Woodpecker Deterrent Design Report

Team Lavendar

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Executive Summary

Woodpeckers Pro is a product design prototype that detects and deters woodpeckers with the goal of house protection. Ultrasonic sensors are used to detect presence of woodpeckers or any invading birds, and predator call is played when detected and regularly every 10 minutes as a protection mechanism. It has the following minor functionalities that it automatically turns off at night, recharges with solar panel, and notifies house owner when battery falls under 70%.

Introduction and Problem Statement

Bird damage particularly to wood structures, can be a massive problem for a homeowner. Woodpeckers are known to be very persistent and annoying pests causing massive amounts of damage. The objective of this project is to build a device capable of detecting and deterring a woodpecker. The device must detect invasion of woodpeckers within a 2m x 2m area and deter by playing a 15-second predator call as detection and deterring mechanisms. The device must also be water resistant and be hung on the wall gutter of a house. The device would deter for 2 minutes for every 10 minutes and whenever bird invasion is detected. It must be programmable and have day and night mode that can be activated with light sensors. Regarding power supply of device, it has to run on battery that is rechargeable by solar panels. When the battery level is under 70%, it should send alert messages to homeowner's phone. The budget constraint is no more than $400.

Design Alternative Considered

Before mapping out ideas of how to build this device, we created a function versus means chart. Below is a list of our brainstorming with a functions versus means chart of possible ideas.

Function	Means 1	Means 2	Means 3	Means 4
Detect woodpeckers	Motion Sensor	Camera	Heat Sensor	**Ultrasound Sensor**
Deter woodpeckers	**Play a predator's call**	Moving sculpture of predator	Reflective panels	Video image
Monitor battery life	Computer program that alerts homeowner to charge of battery	AI (like Alexa) that automatically charges device when battery is low	External backup	**Resistor sensors paired with Arduino that automatically check if battery has fallen below 70%**
Run automatically for 2 minutes out of 10	Make sound every 10 minutes	Timer	Computer programs	**Internal clock of Arduino, using millis() function**
Rechargeable with solar energy	**Solar panels**	------	------	------
Turn off at night	Timer (assume 18 hours of daylight)	**Photodiode sends signal to Arduino**	Light Switch	------

Table 1 shows the design space of Woodpeckers Pro. It is a function-means chart where we explored different means to accomplish each function. The bolded means are what we chose finally to build the prototype.

Basis For Design Selection:

The idea we chose was to have ultrasound sensors paired with light reflections to deter the woodpecker. We chose the ultrasound sensor because the heat sensor would be too unpredictable and expensive. We considered using a PIR (Passive infrared motion) sensor however that too was not consistent enough to detect motion of a woodpecker. We used acrylic to construct the box because it must be waterproof. We chose solar panels as a backup power source. We chose a light diode paired with an op amp to enable automatic switch of device. We paired the circuit board with arduino so we could program to sense motion, play a predator sound call and go into day or night mode.

Bill of Materials

Part Name	Quantity	Price	Function
Arduino	2	$50	control overall operation of device
Sparkfun MP3 player shield	1	$25	facilitate mp3 playing
Adafruit FONA 808 Shield	1	$25	notify house owner when battery level is low
Resistors	5	Free	act as sensor for voltage
Speakers	1	$20	deter woodpeckers with predator call
Ultrasonic sensors	4	$28	sense presence of woodpeckers
Light Diode and LMC6482 Op Amp	1	$3	enable automatic switch off at night
Solar panel	1	$15	charge battery with sunlight
RC rechargeable battery	1	$20	power Arduinos and other circuit components
Lipoly battery	1	$15	charge FONA 808 shield
SIM card with cheap plan	1	$3	send text to homeowner

GSM antenna	1	$3	make FONA 808 shield function
Reflective Tape	1	$7	visual deterrent
Breadboard	1	Free	circuit board
Total	/	$214	/

Table 2 shows the bill of materials of Woodpeckers Pro. It provides information about specifications, quantity, cost, and uses of all parts used to build the prototype.

Circuitry and programming

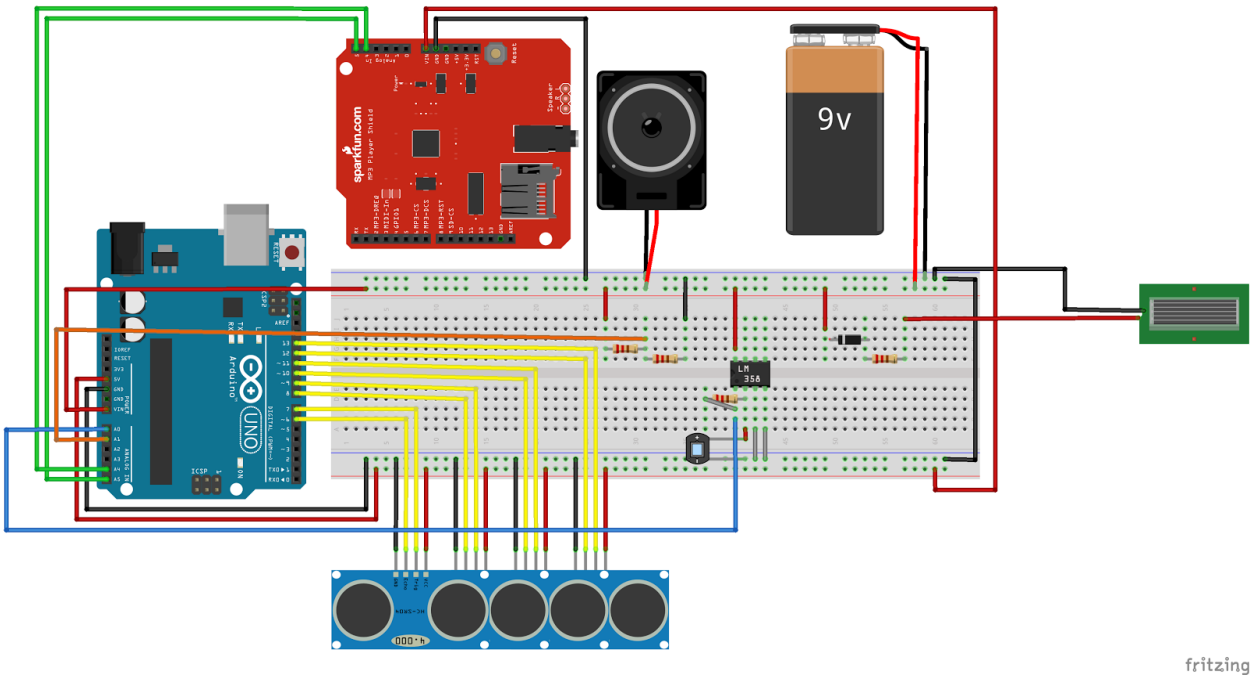

Figure 1. Circuit board used to build Woodpeckers Pro. The following remarks below illustrate specifications not shown on Figure 1: FONA 808 Shield should be put on top of the main Arduino, the one on the left of the figure, resistor used in series with solar panel depends on the voltage of solar panel and RC battery, resistors used to indicate voltage have to be of the same value, and the speakers' audio jack has to be plugged into the MP3 player shield.

Woodpeckers Pro is designed to have heavy emphasis on hardware and programming. The source code can be found in this Github repository: http://bit.ly/2osEBQd . There are two main folders for the programming: src and test - that contain source code for both Arduinos and individual tests for all components respectively. Below is a brief description of how the main program works:

If photodiode detects that light level is higher than the threshold, which is arbitrary value of 2 set after testing, the device will run in a loop that keeps checking if battery level is high with **voltageHigh()** function and detecting if there is bird invasion with **birdDetected_new()** function in the first 8 minutes. In the remaining two minutes in every 10-minute interval, the device will play predator call with **playSound()** function.
In voltageHigh() function, Arduino reads voltage value of voltage in between two resistors of same value connected respectively to positive and negative terminal of battery. If the voltage value is under 70% of the battery capacity, the function voltageHigh() will return false and a message will be sent to the homeowner using the Adafruit_FONA library.
The birdDetected_new() function uses NewPing library to trigger all four ultrasonic sensors and receive echoes. If the echoes received by any one of the ultrasonic sensors are shorter than 2m, function will return true and trigger the playSound() function. The playSound() function communicates with the second Arduino, which will play predator call when signal is received.
The timing of active and passive deterring modes is enabled by the internal clock of Arduino. By using its millis() function, we get the current time of how long Arduino has been operating and store it in the *time* variable. In order to ease the timing of program, we keep track of the time by (*time* - *currentTime*). When (*time* - *currentTime*) is over ten minutes, we reset the time interval by storing current *time* into *currentTime* variable, hence (*time* - *currentTime*) becomes zero in the beginning of every 10-minute interval. When (*time* - *currentTime*) is 0 to 8 minutes, it only sends signals to play sound when invasion is detected. When (*time* - *currentTime*) is 8 to 10 minutes, program keeps sending play-sound signals until the total duration of sound played exceeds 2 minutes.

Manufacturing

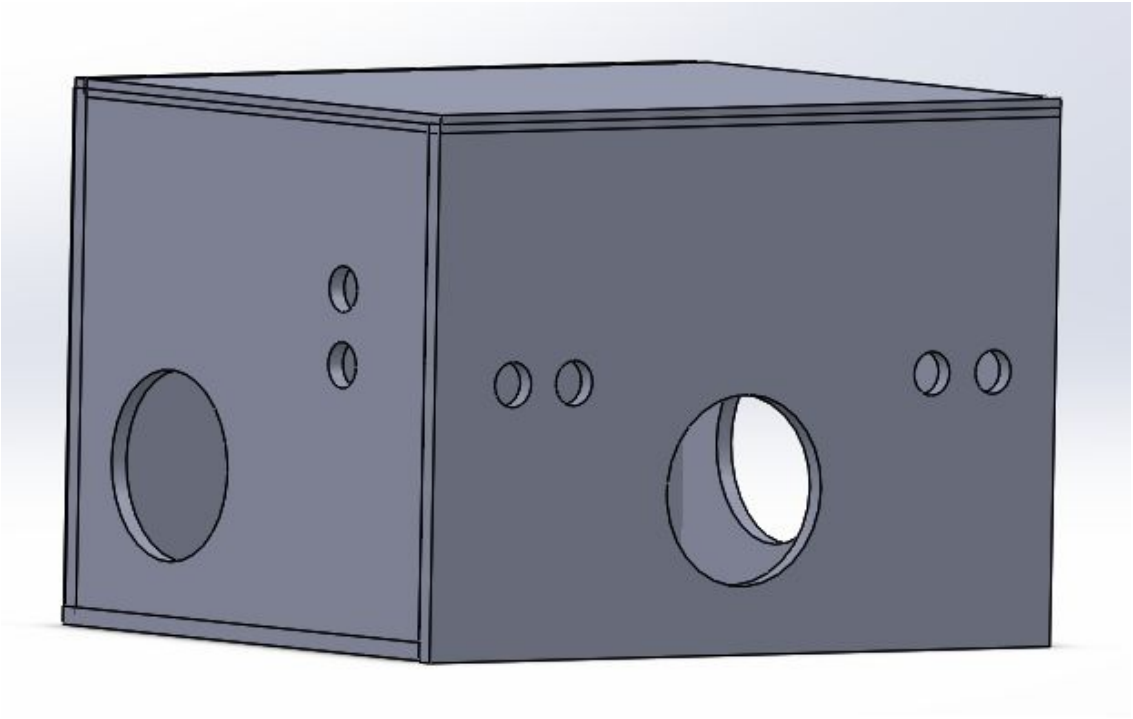

Figure 2. 3D drawing of the box containing circuits, battery, and speakers of the device Woodpeckers Pro.

Simultaneously we constructed the box made out of acrylic to hold the system constructed. The box comprises of 6 faces. All are made of acrylic. The front has a hole in the middle to feed wire through and four sets of small holes for the ultrasound sensors. The left and right sides have 2 holes in the side for the ultrasound sensors and a large hole for speaker. The top and bottom are solid acrylic. We drilled four small holes in the top and bottom and four small holes in the front face and connected zip ties to hold the box in place. There is also a small hole drilled in the middle of the top face to hold the photodiode. We used acrylic glue to glue the other five faces together. When gluing we made sure to use guides to make sure it glued at a 90 degree angle. To cut the acrylic we used the laser printer. Before inserting the acrylic into the machine we went on the computer and uploaded our CAD drawings.

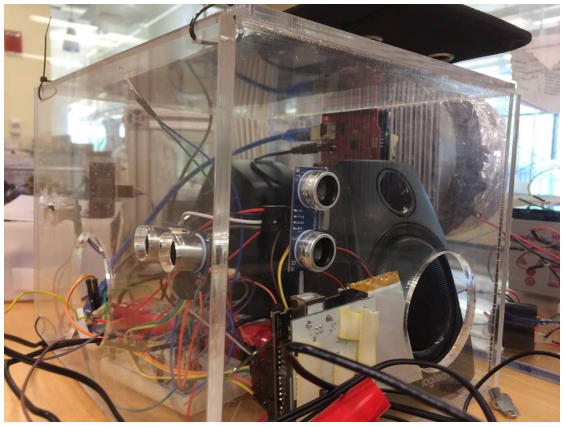
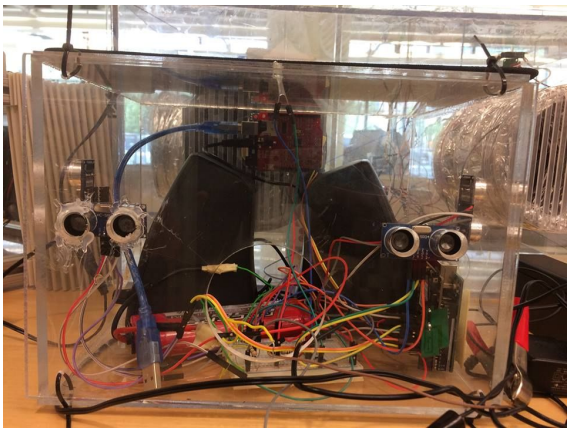

Figure 4 and 5. Pictures of the actual prototype. Figure 4 captures the right side and figure 5 captures the front face of the prototype. The black panel above the box is the solar panel.

Evaluation of Results:

Detecting and deterring

The device is able to detect woodpeckers invasion. By using four ultrasonic sensors placed on different faces of the device, it is capable of detecting invasion at any angle within 2m x 2m area when woodpeckers approach house. Although we haven't tested the effectiveness of using predator call to deter invading birds, the objective of playing a 15-second call is accomplished. If actual tests are carried out with birds and the device is not deterring fully, we recommend adding visual deterrent as a secondary deterring mechanism, such as shining bright light and reflecting sunlight towards the invading birds when detected.

Automatic switch and battery life

The device runs on both active and passive deterring mode. It effectively plays predator call whenever invasion is detected and actively for 2 minutes in every 10-minute interval. By changing the phone number to the homeowner's in the Arduino code, the device will send an alert message "Battery level is low!" to homeowner when battery level is under 70%. Solar panels are hooked up in parallel to the rechargeable battery and they always charge whenever there is sunlight. Since we assume that woodpeckers stop invading at night time, the device automatically switches off when light level is low.

Supporting Materials

Solidworks Drawing of Housing

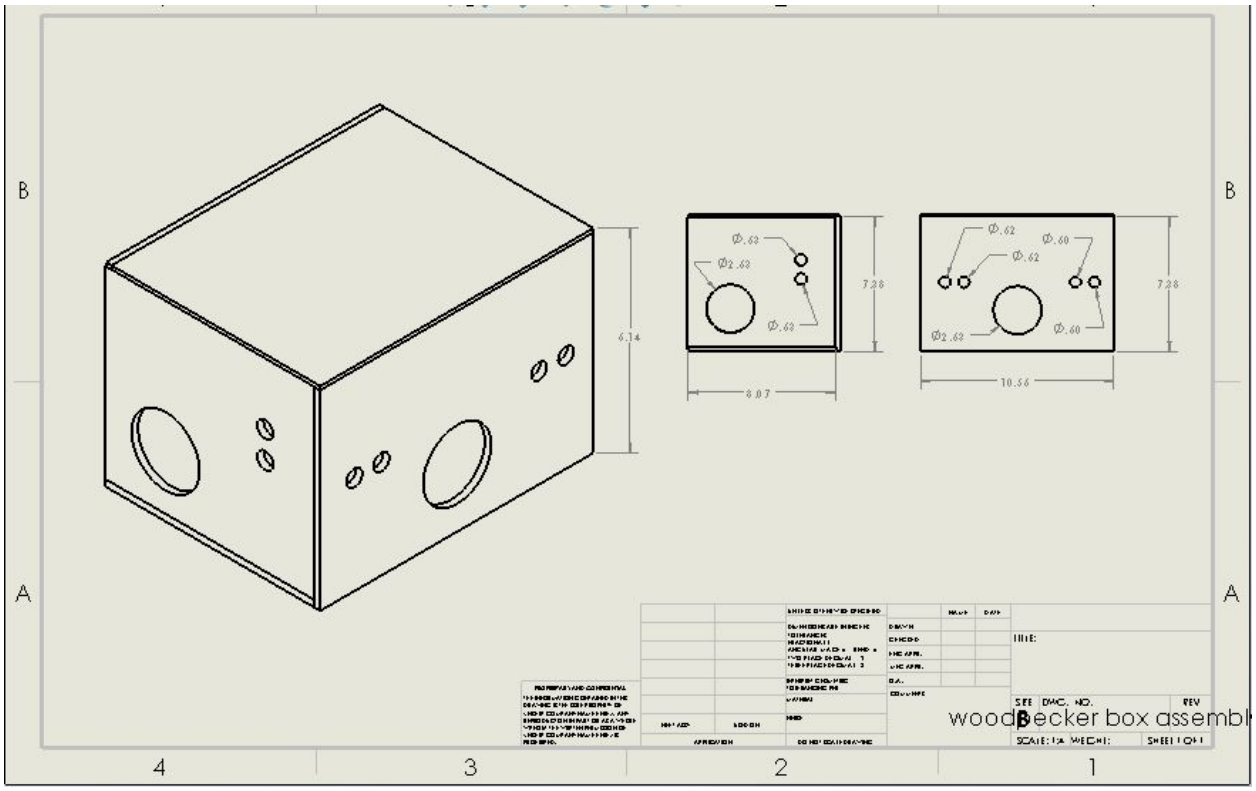

Figure 3. Solidworks drawing of container of device. All dimensions are listed in inches.