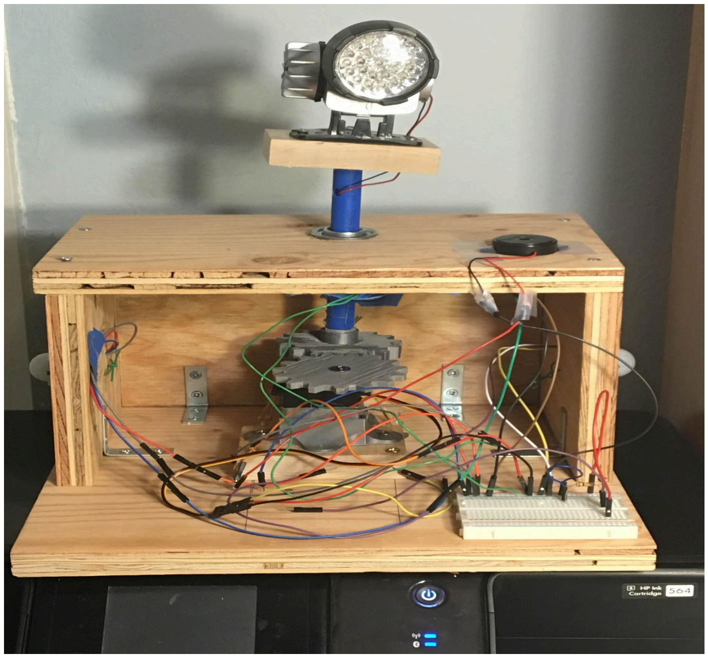
ME106/EE106 Mechatronics Term Project, Fall 2016

Squirrel Repellent

Submitted to Dr. Winncy Du



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Objectives

The project's objective was to scare away unwanted small urban animals in an area of the user's choice. This squirrel repellent should detect nearby heat signatures and either play a sound or flash a light to scare them away. The goal is to reduce the amount of garden and trash products being eaten or destroyed due to these animals.

Description

Project Description

Squirrel Repellent uses three infrared sensors to detect any heat signatures within a parameter. When theses sensors detect heat it will activate the servomotor to rotate to the position of the sensor detecting that heat. Once the animal is detected a buzzer will sound if it is daytime or a LED will flash if it is night time. The goal was to get our project operating at max efficiency and to be useful in most environments. The squirrel detector ended up working in principle, but it needs to be tested in realistic field like the back yard garden. An attempt was not made to actually scare squirrels due to time constraint combined with possibility of such animals damaging electronic components. The application of this equipment is particularly useful for those customers who grow plants in their backyard or who are bothered by animals roaming around in search of food from trash at night.

Challenges

Some of the challenges faced were construction, stability, coding, and hardware. The whole mechanism coming together was hard to visualize in the early stages of design. But, once a base was formed it became easy to dimension everything off of that. During the building stages for the PVC pipe to the bearing holder, the pipe started to experience a lot of sway. This was solved by adding the roof with the second bearing to give our pipe more stability. The length of the pipe is crucial so the bearings still have effect to stop the sway. Calibrating the servomotor to be in sync with the infrared sensors was a challenge. Luckily, the code created was able to bring all of the sensors in unison with the servomotor.

Design

Introduction

The mechanical design consists of seven pieces of wood, two 3D printed gears, PVC pipe, two bearing holders, servomotor, photoresistor, three infrared sensors, LED, a buzzer, two 3D printed mounts for the servomotor, pvc pipe, and four L-brackets. The wood used was purchased for this project as one piece and was cut to five rectangular pieces that constituted a platform base, three walls, and a roof. Decision on the size of the system's component was a challenge in sense that a balance need to be struck between portability and functionality of the product. As such, a bigger base was used so as to accommodate all the essential components from which the walls were built as a holder of the three sensors. The rectangular design was necessary in order to separate the three sensors sphere of influence which in turn allows for accurate detection of the animal as well as correct programming logic implementation.

Wooden Structure

On each of the three walls of the rectangular structure, small holes were drilled not only to mount the infrared sensors but also to connect the wires to the Arduino that was located on the base platform. A large hole was drilled on the roof of the rectangular framework so a bearing holder could fit to secure the PVC pipe to reduce friction with the wood. The three wooden sides are connected to the base by L-brackets one for the left and right sensors and two for the middle sensor. The roof is screwed vertically onto the side walls of the structure. On top of the PVC pipe, a block of wood was used to hold the LED while balancing the rotating PVC pipe. Moreover, another block of wood was used to give our servomotor's gear the correct height needed to match up with the PVC pipe's gear.

3D Printed Pieces

A 3D printed gears were ideal for this project since it offered lighter weight for the PVC pipe and the servomotor. Furthermore, it offered cheaper alternative to finding a place that custom produce it or buying it online. Consequently, SJSU 3D printing service were utilized. Solidworks was used to custom design the two gears so they have a 1:1 gear ratio. This saved time and calculations since a 1:1 ratio guarantees a minimal torque friction, thus leaving us with a smooth rotation. Two custom mounts were designed and 3D printed; one for the bottom bearing and another for the servomotor. The design allowed us to screw these mounts into our wooden base. This provided more security and reduced any friction or vibration that could be caused.

PVC Pipe

The ⅝ inch PVC pipe used for this project was bought at Home Depot. The PVC pipe holds up the LED and is the main axis of rotation. It's held into place by two bearings one on the bottom attached to the bearing holder and one on the roof just placed in a hole. A hole is drilled into the wooden block that holds the LED so the pipe could fit in there. Such an arrangement allows the LED to rotate at the expense of the PVC pipe's rotation.

Arduino

The three infrared sensors could detect heat sources within 100 ft. Harnessing the power of these infrared sensors, servomotor, and photoresistor to create a practical application such as this project. The sensors read any heat changes and send that value to servomotor so it will then turn to that particular sensor where an animal is detected. The second sensor that was used was a photoresistor. Such a sensor was used as a switch for the LED to be on during darkness and stay off during daytime. A buzzer would sound during daytime if one of the infrared sensor is activated. This constitute the main function of our project that utilizes Arduino platform.

Circuit Design/Control Algorithms

The circuit consists of 7 different types of components. The Arduino is the ATMega Microcontroller of the circuit, connected to a photoresistor, a 1k ohm resistor, a buzzer, an LED, a servo and 3 PIR sensors. The photoresistor detects sunlight intensity and connected in series with 1k resistor. The current supplied to the photoresistor is 5 mA , if the light is present, the buzzer will be used as the main repellent; if light is not present, the LED will be used instead. Three PIR sensors use infrared wavelength to detect the presence of a living object. Such that squirrel passes by a PIR sensor that are located on left, right and front, the squirrel repellent will be activated. The servo is responsible to direct the LED or buzzer toward the location of the squirrel. If the PIR sensor on the right detects the squirrel, the PIR sensor gives a high signal output to the microcontroller, indicating that the servo to turn right and flashes light or sound the buzzer accordingly. Additionally, the servo is pre-programmed to turn in 90-degree angle. It is programmed to turn either left, right or toward the front. A photoresistor is connected to a 1k ohm resistor. This is to measure the voltage across the photoresistor since that the voltage of 5V is constantly applied to it. Analog 5 is the assigned pin on the Arduino, it is used to detect analog signals/ voltage from the photoresistor to indicate the presence of light.

The audible frequency range for human ranges from 20Hz to 20,000Hz. Since the noise from the buzzer may be audible to human, the buzzer is configured to emit a higher frequency. Squirrels can hear sound in the range of 50,000Hz to 75,000Hz, hence the respective value (50,000Hz) is used in this event. The code, *tone(5,50000);* indicates that buzzer on pin 5 subjects to emitting 50,000Hz of beeping noises to repel the squirrel.

There are two functions created for the repeller, the *void flash()* is used to flash the LED toward the squirrel and the *void sound()* is used to generate noise. The *stateSwitch* state reads the value of the photoresistor and controls the components used (LED or buzzer). Both *stateLeft* and *stateRight* shows the signal received by the PIR sensors respectively; *stateFront* does the same as well. In order to immediately call the function of *void sound()* and *void flash()*, a while statements is used to cut off any on-going program.

Flowchart of the program

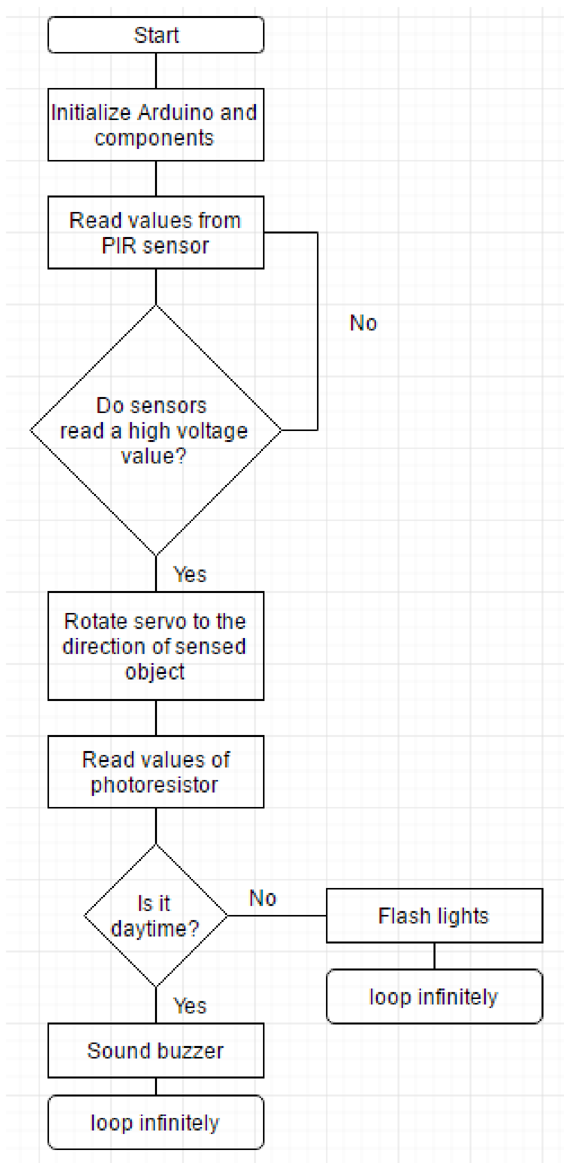

Figure 1: Flowchart for the program

Code (Read from left to right, code may continue on next page)

```
//Squirrel Repellent ME106
//Author/member:
Patrick,Beniam,Henok,Brandon

#include <Servo.h>

int left = 11; //left motion
int front = 12; //front motion
int right = 10; //right motion

int stateRight = 0; //init right value 0
int stateLeft = 0; //init left value 0
int stateFront = 0; //init front sensor
value 0
Servo servo; //init servo


int led = 9; // led pin 9, may also wire
with 100ohm resistor/ any less than
500ohm
int photo = A5; //photoresistor pin 10,
wire with 1k resistor
int buzzer = 5; //buzzer pin 5
int stateDay = 0; //init photoresistor
value
int stateSwitch = 0;
int stateFlash = 3;
//////////////////////////////////////////////////////

void setup() {
  servo.attach(8); //attach servo to pin 8
  servo.write(90); //set 90 degrees as
"home" position
  delay(1000); //delay for setup stability
  Serial.begin(9600);
  pinMode(photo, INPUT);
  pinMode(led, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(left, INPUT);
  pinMode(right, INPUT);
  pinMode(front, INPUT);
}

void flash() { //flashes 5 times
  stateFlash = 1;
  digitalWrite(led, HIGH);
  delay(250);
  digitalWrite(led, LOW);
  delay(250);
  digitalWrite(led, HIGH);
  delay(250);
  digitalWrite(led, LOW);
  delay(250);
  digitalWrite(led, HIGH);
  delay(250);
  digitalWrite(led,LOW);
  delay(200);
}

void sound() { //sounds 5 times
  stateFlash = 0;
  tone(5, 25000);
  delay(250);
  noTone(5);
  delay(250);
  tone(5, 25000);
  delay(250);
  noTone(5);
  delay(250);
  tone(5, 25000);
  delay(250);
  noTone(5);
  delay(200);
}
/*******************************
**/
void loop() {
  stateLeft = digitalRead(left);
//DIGITAL READ LEFT
  stateFront = digitalRead(front);
//DIGITAL READ FRONT
  stateRight = digitalRead(right);
//DIGITAL READ RIGHT
  stateDay = analogRead(photo);
//ANALOG READ NOT DIGITAL
READ
  if (stateDay > 500) { //ambient daylight
more than 70, 100 is a good value
    stateSwitch = 0; //day
  }
  else {
    stateSwitch = 1; //night
  }

  //////////////////////////////////////////////////////

  //codes for DAY only
  while (stateLeft == 1 && stateSwitch
== 0) {
    servo.write(180); //turn to "0" degrees
    sound();
    break;
  }
  //------------------------------------------
  while (stateFront == 1 && stateSwitch
== 0) {
    servo.write(90); //turn to "90" degrees
    sound();
    break;
  }
  //------------------------------------------
  while (stateRight == 1 && stateSwitch
== 0) {
    servo.write(0); //turn to "180" degrees
    sound();
    break;
  }

  //////////////////////////////////////////////////////

  //codes for NIGHT only
  while (stateLeft == 1 && stateSwitch
== 1) {
    servo.write(180); //turn to "0" degrees
    flash();
    break;
  }
  //------------------------------------------
  while (stateFront == 1 && stateSwitch
== 1) {
    servo.write(90); //turn to "90" degrees
    flash();
    break;
  }
  //------------------------------------------
  while (stateRight == 1 && stateSwitch
== 1) {
    servo.write(0); //turn to "180" degrees
    flash();
    break;
  }

  Serial.print(stateLeft);
  Serial.print("     ");
  Serial.print(stateFront);
  Serial.print("     ");
  Serial.print(stateRight);
  Serial.print("     ");
  Serial.print(stateDay);
  Serial.print("     ");


  if (stateLeft ==0 && stateFront ==0
&& stateRight==0){
    stateFlash=3; //no motion detected
  }
  if (stateFlash == 0) {
    Serial.println("Motion detected.
Alarm activated.");
  }
  else if (stateFlash == 1) {
    Serial.println("Motion detected.
Flashlights activated.");
  }
  else if (stateLeft ==0 && stateFront
==0 && stateRight==0){
    Serial.println("No motion detected");
```

```
}

digitalWrite(led, LOW);
```

```
noTone(5);
delay(50);
}
```

The program initiates when the Arduino is started up. All the components are initialized and the states are set to zero, except for *stateFlash*. The components are defined with either input or output. Three sensors are initialized and the values are read using the *analogRead* method. The values are then processed to see if they are of high or low values. If one of the sensors reads a high voltage value, the servo will be rotated toward the direction of the sensed object. Otherwise, if all sensors read a low voltage value, nothing will be done. The photoresistor will tell the value by detecting light. It will then tell if it is daytime or nighttime. If the photoresistor registers a “daytime” value, when a PIR sensor detects motion, the buzzer will sound. Otherwise, if the photoresistor registers a “nighttime” value, and if a PIR sensor detects motion at the same time, the LED lights will flash.

For the code, again, the sensors and components are initialized in respect to their pins. Their states are defined to be zero except for *stateFlash*. The *void sound()* and *void flash()* functions state the pre-programmed buzzer beeping sound and the flashing of lights. In order to create a strobe of lights and sound, the *digitalWrite* of *HIGH* and *LOW* is used with a *delay(250)* interval in between. The *stateSwitch* obtained from *stateDay* value is defined using a trial and error method. (covering and uncovering the photoresistor) In the *void loop()* section, the states of the sensors are combined together with the states of the photoresistor. A total of 6 combinations is possible. Each combinations have either *flash()* or *sound()* function and they run programs that are pre-defined. While loops are used to cover all these functions as they cut through the main loop when a PIR sensor detects motion. In the end, the Serial monitor will print the states of these sensors.

Performance and Discussion

Advantages

Squirrel Repellent performed to our expectations. It was operational and able to register which sensor was being activated. As well as being constructed evenly so we didn’t have any weight distribution issues. The gears came out with no issues and ran smoothly during operation and even for long amounts of time. There was also no rotational friction while performing due to the bearings.

Disadvantages

Sensitivity became a major issue due to the sensors registering to many things at once. The major weakness for Squirrel Repellent is the degree to which the squirrel is being scared. Due to the lack of field testing, Squirrel Repellent was unable to gather the data required to scare squirrels. Squirrel Repellent is also unable to do anything else besides flash a LED and make a buzzer sound.

Conclusion and Future Work

The Squirrel Repellent uses 2 type of sensors. The first type is the infrared sensor used in these application to detect heat in order to identify the presence of the small animal. The second type is photosensor to distinguish between darkness and light. While the former sensor helps in identifying if an animal is in the vicinity, the latter one is used to scare it away by initiating the LED to flash. Furthermore, a buzzer sounds up on detection of heat during day time. Meanwhile, the servomotor rotates the front of the light to ether 0, 90 or 180 degree corresponding to the sensor being activated by the presence of heat.

The function of this equipment is to detect the presence of squirrel or other similar animals in a controlled area like a garden or backyard lawn to deter such animals from being comfortable to cause damage to the mentioned areas. According to controlled test conducted, the sensor correctly identifies the presence of heat from our hand depending on which of the three sensors our hand came near. Theoretically, the infrared sensors could detect heat from 0 to 100ft away from it. Thus, this equipment is effective in identifying the presence of animals with in 100ft envelop. However, it is anticipated that if the animal is far away the buzzer may not bother the animal at all thereby reducing the functionality of the system. During night time, the flashing light from the LED is anticipated to cause enough destruction to invading animals regardless of distance.

In this project, we learned how to work with team members with different ideas, capabilities and experience. Such a resource of diverse students were responsible for the timely completion of this project. Even when a given member may be weak in certain respect say in programming, he still contributed ideas that help the stronger programmer in debugging the program. We learned about cost management so as the finished product is affordable for the end user. Most importantly, integrating mechanical device with electronic components accompanied by programming to impart intelligence to the device reminded us the power of mechatronics to make human life easier.

The equipment can further be improved either by adding wheels that follow the identified animal so as to scare it in real sense. It also can be equipped with attack mechanisms in the event that the animals come to close to it. The buzzer sound should be in the frequency where the animal find it irritating enough to run away from it. As such, field experimentation should be conducted to make sure the effectiveness of the product.

Appendix

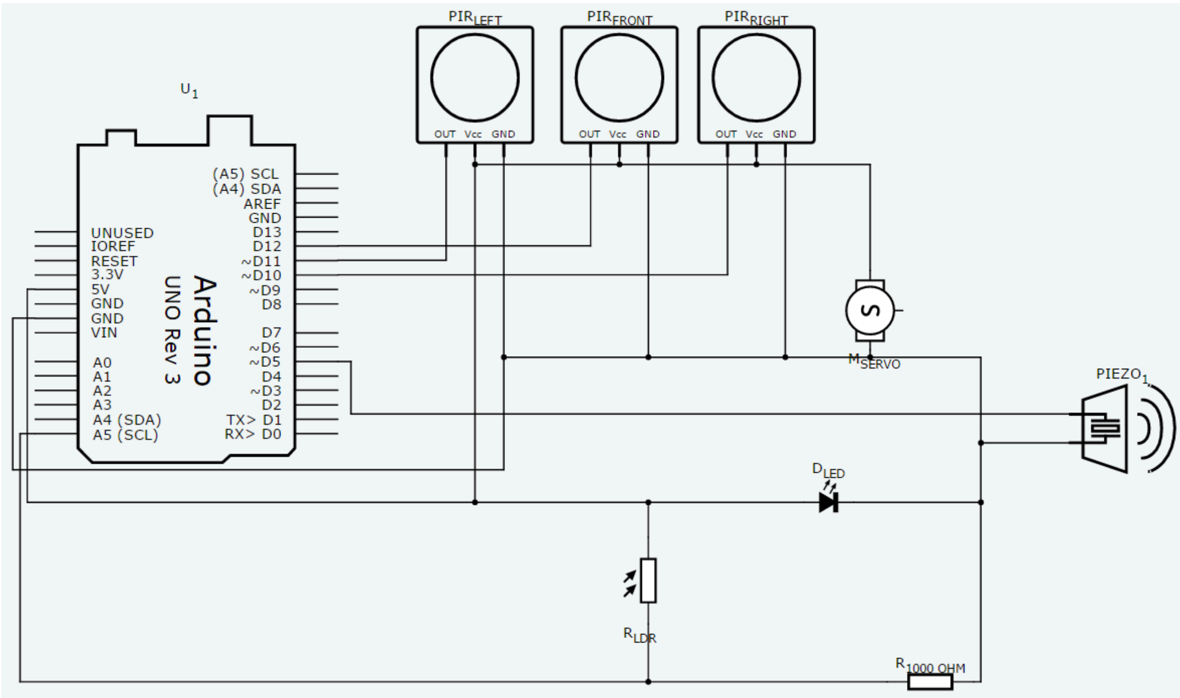

Figure 2: Layout of Wiring for Squirrel Repellent

Current calculation for photoresistor

Voltage supplied to 1K resistor = 5v

$$V = IR$$
$$I = V/R$$
$$I = 5V/1Kohm$$
$$I = .005A = 5mA$$

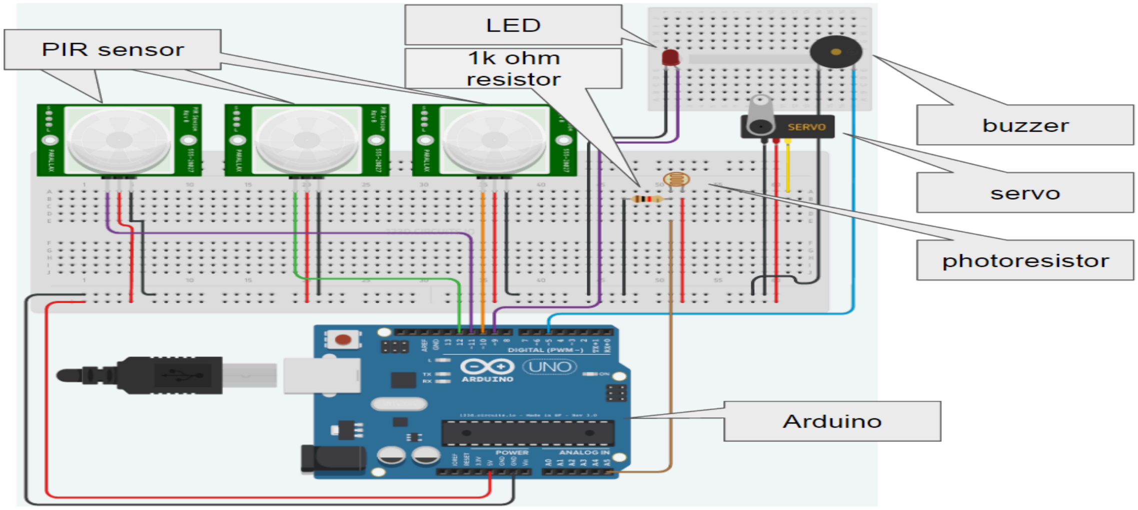

Figure 3: Wiring Detail for Squirrel Repellent

Table 1: Bill of Materials

Bill of Materials			
No.	**Name**	**Qty.**	**Price/ unit**
1	**Servomotor**	**1**	**Ready in hand**
2	**Bearings**	**2**	**$3**
3	**Arduino**	**1**	**Ready in hand**
4	**PIR Sensors**	**4**	**$9**
5	**Speaker/ buzzer**	**1**	**Ready in hand**
6	**3d printed arm**	**1**	**Free**
7	**3d printed base**	**1**	**Free**
8	**3d printed gears**	**2**	**Free**
9	**Wood**	**1**	**$5**
10	**PVC**	**1**	**$7**
11	**L-Brackets**	**4**	**$4**
12	**LED**	**1**	**Free**
	Total		**$28**

References

Alciatore, D. and Histand M., 4th edition: Introduction to Mechatronics and Measurement System
http://www.engr.sjsu.edu/bjfurman/courses/ME106/labexperiments-arduino.htm