Motorized Window Blinds for Better Sleep

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I. Introduction

A. Motivation

Waking up from a nights rest to a preset alarm can disrupt a persons natural sleep. REM sleep is the deepest form of sleep that provides the most relaxation for dreams to occur. However, REM sleep is considered a delicate stage that a forceful abrupt alarm can lead to grogginess and difficulty waking up. Thus, motivation exists to allow the body to naturally enter a lighter stage of sleep before waking up. Cortisol is a hormone that releases the amount of sunlight present. However, to protect privacy in densely populated areas or personal preferences, shutter blinds block high amounts of sunlight from entering an area.

B. Outcomes

A mechatronic system can mechanically open shutter blinds at a preset time to allow time for the indiviudal to enter lighter forms of sleep to increase recovery and alertness in the morning. An abrupt noise can remain to ensure a person wakes up at a specified time after the blinds are opened after cortisol has been released. Further, this system can automate a tedious home task to a single signal sent through a phone.

II. Approach and Methods

A. System Components

A pull cord shutter blind is difficult in that there is a lock mechanism due to the angle the cord is pulled. An initial design places the motor at the upper portion of the window to allow for constant tension but the angle of force requires special considerations. The motor must not pull too far to reduce the risk of breaking the motor or shutter blind. Thus, future closed-loop designs ensure the blinds are fully open at any amount the blinds are closed.

The initial open loop tests require prototypes of the mechanical design. 3D-printed mounts are expected to be cheap and easy to test. A mechanical design is expected to be completed by April 15th. A load cell sensor is expected to allow for closed-loop control of the system. The testing of the closed-loop system is expected to be completed by April 30th.

B. Bill of Materials

Motorized blinds are designed to be designed with regards to cost and modularity. The motor is implemented to existing blinds given that houses are expected to have existing shutter

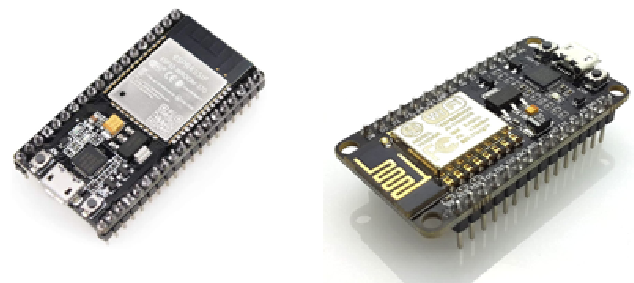

Fig. 1. ESP32 (left) and ESP8266 (right)

blinds. Thus, the added costs to automate the system should remain low. The materials list follows:

- ESP32: $10 per part
- ESP8266 (2 pack): $10
- 28BYJ-48 5V stepper motor and ULN2003A motor driver (5 pack): $20
- 12v external power supply: $7.89
- Power Supply Module 12V to 5V (6 Pack): $9.65
- 3D printed female to female blinds adapter: free
- 3D printed housing unit: free

The implementation requires the ESP8266 or ESP32 nanocontroller. In instances of close blinds, one nanocontroller is required for control of both blinds, thus reducing cost. All mounting systems are expected to be 3D printed through available resources and remain low-cost.

C. Budget

- ESP32: $10 or ESP8266: $5
- 28BYJ-48 5V stepper motor and ULN2003A motor driver: $5
- 12v external power supply: $7.89
- Power Supply Module 12V to 5V: $1.60
- 3D printed female to female blinds adapter: free
- 3D printed housing unit: free

The total cost to the entire assembly is $20 or 25. An analysis of the ESP32 and ESP8266 can be found in the subsequent section.

D. Specifications

The first iteration of the system is designed as an open-loop controller for a constant window. The window is constrained to be fully opened or closed such that the rotations in the motor are mapped to vertical displacement. There are no signal processing requirements as there is no induced noise in the electrical signals. The mechanical design must be well-designed to lift the weight of the blinds evenly.

Fig. 2. Female to female connector that connects to the rotating shaft outside the housing unit.

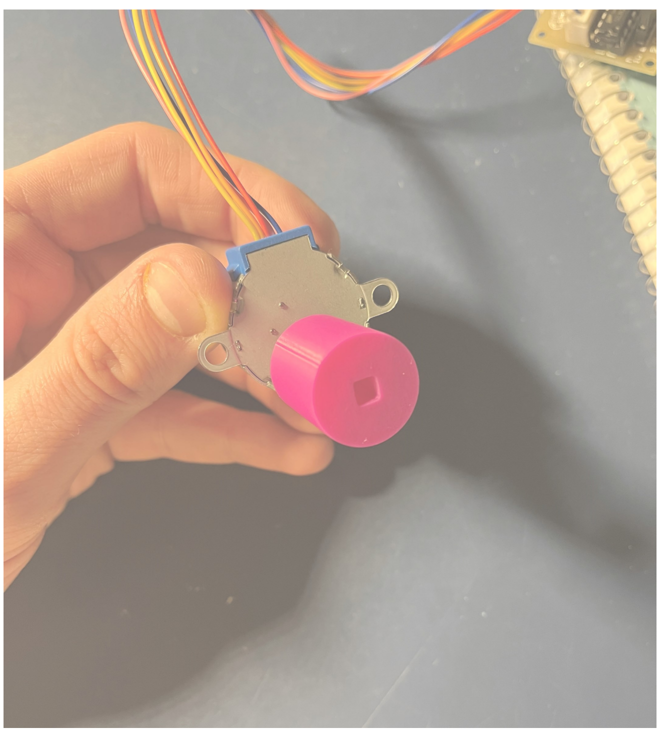

Fig. 3. Female to female connector that connects directly to the rotating shaft in the housing unit.

The ESP32 and ESP8266 are products that allow for connection to WiFi networks and allow for bluetooth capabilities to send wireless control to the nanocontroller. The ESP32 has a robust GitHub repository called HomeSpan that allows for connection to HomeKit designed by Apple as seen in Figure 4. In this, the user interface in IOS is intuitive. An on/off button can be seen in Figure 5. However, there are minimal options to add additional inputs such as alarms.

The ESP8266 is half the price than the ESP32. There exists numerous repositories that allow for a wireless interface such as PubSubClient.h and ESP8266wifi.h. Further, when interfacing via a MQTT connection, there are numerous options to create a timer, alarm, or button signal making this nanocontroller a worthwhile solution. The connection with the nanocontroller is seen in Figure 6 and the wireless command is seen in Figure 7.

III. Results

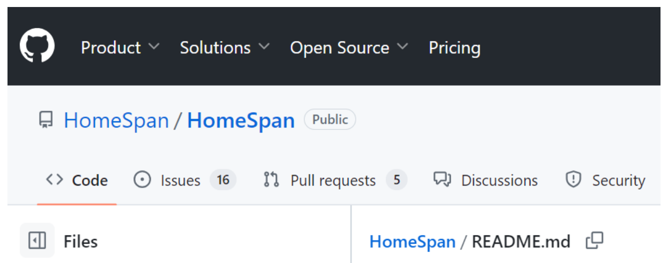

Fig. 4. HomeSpan GitHub repository providing interface between Arduino.IDE and the HomeKit app.

Fig. 5. Command on Apple's HomeKit app service for on state of a device.

A. Figures

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Connected to the WiFi network
Connecting to MQTT Broker as esp8266-client-48:55:19:ED:BA:5D.....
Connected to MQTT broker
Message received on topic: emqx/esp8266
Message:fdsosbvob

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Message received on topic: emqx/esp8266
Message:Hi EMQX I'm ESP8266 ^^

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Fig. 6. Initial WiFi connection setup to the nanocontroller.

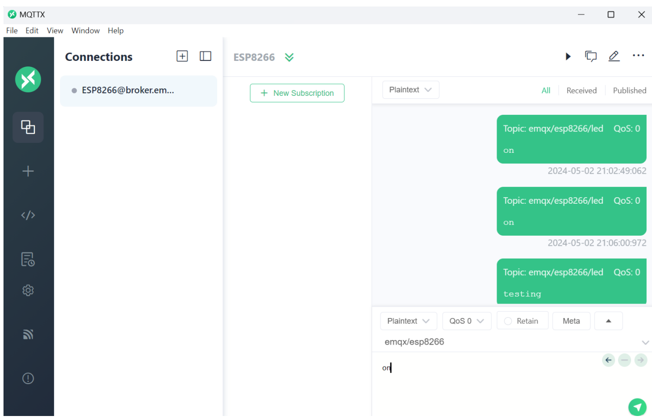

Fig. 7. Wireless command through MQTT to the nanocontroller.

B. Final Deliverables

The motorized blinds can connect to WiFi and send signals via bluetooth. However, the motor cannot overcome the weight of the blinds. Thus, an external power supply greater than the 3.3v supplied is required. A power supply module can step down the 12v to 5v and stay within the rated voltages of the nanocontroller. When severing the red wire in Figure 8, the stepper becomes bipolar (i.e. a different voltage can be sent to the motor than the second bridge that sends information back from the motor.

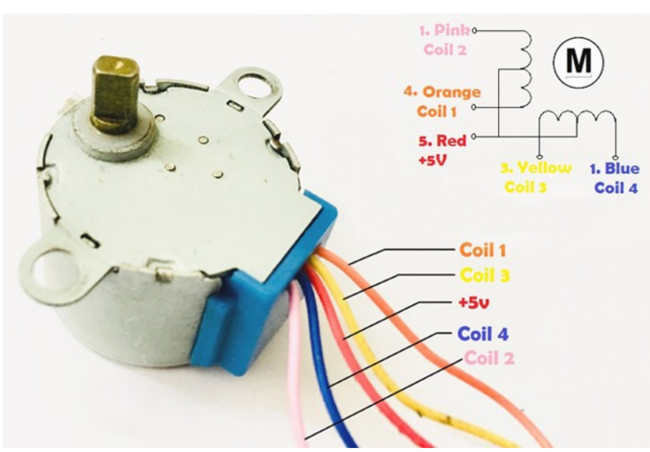

Fig. 8. Stepper motor wire diagram.

IV. Discussion

The ESP32 and ESP8266 are two nanocontrollers that can effectively provide wireless connection to automate a home. Window blinds are one aspect of daily home activities that can be controlled through a set of wireless devices. A series of relays can be implemented to automate multiple devices and projects. A 12v external power supply increases the maximum working voltage from 3.3v. The stepper motor can be wired to 12v for increased torque output. [1]–[4]

V. Conclusion and Future Work

Wiring a stepper motor to 12v for increased torque output is a necessary step to overcome the load that is unable to be done with 3.3v. Future actions with the connection with MQTT should allow for presetting times to open the blinds through timer and alarm functions. Iterations of the housing unit must provide aesthetic benefits.

VI. References

References

[1] EMQX. "ESP8266 MQTT LED." Accessed: May 6, 2024. (n.d.), [Online]. Available: https://www.emqx.com/en/blog/esp8266_mqtt_led.

[2] G. Media, *ESP32-HomeSpan*, https://github.com/galbraithmedia1/ESP32-HomeSpan, Accessed: May 6, 2024, n.d.

[3] HomeSpan, *05-WorkingLED.ino*, https://github.com/HomeSpan/HomeSpan/blob/master/examples/05-WorkingLED/05-WorkingLED.ino, Accessed: May 6, 2024, n.d.

[4] M. M., *Why do we fall - motivational video*, https://www.youtube.com/watch?v=1O_1gUFumQM, Accessed: May 6, 2024, Jan. 2013.

VII. Appendix

https://github.com/ertulsky/WindowBlinds