SENIOR PROJECT SD2-2022

Smart Lighting in Campus: The Web Application and Data Analytics

Requirement Specifications

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by

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Abbreviations

The technical terms listed below will be expressed by their abbreviations in this report. Other abbreviations will be defined at their first occurrence.

API	Application Programming Interface
CMS	Central Management System
HTTP	Hypertext Transfer Protocol
QoL	Quality of Life
REST	Representational State Transfer

Chapter 1

Project Concept

1.1 Summary

This project implements and develops an easy-to-use control and maintenance platform for a smart street light system installed inside Thammasat University, Rangsit campus, Thailand. This project is separated into two parts: the web application and the data analytics. In the web application, we provided the dashboard for visualizing data from the environmental sensor and various devices, the interface for monitoring and controlling devices, and API for connecting with CMS API, which is the interface for controlling the smart street light on the campus. For data analytics, we build prediction models using the feature extraction technique and machine learning to optimize light dimming values based on the campus environment.

1.2 Motivation

In this project, we aim at the automatic system to adjust the proper lighting environment for the campus. Smart street lighting devices along six main roads in Thammasat University, Rangsit campus are scheduled to turn on and off at the specified time daily, allowing safety and convenience for the public. However, static scheduling does not guarantee the optimized lighting solution for the campus, and weather conditions always change by the influence of the environment, which is uncontrollable and mostly unpredictable. Lighting devices may need to turn on or off in response to those weather conditions, which is not the current specified period, thus generating unnecessary electrical usage or reducing road safety. Several cities have implemented smart street lighting systems. For example, Amsterdam Smart City (ASC) in Amsterdam, the Netherlands, developed an automatic system used with smart lighting devices to adjust luminance according to the surrounding environment in the area to serve different weather conditions and control the pedestrian flow [1]. Another example can be seen in the smart street light project in Barcelona, Spain, which installed an LED lighting system. They developed an API to communicate with the management system [2] and integrated it with data collection of meteorological data [3].

When considering the availability of devices including 167 smart lighting devices with each device connected by one of the three gateways, and measures meteorological and environmental surroundings by using the environmental sensor, we can collect the data to predict environmental conditions in the future using an AI-assisted machine learning framework (SparkBeyond) and send commands to control the light dimming value of lighting devices for adjusting it accordingly. By developing the web application to monitor and control the system and integrating data analytics from the environmental sensor data, we expand the following potential to users, which are university maintenance personnel, and benefit students and residents. Moreover, it may reduce unnecessary electrical usage and cost, enhance road and public safety, and improve the Quality of Life (QoL) of residents at Thammasat University, Rangsit Campus.

1.3 Users and Benefits

Two main groups of users and stakeholders will receive benefits from this project. The first group is students, staff, and residents who live around Thammasat University, Rangsit Campus. They will benefit from this project because there will be sufficient lighting in the area, which will improve their security and QoL. The other group is the staff who monitor and control the light system of the campus. Most of them are from the building and ground services department. The easy-to-use web application interface will help them monitor and control the light system and respond to maintenance easier and faster. They can also help the executives in energy saving and cost reduction. They will have insight into power usage based on weather conditions and help them plan the power usage plan in the future.

1.4 Typical Usage

The typical scenario to use this web application is for monitoring the system, controlling the lighting devices in the area automatically, and maximizing energy efficiency. To maximize efficiency, the installed environmental sensor first collects the data from the surroundings. The collected data consists of meteorological data such as temperature, humidity, illuminance, Ultra Violet A, Ultra Violet B, wind velocity, wind direction, air pressure, etc. Then, the prediction model is constructed using the SparkBeyond platform by using feature extraction techniques based on the collected data. The model is later used to predict the future illuminance value and find the optimal light dimming value. This process ensures there is sufficient lighting in the area at all times, instead of the default setting that is only turned on and off based on the threshold value. The application then executes the command to lighting devices around the university to adjust the light dimming value accordingly.

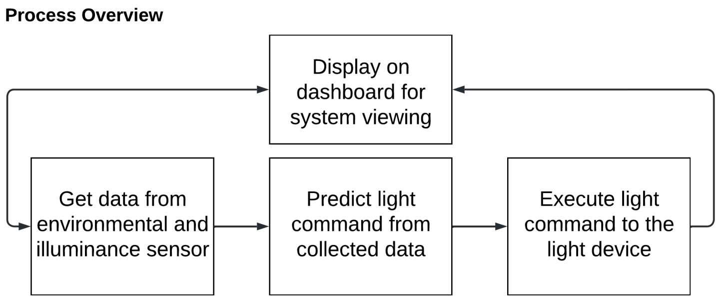

Figure 1.1: The overview of the system process

After all, the web application is provided for maintenance staff for system viewing by showing data on the dashboard in numerical and graphical forms to show the current environmental condition in the area. It can also display the connection status of installed devices and notify staff to repair and make the maintenance correctly Moreover, the web application can be used to control lighting devices in the university area, and report the power usage and lighting control back to the system. The overall process of the web application and the system is illustrated as shown in figure 1.1.

1.5 Main Challenges

The main challenge of web application development is the system instability related to the electrical grid connected to the devices on the campus. Blackouts and electricity drops happen frequently during severe weather conditions and cause devices to malfunction and data loss. Therefore, the web application may not work as intended during those downtimes. Meanwhile, the challenge of data analytics is the usage of the SparkBeyond platform to create a prediction model. Since this platform is new to all project members, thus we need to learn how to use it for our project. To ensure the prediction model gets the most accurate result and reflects the real-world situation as much as possible, the study of the environmental sensor data must be carried out thoroughly.

Chapter 2

Requirements Specifications

2.1 System Description

The smart street light system at Thammasat University, Rangsit Campus, is installed to provide sufficient luminance to students and residents in the area with control of the system accessible via the internet. The web application is created to help maintenance staff to monitor and control the system easier. As mentioned in the previous section, lighting devices are turned on and off at the specified time which may not provide sufficient luminance and waste electrical energy. The data analytics will help to improve the efficiency of energy consumption and promote sufficient lighting by predicting the future illuminance in the area based on the current environmental condition and calculating the light dimming value to adjust it accordingly. This will later create an automatic light control system that adjusts the light for the future and provide more efficient lighting in the area. Furthermore, the web application provides a dashboard to show the environmental data, energy usage, the lighting control report, and system status for easier maintenance and monitoring.

2.1.1 Perspective

The interaction between the users and the web application is illustrated in figure 2.1

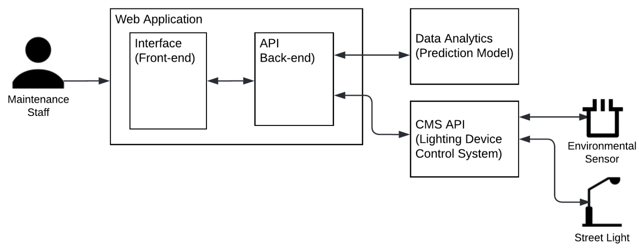

Figure 2.1: Perspective diagram of the system

From figure 2.1, maintenance staff can interact with the system via the web application to monitor and control the smart street light system on the campus. The data analytics platform is connected to the web application in the background to predict the future environmental condition when the new measurement is obtained, as well as communicated to CMS API which is the interface between our system and the control platform.

2.1.2 Functions

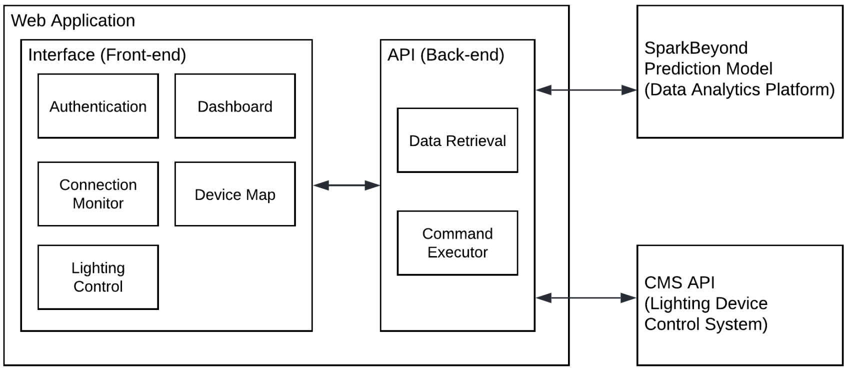

Figure 2.2: The diagram of all functions in the system

The system can provide the web application and data analytics as shown in figure 2.2. Provided functions of the system are listed as follows.

- The frontend web application interface act as an interface between the system and users to provide the following functionalities:
  - Authentication for users to log in to the system
  - System dashboard for displaying graphs of collected environmental data and power usage and control data from installed devices and sensors.
  - Device connection monitor for monitoring connection status of lighting devices.
  - Device map view for showing the location of installed devices.
  - Lighting control panel for adjusting light dimming value of each device.
- Backend API act as a mediator between front-end application, CMS API control system, and SparkBeyond platform.
- Data analytics using the SparkBeyond platform to predict the future illuminance from current environment data using the trained prediction model.

2.2 Requirements

The requirements of the system are listed in the following subsections.

2.2.1 Web Application

WA1 The web application should be clear, easy to use, and easy to navigate.

WA2 The web application must be responsive to any screen sizes.

WA3 The web application must be deployed on the cloud platform.

2.2.2 Data Visualization

DV1 The dashboard must be able to display data from the environmental sensor and illuminance sensors as numerical values and graphs.

DV2 The dashboard must be able to display data from the lighting control and power usage report as numerical values and graphs.

DV3 The dashboard should be able to display data based on the installed area filter.

2.2.3 Device Control

DC1 The lighting device should be controllable using the web application.

DC2 The status of installed devices should be displayed on the web application.

DC3 The map of installed devices should be shown on the web application.

DC4 The disconnection log of devices should be displayed on the web application.

2.2.4 API

AP1 The API should follows the REST architecture and available to use over HTTP.

AP2 The API must be able to send the collected data from installed sensors.

AP3 The API must be able to send the power usage and lighting control report.

AP4 The API must be able to send the current connection status of installed devices.

2.2.5 Data Analytics

DA1 The prediction model should be able to predict future illuminance values using collected data from the environmental sensor.

DA2 The model should be able to calculate the suitable light dimming value for lighting devices based on the environment in the area.

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