OptView Window

Requirements Doc

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Introduction

1.1. Purpose

The OptView Window system aims to improve environmental health and economic optimization in buildings by optimizing window operation and ventilation based on real-time data from AI-powered sensors. It provides real-time insights and recommendations to enhance both occupant health and economic efficiency, while balancing environmental sustainability, human well-being, and economic viability in buildings.

1.2. Scope

The scope of OptView Window is to provide an AI-powered adaptive window system that aims to optimize both environmental health and economic efficiency in buildings. The system uses sensors, machine learning algorithms, and actuators to adjust the window's transparency, shading, and ventilation in real-time based on various factors such as outdoor weather conditions, indoor air quality, and energy consumption. The goal of OptView Window is to create a comfortable and healthy indoor environment while minimizing energy costs and reducing the building's carbon footprint.

1.3. Definitions, acronyms, abbreviations

ESP: The ESP-WROOM-32 module is a wireless communication module designed for internet of things (IoT) applications. It features both Wi-Fi and Bluetooth connectivity, and is based on the ESP32 chip, which has dual-core processing capabilities and various peripheral interfaces. The module has specific technical specifications, such as power consumption and security features, which are important to consider when designing and implementing it in IoT applications. ESP can be utilized to wirelessly communicate and control the OptView Window system, enabling real-time data collection and analysis for environmental health and economic optimization.

PDLC glass: PDLC (Polymer Dispersed Liquid Crystal) glass is a type of smart glass that can switch from transparent to opaque in response to an electrical current. It consists of a layer of liquid crystals sandwiched between two glass panels or other transparent substrates, with a layer of conductive material applied to each surface. When an electrical current is applied, the liquid crystals align and make the glass appear opaque, blocking light from passing through. When the current is turned off, the liquid crystals become disordered again, and the glass becomes transparent. PDLC smart glass is commonly used in applications such as privacy windows, projection screens, and dynamic facades. PDLC will be a key component in the OptView Window system, as it allows the window to switch between transparent and opaque states, enabling control over the amount of natural light and heat entering the space, thereby improving energy efficiency and indoor comfort.

Breadboards: A breadboard is a tool used for prototyping electronic circuits. It consists of a plastic board with holes arranged in rows and columns, allowing electronic components to be inserted and connected without the need for soldering. The board typically has power rails along the sides, which provide power to the components, and distribution strips in the middle, which allow for easy connections between components. To use a breadboard, you simply insert the components into the holes, making sure to connect them in the desired way by using the distribution strips and power rails. Breadboards are used in the OptView Window system as a platform to prototype and test electronic circuits, allowing for easy modification and troubleshooting during the development phase of the project.

BME680: The document is a datasheet for the Bosch BME680, a digital environmental sensor that can measure temperature, humidity, pressure, and indoor air quality. The sensor is designed for use in a wide range of applications, including indoor air quality monitoring, home automation, and wearable devices. The datasheet provides technical information on the sensor's specifications, including its measurement ranges, accuracy, and power consumption. It also describes the sensor's interface and communication protocols, as well as its calibration and compensation methods. The document includes diagrams and tables to help developers understand and use the sensor in their projects, making it a valuable resource for those working with environmental sensors. BME680 is a sensor that is integrated into the OptView Window system to measure indoor air quality parameters such as temperature, humidity, pressure, and volatile organic compounds (VOCs), providing real-time data to the AI-powered adaptive window system for environmental health and economic optimization.

Stepper motors: Stepper motors are used to control the precise movement of a mechanical system. They work by converting electrical pulses into rotational movement, with the rotor moving in precise steps rather than continuously. Stepper motors are commonly used in applications such as CNC machines, robotics, and automation systems, where precise control over the position and movement of a mechanical system is required. They offer advantages such as ease of control, high torque at low speeds, and the ability to hold their position without the need for external control. Stepper motors are used in the OptView Window system to control the movement of the PDLC glass, allowing it to switch between transparent and opaque states, thereby regulating the amount of natural light and heat entering the space, and improving energy efficiency and indoor comfort.

Si1145: The Si1145 is a low-power, reflectance-based infrared proximity and ambient light sensor with an I²C interface. It includes an integrated photodiode, LED driver, and signal processing circuitry to accurately measure proximity and ambient light levels. The device also features a programmable LED drive current and can be used for gesture recognition applications. It operates on a supply voltage range of 1.71V to 3.6V and is housed in a compact 10-lead 2mm x 2mm QFN package. SI1145 is a UV/IR sensor that is integrated into the OptView Window system to measure UV and infrared radiation levels, providing data to the AI-powered adaptive window system for environmental health and economic optimization, such as adjusting the PDLC glass to block excessive UV radiation to protect human health and prevent furniture fading.

Stepper motor controller: A stepper motor controller can optimize the performance, reduce power consumption, and increase lifespan of the OptView Window system's stepper motor while enabling control over its speed, direction, and position, and providing additional features such as microstepping for smoother movement.

1.4. Overview

This document outlines the detailed specifications for the OptView Window project, which aims to create an adaptive window system that utilizes artificial intelligence to optimize environmental health and economic efficiency for buildings. The document is structured into two main sections. The first section, Description, provides specific details about the OptView Window product, including its perspective, functions, user characteristics, constraints, and assumptions and dependencies. The second section, Specific Requirements, outlines the external interface requirements, functional requirements, and non-functional requirements of the OptView Window system, providing a comprehensive list of the features and capabilities that the system must have in order to achieve its objectives. This document is essential for anyone involved in the design, development, or implementation of the OptView Window system.

2. Description

2.1. Product perspective

OptView Window is an innovative technology that combines ESP, breadboards, BME680 sensors, SI11145: UV/IR sensors, stepper motors, PDLC glass, and a stepper motor controller to improve environmental health and economic optimization in buildings. Using AI-powered adaptive technology, OptView Window is capable of providing optimized ventilation, lighting, and temperature control based on real-time environmental data and user feedback. The system's advanced sensors and algorithms take into account the impact of outdoor air pollution on indoor air quality, allowing for proactive mitigation measures. OptView Window's unique ability to optimize indoor conditions through efficient energy usage and indoor air quality management sets it apart from traditional window systems.

2.2. Product functions

- Environmental Health Monitoring: The system uses the BME680 sensor to monitor the air quality and temperature inside and outside the building. The data collected is then analyzed by the AI-powered algorithm to provide real-time information on the quality of the air.

- Adaptive Window Control: The system uses the data collected from the BME680 sensor to control the opening and closing of the window, ensuring that the indoor air quality is maintained at an optimal level.

- Energy Optimization: The OptView Window system can help reduce energy consumption by automatically adjusting the window's position to regulate the temperature inside the building.

- Economic Optimization: The system can help save money by reducing the need for expensive air purifiers or HVAC systems, as well as minimizing the amount of energy used to regulate indoor temperature and air quality.

2.3. User characteristics

- Building owners and managers who are responsible for ensuring a safe and healthy indoor environment for occupants while minimizing energy costs.

- Homeowners who are interested in improving the indoor air quality and reducing their energy consumption.

- Architects and engineers who design buildings with a focus on sustainability and environmental health.

- Environmental and public health professionals who are interested in monitoring air quality and its impact on human health.

- Researchers and academics who study the relationship between the built environment and human health.

2.4. Constraints

- Technical constraints: The system's functionality may be limited by the technical capabilities of the ESP, breadboards, SI11145, Stepper motor, PDLC glass , Stepper motor controller and BME680 sensor used to create it.

- Cost constraints: The production cost of the system needs to be within a reasonable budget to ensure it is commercially viable.

2.5. Assumptions and dependencies

- Availability of network connectivity: The system assumes that there is reliable network connectivity available for data transmission and communication between the system components.

- Accuracy of the BME680 sensor: The system depends on the BME680 sensor's accuracy to collect reliable data on temperature and air quality.

- User acceptance: The system assumes that users will accept and use the system effectively to optimize environmental health and economic benefits

- Power supply: The system assumes that there is a reliable power supply available to support its operations.

3. Specific Requirements

3.1. External Interfaces

- User Interface: The system may have a user interface to allow users to interact with the system, such as a mobile application or a web-based dashboard.

- Network Interface: The system may use network interfaces to communicate with other devices or systems, such as Wi-Fi or Ethernet.

- Sensor Interface: The system may use interfaces to connect with sensors, such as the BME680 sensor, to collect data on temperature and air quality.

- Window Control Interface: The system may use interfaces to control the opening and closing of windows, such as motor controllers or relays.

- API Interface: The system may have an API (Application Programming Interface) to allow other software applications to access its data and functionality.

3.2. Functional requirements

- Environmental monitoring: The OptView Window system should be able to monitor and analyze the environmental conditions inside and outside the building, such as temperature, humidity, air quality, and noise levels.

- Adaptive window control: The system should be able to control the opening and closing of the windows based on the environmental data and the user preferences, in order to optimize the indoor environmental quality and energy consumption.

- Data visualization: The system should be able to display the environmental data and the window control status in a user-friendly interface, such as a mobile app or a dashboard, to facilitate the user's understanding and control.

- Alert and notification: The system should be able to send alerts and notifications to the user when the environmental conditions reach a certain threshold or when a malfunction or error occurs.

3.3. Performance Requirements

- Accuracy and reliability: The system should be able to accurately measure and analyze the environmental data, and reliably control the window operations, without significant errors or failures.

- Responsiveness and speed: The system should be able to respond quickly and efficiently to the changes in the environmental conditions, and adjust the window control accordingly, without noticeable delays or lags.

- Energy efficiency: The system should be able to optimize the energy consumption of the building by controlling the windows in a way that balances the indoor environmental quality and the energy savings.

3.4. Non-functional requirements

- Usability and user experience: The system should be intuitive, easy to use, and visually appealing, in order to attract and engage users, and encourage them to use the system regularly.

- Accessibility and inclusivity: The system should be accessible to users with different abilities, languages, and cultural backgrounds, and comply with relevant accessibility standards and regulations.

- Maintainability: The system should be easy to maintain and update, and it should be designed with future modifications and upgrades in mind.

- Availability: The system should be available and accessible to the end-users whenever they need it, and it should have a high level of uptime.

Work Cites

Bosch Sensortec GmbH. (2017). BME680: Low power gas, pressure, temperature & humidity sensor. [Datasheet]. Retrieved from https://www.bosch-sensortec.com/media/boschsensortec/downloads/datasheets/bst-bme680-ds001.pdf

Espressif Systems. (2016). ESP-WROOM-32 Datasheet. Mouser Electronics. https://www.mouser.com/datasheet/2/891/esp-wroom-32_datasheet_en-1223836.pdf

Silicon Laboratories Inc. (2014). Si1145/46/47: Ultraviolet/ambient light sensors with I2C interface. [Datasheet]. Retrieved from https://www.silabs.com/documents/public/data-sheets/Si1145-46-47.pdf

Smart Glass World. (n.d.). What is PDLC Smart Glass? Retrieved from https://www.smartglassworld.net/what-is-pdlc-smart-glass.