

# AN SMART AUTO SHUTTER CONTROLLING SYSTEM FOR INTELLIGENT HOME BASED ON DATABASE ANALYZING AND MECHANICAL DEVICES

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## ABSTRACT

*Currently, smart home systems have developed rapidly and really convenience people's lives [1]. However, by focusing on the shutter and curtain in a smart home system, shutters can only move on manually, and shutter used less because the curtain is easy to control [2]. In order to try to fix these questions on shutter, we designed an application and hardware integrated system which can control the shutter automatically depending on light and temperature, and also can allow users to control their online shutters devices remotely. Besides, we used the firebase database to store the device's data and status, so that devices can be more memorable and smart in controlling the shutter even if the weather conditions affect the logic decision. We applied our application to some window shutters at home and conducted a qualitative evaluation of the approach. The results show that the system can make the decision based on the software logic and eventually control the shutter under different light and temperature conditions in order to have the best balance between sunlight and home light [3].*

## KEYWORDS

*Auto Controlling, Database Analyzing, Mechanical Device, Smart Home*

## 1. INTRODUCTION

Smart homes are one of the forms of technology application, which is beneficial and convenient to daily life [4]. More and more technology companies seek the opportunities on smart home systems as a new technological application, for example, Google Nest, Roku etc.. When I was researching the market of smart homes, I found that there are many smart home systems including the close and open of the curtain or shutter. But most of the controlling systems are connected to the smart speaker of mobile app controlling. By using solar energy to power the integrated controlling system, we want to keep the ideal of saving energy and environmental-friendly [5]. On the other hand, automatic shutter can keep the balance of natural light and light bulbs, which can not only save electricity, but also sufficiently use the sunlight at home which is also a benefit for physical health. It is a critical idea that using databases in smart home systems, take considers we have in our project as an example, databases increasing the intelligence level into data level. Power computing functions in an integrated computer or hardware system can make the learning and experiences in non-living objects possible. Though there are great debates on whether smart learning objects would be dangerous for the human future or take advantage of humans, the benefits and profit we can gain from it nowadays are enough for people living in the

moment. As a result, rather than a further application of technology, the auto shutter integrated system we made is an attempt and choice of intelligent technology.

Some of the related techniques and systems are proposed to control the shutter with a remote controller or mobile controller, which allow the user to control the opening or closing of the shutter if the user's hands can not reach the shutter or window. However, these proposal indeed make remotely controlling of the shutter possible and these idea and examples developed the first version of the smart homes, there are still limitations in these manually controlling system, for example, if the login informations expired and user are not at besides of devices, the device would be useless until the login information been update. Besides, the remotely controlling signal would be blocked if there are concrete or other certain blocking stuff on the route signal passing, which is also an uncertain factor in the controlling system. On the other hand, for other techniques which give up any curtains or shutters but install a new auto controlling curtain or rolling shutter which connect to wifi or mobiles to achieve the auto or manually controlling of the blinding shutter. Their implementations are also limited in scale. These techniques cannot be used on plantation shutters, it is not worthy for the house owner with plantation shutter to tear down all of the plantation shutters in order to have an auto shutter controlling system. However, there are personal applications of the auto controlling system for plantation shutters; the personal design of the plantation shutter controlling system is fit for it but these techniques' limitations make the application can not be used in public or large groups of shutter users because differences in different house would make the specific design hard to change and also these are too specific on plantation shutters which lead to lack of market and less available producers. In the nutshell, none of the techniques above have the mature techniques of automatically controlling based on natural information and database.

In the project, I research the existing windows or shutter controllers. I found out that most of the controlling system is trying to provide actions on an object that could make the whole target object move in the actions instructors want. Following the major goal in my hardware controlling part, the method I use is the winch and lines which connected on the rod in the middle of the window. The motor in the central controlling system in the middle of the side of the window will pull or push the line through the eye pin for the turning and making effort to move the shutter up and down. Our method are inspired by the crane and fishing rod. Though there are still some places need advanced, there are some fascinating features of my project. First, most of the existing products of shutter moving method are using the angular moving on the shutter, which expose the problem that angle may not being covered through fully closing up and down. Though my controlling method have more occupied area on the wall, the winches, line and homing button system provide balanced, stable, and directly motions on the shutter. Second, the most creative and different part in my project is the coding part in the computer system that could automatically react to the light and temperature variables and controlling the shutter close or open.

In two application scenarios, I demonstrate how the controlling and data analyzing system advanced in the case of shutter controlling. First, the demonstration of the winches and lines which show the evolution of the motor action system that not limited by the angle of the shutter, but moving freely and stable. By making experient about the winch moving system, I found out the pulling and push of the line should be accurate in the motion in order to reduce the possibility of too tighten or too loose of the line. In fact, because of the existing of the homing button as the last insurance of the moving system, there would be less problems during the moving action in hardware. Second, I analyze the data from the computer which receive the data from the temperature and light sensor. By involved into the combination and specific calculation method in the program, the data would hardly performed keeping moving downward and upward which lead to much useless motion. In addition, the saving of the data in the firebase database is the most developed and evolutionary part in my project, data science provide access to the solution

of keeping track of the data from nature and light bulbs, and remaining record of data which lead to moving or any problems.

There are several following sections in the rest of the paper: section 2 gives the details on the challenges that I met during the experiment and designing the sample; Section 3 focuses on the details of our solutions corresponding to the challenges that we mentioned in Section 2; Section 4 presents the relevant details about the experiment we did, following by presenting the related work in Section 5. Finally, Section 6 gives the conclusion remarks, as well as pointing out the future work of this project.

## **2. CHALLENGES**

In order to build the project, a few challenges have been identified as follows.

### **2.1. Choosing Topic**

At the beginning of the project, I faced a hard time to decide a property and meaningful topic of my project. First, I tried finding some academical resources and trying to gain some idea from it, during the research, I found that cyber security and coding project are popular [6]. But it is not a good idea to copy others idea and making changes on it, so I decided to focus on little things which benefit to people daily life. Because of the smart home system interested me and I found out that curtain is the major project but there are still people using wood shutters in their home, so the topic of an auto shutter device concentrate with the climate, people's life comes up.

### **2.2. Selecting Data**

In order to auto adjust the angle of the shutter, I have challenging in finding the better data which can represent the different condition of outside and inside of the windows. There are several alternative data for me to choose in the auto controlling part, such as light, time, temperature, weather and sunlight angle etc.. After researching online and the existing product about the detector using, I decided to use light and temperature sensor to forming auto controlling based on natural condition. At first, I decided to connect sunlight angle with season, indoor and outdoor light condition and move shutter in a perfect position for balance between indoor and outdoor condition. But based on the winch and line moving mode, it is nearly impossible to control shutter position by simply control winches in a same pace I want of the shutter and lines. In order to save the idea but changing way to think about it, I create other mode that costumes can choose control on themselves or let it automatically control itself but also remain the temperature and light sensor for the auto mode.

### **2.3. Controlling Arrangement**

Considering the force motor need to move the shutter, I firstly decided using smaller motor that occupied less spaces in the central controlling. But by directly using the small motor to push and pull the shutter, it is hard to making any progress from this idea. Otherwise, I comes up the idea that using greater motors and winch and ropes, though it may not good looking anymore, it not only provide a more tensive central controlling part but also provide enough force to moving the shutter. On the other hand, it is a good idea to make a protecting cover on the line and wires and make it same color as the edge of the window. By protecting the connection and cover it with similar color, controlling and moving will be more stable.

### 3. SOLUTION

Spoter is a smart, data based home device serve for controlling shutter smartly. In auto mode, Spoter would tracking light and temperature in both indoor and outdoor condition, based on the data stored in server and database, Spoter can moving shutter to open or close position automatically. By using firebase as the server and database, server can tracking and saving the data from the sensor which carries the important data help Spoter determined the moving process and decisions [7]. On the other hand, there is still more directly manual controlling mode in Spoter, as the name suggests, it is the additional controlling mode which can let users remotely control there Spoters with a application on their terminal. In order to relize the remote control, database and server still plays and important role in it. By programming, I connected app controlling with the server, because of the connection between Spoter and server, the data variation could be simply detected by the program in the central controlling of the Spoter, which could finally achieve the remote, manually controlling. In the central controlling part of the device, I trying to develop python codes in raspberry Pi and relize several functions such as connecting with server, receive the data from sensors and server and decide the movement of the motors [8]. To achieve the goals I explain above, my main component in the system and the figure are below:

- Device and central controlling part(powerd by raspberry pi)
- Server and database brige between device, remote control and sensor data
- Application on terminal in order to control manually

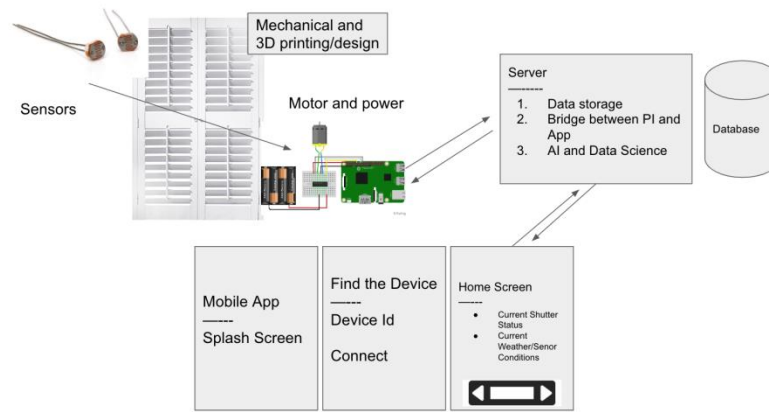


Figure 1. Overview of the solution

- Controlling Device component:

Controlling Device, which is the major part and the only part of the hardware system of the Spoter. Controlling Device is based on Raspberry Pi, connected with the firebase database and coding in Raspberry Pi by Python. Controlling Device connected to firebase and will upload the data from sensors to the server, data in the server would be used as reference of terminal application or the device program [9].

- Code segment:

```
def homing():
    while True:
        if not limit_switch_top.is_pressed:
            for i in range(10):
                kit.stepper1.onestep()
                kit.stepper2.onestep()
            print('homing blinds')
        else:
            break
    time.sleep(0.1)

#close top function
def close_top():
    while True:
        if not limit_switch_top.is_pressed:
            for i in range(10):
                kit.stepper1.onestep()
                kit.stepper2.onestep()
            print('closing top...')
        else:
            break
    time.sleep(0.1)

#close bottom function
def close_bottom():
    while True:
        if not limit_switch_bottom.is_pressed:
            for i in range(10):
                kit.stepper1.onestep(direction = stepper.BACKWARD)
                kit.stepper2.onestep(direction = stepper.BACKWARD)
            print('closing bottom...')
        else:
            break
    time.sleep(0.1)

#max light function
def max_light():
    inside, outside = getLightValues()
    light_diff = outside - inside
    print(inside, outside, light_diff)
    if abs(light_diff) > LIGHT_DIFF_THRESH:
        if light_diff > 0:
            kit.stepper1.onestep()
            kit.stepper2.onestep()
            print('move motor up')
        else:
            kit.stepper1.onestep(direction = stepper.BACKWARD)
            kit.stepper2.onestep(direction = stepper.BACKWARD)
            print('move motor down')
    else:
        print('do not move')
```

```

#roaming
homing()
while True:
    temp = aht.temperature
    print('temperature', temp)

    if state == 'close':
        close_top()
        time.sleep(0.5)
    elif state == 'close_bottom':
        close_bottom()
        time.sleep(0.5)
    elif state == 'max_light':
        max_light()
        time.sleep(0.01)
    else:
        time.sleep(0.5)

    print('main loop')

```

- Server/Database

Server and database component is experienced by firebase by using the server to upload and download the data to the component need in the system, server would perform as a bridge and storage component in the Spoter. Because of the development of the big data technology, server and data science like that would be able to memorize the interests of customers and provide better service of the system.

- Screenshot of the Server

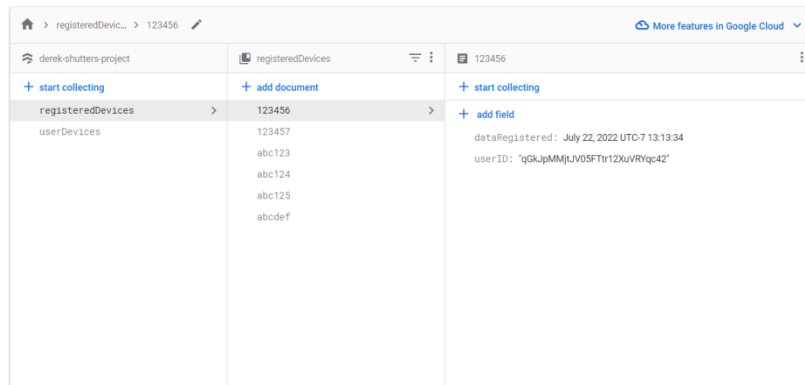


Figure 2. Screenshot of the Server

- Terminal Application

In the component of terminal application, I used Android Studio to create a application on a emulator. The major function of the terminal application is the additional way of controlling the Spoter. Customers could use the application on their terminal to control the existing devices remotely, therefore, there will be more choices for the users to control the Spoter.

- UI Screenshot

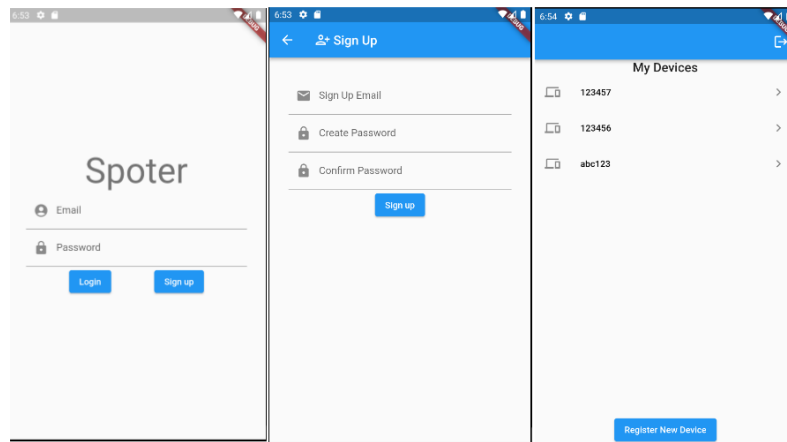


Figure 3. Home page, Sign up page, and Device page

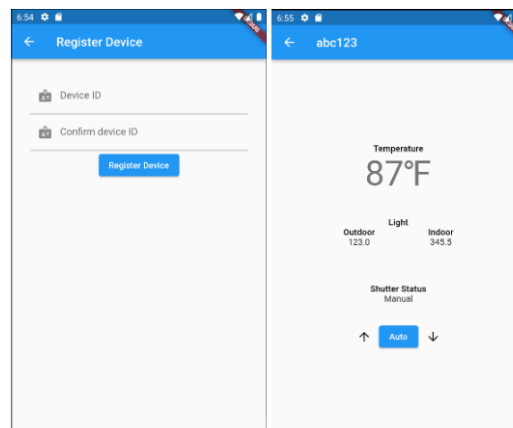


Figure 4. Register device page and Controlling page

## 4. EXPERIMENT

### 4.1. Experiment 1

In order to find the most efficient and best fit motors for the moving of the shutter, I research and take experience of several different motors with different size, force it can produce and the voltage. I found 3 different types of stepper motor and compare it dragging performance on my shutter, which could show the result of the best fit motor for the project.

- |    |   |   |           |         |         |             |
|----|---|---|-----------|---------|---------|-------------|
| A. | Small Reduction Stepper Motor   | - | 5VDC      | 32-Step | 1/16    | Gearing     |
|    | <a href="https://www.adafruit.com/product/858">https://www.adafruit.com/product/858</a>   |   |           |         |         |             |
| B. | Small Reduction Stepper Motor   | - | 12VDC     | 32-Step | 1/16    | Gearing     |
|    | <a href="https://www.adafruit.com/product/918">https://www.adafruit.com/product/918</a>   |   |           |         |         |             |
| C. | Mini Stepper Motor  | - | 200 Steps | -       | 20x30mm | NEMA-8 Size |
|    | <a href="https://www.adafruit.com/product/4411">https://www.adafruit.com/product/4411</a> |   |           |         |         |             |

	A	B	C
moving up	√	√	
moving down	√		
voltage fit	√		√
size fit	√	√	

Figure 5. Table of experiment 1

By comparing different types of stepper motor in the list I chose, the result shows that the most fit and performed product is the reduction stepper motor 5VDC, all of the functions performed effectively. In the comparison, though the reduction stepper motor same but only difference on 12VDC, it can not provide stable force to the winch when moving downward, and also the device temperature is increased fast because of the voltage doesn't fit to the raspberry pi. In the experience of type C it provide less force to move the winch and the shutter, and also its size is quite small to the whole system.

#### 4.2. Experiment 2

In order to figure out the working process of system during different conditions, I record the controlling in sunny, cloudy and night time. And also record the time of the system to close or open the shutter. By covering the light and temperature sensor, I can simulate the natural conditions such as the experiment conditions.

	Sunny	Cloudy	night
Moving time	34s	71s	42s

Figure 6. Table of experiment 2

By analyzing the movement I observation and the data I collect, there is difficult to make a stable moving during the cloudy weather. Because of the light and temperature are quite close to our calculation value, code will "hesitate" to the movement during the weather such as cloudy, raining, which would cause the longer time of the movement to close status. On the other hand, our manually controlling system still have the highest priority to the controlling if users want to control it manually.

Experiment 1 and experiment 2 both show the challenges on controlling part, choose a suitable motor for the controlling system is the most important and major challenge part for the project. Both of the result of the experiment show the space of improvement of the projects, and the challenging part in the controlling design. Especially experiment 2, show the controlling and coding problems from the specific weather conditions which could affect the movement. In experiment 1, there is different types of stepper motor for the controlling part, based on the setting of the central controlling from raspberry pi and the weight of the shutter, there is mistake that firstly choosing the mini stepper motor. But the experiment result eventually help me find out the best suitable motor for the project.



## 5. RELATED WORK

Combining the principle of roller shades with the spectral filtering nature of various coated films, a dc drive with solar-electric power supply, controlled by an electronic circuit, provides the actually appropriate type of film into action [11]. This project is the commonly thinking of the eco-friendly windows or shutter project that using special and variable materials on the window or shutter to improve the energetic recycle efficiency. On the other hand, my project is a more affordable and safe mechanical system of automatically control the shutter. The special material on the windows or shutter will be easy to be harmed and lose it function. And also, it would be a hard time for people who want to controlling themselves such as at night.

The use of phase change materials (PCMs) is presently a technology advanced solution to improve the energy performance of building elements, particularly with window blinds or shutter protections [12]. Though it is not a same idea by moving shutter to forming a better eco-friendly house environment, the using of the PCM is in the same purpose of my project that reducing the house environment heat loss. The strength that I have is that an additional way to manually controlling the shutter, which can follow users interests better.

It is possible electronically to alter a window's transmission and reflection properties by use of electrochromic thin films [13]. This allows regulation of conductive and radiative heat transfer rates, with variable optical attenuation. As a result, an aperture can be optically and thermally managed, reducing space heating and cooling loads. There are significant differences and accessibilities of this project that electronically alter the feature of the materials on the windows or shutters.

## 6. CONCLUSIONS

My project is a smart system used to control window shutter smartly. My project is based on hardware and electronics development direction, there are also some programming and software study including the project developing process [14]. There are three important separate parts in my project. Which is the Mobile app controlling; Raspberry pi hardware controlling; Firebase database & storage. When I was researching the market of smart homes, I found that there are many smart home systems including the close and open of the curtain. But most of the controlling systems are connected to the smart speaker of mobile app controlling. In the result of researching, I decided to make a shutter controlling system using different sensors to auto move the shutter. In the mobile app controlling system, I used the android studio to develop the app on a virtual phone [15]. In the motion controlling system, I used two stepper motors with winches on both the down and upper side to pull and push the string to accomplish the motion of the shutter automatically. I also uses Firebase to store controlling datas to make it 'smart' and memorable.

There are several limitation of the project. First of all, the button and sensor are hard to get a wonderful places to place, as a result of placing them on a place that easier get the data, I can make it more good looking than other products and devices. Second, the efficiency of the winches and lines system in controlling the shutter lower than average level, because of the energetic transferred during the motor moving in order to move the shutter, there are more friction and energy losing when the device trying to work.

In order to try my best on fix all of the limitations above, firstly, I would find a balanced places for the sensors and buttons to have a better looking and better data conserving places. If it is allowed, I would make a protection case for the whole system which could make it working more stable and make it looks better. On the other hand, because of the design of the device and system

can not be changed any more, the acknowledge of the limitation of the losing energy and lower efficiency is necessary, but by updating the connection between the energy transferring part, it could be a kind of improvement of the system and the device.

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