Autonomous Smart Window

EEL 4914 - Senior Design I
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University of Central Florida
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Fall Term 2020 - Group 7
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Project Narrative

Motivation

The motivation behind the Autonomous Smart Window stems from the shortage of fully customizable window options that are currently available on the market. In addition to the aesthetic beauty of windows, there are economic features and security functions that have yet to be integrated simultaneously within a single window unit. The goal of the Autonomous Smart Window project is to identify and incorporate as many window features as possible within a single window unit, and to make the entire system customizable, controllable, and autonomous.

There are many window accessories available to consumers, each of which is designed to accomplish a specific goal. For example, if one wishes to limit the amount of light coming through their windows, this can be accomplished using curtains, blinds, tint films, stained glass, etc. The same applies if one wishes to have a privacy feature (blackout curtains, blackout tints, blinds, light scattering films, etc.). However, it is extremely difficult, if not impossible, to find a window or accessory that can accomplish more than one or two functionalities at the same time. With that being said, the primary goals of the Smart Window are as follows:

- Provide the most visually appealing appearance possible, yet deliver a different aesthetic look than the typical window
- Allow for full privacy at the click of a button, while maintaining a beautiful appearance
- Contain a variable tint feature that can be controlled to select the amount of light being transmitted through the window; also be used to control the amount of transmitted heat radiation
- Integrate each of the functions seamlessly through a fully autonomous system, which can be switched on or off

Proposal

The primary design specification of the Autonomous Smart Window is to create a compact window unit that will house all of the optical and electrical components. In order to meet this requirement, each functionality of the Smart Window must be designed to be as space-efficient as possible. With that being said, each mechanism will be constructed using the smallest, thinnest, and lightest components possible.

To create the variable tint mechanism, we intend to utilize a series of linear polarizers. One polarizer will be stationary, and the other will be attached to a rotating axle; the non-stationary polarizer can then be rotated to allow any percentage of light through the window. Since rotating a polygonal window would be complicated and potentially problematic, we envision the Smart Window consisting of a circular dual-pane window unit. The privacy screen will not be built; it will instead be purchased and installed between the two panes. The screen is a simple light scattering film, and therefore will not require much engineering design to incorporate.

Another aesthetic feature that will be included is an RGB LED window lighting system. LED strips will be placed around the inside edges of the window, allowing for the user to select what color to make the window glow. This visual element will be useful for turning the window into a bright centerpiece of attention during night hours. A light collecting/redirecting film will be placed somewhere on or inside the window to allow for the propagation of the LED light across the entire window. Depending on the brightness and efficiency of the LED/film system, it may be possible to use it in tangent with the privacy screen during the day.

Finally, the Smart Window will contain PIR sensors and a photometer to allow the autonomous system to monitor and control the device. The PIR sensors will tell the system when to turn on the privacy screen, and the photometer will determine what tint level the window should be at.

Specifications

Window and Film Specifications

- Window will contain switchable light scattering film to provide instant privacy on demand
    - When turned on, window will appear frosted over, emitting a bright white hue
    - When turned off, window will be fully transparent
    - Will be contained within the dual-pane window (between the panes)
- Window will have colorful lighting options that can be customized and changed
    - RGB LED strips placed around the inside edges of the window will illuminate the entire inside face of the window, providing a bright, uniform glow
    - LEDs will be facing towards the center of the circular window, shining light across the glass window
    - Light collecting/redirecting film will be placed either within or outside the window to enhance the light propagation across the area of the window
    - Allow for the color to change on its own as a function of time (built-in presets)
    - If possible, make the color lighting bright enough to be operable during daytime (with privacy screen turned on)
- Variable tint mechanism will be built into the window's design
    - Makes use of two linear polarizers. One (or both) will rotate, changing the amount of light that is transmitted through the window
    - Polarizers must be mounted onto rotating axles (perhaps each pane will be embedded in an independent rotating bezel) with a motor connected to one or both of them
    - Allow for full control over the window transmittance level

    - If possible, utilize a third polarizer centered in-between the other two, containing an image or design. The image could be made to be dark with a transparent background or vice versa. This feature would require both linear polarizers to be rotatable
- Entire window will be designed to contain all features within a single, compact unit
    - Circularly shaped with a diameter between 12 in. and 14 in.
    - Design should allow for some kind of rotating capability
    - Window encasement should contain most, if not all, sensors, computers, and electrical components
    - All films will be contained within or on the inside of the window

Electrical and Computer Specifications

- The Window shall utilize 120V AC power utilizing wall outlets
- There shall be an AC-DC converter to power the controller and other electronic components
- The Window shall contain a power meter to measure power consumption
- The power used shall be kept at or below 3-5 watts per square-meter of glass
- The controller shall adjust the voltage of the power supply to control light transmission levels
- The Window shall contain a custom PCB
- The app will be used to configure the system with information such as window area, user light preference, and out of home hours

Sensor Specifications and Descriptions

- PIR motion sensor

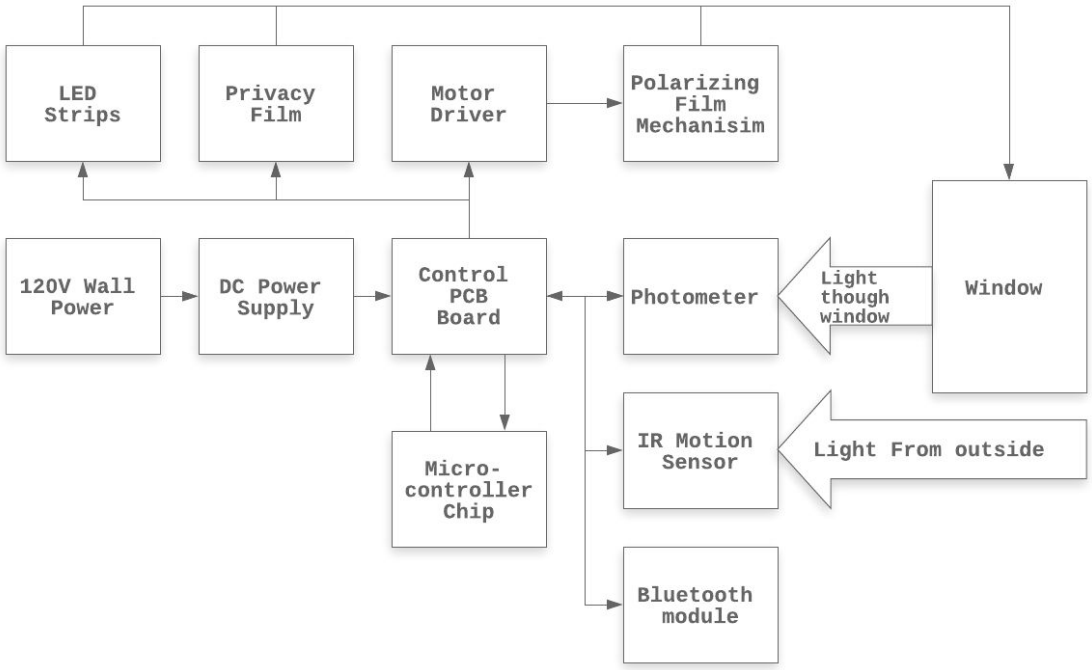
The customized window will allow for unrivaled privacy. It will use two custom built passive infra-red or PIR motion sensors. One will be placed facing the outside of the window unit while the second one will be placed

facing the inside. The PIR sensors will detect human movement and relay the information back to the user, who will have the ability to set the window to immediately activate privacy mode if a person is within 10 meters of the window. The PIR device will also allow for users to elect for privacy mode which gives the ability to frost the window if the owner is detected inside of the perimeter.

- Photometer

The unit will come equipped with a miniature photometer. The photometer will be used to measure the intensity of light coming through the window after the light has been polarized. It will be custom built to be small enough so that it is barely visible to the user. The photometer will record it's data and then relay the information to the chip that controls the rotation of the polarizers. The user will be able to use this data to customize how much light they want to enter the window. The window will also come with a pre-built energy saving feature that will use the photometer readings to auto set the polarizer positions, blocking out sunlight and unwanted heat.

Diagrams and Schematics/Illustrations



Project Budget

Item Description	Quantity	Constraint	Cost
PIR Motion Sensor	2	1.) Small enough to fit inside of 2 inch thick hollow window frame 2.) Connect to same arduino board as photometer	$10
In-unit Photometer	1	1.) Be hardly visible to the user (small and semi-transparent) 2.) Must connect to same arduino board as photometer	$70
Polarizer	3	1.) Needs to allow for at least 80% of transmission when all polarizers are aligned 2.) Thin enough to fit between panes	$120
Privacy screen	1	1.) Ability to turn on and off with data from PIR 2.)Thin enough to fit into window	$50
Arduino Bluetooth	1	1.) Connectable to any phone	$5
PCB	1	1.) Must be able to connect all Arduino boards and run polarizer movements	$50
Dual Pane Window	1	1.) At least 1 inch of gap in between pains 2.) Hollow window frame for mounting of electronics	$140

LED strip	1	1.)Allow privacy screen to change color 2.)Diffuse light fully through the privacy screen	$25
Total cost			$470

Project Milestones and Timeline

Number	Task	Start	End	Status	Responsible
Senior Design 1					
1	Form Group and Discuss Ideas	8/25/20	8/27/20	Completed	Group
2	Complete Bootcamp Document	9/2/20	9/4/20	Completed	Group
	Project Reports				
3	Initial Divide and Conquer Document/ Idea Approval	9/11/20	9/18/20	In Progress	Group
4	Divide and Conquer Document Version 2	9/21/20	10/2/20		Group

5	60 Page Senior Design Document Draft	10/26/20	11/13/20		Group
6	Final Report	11/9/20	11/27/20		Group
	Project Research				
7	Mechanical Rotation of Polarizers	9/11/20	10/2/20	Researching	Nomar and Kenneth
8	Motion Detection Sensors	9/11/20	9/25/20	Researching	Bradley
9	Light-Scattering Films	9/11/20	9/25/20	Researching	Abdullah
10	LCD Screen	9/26/20	10/2/20	Researching	Abdullah and Bradley
11	Photo-meter	9/26/20	10/2/20	Researching	Abdullah and Bradley
12	Circuit Schematics/ PCB Layout	10/3/20	10/16/20	Researching	Nomar and Kenneth
13	Power Supply/ Power Meter	10/3/20	10/16/20	Researching	Nomar

14	Auto-CAD Window Design	10/3/20	10/16/20	Researching	Bradley
15	Phone App Control	10/17/20	10/31/20	Researching	Kenneth
16	Start Ordering Parts and Testing them/ Gathering Funds	11/1/20	11/30/20	Researching	Group
Senior Design 2					
18	Error Checking/ Failure Analysis/ Redesign	TBA	TBA		Group
19	Finalize Window Prototype and Custom PCB	TBA	TBA		Group
20	Peer Presentation	TBA	TBA		Group
21	Final Report	TBA	TBA		Group
22	Prepare Final Presentation	TBA	TBA		Group