IntelliTint

Shade, Safety, Style Combined

EEL 4914 | Senior Design I | Spring 2024 | Group 8

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2. Project Description

2.1 Introduction

The purpose of this project is to address the escalating concerns over energy consumption, particularly in HVAC systems, within the context of a world marked by continuous development and population growth. By collecting and analyzing temperature and light intensity data, the system aims to dynamically adjust window tint percentages, contributing to energy efficiency and a more sustainable lifestyle. As for the stretch goals, the project envisions implementing presence detection at each window to increase transparency when someone approaches to look outside. Artificial Intelligence is proposed to adapt the system's automation based on user activity and preferences, adding a layer of sophistication to the overall user experience. Ultimately, the project seeks to offer a holistic solution that not only addresses energy challenges but also aligns with the growing trend of smart home technology.

2.2 Motivation and Background

In a world marked by continuous development and population growth, alongside significant advancements in science and technology that contribute to increased life expectancy, the issue of energy consumption has become a growing concern. The escalating awareness of our environmental impact and the strain on limited resources has prompted an urgent call to action. It is imperative for us to acknowledge and address this problem by incorporating numerous energy-saving systems in our surroundings.

When examining our homes and the various devices contributing to energy consumption, HVAC systems emerge as the most energy-intensive. According to the Department of Energy, heating and cooling account for approximately half of a typical home's energy usage. Effectively addressing this challenge requires a concerted effort to assist HVAC systems in minimizing their energy consumption. By tackling the intense energy use of these systems, we not only contribute to a more environmentally friendly future but also deliver tangible benefits to homeowners, including potential cost savings and increased energy efficiency. As Floridians, we understand firsthand the energy cost challenges, particularly during the summertime, and the importance of supporting HVAC systems for a more sustainable lifestyle.

The concept of the smart tinting window system originated from a team member who encountered Smart Film PDLC. PDLC is a film that rapidly transitions from opaque to transparent when a specific amount of electricity is applied, commonly used in commercial spaces with a binary on/off system. Our idea was to introduce a similar system to residential customers, capitalizing on the growing trend of smart home technology. As individuals increasingly seek to connect and automate every aspect of their homes, this system can facilitate and enhance those connections.

Another team member observed the potential use of this film in other automated systems, particularly in cars. Recognizing the almost essential need for window tinting in states like Florida, where dealing with intense heat and sunlight is challenging, an automated shading system for car windows could mitigate heat-related incidents during hot Florida summers. We considered adding a detection feature to identify when a person is in the car, activating the shading accordingly. Additionally, integrating the system into the car's computer would allow for automated control of the shading. The decision to focus on the house system was influenced by complex legal considerations surrounding the car window system. Ensuring compliance with state laws for the car system would demand meticulous attention to detail. We also took into account potential risks to customers' cars, avoiding interference with the complex computer systems and recognizing the associated challenges.

2.3 Existing Product / Past Project / Prior Related Work

Numerous commercial companies provide smart glass systems utilizing the PDLC system for window shading. This technology proves versatile in settings like office spaces, where shades can be activated during meetings or privacy levels controlled based on activities within the building. These systems are extensively used in work offices, catering to diverse needs.

One noteworthy company offering smart window film systems in our area is Gauzy. Primarily marketed for privacy applications, Gauzy showcases examples in office spaces where occupants can seamlessly toggle the system based on room activities. Gauzy has improved the glass, adding a scratch-proof coating for durability. The adhesive used ensures longevity, preventing peeling over extended use. Their system features default tinted glass, clearing only when an appropriate amount of electricity is applied.

Another player in this space is Smartglass Technologies, providing similar services to Gauzy but with a broader range. While emphasizing commercial office spaces, they offer additional services, including an online-connected interface through an app. Smartglass Technologies targets a wider audience, particularly focusing on the healthcare sector, promoting privacy solutions in areas like surgery rooms. However, a common issue among these companies is the dependence on their services, tying users to their apps and subscriptions for the devices to function. This reliance on subscription services, amid a trend towards monthly subscriptions, may pose potential issues later on. Our goal is to provide an independent product, granting users complete control without hidden features behind paywalls.

Despite the prevalent use of this film in various systems, there's a concentrated emphasis on commercial spaces like offices and meeting rooms. While valuable, there is untapped potential for energy savings. Implementing the same film used in offices on windows, coupled with a system that detects sunlight levels to decide whether to tint or not, could significantly contribute to energy efficiency. Furthermore, integrating the window with the HVAC system could optimize temperature control, utilizing sunlight to either cool down or warm up the space based on user preferences.

2.4 Goals and Objectives

The primary goals of this project are to offer the satisfaction and convenience of an automated window tinting system, including the maintenance of a desired indoor temperature and light intensity, as well as to save the user money on electricity costs associated with indoor cooling.

This will be done by integrating the existing technology of smart glass with a uniquely designed control system. Our control system will be implemented in a building - a model house for the scope of this project, and it shall adjust the tint percentage of windows based on indoor temperature and sunlight intensity shining on the building's windows. The advantage of this system over a static tinting system is its ability to adapt to changing conditions and maximize outdoor visibility when tinting is not appropriate for the current conditions.

On the software side of this project, there is an essential goal to design a mobile application that allows users to manually control the tinting system and customize functionality to their liking.

Basic Objectives:

These objectives are critical for the functionality of our project.

1. Collect temperature and light intensity data using thermal and luminosity sensors.

In order to achieve the goal of targeting the user's desired light intensity and indoor temperature, we will of course need sensors to determine the present values of these factors. This information will be essential for our automated system's tinting decisions. We will choose and place sensors to ensure accuracy and reliability, avoiding user frustration. The thermal sensors will be placed in a discreet location on the interior wall to measure the indoor temperature, and the luminosity sensor will be placed on the exterior wall, as we want to measure the light before it goes through the tint.

2. Transmit data via wireless relays to and from a central microcontroller.

This system will have a central controller that will control the tint percentage of all of the windows. The data from the sensors must somehow be transmitted to this unit, and the instructions from the control must be transmitted back to the window. However, the controller cannot simultaneously be close to all of the windows of the building. We will implement wireless relays to mitigate the need to run an unsightly wire from each window to the central controller or hide said wire. This solution helps achieve the goals of providing user convenience and satisfaction, as this makes the system easier to install, less cumbersome, and more aesthetic. Additionally, these wireless relays will integrate with the user's home WiFi network, allowing the user to interface with the device over a network they already understand and facilitating smartphone app control.

3. Program microcontroller logic to output voltages that act as a control signal.

Once sensor data is transmitted via wireless relays to the central control unit, the microcontroller inside of it will compare sensor data to user's desired indoor temperature and light intensity, then determine if tinting the windows will aid in cooling. It will increase tint percentage if it is both warm inside and sunny out, or if the light intensity surpasses the desired level. The output voltage will be a wireless control signal and does not power the tint itself. The logical operations carried out by the microcontroller are essential for achieving the goal of making this a dynamic system that adapts to changing conditions. This helps increase electricity savings while also maximizing outdoor visibility when possible.

4. Design a PCB and implement a controller to transform control signals into the proper voltages for the desired tinting percentages.

In order to actually change the tinting percentage at each of the windows and achieve the basic functionality of dynamic tint outlined in our goals, we will need to transform the wireless instructions from the central control unit into the proper voltages to change the tinting percentage. We will integrate a 120VAC dimmable controller in order to output the higher voltage necessary to tint the windows. There will be a PCB that contains a wireless transceiver and a basic microcontroller to transform these signals into the appropriate control voltages for the dimmable controller. The PCB and dimmable controller will be as small as possible and discreetly placed in order to reduce the footprint of the system at the windows and avoid creating an eyesore, which would lower user satisfaction.

5. Implement an AC to DC converter to power the hardware at each window from an outlet.

We will power each window's hardware, including wireless transceiver, microcontroller, sensors, dimmable controller, and tint from a standard outlet, avoiding the need for the user to ensure that a multitude of batteries are powered. This would be very high maintenance for the user and would detract from our goal of convenience.

6. Incorporate an Android smartphone application into the logic of the microcontroller.

We do not want the user's only mode of control over the system to be determined by the automation outlined above. The user may desire a different tinting state than that determined by the automated logic, and it would be very frustrating to lack control over the system's output. We will design an Android smartphone application that will give the user increased control and customizability over the functionality of the tinting system. In the modern age, virtually everyone has a smartphone, so using this technology is very convenient and familiar to the user. Basic app features will be setting desired indoor temperature and light intensity values, a manual tint percentage override, and viewing of sensor data.

Advanced Objectives:

These objectives are more complex and expand or improve functionality of the system.

1. Minimize response time.

   The system would not meet its goal of increasing convenience if there is a noticeable delay after conditions change or the user performs an action on the app. We will design the relay system and optimize microcontroller code to reduce latency. This will help mitigate user frustration.

2. Design and incorporate advanced app functionality.

   We want the user to have control of the system beyond simple manual control. The app will have more advanced features, including allowing users to control each wall of windows individually and create a schedule for the windows' tint levels. They will be able to toggle between automatic, manual, and scheduled control. This increased level of control will help increase user convenience and satisfaction by creating customizable satisfaction.

Stretch Objectives:

These objectives are not essential for the core goals project, but would add additional functionality. These objectives will only be worked towards only once all other objectives have been completed and may fall outside the scope of the project.

1. Integrate with Smart-Home technology (Alexa and Google Home/Nest).

User convenience is an essential goal in this project and we recognize that many other smart-home products integrate with Alexa and Google Home/Nest, the two most common smart-home controllers to achieve this. Doing so would enable voice commands to control the tinting system. This would add another avenue of control beyond the automation and app controls, which further increase convenience and accessibility. An example command could be, “Alexa, darken the windows in the living room”.

2. Implement fail-safe mechanisms.

Inevitably some part of the system will fail, and we want to make sure that the system has a stable state as its default. If a sensor malfunctions at a window, we will utilize data from the closest sensor, on the same wall if possible, to control that window’s logic. In the event of a microcontroller or WiFi failure, we will design the system to revert the windows to a default tint percentage. We do not want the windows to become completely opaque or fluctuate widely, which could cause user frustration and detract from our goal of user satisfaction.

3. Implement presence detection sensors.

In the current scope of the project, the automatic tinting of windows may create an undesired limitation of outdoor visibility, and the user would need to go on their smartphone application to perform a manual override. This is an inconvenience that could be avoided if the window automatically untinted when approached. We would place presence detection sensors on the interior of each window and program the microcontroller to lower the tint percentage at each window when someone approaches to view outside. This solution would expand functionality towards our goal of maximizing user convenience.

4. Implement UV sensors.

A common reason people install tinted windows on their building is to increase protection from ultraviolet rays. In order to expand the functionality of our system to protect from UV rays, we would place UV sensors on the exterior of each window and program the microcontroller to darken the windows when the ultraviolet light coming through the window is dangerously high, which can occur even when it is not bright outside. This would increase user safety and health, which could increase user satisfaction.

5. Utilize live weather data.

Instead of expanding the hardware scope with additional UV sensors, we could pull UV index data from a weather database and adjust the tint percentage accordingly for user safety and health for similar user benefit. The live weather data could also be used to control the tinting system more accurately and potentially increase electricity savings from cooling.

6. Incorporate artificial intelligence.

The ultimate step towards our goal of user convenience would be a system that intelligently adapts to a user's preferences. The system would seek out patterns in the smartphone app interactions and learn their daily work and sleep schedules. The AI would dynamically regulate the tinting of the windows to provide an enhanced and personalized user experience.

2.5 Requirements and Specifications

This section outlines in a more section-specific manner some of the goals, basic objectives, and Advanced Objectives that we have set out to start this project. This will demonstrate the specific areas that some of the specific objectives that we have set will fall in when it comes to the workload that it will require.

2.5.1 General

- A window tinting system that can be set up in different modes to tint to different levels based on the user's need and specific specifications.
- The windows can always be controlled manually through the app so that the user can control it manually if needed.

- Temperature and light sensors that take in the current environment reading and adjust the tinting level based on the current amount of light.
- Minimum 1 pair of windows connected and communicating with one another.

2.5.2 Hardware

- A light sensor on the outside of the window takes in information from the outside and sends input to the MCU.
- A temperature sensor to read the current temperature of the room and send inputs to the MCU.
- At least two windows of smart glass allow users to shade the window at different levels based on the user's needs.
- A custom PCB for the individual window with the sensor and power control for the tinting system.
- A custom PCB for the control station allows for the sync and control of the windows.

2.5.3 Embedded Software

- Integration of sensors and devices
  - The MCU will get information from the sensors and adjust the tinting values accordingly.
  - Inclusion ofDifferent modes allowing the user control over the system.
  - Wireless communication between the windows and the MCU for seamless integration.

2.5.4 App and UI integration

- Dashboard Access:
  - Quick access buttons for common actions like "Tint All," "Untint All," and customization options.
- Scheduling Features:
  - Flexible scheduling options for automated tinting based on time, day, or external conditions.
  - Customizable schedules for different windows or groups, enhancing user convenience.
- Push Notifications:
  - Instant push notifications for essential events, including active tinting, low battery alerts, or system malfunctions.
  - Keeps users informed and in control of the smart tinting system.

- User-Friendly UI Design:
    - Visual representation of the house layout with interactive icons displaying real-time window tinting status.

2.5.5 WiFi Connectivity

- Connecting the individual windows allows them to sync when it comes to the sensor reading.
- Connect the user with the System allowing them to control from the applications.

2.5.6 Power

- Windows will be connected to an MCU with a dimmable controller and will be connected with an AC power supply.
- The MCU PCB will be powered by an AC power supply.

2.6 Marketing and Engineering Requirements

The table below describes the various engineering and marketing requirements that are relevant to our project. The three columns outlining the engineering requirements we have laid out for our project and the aligned marketing goals. Highlighted amongst the requirements are our chosen requirements which we must provide with our device in Senior Design 2.

The first of our requirements is that the sensors must read and send inputs every second. Most sensors are capable of doing this and filtering their signals will be the valuable aspect. Frequent sensor readings will allow our system to change its behavior based on up-to-date information, ensuring more reliable performance. Our second requirement is that our service must react quickly to user demand. The user must not be waiting around for minutes on end for our system to function or else they would become frustrated with its lack of responsiveness, and the ability for the system to aid in reducing solar heat would be impaired. Our final requirement is that in less than 1 out of 100 times, our service will fail. This means that our service will nearly always be reliable, which is essential to ensure the user experience of our product is satisfactory.

Marketing Requirements Key:

1. Ensure rapid system performance.
2. Delivering quality and luxury while maintaining affordability.
3. Ensure reliability in temperature and light sensing.
4. Keep device maintenance requirements low.
5. Ensure accessibility for all mobile users.
6. Design a user-friendly interface.
7. Make user experience pleasant and convenient.
8. Install the system in an aesthetic, non-obstructive manner.
9. Ensure the system aids the user's air conditioning system in keeping the building cool.

Marketing Requirements	**Engineering Requirements**	**Justification**
2, 4, 7	The central MCU should have enough power to run for 1 month on 4 AA batteries.	The system should have enough battery life to be "hands off".
1, 3, 9	The sensors should read the temperature and light at least once per second.	The system should be adaptive and respond to rapidly changing circumstances.
2	The cost of the device should not exceed $500 with some of the tinting.	The device should be a luxury but somewhat affordable.
1, 7, 9	Real-time Tinting Updates: Updates with < 5 seconds delay.	Timely updates enhance user satisfaction by providing real-time information about window tinting.
1, 6	Achieve an average UI response time below 300ms.	Ensuring quick and smooth response to user interactions within the mobile application.
7	Connectivity Stability: < 1% occurrence of connectivity issues.	Ensuring stable connectivity between the mobile app and smart tinting devices.
8	Sensor dimensions should not exceed 3" x 3" and PCB dimensions should not exceed 5" x 5".	This system should increase convenience and aesthetics, not create an eyesore.

7, 9	MCU logic should accurately control tint based on sensor data to meet user preferences and save money on cooling. <1% of inaccurate behavior occurrences.	A system called “IntelliTint” should display intelligent behavior.
9	System should aid in reducing indoor warming from the sun and reduce cooling electricity usage. >10% electricity savings.	This system should be an investment by the user and save money in the long-term.
5, 7	Wireless capability range between MCU and window PCB, and MCU and smartphone, should be at least 100’.	The MCU should be able to communicate with any window or phone in a standard-sized house.

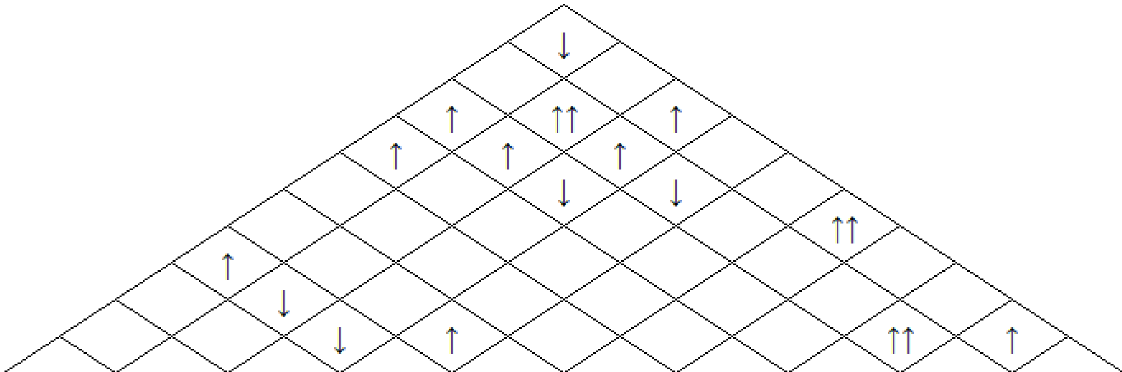
2.7 House of Quality

The table below depicts the trade-off relationships between the customer and engineering requirements of this project. It also depicts our target trajectory for each quality, the ranked importance of each customer requirement, and the target values for the engineering requirements. The “roof” of the house shows the trade-off relationships between the engineering requirements.

This is a visual aid for our group to use when making decisions on how to allocate funding for this project, as well as focus efforts to improve the different aspects of our system’s technical functionality in order to meet customer requirements.

House of Quality Legend	
▲	Maximize
▼	Minimize
↑	Positive Correlation
↑↑	Strong Position Correlation
↓	Negative Correlation
↓↓	Strong Negative Correlation

House of Quality Table:



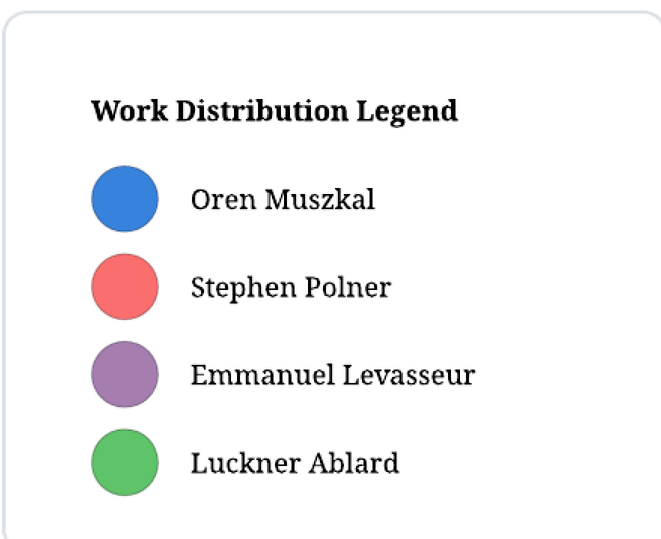
Importance Ranking	Direction of Improvement	Customer Requirements / Engineering Requirements	Battery Life	Frequent Sensor Polling	Cost of Components	Tint Update Delay	UI Response Delay	App Connection Stability	Hardware Dimensions	Electricity Savings	Accurate Tint Control by MCU	Wireless Range
		Direction of Improvement	▲	▲	▼	▼	▼	▲	▼	▲	▲	▲
3	▲	Performance Speed		↑	↑	↓↓	↓↓					
9	▲	Luxury	↑		↑↑	↑	↑		↓	↓	↑	↑
4	▲	Sensor Reliability		↑↑	↑	↓					↑↑	
7	▼	Maintenance Requirements	↓↓		↓						↓	
5	▲	Accessibility for All Mobile Users					↓	↑↑				↑↑
6	▲	User-Friendly App Interface					↓↓	↑				
1	▲	Pleasant/Convenient User Experience	↑		↑	↓↓	↓↓	↑↑	↓		↑↑	↑↑
8	▲	Aesthetics			↑				↓↓			↑
2	▲	Indoor Cooling		↑	↑	↓	↓			↑↑	↑↑	
Target for Engineering Requirements			> 1 Month	> Once Per Second	< $500	< 5 Seconds	< 300 ms	< 1% of Connect-ivity Issues	Sensors: < 3" x 3" PCB: <5" x 5"	>10% Bill Reduction	< 1% Innacurate Behavior	>100'

2.8 Hardware Block Diagram

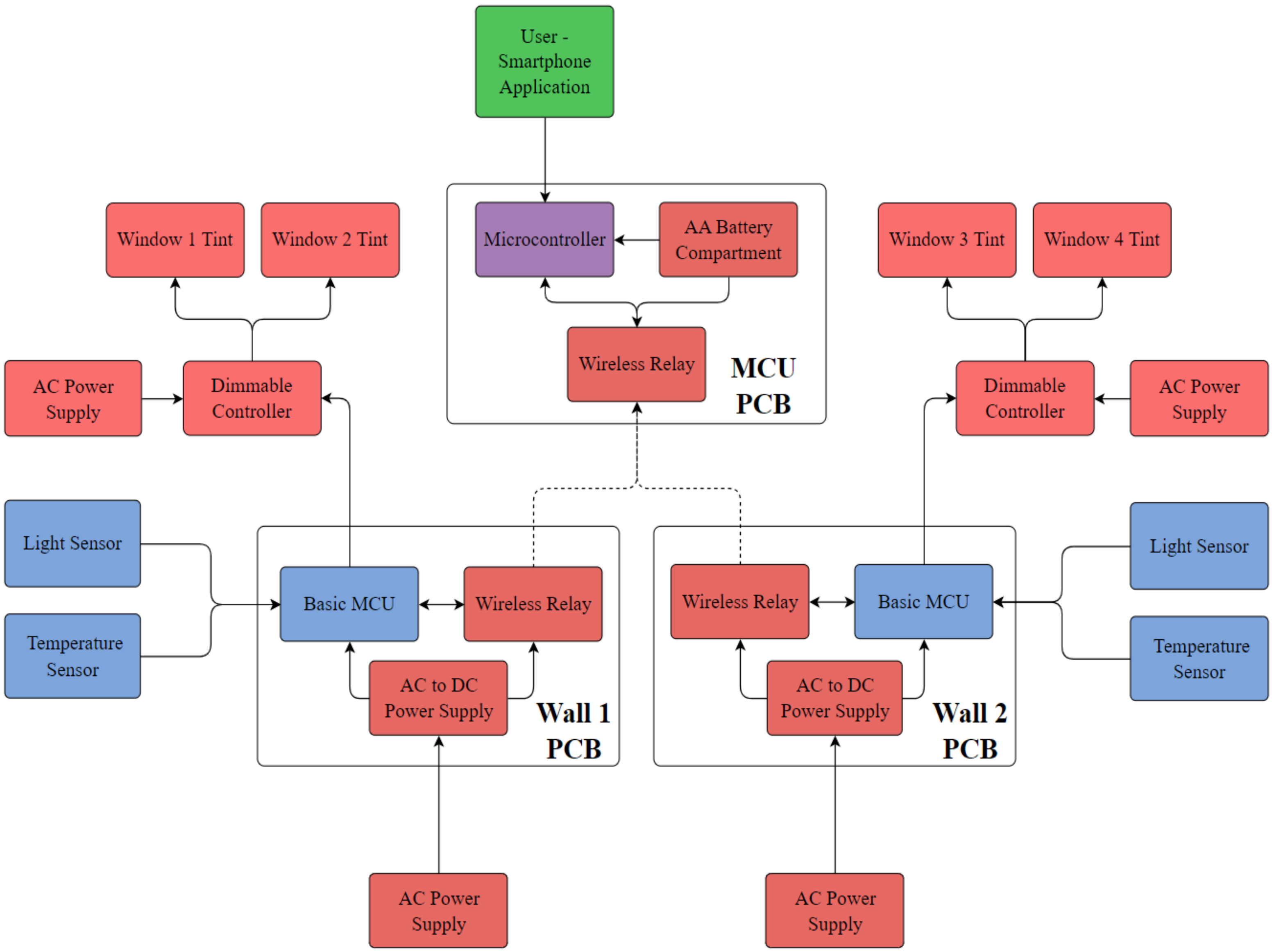
Presented is a block diagram meticulously crafted by our group to visually outline our hardware plans and the individuals responsible for each hardware aspect. Our project poses several challenges in the hardware domain, including the need for a constant voltage for the window tinting system, requiring a connection to an outlet. Additionally, the chosen MCU must be mobile and easily mountable, necessitating a wireless configuration. The sensors must be strategically mounted on the window to ensure accurate readings for all window types. Moreover, the window board receiving input from the sensors should be capable of wireless communication with the MCU board.

In the diagram below, the window tint and dimmable controller are shown. These components will be purchased rather than designed, as the tint involves material engineering outside of the scope of this project, and a UL and CE certified dimmable controller is required by the smart glass manufacturer.

At the core of the diagram are two main components: the window tinting board and the MCU. The connections between each piece are illustrated, with hardwired connections represented by full lines and wireless connections indicated by dotted lines. The majority of hardware responsibilities have been assigned to Stephen Polner and Oren Muszkal, leveraging their extensive hardware experience. Emmanuel is tasked with the MCU block, responsible for deciding on the MCU and overseeing its programming. Luckner Ablard is spearheading the development of the user-side application, considered a technical aspect of hardware since users cannot directly interface with the project. This additional block has been included to encompass this crucial aspect of the overall system.



Hardware Block Diagram



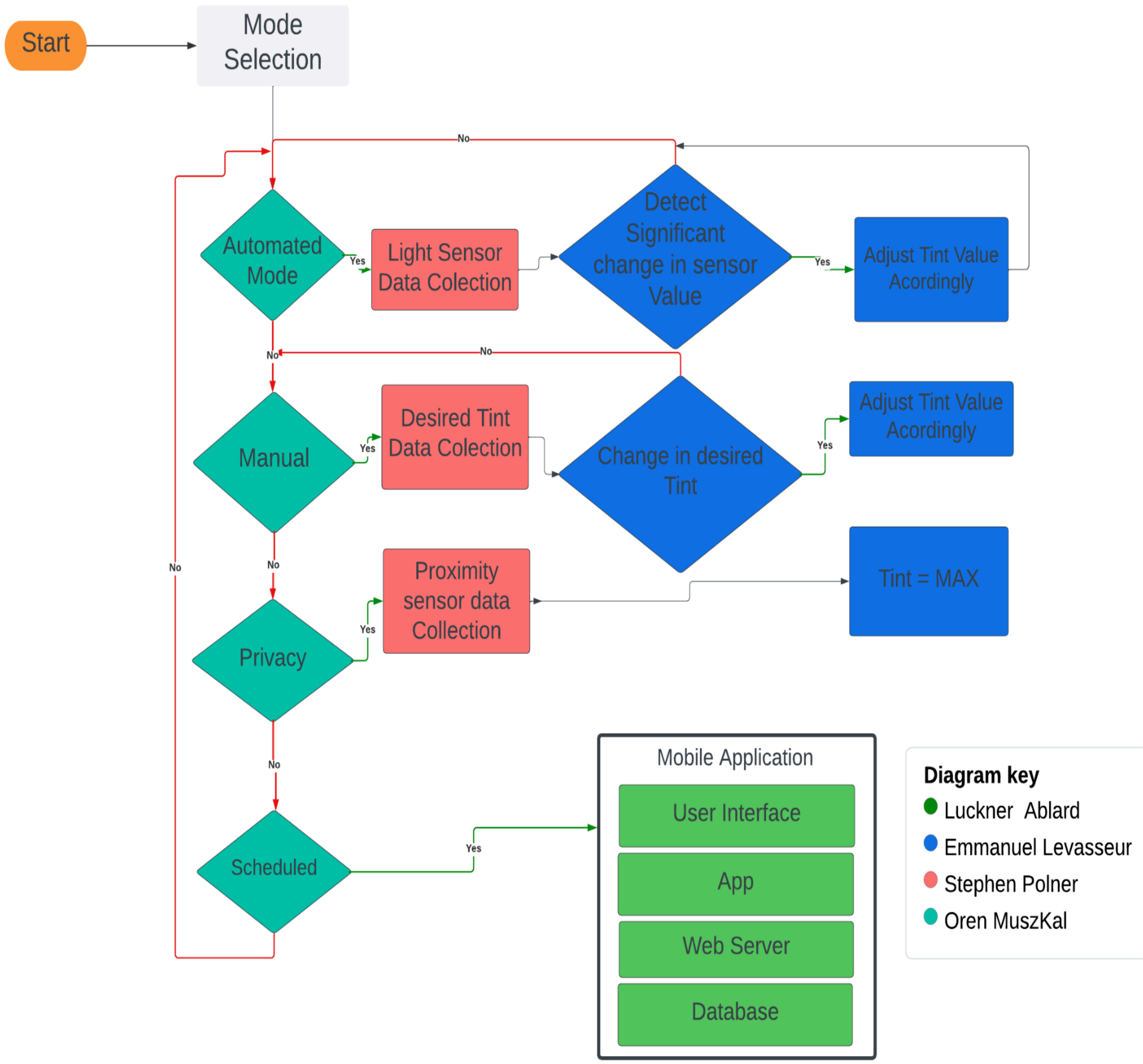
2.9 Software Flowchart

The provided diagram illustrates key software aspects integral to our project. To realize the desired features, we envision implementing a mode system, enabling users to switch between different operational modes. The initial focus lies on implementing fundamental modes, such as user-controlled mode utilizing analog input through knobs and buttons. This is deemed essential as, despite perfect error handling within the software, unforeseen situations may arise, necessitating analog control.

Consideration is also given to a privacy mode, where the tint is set to maximum regardless of the situation, only changing if the user switches to a different mode. The automated mode emerges as a central focus, leveraging the system's ability to read ambient light levels and autonomously tint the window accordingly. Integration with the house HVAC system is explored to enhance overall system efficiency.

In addition to its versatile operational modes, the mobile app plays a pivotal role in the smart tinting project by empowering users to establish customized schedules effortlessly. This functionality allows users to set predetermined times for the smart window tinting system to activate and deactivate, enhancing the overall user experience. For example, individuals may utilize the app to schedule window tinting until sunrise, ensuring a gradual exposure to natural sunlight upon waking up. This purposeful integration of scheduling capabilities not only contributes to energy efficiency but also aligns with users' preferences and daily routines. The mobile app serves as a centralized hub, offering a user-friendly interface for seamless control, scheduling, and personalized customization, making the smart tinting house project a truly intelligent and adaptable solution for modern living environments.

Software Flow Chart



10. Administrative Content

10.1 Project Budgeting and Financing

Budgeting and financing are crucial for the success of the smart tinting window project. Acquiring the necessary components is estimated to cost around $500.00 USD, with each of the four members contributing $125.00 USD. This even distribution ensures a fair financial commitment, covering the basic expenses for the project's success.

Item	**Total Price (USD)**	**Quantity**
PCB	$140.00	3
Smart Glass	$240.00	4
Microcontroller	$30.00	1
Connectivity Devices (Wi-Fi/Bluetooth)	$20.00	3
Demo House	$50.00	1
Light Sensor	$10.00	2
Temperature Sensor	$10.00	2
Total	**$500.00**	

10.2 Initial Project Milestones for Each Semester

Semester I (Senior Design)

Week #	Dates	Milestone Description
1-3	1/8/2024 - 1/29/2024	Complete and Submit the divided and conquer assignment and start working on the research portion of the paper.
3-6	1/29/2024 - 2/19/2024	Complete and Submit a 60-page draft and meet with advisors to further discuss ideas.
6-9	2/19/2024 - 3/4/2024	Start ordering parts begin elementary testing and continue to work on the 120-page paper
9-10	3/4/2024 - 3/18/2024	Continue to work on the 120-page paper
10-13	3/25/2024 - 4/15/2024	Begin working on an Initial PCB
13-16	4/15/2024 - 4/29/2024	Start working and finish Initial testing prototype

Semester II (Senior Design)

Week #	Dates	Milestone Description
1	5/13/2024 - 5/20/2024	Append to the 120-page document thing we've learned from the prototype.
2	5/20/2024 - 5/27/2024	Individual System design (APP, MCU, PCB)
3	5/27/2024 - 6/3/2024	Continue working on PCD MCU and APP (update 120-page paper)
4-9	6/3/2024 - 7/8/2024	System integration (Make sure everything is working together and connected)
9-10	7/8/2024 - 7/22/2024	Practice project demo (Go through a knock demonstration in front of our committee members)
11	7/22/2024 - 7/29/2024	Finalize project demo and documentation
12	TBD	Final Presentation

10.3 Work Distributions

To enhance the coherence of our team's project workflow, we decided to define specific roles for each member involved in this project. These roles are designed to cluster related tasks within the project, preventing potential role ambiguity among team members. Addressing role ambiguity is crucial to avoid hindering project progress, maintaining efficiency, and ensuring a balanced distribution of workload among team members. It's important to note that the roles outlined here are flexible, and if a team member wishes to contribute to a project task outside the scope of their designated role, they are encouraged to do so with the majority agreement of the remaining team members. The roles utilized in this project, along with brief descriptions of each role and the team members assigned to them, are as follows:

- **Project Manager -** *Structured team meetings, established goals and objectives, and assigned different roles to team members to ensure the timely completion of all necessary tasks for the project's smooth progression. The project manager was designated as the primary representative for direct interaction with the instructors of the Senior Design course. They consolidated questions and issues raised within the team related to the project, facilitating efficient and effective resolution by instructors, other team members, or additional mentor figures.*
  - *Assigned to:* Oren Muszkal

- **Software Engineer -** *This role is designated for project team members with experience in programming software, specifically focusing on mobile app development. In undertaking this role, individuals are expected to engage in a diverse array of tasks that span both frontend and backend but also entail the crucial aspect of effective communication with hardware and embedded engineers. It is imperative for the incumbent to conduct thorough research and meticulously choose the most optimal software solutions, ensuring seamless integration and development aspects of crafting innovative and user-friendly mobile applications.*
  - *Assigned to:* Luckner Ablard

- **Embedded Software Engineer -** *Responsible for the microcontroller programming that manages the tinting system including the code to collect and process the data from the sensors, control the film, and communicate with other components. This person is also responsible for working with the hardware and software engineer to integrate the temperature and light sensor into the system. The Embedded Software Engineer is also responsible for the automation logic that takes in all the information from the sensor and adjusts the tinting level accordingly. As part of this role, this person is also responsible for selecting the appropriate microcontroller platform for the tinting system. They work* *on the integration of the microcontroller with other components and systems that form the main tinting system.*

  - *Assigned to:* Emmanuel Levasseur

- **Hardware Engineer -** *This role is assigned to all team members who are involved in the physical aspect of the project. Responsible for PCB design, sensors, and power management. Members assigned this role have experience and a strong background in transistors, diodes, PCBs, and other integrated circuitry.*
  - *Assigned to:* Oren Muszkal, Stephen Polner

- **Mechanical Engineer -** *This role is specifically for the building of the prototyping of our devices. This role has been tasked with the construction and design of all non-electrical components in our product. The member assigned this role must have prior knowledge in woodworking and constructing models.*
  - *Assigned to:* Emmanuel Levasseur

- **Project Documentation -** *This role involves active participation in meetings, capturing essential details such as discussions, decisions, and action items. The responsibility of this grows as we go further in this project when we start making decisions in which direction to go with different aspects of the project.*
  - *Assigned to: Emmanuel Levasseur*