitoring overall energy usage. While this project might be a little pricey, the objectives of creating digital intelligence for electronic devices are worth it. Many IoT projects has been developed over the years for home automation but not for public facilities. In my opinion, I believe IoT implementation can also be incorporated in popular areas to provide everyone with an open, user-friendly service. Gymnasiums, cafés, malls, leisure parks and food courts are some locations that strongly welcome such technology.

Acknowledgement

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