Smart Home Window (SHW)

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April 2022

Western Engineering

Introduction

The operation of conventional windows along with their coverings can be a tedious low level task. Leaving windows and window coverings in the incorrect mode can also lead to property damage, safety risks, energy loss, and economic waste. As such there is a need to address this problem using smart technologies to operate windows conveniently and intelligently.

Problem Definition

Due to the tedious nature of opening and closing windows along with their coverings, there exists a need to develop a device or system that intelligently automates the operation of home windows and its coverings to provide convenience for the occupant while preventing the consequences of leaving them in an unwanted state.

Solution

The goal of the product is to design a fully automated device/system that can accurately obtain input data from various weather sensors and online weather data and make the appropriate decisions to control the window and its coverings along with the option of remote control settings for the user.

Design Objectives	
Property	**Objectives**
Economical	Product's price is aligned with user's budget
Useful	Eliminating manual labour/low-level work
Safety	Device has fail-safe measures
Simple to Use	Device is fully automated
Subtle	Outdoor components are hidden with housing
Durable	Normal service life of household appliances

Design Constraints	
Property	**Constraints**
Economical	Cost less than $1000
Environmental	No hazardous materials and debris
Ethical and Legal	Design does not copy any patents
Functional	Design can withstand harsh weather
Safety	Sensor logic does not create new risks
Consistent	Window retains original features

Design Layout

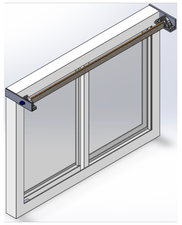
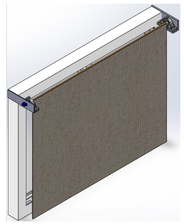
Process Flow Chart

The device selects program modes by retrieving data from the real-time database. The program modes are:

- Manual Mode: Gives user the functionality to change blind/window position via mobile app
- Automatic Mode: Device cyclically changes blind/window positions based on user-set time intervals
- Smart Mode: Device autonomously changes blind/window positions based on sensor inputs and API data

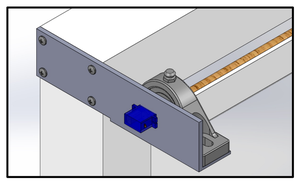
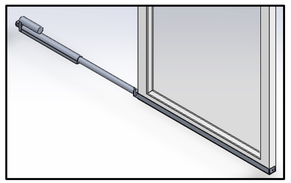
Mechanical Design

Below shows the window when the sliding window is closed, when the blinds are closed and when the window is open

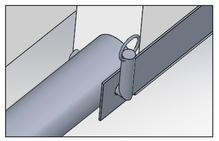



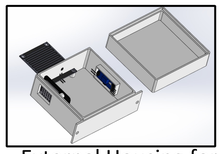

Major Subsystems in this assembly include:

- Motor with bearing and shaft to translate blinds
- Linear actuator with mounting bracket to translate sliding window

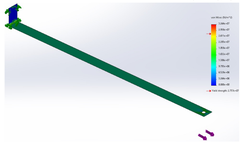



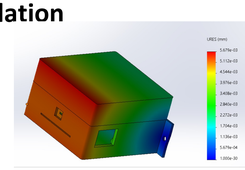
Special Features


Safety Pull Pin for emergency scenarios


External Housing for exterior sensors

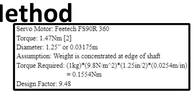
FEA Validation

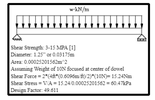

Static Analysis was conducted for the Linear Actuator Bracket using Max Force for an extreme case


Thermal Analysis was conducted for the Electronic Housing to prevent device from overheating

Validation for Blinds Method

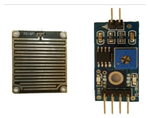
Shear Force and Torque calculations were done to ensure that the shaft would not fail from the blind's shear stress and so that the motor has sufficient torque to translate the blind





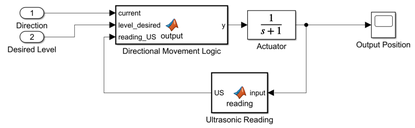
Sensors Used

Light Sensor (x1): Obtains light intensity in lux to determine what level blinds shall be set to
Temperature Sensors (x2): Obtains interior and exterior temperatures for Smart Mode calculations for blind and window states
Rain Sensor (x1): Provides instant feedback to close windows when there is a drop in voltage across the plate
Ultrasonic Sensor (x2): Provides real time position for blinds and sliding windows for feedback control




Position Control

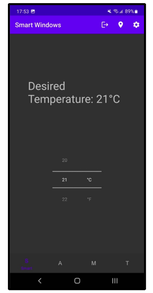
- This device relies on accurate ultrasonic readings as a feedback control system for the position of the blinds and sliding window.
- To mitigate incorrect ultrasonic readings, a bandpass filter was implemented to remove erroneously high or low values



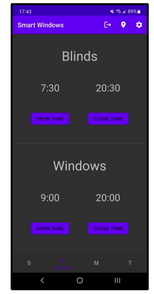
FeedBack for retrieval of Ultrasonic Sensor values

Software Design

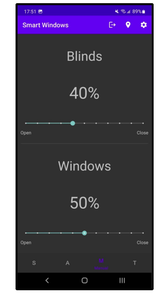
Mobile Application



Smart



Automatic



Manual

- Three modes to select how blinds/windows shall be controlled
- Geofences to prevent break-ins while user(s) is/are out of the house

Firebase

- Shared data (device settings) stored on Firebase and can be changed by any user
- Personal data (location) encrypted using HTTPS during transfer and saved on Firebase storage using AES256 [1]

Business Analysis

The target market for Smart Home Window are new home buyers that want motorized, automated windows installed in their homes. The average Canadian household uses 11,135 kWh of electricity per year costing $1,096.24 to regulate the house's temperature and lighting [2]. The Smart Home Window's energy usage is 39.55 kWh. The device would only need to replace 0.65% of the home's energy usage of air conditioning, heating and lighting to breakeven.

Conclusion & Future Directions

SHW has proven to be an energy efficient and easy to use alternative to existing windows and coverings. Next steps involve creating an iOS version of the mobile app and concealing sensors and actuators in an aesthetic housing in order to market SHW as a consumer product.

References

[1] Google Inc., 2022. *Privacy and Security in Firebase*. [online] Firebase. Available at: <https://firebase.google.com/support/privacy#:~:text=Security%20information-,Data%20encryption,Cloud%20Firestore> [Accessed 3 April 2022].
[2]"Electricity prices in Canada 2021," energyhub.org, 26-Dec-2021. [Online]. Available: https://www.energyhub.org/electricity-prices/#:~:text=the%20two%20seasons.-,Ontario,%24125%20per%20month%20in%202020. [Accessed: 06-Mar-2022]