2015

Sigma Autonomous Electric Blinds

Sigma Autonomous – "For the betterment of human condition"

SAEED SHOKOYA	301260740
DEVPREET BHULLAR	301217638
DAVID JUAN	301223102
ANGELA WONG	301202837

1 TABLE OF CONTENTS

EXECUTIVE SUMMARY

Sigma Autonomous aims to design and manufacture automated Electric Blinds that are affordable to the middle class. Autonomous blinds address the inconvenience of manually opening each set of blinds multiple times per day, resulting in a significant loss of efficiency. Our autonomous slatted Electric Blinds focus on convenience for the user with an emphasis on increased productivity where it matters. The Electric Blinds consists of two sensors; temperature and light, as well as an infrared receiver for the remote. The components work together to create blinds that are “intelligent” and can adjust automatically according to temperature and ambient light intensity. On the current market, manual blinds are the obvious choice for the price conscious, however, we believe that the savings our blinds incur compared to current automated blind options will drive the general market toward higher calibre products such as ours.

Consequently, our goal is to achieve movement in all required directions and according to a set of conditions to evaluate the validity of such a project. At the touch of a button, our Electric Blinds can be easily controlled within two meters through the use of a remote control. In addition, although the blinds are also designed to be autonomous, it can be turned off to allow full manual control. With the use of a light and temperature sensor, the blinds adjust accordingly depending on the amount of sunlight and heat it detects to improve the environment inside the room. Moreover, one main advantage of implementing sensors and motors is that it allows custom programming and any preference in tilting or lifting can be accommodated to a degree. With the convenience our electric blinds bring, they are a great addition to any household. In order to determine public interest, we will monitor attentiveness and various other indicators as a form of consulting to determine whether our project is feasible during demonstration.

INTRODUCTION

As automation is becoming increasingly popular in everyday life, the convenience of autonomous systems is also in an increasingly high demand. Automated blinds are an integral solution in increasing productivity for individuals with a busy lifestyle. Coupled with the unmatched competitive pricing of these blinds, they will viably become an essential improvement in consumers' homes as we progress into the 21st century.

As we set out to determine if such a project was feasible, our research found that many others had similar ideas. Some projects we noticed were able to successfully figure out how to configure their own blinds to automatically tilt them. However, we did not come across any previous projects that were able to raise and lower the blinds automatically with the type of blinds we obtained (slatted wood). As such, we set out to meet the challenge.

Currently, the average home set-up offers only manual control. With this limited ability each set of blinds in the house are required to be opened and closed on a repetitive basis multiple times per day. As such, this leads to minutes accumulating to hours of wasted time spent managing blinds. Furthermore, window blinds tie into the ability of keeping the house cool using an integral part of the house during the summer as well as the ability to lower the energy usage by using the sun to heat the house to keep costs down. We believe that the manipulation of household blinds will provide energy solutions that use the ability to harness the sunlight that is inevitably reflected upon the blinds to saving energy consumption. The advantages of such a system outweighs the upgrade cost which becomes exceedingly reasonable on the market today.

The niche market of home automation has yet to provide an affordable solution to the productivity problem at hand. Previous proposed ideas often require a complete replacement of an entire home's existing blinds but realistically, this is not a suitable solution for the average consumer. With the implementation of our automated system, we aim for a system where household blinds can be converted to become fully autonomous with a set-up adjacent to any existing blinds.

OBJECTIVES

1. Achieve autonomous capabilities including adjusting accordingly to surrounding brightness and temperatures to within a degree of precision.
2. Enable the actions of tilting and lifting/lowering the blinds in an efficient and timely matter (subjective) with high resolution movement.
3. Create an affordable prototype for the average consumer to compete with the retail market at a price less than or equal to $200 CAD plus retail markup at 50%.

METHODS AND APPROACHES

SYSTEM COMPONENTS

Arduino Microcontroller: A small computer designed to take the data from sensors and process the information for programming the system.

Light Sensor: An electronic device that gathers light intensity data.

Temperature Sensor: An electronic device that gathers temperature data.

IR Sensor: A remote that emits infrared signals to be read by the receiver used to operate the lifting and lowering of the blinds.

Servo Motors: An electric motor coupled with a positional sensor for precise angular position control used for tilting and lifting. A generic servo motor will be used to tilt the slats while a high torque servo motor will be used to life and lower the blinds.

System components – Fig. 1

After some further research, we decided against using the gesture sensor in favor of keeping the current energy consumption low and to keep costs down. Instead, the IR remote was used to manually control the blinds when necessary. We also replaced our original Turnigy battery with the battery shown in the figure of system components with a 13000mAh Duracell lantern battery to accommodate for peak stall current of the high torque servo used for lifting and lowering the blinds.

SOFTWARE CONFIGURATION

To control the blinds, the autonomous system is programmed using C++ language. The only external libraries used in the code were provided by Arduino with the exception of the infrared (IR) remote library. All other libraries and software was written specifically for this project. Essentially, the programmed software processes the tilting and lifting algorithm using an Arduino Uno microcontroller, and depending on the data received from the sensors, each motor will act accordingly.

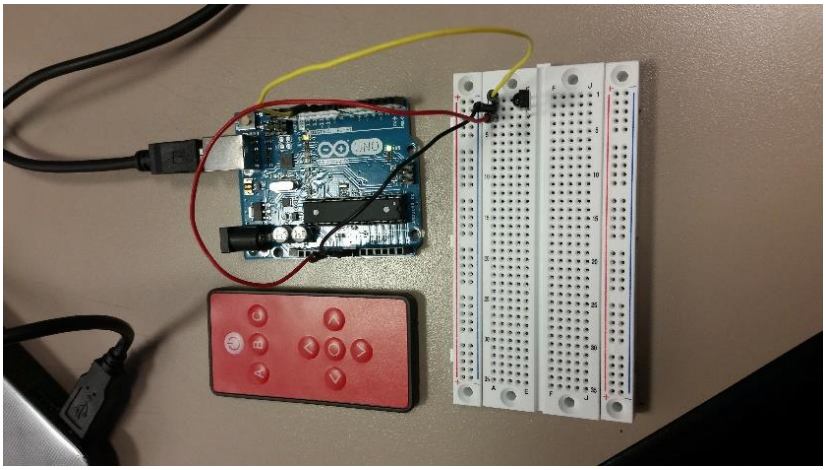
After checking the level of brightness with the light sensor, the system will check the ambient temperature using the temperature sensor. With the servo motor, it will rotate a pre-defined amount to increase or decrease the amount of sunlight allowed into the room. Furthermore, if the time of day changes, the blinds should adjust according to the light intensity at the different stages of the day. For example, at night, the light intensity outside is low, therefore the blinds will close completely.

The numerical settings are as follows:

Light Intensity	**Low**	**Moderate**	**High**
Autonomous Response	Tilt to 80° to close blinds completely, but if temperature is high, tilt 10° to open slightly (assuming window is open). Option to make blinds lower fully autonomously.	Tilt to 0°, but if temperature is high, tilt 35° to alleviate heat. Option to make blinds raise fully autonomously.	Tilt to 0° (wide open), but if temperature is high, tilt 45° to alleviate heat slightly. Option to make blinds raise fully autonomously.

The remote functions as follows:

BUTTONS	***RESPONSE***
BUTTON “A”	80° position tilt – closes completely
BUTTON “B”	0° position tilt – open completely (horizontal slats)
BUTTON “C”	45° position tilt – partially open
BUTTON “CIRCLE”	Stop lifting motion at any moment in time
POWER BUTTON	Toggle autonomous system ON/OFF
BUTTON “UP”	Lift the blinds up
BUTTON “DOWN”	Release/Let blinds fall slowly
BUTTON “LEFT”	Decrease the threshold temperature for sensor by 1 degree
BUTTON “RIGHT”	Increase the threshold temperature for sensor by 1 degree



Programming the IR sensor and receiver – Fig. 2

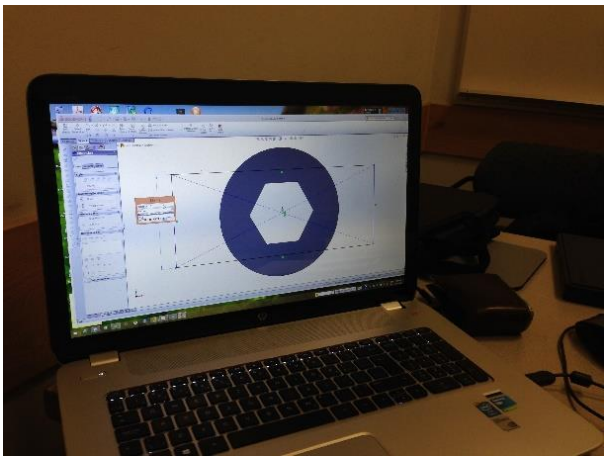
CONSTRUCTION PROCESS

Since our Electric Blinds are designed as simple as possible for easier maintenance and replacement of components, the construction process is relatively straightforward. The main issue during the process was managing to fit every motor and component onto the system. As

there was a limited amount of space located at the top of the blinds, maintaining enough spacing for high efficiency and uninterrupted performance was a top concern. In addition, racks (or stands) were designed to mount the motors securely onto the blinds. This required precise dimensioning using calipers for accurate 3D printing of the parts. In order to figure out which high torque servo we needed to lift/lower the blinds, we had to calculate the torque required to overcome gravity as well as the weight of the blinds. The high torque servo was also modified to allow for continuous motion.

The process can be concisely summarised as choosing the required components, developing software libraries for each sensor and actuator, designing hardware to implement the components properly, testing and configuring each sensor and actuator individually, combining the libraries into one main code, and finally, testing and optimizing everything as a whole.

Below are some pictures taken during the construction process:



Designing tilting shaft attachment for the servo – Fig. 3

Drilling holes for screws into the lifting servo spool – Fig. 4

Cutting the limiting pin on lifting servo to allow continuous motion – Fig. 5

Four AAA batteries power the Arduino microcontroller board and the sensors. The Duracell battery is used to power the servo motors only for consumption reasons.

In order to make our high torque servo motor continuous, we needed to take it apart. We used a soldering tool to manipulate the circuit with new resistors and removed the limiting pin (Fig. 5) that only allowed the servo to turn 180 degrees.

OUTCOMES

The final product features are as followed:

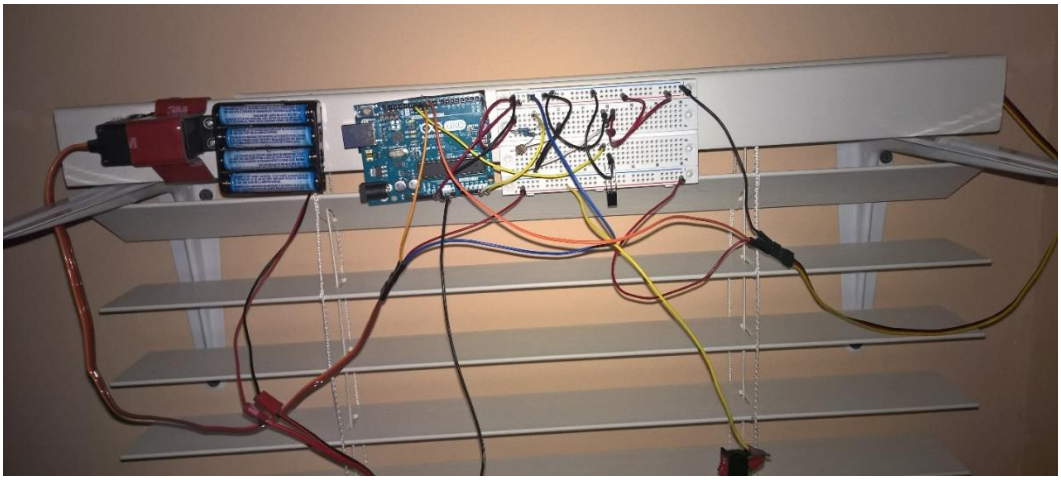
1. Temperature Regulation

- Blinds adjust according to the thermal energy gained from the sun. If the heat from the sun surpasses our threshold, the blinds will adjust to cool down the area within

2. Ambient Lighting Recognition
    - Blinds adjust according to the light intensity outside to differentiate between morning, afternoon, and night
3. Remote Controlled
    - Can turn autonomous system on and off
    - Option to manually raise, lower, and tilt blinds according to preference

During the construction process, the configuration of the system was modified multiple times, even up to the final day. From experimentation, different components were tested for real-life with realistic scenarios, and as a result, we believe we have a product that would be ready to hit the market.

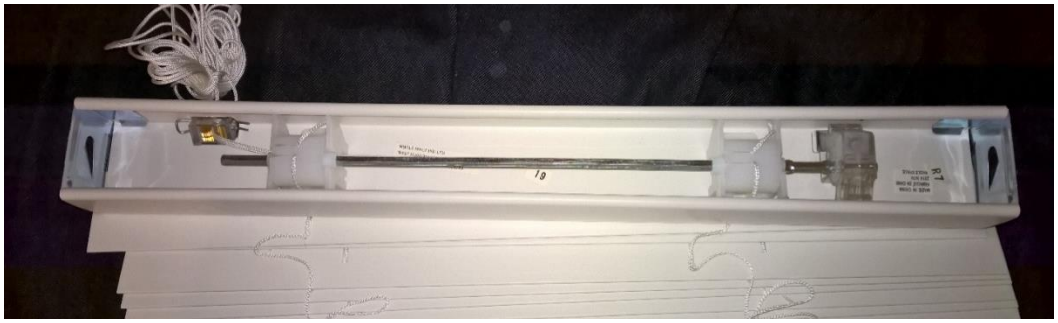
Being approximately $75 under budget our product will be even more competitively priced than before. With a 50% retail markup our products comes to approximately $190 which is 59% cheaper than the average market blinds that are tilt only (at $460.00) and 73% cheaper than the one that tilt and lift/lower (at $706.40). This is a huge 17% improvement from our forecasted 42% cheaper from the average market blinds that are tilt only.



Back side of the blinds (before gluing the wires to the back) – Fig. 6

Tilting servo attached to tilting shaft with 3D printed attachment – Fig. 7

Lifting servo along with the 3D printed spool – Fig. 8



The head-rail before any modifications – Fig. 9

The head-rail after all modifications – Fig. 10

DISCUSSION

INSTALLATION

As an essential component in a household, the construction and maintenance for window blinds should be straightforward for everyone. Therefore, Electric Blinds were designed to be as simple as possible. As one of our objectives, the system was constructed to be attached to any existing blinds in a home, with fairly basic installation.

The final product is designed as a modular system so that any blinds with slats can be modified with a minimal use of tools. It will have two parts (for lifting/lowering and tilting on either side) than can slide into the gap inside the head-rail so that no screws are necessary as the gap will be used to hold the parts (similar to tilting servo in the prototype) with resistance. If the gap happens to be bigger on the consumer's set, a simple mechanism to provide resistance with the extra width will be provided within the set.

To begin, the user will only need to take out the existing plastic gear mechanism and the tilting wand requiring no tools in the process. Then, both parts can be easily slid inside the head-rail. The tilting mechanism will have a motor connection sized accordingly to the tilting shaft (similar to 3D printed shaft holder on tilting servo). The lifting component will have a spool on one end (Fig. 8) where the lifting thread can be rolled and is shaped similar to the tilting spools (Fig. 7) that are already installed in the blinds. This ensures that the thread doesn't slip on the spool. Lastly, the head-rail shaped housing of both parts will reduce noise considerably as well as securely storing the battery and sensors (Fig. 10).

COSTS

Total expenses are as followed:

	Sensors and Motors	Window Blinds	3D Printed Parts	Batteries	**Total**
Cost (CAD)	$83.60	$15.65	$11.00	$15	**$125.25**

The final cost for Electric Blinds is approximately 35% lower than the first estimated cost as expenses were kept as low as possible and some features were cut in the interest of time. Finally, when it comes to mass production, the cost will be greatly reduced due the higher volumes being manufactured.

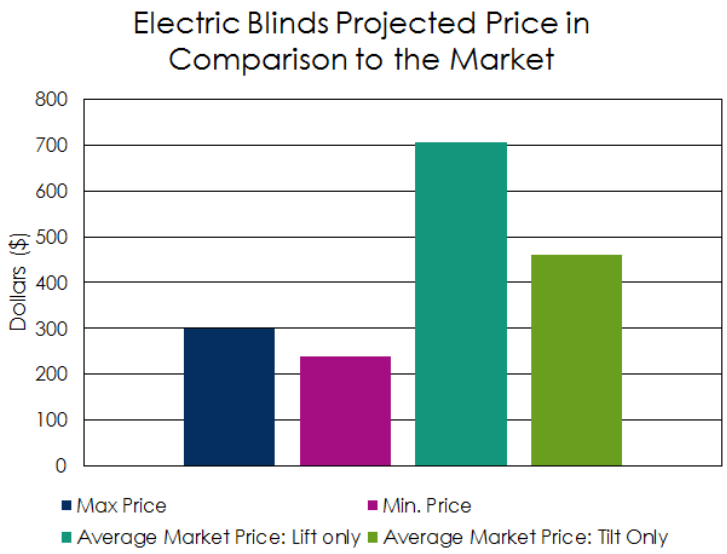


Fig. 11

SUSTAINABILITY

Regarding sustainability, the blinds are fairly easy to care for. For cleaning and maintaining the system, the slats and remote can be carefully wiped down using a dry microfiber cloth to prevent any dirt and dust from building up. To store the system, all components must be securely stored to avoid accidentally damaging any components. As our Electric Blinds not prone to failure, the system is likely to last many years without repair or replacement.

RECOMMENDATIONS

A major recommendation for our project would be to install solar panels onto the blinds, or more specifically, the slats. Instead of using a battery to power the blinds, the energy received from the sun could be stored in rechargeable batteries and utilized. This would result in reduced energy bills and eliminate the need to replace a dead battery.

Another recommendation is the inclusion of a Wi-Fi receiver and a mobile app. Using the proposed app, users can control the blinds from anywhere in the home or around the world for that matter, instead of the current two meter range. A possible application for this is if one has plants that need sunlight periodically, the user could shine sunlight onto the plants whenever is needed. Furthermore, the app could also display the current values retrieved by the light and temperature sensors. With those values, the user can modify the threshold to change how the system reacts to different settings. Through the app, more customizable options can be implemented to allow the user full control over the system.

CONCLUSION

With the completed prototype, the implementation was fairly similar to what was initially designed. One objective was to create an autonomous ability for the blinds. This goal was met as both the light and temperature sensors were able to reach the desired accuracy necessary for execution. Another objective entailed the lifting and lowering motion of the blinds. Although this proved to be a difficult task at first, a few configurations, including modifying the servo motors and printing custom 3D parts ensured success. As such, the blinds were able to move up and down with ease. Lastly, the objective was to create an affordable set of autonomous blinds. Set at a budget of $200, the final cost of our Electric Blinds came to a total of $125.25. This result is well below our initial budget as well as being below the retail market price of similar products.

The final marketable prototype would be considerably cut down in costs and power consumption as well as including new features. The microcontroller, along with two servo

motors, accounted for the majority of our expense. These costs can be reduced by implementing a bare-bones microcontroller and DC motors with encoders. Power consumption can be reduced by introducing interrupts in the software so that the microcontroller 'sleeps' when inactive.

As discussed earlier, more features that will greatly benefit the final prototype include a mobile app which can replace the IR remote and display states such as temperature and light intensity in real-time. An array of solar panel would also improve the system by charging the batteries for a truly sustainable system. An array of solar panels that can provide 6V and a current discharge rate of more than 500 mAh can easily recharge our AAA batteries within a reasonable amount of time of approximately 2 hours.

With this project, the options are endless in terms of implications and improvement. Automated systems will become more prevalent in households as the technology develops for potential future applications to extend to all areas of home in one truly integrated system. The aim being improved human productivity and improved lifestyle. Ultimately we believe we have lived up to our temporary motto: "For the betterment of human condition".