ECE 120 honor project

Improvement of automatic curtain

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Introduction

Problem statement

Last semester I made the prototype of the automatic photoreceptive curtain, which can roll up and down automatically according to the external light intensity. The basic program idea is when the light intensity is beyond the threshold, the continuous servo motor will roll up and when is below the threshold, the servo motor will roll down. Also, I used one hall effect sensor to indicate the location of the curtain. But this design has several deficiencies:

1. It can only roll up and down the curtain completely, but in practice, I want to build one that has several available positions so that I can choose my idea position, since the light will change over the whole day.
2. Although servo motor is easy to use, I may need a more powerful motor to drive a real curtain which is heavier and has more friction with axis.
3. I want to build a model that closer to real life. This prototype does not consider the presence of real people in its design and the control system should make the decision based on the people's need. For example, if nobody is near the curtain, the curtain should not adjust automatically since it is meaningless and waste power.

4. The hall effect sensor is unstable without a track to fix the curtain, can I use another sensor or use another method to get the position feedback?

Overview of solution

1. To have more available positions, I can use more hall effect sensors as the input position signal, and in theory, if I use N hall effect sensor, I can have N+1 available positions.
2. A stepper motor can be a good substitute for servo motor because I can provide much more power and have higher precision.
3. To include the presence of people, I should do some modification to my code. I can include another signal which indicates the presence of people and make decision on that signal.
4. Still thinking about that…

Design

Block Diagram

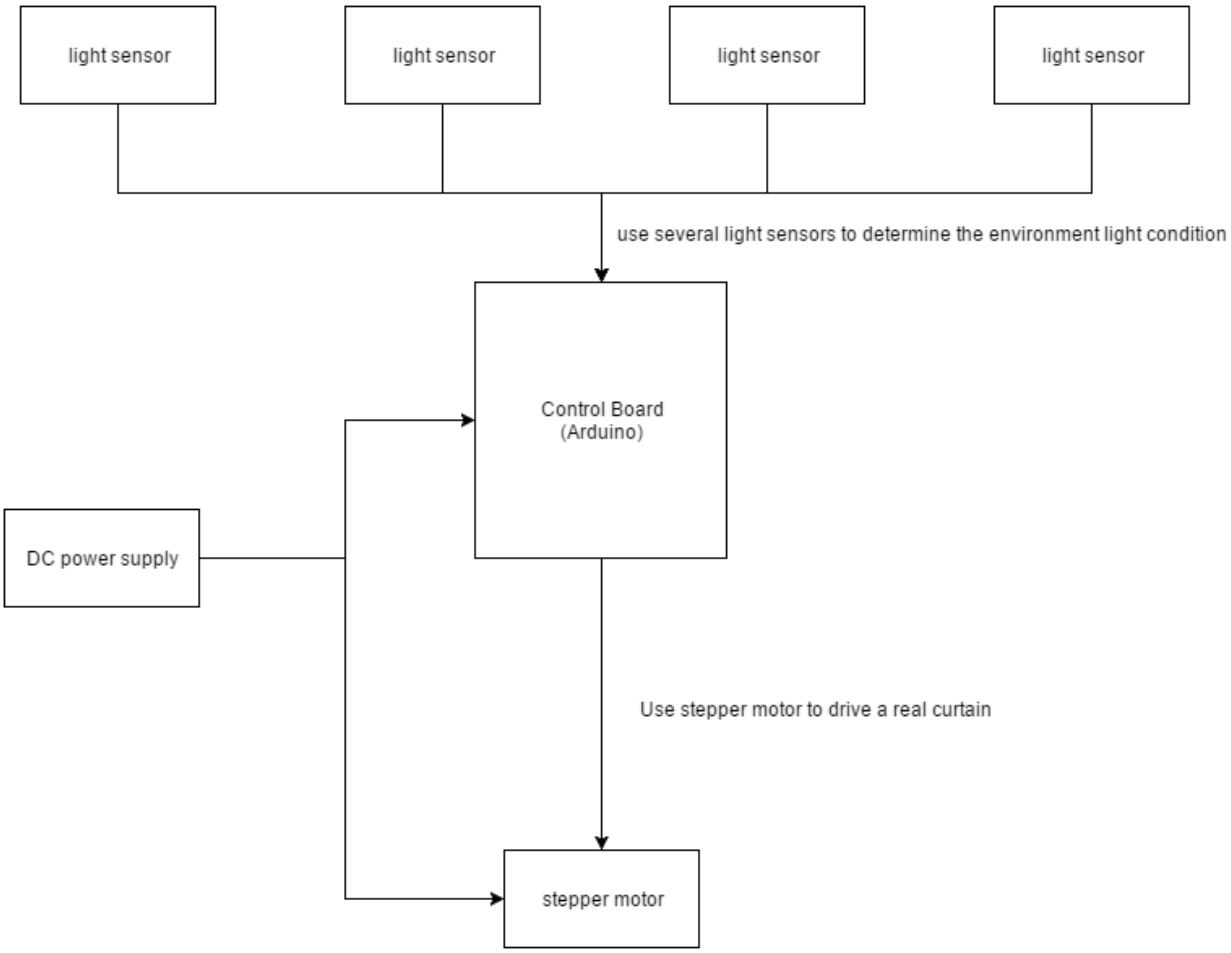

Figure 1: High Level Block Diagram

Description: The overall system is generally the same as previous one, the main difference is that this time I plan to use four light sensors and use stepper motor instead of the continuous servo motor. The four light sensors should be installed the left and right sides of the window and each sides have two, one up and one down. The Arduino board is used to output control signal, when the light is strong beyond the threshold and it detects people sitting in the corresponding place, it will be in the loop to drive the curtain in corresponding position. The whole system has two power supply, one is 5V to drive the Arduino board and another one is 12V to drive the stepper motor which needs much more power.

Picture of device

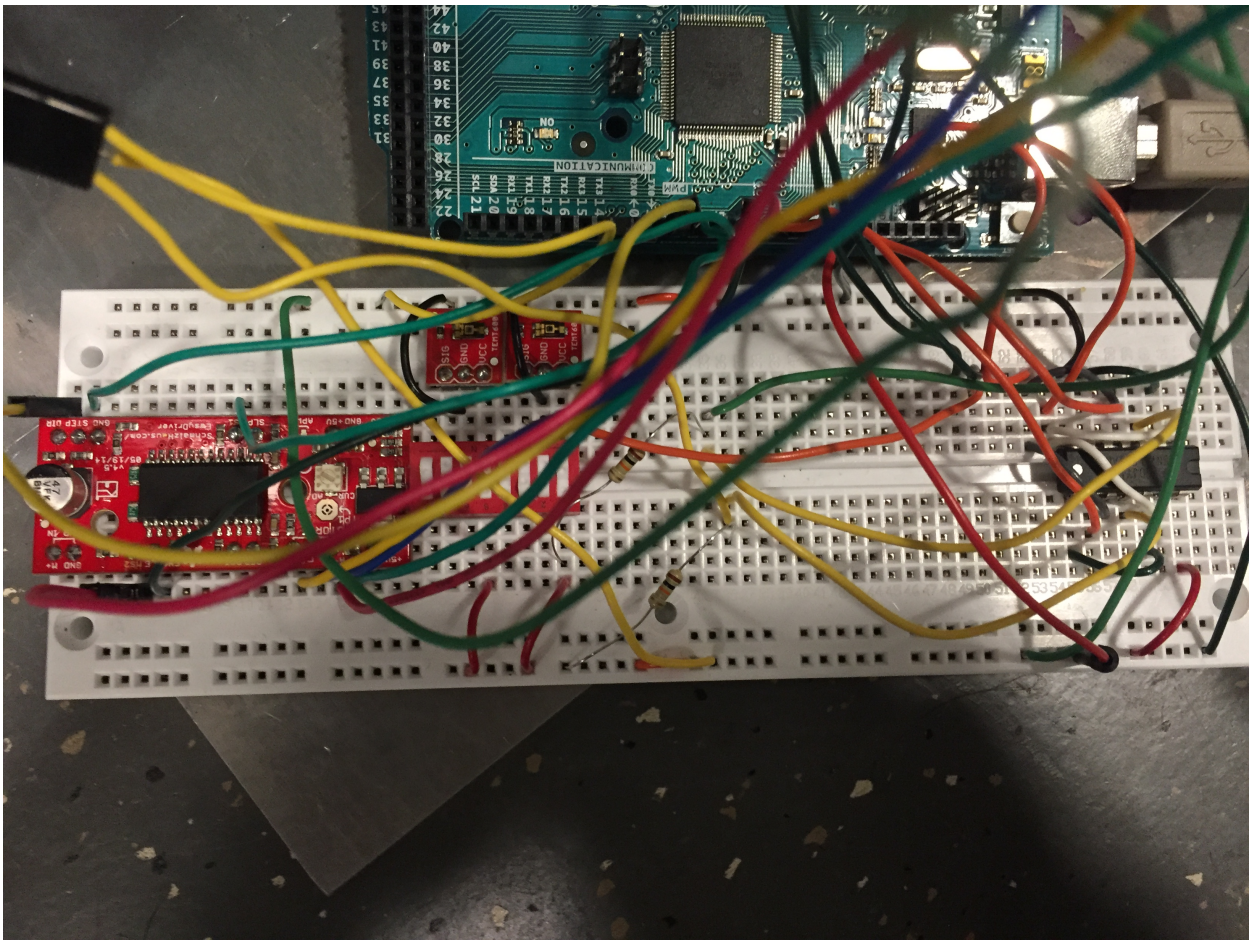

Figure 2: Real circuit

Description: Because of many technical challenge and time limitation, I did not complete a perfect idea final project. For the final project, I used two light sensors instead of four and implement them on the breadboard for the convenience of demonstration. To control the stepper motor, I have also to use a driver board which is the red board in the picture. The black chip is D-flip flop used to generate the position signal.

Code Used

```
int LA = A0;                          #L is the light sensor
int LB = A1;
int dir = 2;                          #dir is used to control direction of stepper motor
int stp = 3;                          #stp is used to generate impulse for stepper motor
int MS1 = 4;                          #MS is used to control the phase of stepper motor
int MS2 = 5;
int EN = 6;                           #enable is used to control the stepper motor
int HA = 7;                           #H is the hall effect sensor
int HB = 8;
int PL = 9;                           #PL is the indicator of people's position
int CLR = 10;                         #CLR is clear signal for D-flip flop
int PRE = 11;                         #PRE is preset signal for D-flip flop

void setup() {
  Serial.begin(9600);
  pinMode(LA, INPUT);
  pinMode(LB, INPUT);
  pinMode(dir, OUTPUT);
  pinMode(stp, OUTPUT);
  pinMode(MS1, OUTPUT);
  pinMode(MS2, OUTPUT);
  pinMode(EN, OUTPUT);
  pinMode(HA, INPUT);
  pinMode(HB, INPUT);
  pinMode(PL, INPUT);
  pinMode(CLR, OUTPUT);
  pinMode(PRE, OUTPUT);
  digitalWrite(CLR, LOW);
  digitalWrite(PRE, HIGH);
  delay(200);                           #initialize D-flip flop
  digitalWrite(CLR, HIGH);
  digitalWrite(PRE, HIGH);
  digitalWrite(EN, LOW);
  digitalWrite(MS1, LOW);
  digitalWrite(MS2, LOW);

}


void loop() {
  int x;
  if(analogRead(LA) > 400 && digitalRead(PL) == HIGH && digitalRead(HA) == LOW)
```

```
# when people is at corresponding position and light intensity is beyond threshold and certain is
# at high position, pull the curtain down.
  {
   digitalWrite(dir, LOW);
    for(x = 1; x<1100;x++)
   {
    digitalWrite(stp, HIGH);
    delay(5);
    digitalWrite(stp, LOW);
    delay(5);
   }
  }
  else if(analogRead(LB) > 400 && digitalRead(PL) == LOW && digitalRead(HA) == LOW)
 {
     digitalWrite(dir,LOW);
      for(x = 1; x<1100;x++)
     {
      digitalWrite(stp, HIGH);
      delay(5);
      digitalWrite(stp, LOW);
      delay(5);
     }
 }
  else if(analogRead(LA)<50 && analogRead(LB)<50 && digitalRead(HB) == HIGH)
# if both light intensity is low and curtain is low, pull it up.
  {
   digitalWrite(dir,HIGH);
     for(x = 1; x<1100;x++)
     {
      digitalWrite(stp, HIGH);
      delay(5);
      digitalWrite(stp, LOW);
      delay(5);
     }
  }
}
```

Circuit Diagram for PCB design

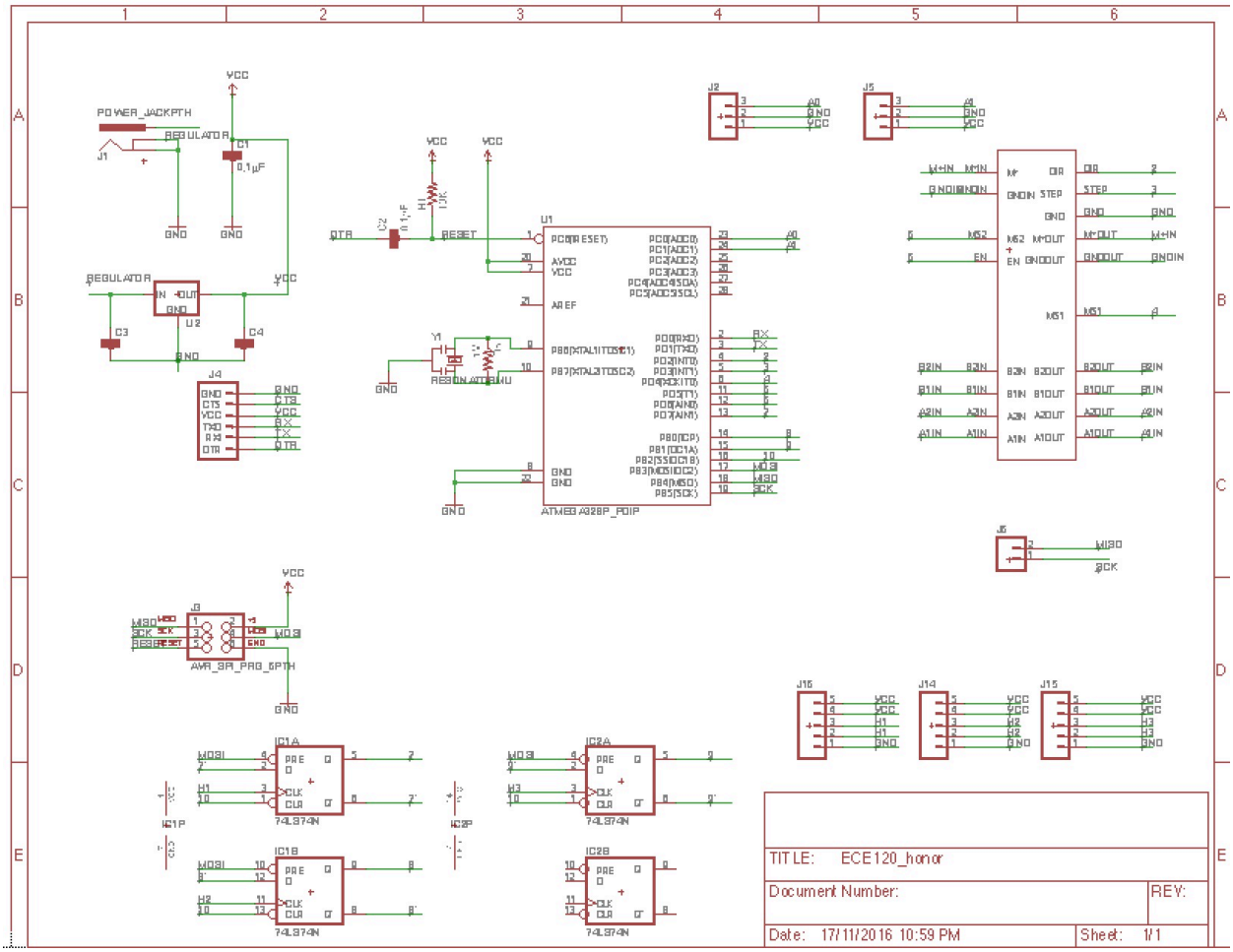

Figure 3: Circuit Diagram

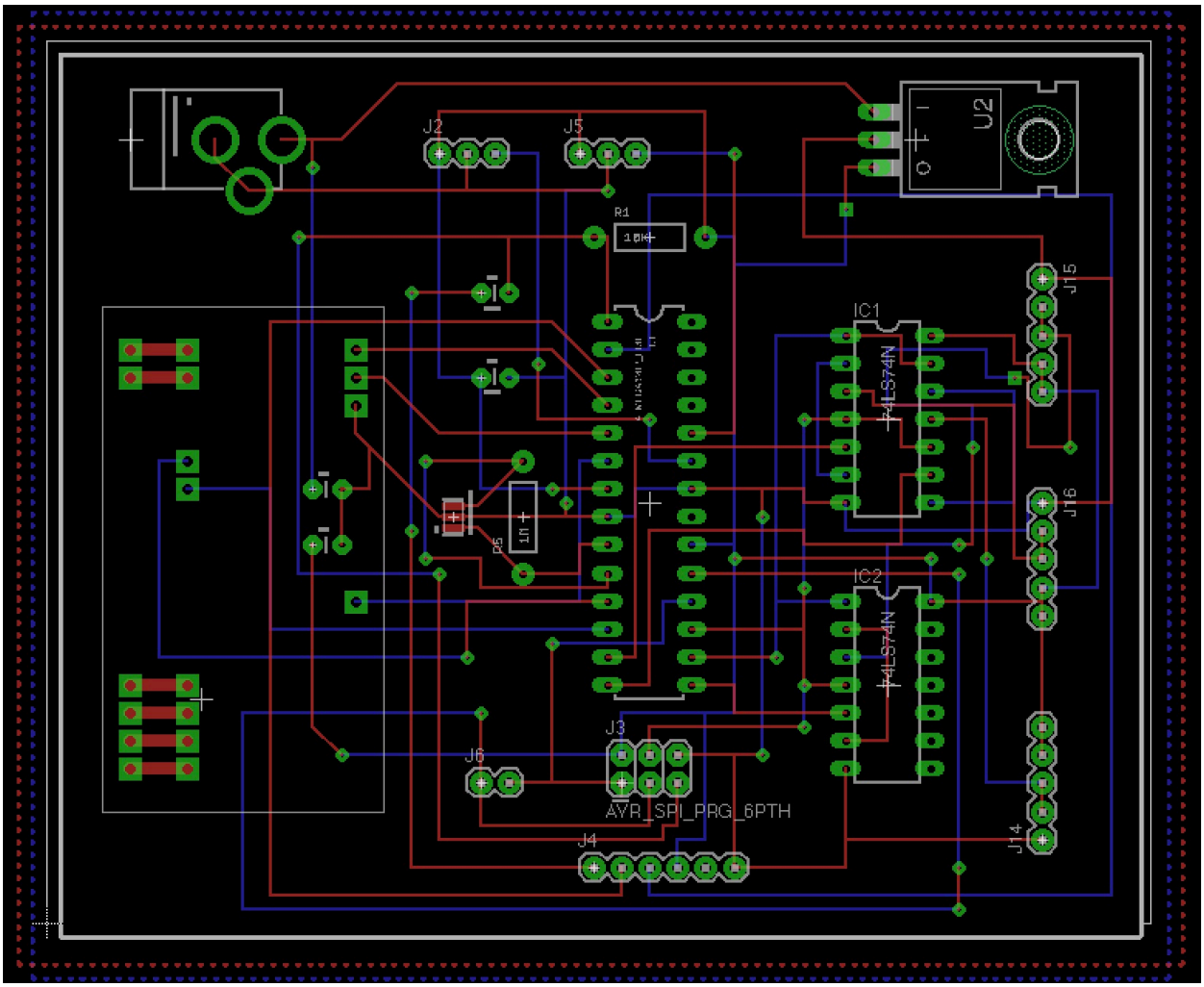

Figure 4: Board diagram

Description: This semester, I try the PCB design which is very interesting but also the most challenging part of the project. It takes me a lot of time to get familiar with EAGLE CAD program. I also try to build my own library for easy driver of the stepper motor. The PCE design basically consist of two parts: the circuit diagram and the board diagram. The second part could be the most difficult and important part. A PCB board usually contains several layers and the red and blue wires in the picture represent wires at different layer.

Components

1 . Light sensor

The light sensor I use this time is TEMT6000, which is a photo transistor which can generate a higher voltage when receive a strong light. But it may not be a good choice for this design because according to the datasheet, the sensitive illuminance is between 10 and 1000, which is a little smaller than the range I want between 0 and 10000. I use Adruino board to read the analog signal in.

2 . Stepper motor

The stepper motor is more powerful than servo motor and also has high precision. Each time the motor will just rotate one phase when receive an impulse signal. The phase can be changed with signal MS1 and MS2. To control the stepper motor, I need first to calculate the number of phase I needed to rotate to the desired position. I also notice that when I try to run the stepper motor, the whole structure vibrates dramatically.

3 . Hall effect sensor (US1881)

The hall effect sensor is the indicator of the position of curtain. I install the magnet on the curtain so that each time when the curtain goes up and down, then magnet will swipe the hall effect sensor twice. Then the hall effect sensor will generate an impulse and I use that impulse as the clock signal of D flip-flop.

4 . D flip-flop (SN74LS74N)

The D flip-flop is used to modify the signal provided by hall effect sensor. Because each time the hall effect sensor will generate a signal looks like an impulse, which has both rising and falling edge. But the information I want to get is the curtain go through the position, so by using the hall effect sensor as the clock signal, I can choose only the rising edge of the signal.

Inputs		Outputs	
CLK	D	Q	$\overline{Q}$
RISING	H	H	L
RISING	L	L	H

Table 1: Truth Table of D flip-flop

Result

Because of the time limitation, I can only finish the simplified model of this project. When the position signal of people indicates left, only the left light sensor will matter. When I shine light on the right sensor, nothing happens. When I shine light on left sensor, the curtain goes up for a certain distance. At this time, if both light sensors indicate low light intensity, the curtain will go down. And if then I change position signal of people indicates right, only the right light sensor will matter. This problem of this project is the hall effect sensor is hard to get stable output with a moving magnet. Because it is very sensitive, sometimes it will change the value several times during one swipe and sometimes it will remain unchanged because the distance of the magnet is too far away.

Future work

I am trying to find some method to stabilize the hall effect sensor, maybe I can make a track to fix the edge of the curtain so that the magnet will move follow the confined route, not oscillating back and forth.

I am considering use a FSM to indicate the position of curtain so that each state will represent one position. By this way, I can know the position of the curtain without any output. The deficiency is without the external feedback, the error can be cumulative, that is, the small error of the stepper motor will accumulate during each move. Or I can fix the hall effect sensor on the axis to counter the round of rotation, as Prof. Schmitz suggested.

Another big improvement I should do is about the program, as I have more and more input and position signal, it becomes harder to make decision. It is hard to determine which position is the best choice without actual experiment, so I think I should do research about the change of light angle during the whole day to help me develop a better model to make the program more reasonable.

Conclusion

Although it is my second time to do this open project, I really meet many new challenges and also learn a lot during the process. I have learned how to use CAD tools to design the PCB board, which is cool and challenging. Drawing the board diagram just like going through a labyrinth, and I failed several times before success. It is really a precious experience. And another thing I have learned is time management. At the first half of semester, I started my work slowly, and later I found that time is not enough at all. This is because the problem of time

management, it will always be better to start work earlier so that we can have time to do modification. If I can start PCB design early, I probably can receive my board and use that in the final project. I have learned that a good time schedule is really important for a project.

Reference

https://www.arduino.cc/

https://wiki.illinois.edu/wiki/display/ECE110HLSF15/Syllabus