Sensor Activated Home Hub Curtains

ECE 445 Project Proposal

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1. Introduction

1.1 Objective:

Calls to help mitigate climate change is a well known issue, but many do not know how effective simply opening and closing curtains can do to help conserve energy. Simply “closing the curtains during the winter helps reduce up to 10 percent in heat loss from a warm room [1].” However, as effective as this simple solution is, the actual process of doing so is rarely undertaken. In addition, waking up through sunlight exposure is a very effective way to improve a person’s circadian rhythm and has been proven to help to help “increases in the level of the hormone serotonin, which is important to sleep [2]” as well as reducing the stress hormone cortisol.

Our device will aid the regulation of temperature and light in a room through automated curtains, thermostat and light control. The decision to open and close a set of curtains depending on the data input of several sensors. These sensors will monitor different factors such as wind speed, temperature, and sunlight. Depending on the readings front the sensors, our device will choose between different types of curtains such as thermal insulated and solar reflective in order to best maintain the temperature and light preferences of the user.

1.2 Background:

Similar products that aim to control curtains in residential homes have been limited to products like the Aqara curtain controller system that focuses on helping users “open or close curtains via [their] smartphone, cube controller, or wireless switch anywhere [3].” These products do not contain any sensors that would analyze the different factors that would minimize the need for centralized heating.

In addition, there have been a few products marketed for Industrial uses such as Curtains for Barns curtain system that does analyze the “temperature, humidity, wind direction and speed [4].” However, these are more focused on air quality for their animals and have not focused on more residential applications. Thus, while there are products that may be a bit similar in concept, our Smart Curtains device is the first of its kind to use automated curtain control to help the average person conserve energy.

1.3 Physical Design:

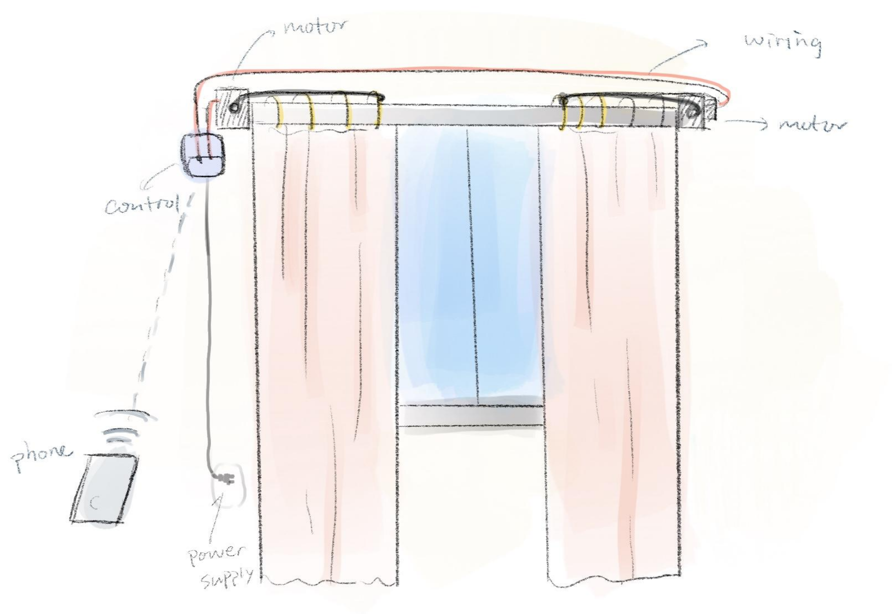

Figure 1: *Physical Design*

1.4 High Level Requirements List:

- The device should exhibit 0.314 N-m torque through the use of each motor, showing that the device is capable of opening and closing curtains that are up to 4 lbs.

- The device should be able to connect to a wifi server in 60 seconds and communicate information with less than 25% data loss.

- The device can use sensor data in order to make decisions to autonomously open or close with an accuracy bigger than 75%.

2. Design

2.1 Block Diagram:

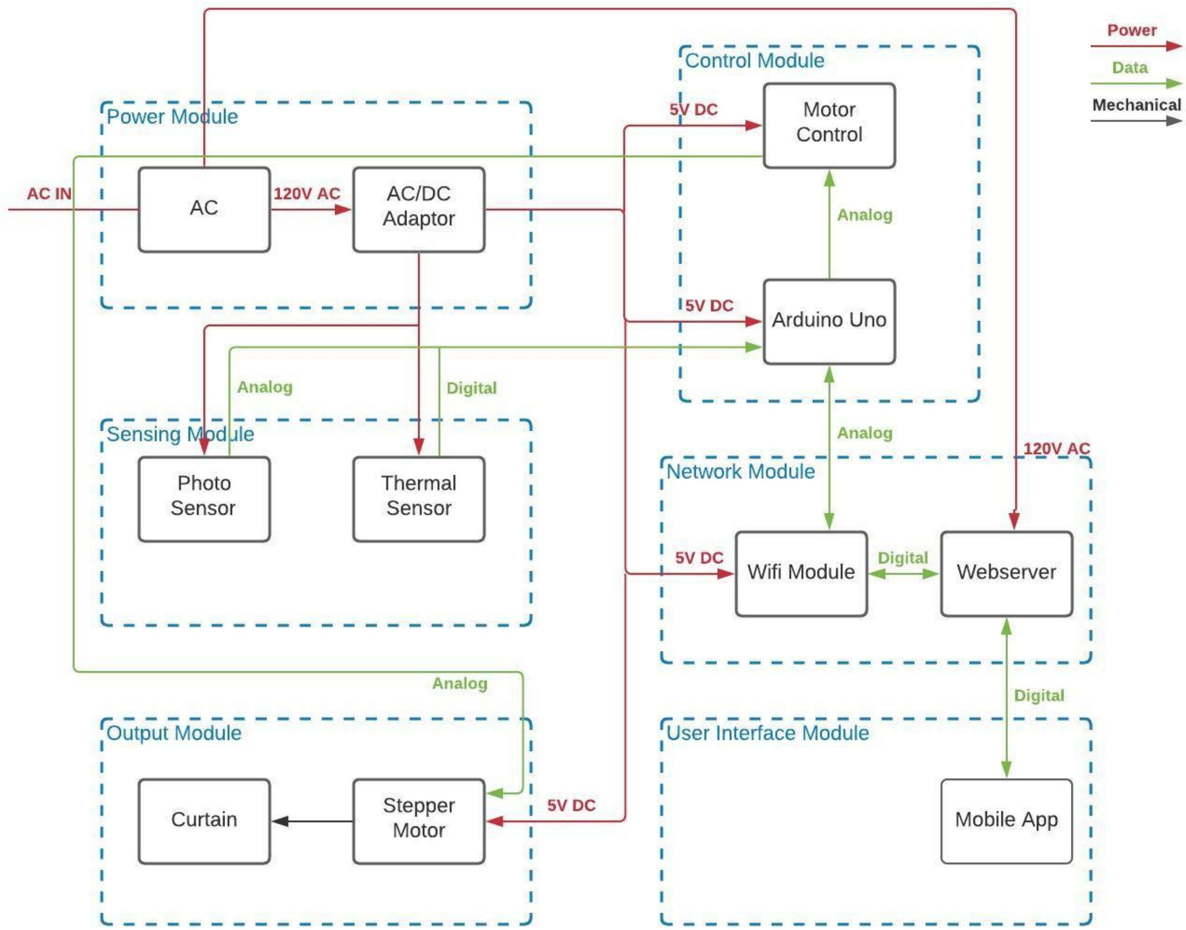

Figure 2: Block Diagram

2.2 Functional Overview:

2.2.1 Power Module

We require a continuous and easily accessible power source to keep our network up running continuously. We chose to get AC power from a wall socket and convert this power into DC to give a more regulated voltage supply to our system.

AC Power Supply

We need a consistent power supply to keep our network up running continuously. Thus, we chose to power up our system with AC power from a wall socket with a voltage of 120V.

AC/DC Adaptor

This adaptor converts the incoming AC into DC so that we are able to deliver 5V or 12V DC voltage to our system. The adaptor must handle the maximum voltage input (120V) coming from the AC power supply, and have a DC output of 12V/2A.

2.2.2 Control Module

This control module communicates with the stepper motor, photo sensor and thermal sensor to decide whether or not to keep the curtains open or closed. This module contains our control logic.

Arduino UNO

The Arduino communicates with both the photo sensor and thermal sensor in order to determine the best state to keep the curtains in. It will also communicate with the Motor control in order to find the current state of the curtains and change it if necessary.

Motor Control

The motor control manages the state of the curtains. If the Arduino sends the signal to change the curtain state, the motor control will provide power to the stepper motor to either draw or open the curtains.

2.2.3 Sensor Module

Photo Sensor

The Photo Sensor will be between the window and the curtains and will be used to find the amount of sunlight passing through the window. It will output its data to the Arduino.

Thermal Sensor

The thermal (infrared) sensor will be placed by the motors such that no sunlight falls on it even when the curtains are open so that it can accurately measure the current temperature of the room. It will send its findings to the control module.

2.2.4 Output Module

The output module will consiste of the physical motors and curtain. It will communicate with the motor control in order to change or retain the position of the curtains.

Stepper Motor

The stepper motor will be responsible for the movement of the curtains. Each of the stepper motors will need to be able to supply 20 N in order to move the heavier thermally insulated curtains.

Curtains
We will have 2 panels of thermally insulated curtains that can be controlled to be drawn and open independently. Each panel will weigh approximately 4 lbs.

2.2.5 Network Module

The network module will support the interface between the mobile app and the wifi. This module will also communicate with the Arduino UNO in order to communicate user preferences with the control unit.

Wifi Module
The wifi module will work as Access Point (AP Mode) to the wifi network. It will connect to the wifi server to be accessed by the mobile application on users' phones.

Wifi Server
The wifi server serves to be the intermediate network between the wifi module and the mobile app. This will be running continuously so that the user is able to change the curtain state at any time. The server will be running a simple webhook that hosts a REST api allowing our mobile app to send, get and post requests to change data on a database.

2.2.6 User Interface Module

The user interface module is the main platform that the user will be able to dictate their preferences to the curtain control system. It will also be able show the user each component's status.

Mobile App
The mobile application will use the wifi network to communicate with the wifi module and subsequently the control module in order to find the current state of the curtains and its sensors. The mobile app will also allow the user to override the energy conserving recommendations for the curtains. In addition, the user can also choose to set a natural alarm for the curtains so that they will be awakened through the use of natural light. Each user will be assigned a user id, that will be their identifier when making calls to the web server. The web server will then perform get and post requests where the user's profile is saved on the database hosted on the web server as well.

2.3 Risk Analysis:

The motor poses the most significant threat to the completion of our project because of the heavy force that it needs to exert on the curtains. While we have chosen to work with the stepper motor which is prone to stalling and slipping when forced to move a heavy thermal curtain. In order to mitigate this we may need to employ multiple motors.

However, this introduces the problem of reduced processing time of the controller. We may need to add an additional processor to allow the arduino to take on other tasks. The minimum weight that the motor will need to undertake is 4 lbs.

3. Safety and Ethics

The power supply that we have chosen poses a significant safety hazard as it is dealing with voltages and currents that are extremely high [5]. In addition to paying close attention not to any personal burns and shocks, we need to be careful not to overload our motor and arduino with too much power. In order to avoid this, we independently test our circuitry in the lab before connecting modules.

We also need to be careful with rain and water damage as much of this circuitry will be in close proximity to windows. The photo and thermal sensor will both need to be waterproof in case of any unintentional runoff. In order to protect the circuitry itself, we will need to have a protective case surrounding the sensor and control modules.

Another concern we need to consider is that of security. Since we are transmitting data and curtain control over the wifi network we need to ensure that only the user will be able to access the information that is being transmitted. This security will be provided through password locks. We would uphold IEEE Code of Ethics, #1: “to hold paramount the safety, health, and welfare of the public…[6].”

Furthermore, since this device interacts with the physical barrier that maintains privacy in a home’s windows. Although heating and lighting are the forethoughts of this project, we must keep in mind to not infringe upon a home by reducing the control of the user to use curtains as a means to not allow outsiders a view on their homes. In order to maintain this, the user must always feel in control of when the curtains are open or closed, and allow the user to disable any behavior that automatically opens or closes the blinds.

4. References

[1] NRDC. 2020. ‘How to Keep Warm and Save on Your Energy Bills This Winter’. [Online] Available at: https://www.nrdc.org/stories/how-keep-warm-and-save-your-energy-bills-winter [Accessed 16 Feb 2020].

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[3] Aqara. 2020. ‘Curtain Controller’. [Online] Available at: https://www.aqara.com/en/smart_curtain_motor.html [Accessed 16 Feb 2020].

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[6] Ieee.org. 2021. ‘IEEE Code of Ethics’. [Online] Available at: https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed 15 February 2021]