March 3rd, 2019

Dr. Craig Scratchley
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 405W Design Specifications for LaserTech System

Dear Dr. Scratchley,

The attached document, “LaserTech System Design Specifications”, outlines the design specifications of our project for the courses ENSC 405W and ENSC 440. The document details the design components considered and selected to build a complete prototype in the next phase of the project. A proof of concept description will be shown, as well as description of changes and additions to be made to the overall and final design of the product. The system aims to be responsive to motions of small moving objects such as crows, and the system will emit safe and harmless laser beam at crows so as to repel them from the home lawns.

The design specifications outlined in this document are of importance for the implement phase of the project. These are aligned to the system requirements specifications along with each component’s desired behavior and performance. The information outlined in this document will facilitate the building and assembly of the final prototype. The design specifications are divided into three parts: motion detection and laser beam module. Lastly, the mechanical measures are to be implemented in the development stage.

LaserTech consists of five Engineering students: Hope Xi, Rex Wu, Liam Li, Wipper Zhai and Bill Guan. Please feel free to contact us should you have any questions or concerns about the documentation, and we can be contacted via email at axi@sfu.ca.

Sincerely,

Hope Wang Xi

Hope Xi
CEO
Group 11
LaserTech Lawn Defence System

Enclosure: Design Specifications for a LaserTech Lawn Defence System

LaserTech Lawn Defense System
Design Specifications
Group 11

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Mar 3rd 2019

Abstract

It has been a common issue for people, especially home landlords who have encounter lawn issues with crows, that land on their front lawn and backyards to peck and ruin the lawn surface. The reason that the crows tend to peck the lawn is because they look for their grub snacks, also known as European chafer beetle.

Nevertheless, it is not enough to keep the lawn healthy even if there is no chafer grubs, since the crows or skunks would still try to peck and find if there is any "jewelry" under the grass as a habit. A solution is urgently necessary to resolve the headache of thousands of home landlords, especially in rainy Vancouver or coastal areas where crows like to reside.

The LaserTech lawn defence system will provide real-time lawn monitoring functionality to protect home landlords' beautiful lawns from being pecked and ruined by crows. The LaserTech system uses a motion detector to detect any moving objects and identify target objects like crows. When the target objects are being identified, the system sends signal to the laser beam module located in the middle of the lawn, and the module triggers the embedded laser pointers to flash the beam at the crows to expel them.

Evidence shows that laser beam can effectively frighten and expel crows, which is also proven by our kick-off experiments of using laser beam by one of our team members. The advantage of laser beam is that the frightening effect for crows is temporary, and it will not cause any temporary harmfulness to them. Hence, We are commencing our project idea to build a system using motion detection technology to identify crows, and emit green laser light beam to expel them in a safe and responsible manner.

The design specifications document outlines the system overview of the physical outlook to give the audience a sense that how the system will look like as well as necessary design metrics for our team to implement the LaserTech project. Furthermore, this document also details steps for hardware design, power supply design, mechanical design, and laser module design. Lastly, the document includes a test plan for our QA process to ensure the system is operating safely, reliably, and robustly.

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0. Glossary

LED: Light Emitting Diode
Environmental Sustainability: when demands from the environment can be met without reducing its living standards capacity
Prototype: early sample, model, or release of a product built to test a concept
Engineering Standard: documents that specify characteristics and technical details that must be met by the products, systems and processes that the standards cover.
Automation: the technique of making an apparatus, a process, or a system operate automatically
Server-Client: specific model of a computer network that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients
CSA: Canadian Standards Association
IEEE: Institute of Electrical and Electronics Engineers
NESC: National Electrical Safety Code
UL: Underwriters Laboratories
PET: Polyethylene terephthalate
ABS: Acrylonitrile butadiene styrene
RoHS: Restriction of Hazardous Substances
PIR Sensor: Passive Infrared sensor
RF: Radio Frequency

1. Introduction

The laser tech system is going to be a laser system that is used to expel crows on the grass. It will include a motion detector to evaluate the existence and the location of the crows on the grass, and multiple laser beams emitted at the crows which can cover 8 x 8 square meters lawn area.

The laser system includes three subsystems: first is a control system, which has a motion detector to identify crows on the grass signaled by arduino system; second, a mechanical module, which includes two motors; third, a laser beam design, which includes multiple laser beams and laser diodes controlling circuit.

1.1 Background

Crows tend to peck the grass roots since they look for grub snacks, also known as European chafer beetle. This causes the destruction and severe damage to the home yards. From time to time, this has been a headache for thousands of homeowners who lives in rainy Vancouver or coastal areas. It costs a tremendous amount of money for people to fix the grass lawn. In order to fight against the issue, LaserTech provides a reliable long-term solution and has invented a laser system to prevent crows from digging out the grass roots. The system is embedded with a real-time motion detector, which automatically emits laser beam at crows as a result of expelling them from the lawns.

1.2 Scope

The scope of the document is to specify the design in order to build an effective lawn defence system, so that it can effortlessly expel the crows once the system identifies if there is any crows landing on the grass that is being monitored. It will include the details of software, hardware, electronic and mechanical systems.

1.3 Intended Audience

The audience of the design specifications document is intended to be Engineering professors, teaching assistants, enterprise clients that are interested in investing in lawn protection technology, as well as home landlords who encounter the issues with their lawns being damaged by the crows.

2. System Overview

Overall, the prototype will have a number of PIR motion detectors, arduino, laser pointers assembled into a mechanical cylinder consists of all mentioning parts. The following figure illustrates the workflow for the whole system:

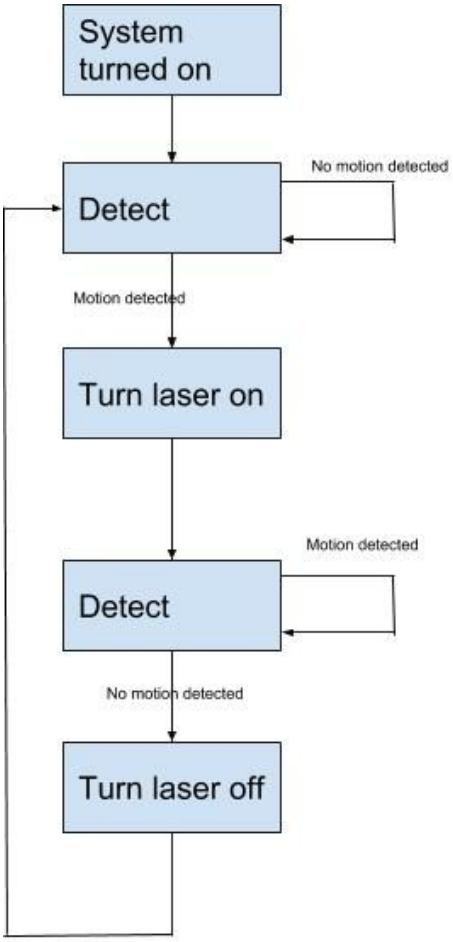

Figure1: LaserTech Workflow Chart

The system operates the cylinder and starts rotating when the system is activated. The idle mode of the laser will be set to idle. The motion detector that is set inside the rod, scans the surrounding motion objects at all time. While an moving motion is being detected, a signal will be generated and transmitted to the laser beam in order to trigger the laser to shoot. The laser is then switched to in-work mode and starts expelling the crows. The signal keeps on running until no motion is being identified. When there is no motion for a period of time, the signal will send to the system and switch back to idle mode. Therefore the laser will be turned off and goes back to standby mode.

3. Hardware Design

The PIR sensor has two slots and two slots are IR sensor can be sensitivity to IR.[1] The lens used here is not really doing much and so we see that the two slots can 'see' out past some distance. Ideally, both slots have the same detection of IR. When there is a warm object passing by the sensor, it will cause the difference of IR. This will be caught by sensor. Therefore, there will be a pulse detected.

The following spec sheet specifies the working operation parameters and basic statistics:

Electrical and Optical Characteristics at 25C

Circuit Configuration	Three-terminal sensor with source follower	
Appearance	TO-5 metal case with hermetic seal	
Output balance between elements	15% max	at 1 Hz
Spectral Response		determined by filter
Filter Substrate	Silicon	
Transmission	> 70%	average in 7 ... 14 µm range
Cut on wavelength	5.0 ± 0.5 µm	at 5% T abs.

Test Conditions: VDD = 5.0 V, Tamb = 25 C, unless otherwise noted.

Symbol	Min	Typ	Max	Unit	Note
Idd		0.2	0.5	mA	supply current (1)
VSSA	- 3.6	- 4	- 4.4	V	referenced to VDD
IVSSA			2.0	mA	sink capability
VREF	3.6	4	4.4	V	VREF = VDD - VSSA

Figure 2: PIR Sensor Data Spreadsheet

Some Basic Stats

These stats are for the PIR sensor in the Adafruit shop which is very much like the Parallax one (https://adafru.it/aKj) . Nearly all PIRs will have slightly different specifications, although they all pretty much work the same. If there's a datasheet, you'll want to refer to it

- **Size:** Rectangular
- **Price:** $10.00 at the Adafruit shop (https://adafru.it/aIH)
- **Output:** Digital pulse high (3V) when triggered (motion detected) digital low when idle (no motion detected). Pulse lengths are determined by resistors and capacitors on the PCB and differ from sensor to sensor.
- **Sensitivity range:** up to 20 feet (6 meters) 110° x 70° detection range
- **Power supply:** 5V-12V input voltage for most modules (they have a 3.3V regulator), but 5V is ideal in case the regulator has different specs
- **BIS0001 Datasheet (https://adafru.it/cIR)** (the decoder chip used)
- **RE200B datasheet (https://adafru.it/cIS)** (most likely the PIR sensing element used)
- **NL11NH datasheet (https://adafru.it/cIT)** (equivalent lens used)
- **Parallax Datasheet on their version of the sensor (https://adafru.it/cIU)**

Figure 3: PIR Sensor Data Statistics

To conclude there will be a digital pulse at 3V when a motion triggered. Then we will use arduino to get this signal and send it to the laser beam module to control laser beam. The following figure displays the arduino board:

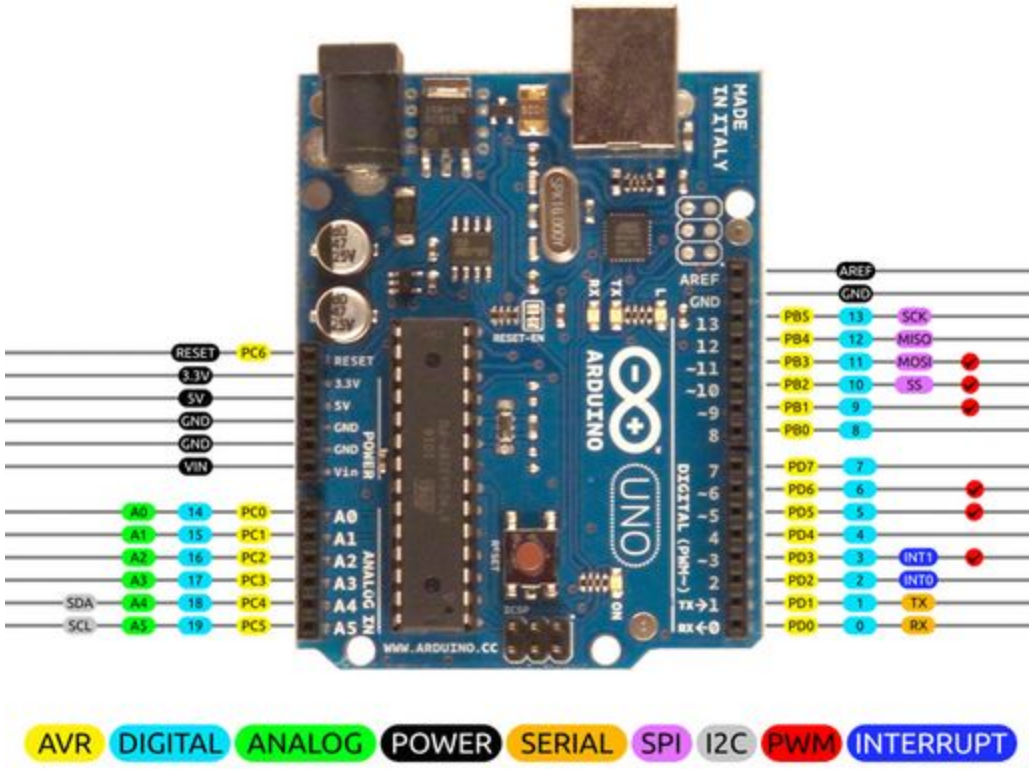

Figure 4:Arduino Logic Board

The arduino has multiple pins, on the left side, it can pin 3.3V and GND is going to charge the motion detector. Pin 2 on right side can read data from motion detector. Pin 11 and Pin GND on right side can control the whole circuit.

Figure 5: Motion Detector Module

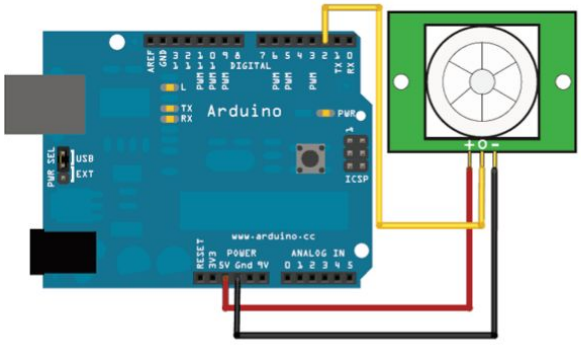

Figure 6: Arduino Module

The figure illustrates the PIR sensor and the connection between PIR sensor and arduino. The PIR sensor has three pins, the red pin is connected to the input voltage, the black pin is connected to the ground and yellow pin will generate a 3V digital output voltage. The arduino uno is connected and to power the motion detector. The digital pin2 will be connected to motion detector output and pin 3 voltage and gnd will connected to red pin and black pin to charge the motion detector.

4. Power Supply and Electronics Design

4.1 Relay (Switch Unit)

The relay will be the one responsible for managing the electricity between the wall voltage and the Arduino. As the Arduino cannot itself drive a high voltage light bulb, a relay with 5V DC port was chosen. The requirement stated that the standard operation voltage should be 120V, the relay with 250V AC will be capable of handling the wall output voltage and control the light bulbs with ease.

Requirement Number	Requirement Description	Keyestudio 5V Single 1 Channel Relay
R3.23-2	The standard operation voltage of the relay is 120V	5V DC - 250V AC
R3.24-3	The relay shall be able to power up the system to the desired intensity	-

Table 1: Relay Specifications

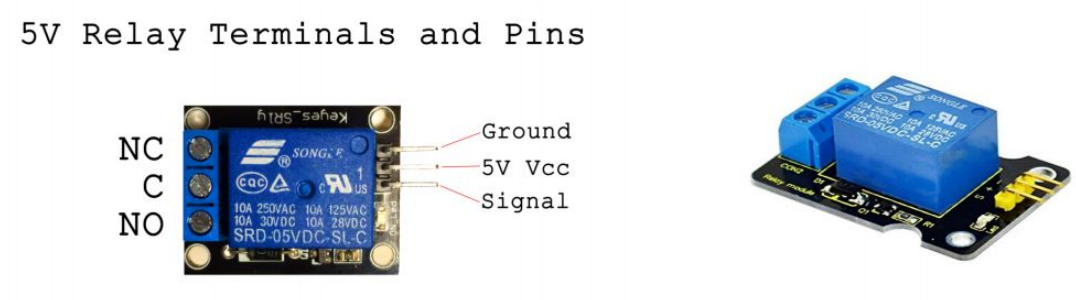

Figure 7: 5V Relay Module

The team chose a regular relay instead of a solid-state relay given that the latter would not be good with bulbs as it does not completely turn off. The relay chosen can perfectly work with the Arduino as it has the 5V port and it can connect to the wall wiring using the 250V AC. As per the dimming capabilities, further research is to be done on this matter to find the easiest and safest way to dim the lights to the desired intensity. The decision on the relay chosen may change in future design revisions based on this research. For installation and use of the relay, the following diagram will be used as a reference:

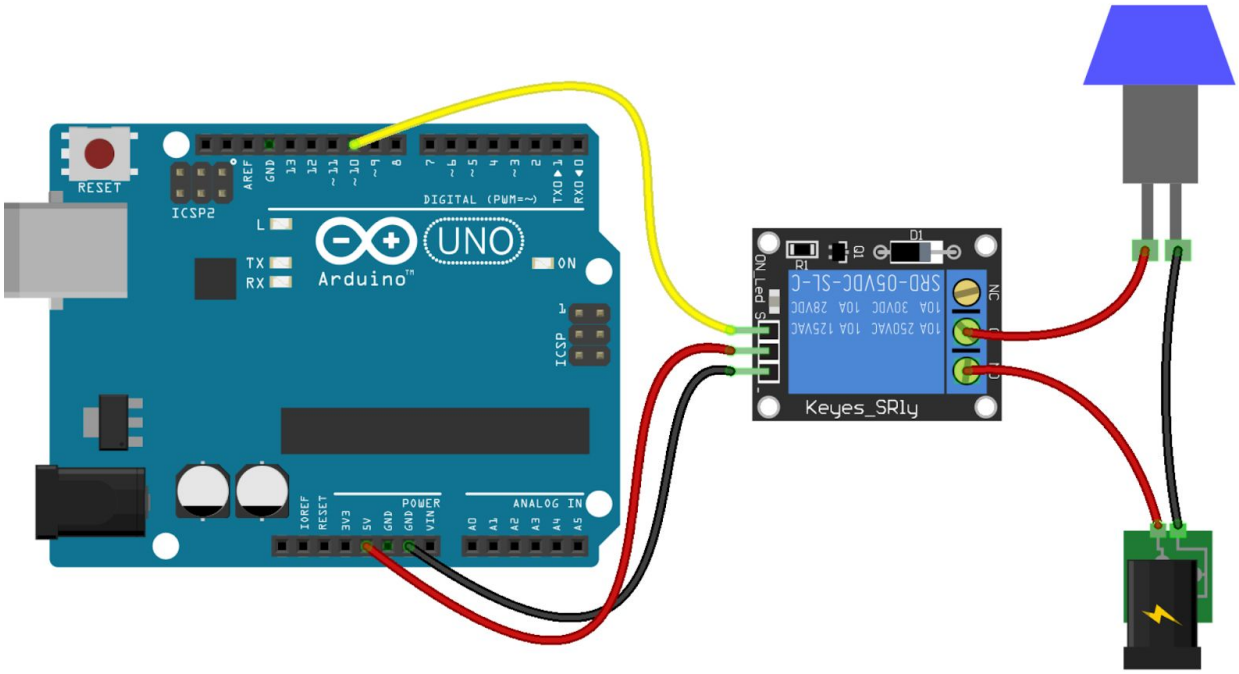

Figure 8: Integrated Motion Detection System with Power Relay

5. Mechanical and Physical Design

The mechanical and physical design contain two main parts: the physical outlook and electric circuit wiring principle. First of all, the draft of devices assembled seem like below:

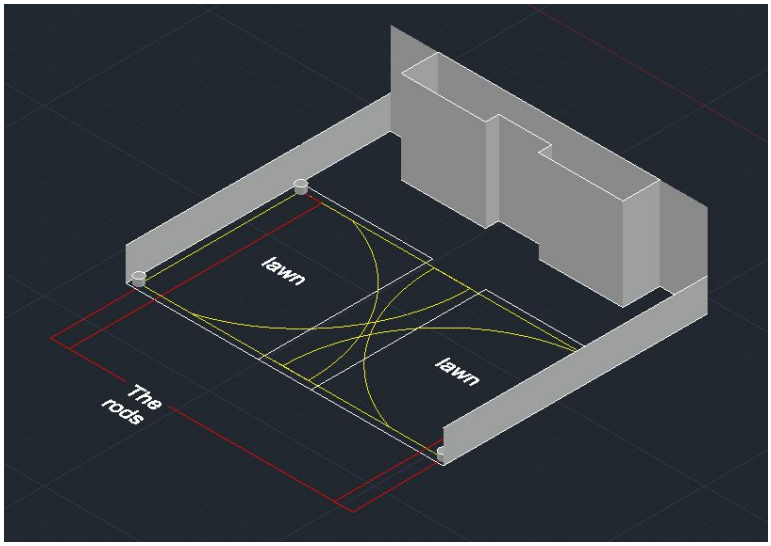

Figure 9: The Finished System

The four rods are assembled in every four corners, and the rods rotates in 90 degree to cover all area of the yard (the yellow lines shows the coverage. The only blind spot is exactly in path, and this is the case that length of red laser beams are only 6.5 meters only, however the normal length of red laser beam is absolutely over 6.5m).

5.1.1 The Physical Outlook and Devices Allocation

The outlook our product contains two parts: a cylinder over a cube. The dimension are as following image:

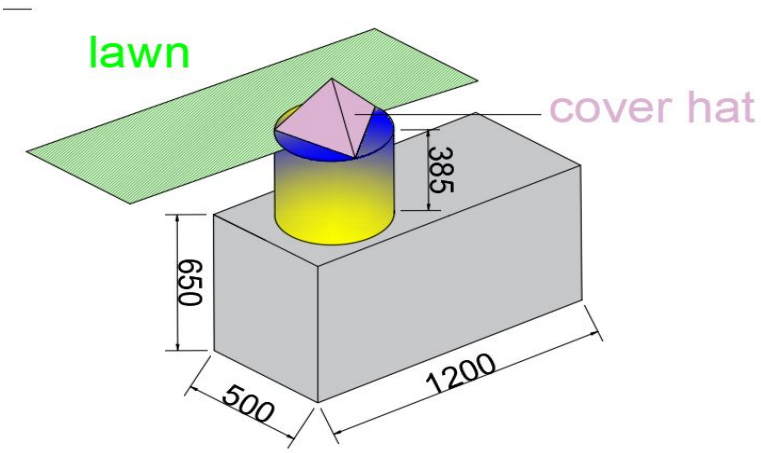

Figure 10: Dimensions for the Laser Beam Module

The image is in millimeter, the figure has shown that the position of the lawn. All the device except cover hat is underground. The purpose of cover hat(pink part) design is for water-proof, the bottom of each triangle has a fixed spring make it closed when the rod is on the threshold rifting down position. The colorful cube and the gray cube are connected without gap, which means there is no possibility to leak water underground.

The device allocation and working principle are more complex, the following cut-off view figure shows more details:

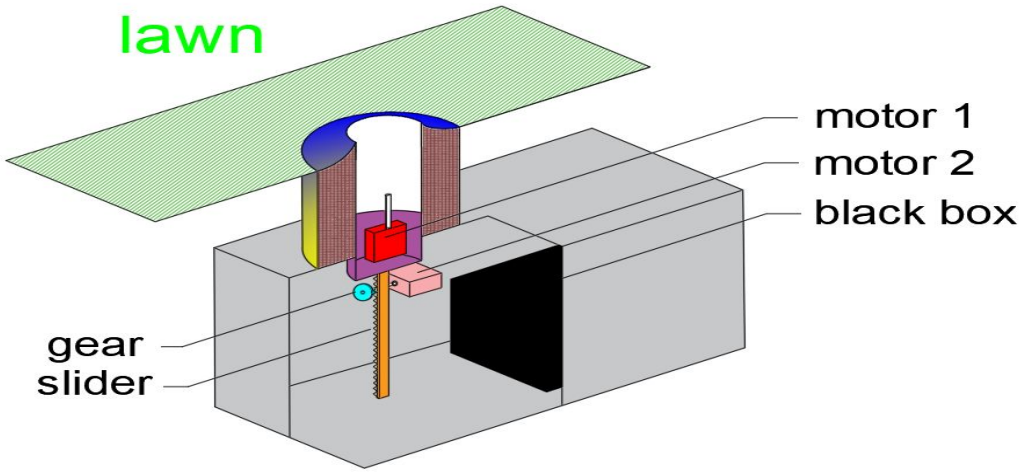

Figure 11: Sectional View for the Laser Beam Module

5.1.2 Description

1. The green lawn: indicate the assemble position
2. The blue hat : there is curve in this part, which can fall in the water drop(in case of the water going to device from the gap between the white part and blue part.
3. The brown part : waterproof material solid filler, which can make a better stability
4. The white rod and purple rod : these two parts combine as the rod part. The white part keep rotating in counter clockwise 90 degree and clockwise 90 degree repeatedly, and the red laser diode and motion detector are all located in the white part, the height of the white is 300 mm. The purple part is fixed and motor1 are located in this part and the height of this part is 135 mm. When the rod lift up to the most top position, the purple part will still have 50 mm leaving underground. The purpose of this design is for waterproof and better stability.
5. The red motor (motor 1) : response for rotating white part rod, which contain laser diode and motion detector as mentioned above.
6. The pink motor (motor 2) : all of the orange slider and the cyan gear work together for the lifting behavior. When the motor rotates counter-clockwise, the rod part will lift up, and it will inversely lift down when the motor rotates clockwise.
7. The black box : contain our arduino, power transformer and electric board and other electrical device.

5.1.3 the power source and electric circuit construction for motors

1. Red motor (motor 1): it is supplied by a low frequency AC power source which can make the white part rod keep rotating in counter clockwise 90 degree and clockwise 90 degree repeatedly(might use some gears to correct the rotation speed and coverage).
2. Pink motor (motor 2):it is supplied by a DC power source circuit as shown below:

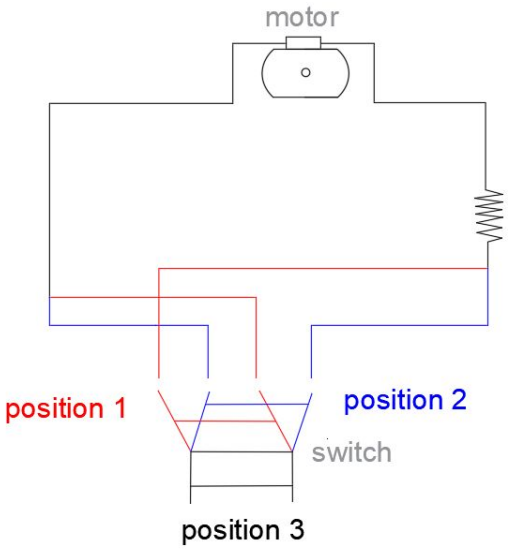

Figure 12: Rotational Motor Circuit

As the figure illustrates, when the switch are in position 1 (red), the motor rotate counter-clockwisely. Furthermore, the motor rotates in the opposite direction when the switch is switched to position 2 (blue). The position 3 is an open switch for disconnection and troubleshootings.

6. Laser Module Design

The laser beam will be emitted by multiple individual laser diode to ensure the effective coverage will point at crow's eyes as the following figure illustrates:

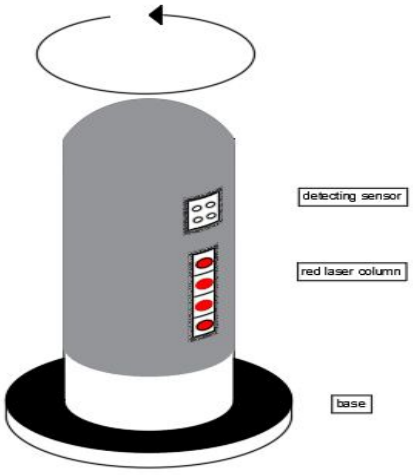

Figure 13: Physical View of Laser Beam Module

The devices been used is simple laser diodes, since the diode can save much more space and make the rod thinner to operate(the weight can be reduced as well). The laser diode are selected from Digi.Key company. The outlook are as below:

Figure 14: Laser Diode Module

The specifications for the selected laser diode are listed in the following table:

Manufacturer	Quarton Inc.
Class of Lasers	Class 2
Manufacturer part Number	VLM-650-02G LPT
Wavelength	650nm
Input voltage	2.6V~5V
Current Rating(Amps)	35mA
Power(Watts)	1mW
Package/Case	Cylinder(10.5mm Dia)

Table 2: laser diode parameters

The laser diode is classified as Class 2, which implies the safety for household and commercial use is safe and causes no danger to human eyes. The input voltage has a range from 2.6V to 5V as above shown, and from section 4 Poc part, it is easy to find that there is a 3V pulse when a motion triggered in device. This voltage pulse is able to been used as a signal to produce a approximately 3.3V ~5V DC.

Once the arduino receives the clock pulse from motion detector, it sends a feedback signal to the laser diode from the laser beam module. On the other hand, if there is no pulse, arduino does not generate signal to the laser beam module.

The whole electric laser system is illustrated in the following figure[5]:

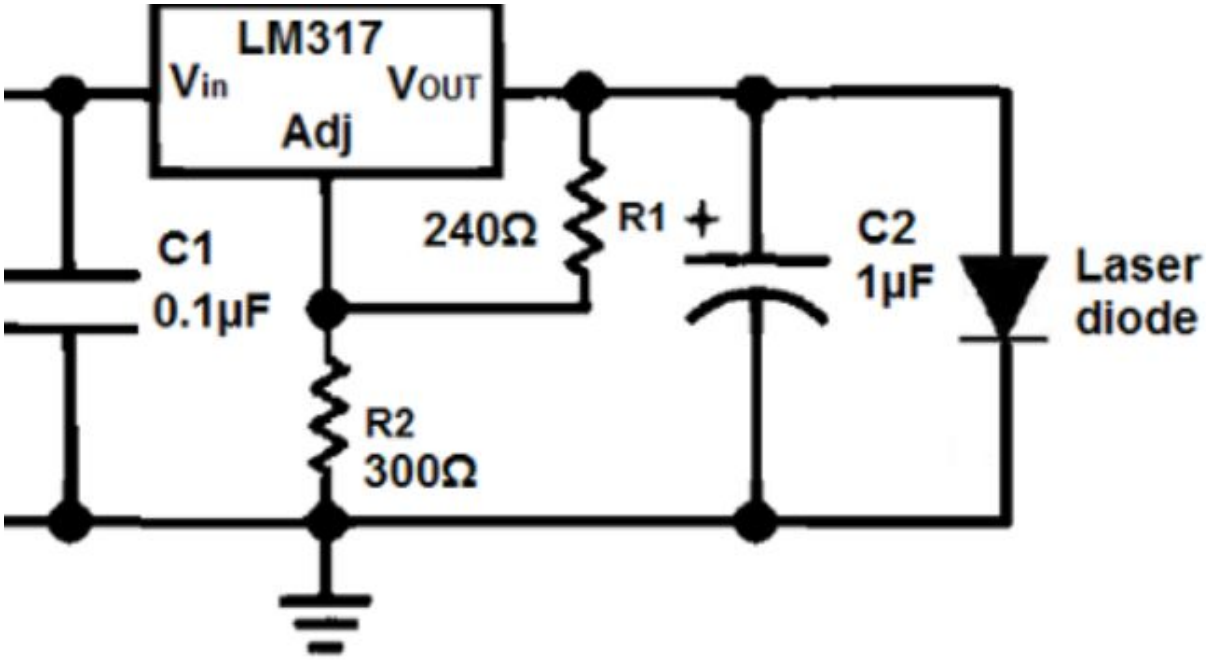

Figure 15: Laser diode circuit

The output from arduino will connect to the vin to create a signal to control the mosfet to control the whole laser beam. Ideally, when a motion detected by PIR sensor, there will be a 3V output coming from yellow pin. By programming the arduino, a voltage can be sent from pin 9 to drive the mosfet to control the laser bin model.

7. Conclusion

LaserTech is a local company that solves real-world problems located in beautiful Greater Vancouver. Crows is a large residence group living among us; however, the damage that they cause to our lawns can be costly, both financially and timewise. While the crows grow smarter and no longer afraid of scarecrows, and sound frequency could potentially harm humans, we are providing a reliable long term solution to prevent them from damaging your lawn without impacting their safety.

The main solution includes emitting laser beam at crow such that the crows know they are in their discomfort zone and fly away. The LaserTech system would not harm the crow, and also our system is set to low enough such that it would not shoot at people's eyes. The system will be rotational and have no dead angles, the coverage is up to 8X8 square meters, and turns on and off automatically upon detection of crows, with the main ON/OFF switch of the whole system controlled by the user. Our device is secure and environmental friendly, low cost and efficient. Users will no longer worry about spending huge amount of money in fixing their damaged lawns.

Crows prefers a good living environment just like us, our city can definitely accommodate them since vancouver is big on nature and its wildlife, after eliminate the fact they like to dig our lawns, we believe the co-existence of human and its nature is worth protecting.

8. Test Plan Appendix

Electrical Test			
Environment: System is connected to an external LED bulb in a low-noise contaminated room Description: To ensure the electrical connection to PIR Motion Detector is working correctly			
Procedure	Expected Result	P	F
Execute the command to turn on the system and leave the system idle for 3 minutes.	The LED bulb turns on and stays on a steady brightness.		

Table 3: Electrical Test Plan

Software Test			
Environment: System is connected to a laptop which has software Arduino Create installed in a low-noise contaminated room Description: To ensure the software initializes PIR Motion Detector correctly			
Procedure	Expected Result	P	F
Execute the command to initialize PIR Motion Detector	Screen displays “PIR Motion Detector Initialization is Successful”		

Table 4: Software Test Plan

Laser Beam Module Test
Environment: Outdoors environment at daytime, nighttime in different weather Description: To determine the effectiveness of the laser which it should have strong enough intensity to expel the crows at anytime, but not harm the crows

Procedure	Expected Result	P	F
Activate the laser to point at the crows at different weather environment to determine if it will expel the crows	Crows will be frightened by the laser beam and fly away		

Table 5: Laser Test Plan

Mechanical Test			
Environment: Motor runs in 5V 100 Hz power supply Description: Determine if the motor can rotate in exactly 90 degrees for a expected period of life cycle			
Procedure	Expected Result	P	F
Power the testing motor in 5V power supply. Find the exact angel with 90 degree when we change the frequency	Fail to find the exact 90 degree		

Table 6: Mechanical Test Plan

PIR Motion Detector Test			
Environment: System is connected to an external LED bulb in a low-noise contaminated room Description: To ensure the PIR Motion Detector is able to response motions from 20 cm,1 m and 8 m away			
Procedure	Expected Result	P	F
Keep the motion detector in front of nothing	LED bulb stays in inactive state		
Wave hands in front of the motion detector from 20 cm away	LED bulb turns on after less than 1 second		
Stop any action in front of the motion detector	LED bulb remains in inactive state		

Wave hands in front of the motion detector from 1 m away	LED bulb turns on after less than 2 second		
Stop any action in front of the motion detector	LED bulb remains in inactive state		
Wave hands in front of the motion detector from 8 m away	LED bulb turns on after less than 5 second		
Stop any action in front of the motion detector	LED bulb remains in inactive state		

Table 7: PIR Motion Detector Test Plan

9. References

[1] “PIR Motion Sensor,” *Overview | PIR Motion Sensor | Adafruit Learning System*. [Online]. Available: https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor. [Accessed: 14-Mar-2019].
[2] *Arduino Uno Rev3*. [Online]. Available: https://store.arduino.cc/usa/arduino-uno-rev3. [Accessed: 14-Mar-2019].
[3] Instructables, “DIY Arduino PIR Motion Sensor Lighting & Security,” *Instructables*, 25-Oct-2017. [Online]. Available: http://www.instructables.com/id/DIY-Arduino-Motion-Sensor-Lighting-Control. [Accessed: 14-Mar-2019].
[4] “Quarton, Inc. - INFINITER,” *VLM-635/650-02G Series | Laser Module, Laser Diode Module,Laser Diode, LD, RED, Green, IR*. [Online]. Available: https://www.quarton.com/content/Laser_Module_1/Red_Laser_Module_11/Adjustable focus Laser_32/157/. [Accessed: 14-Mar-2019].
[5] “Quarton, Inc. - INFINITER,” *VLM-635/650-02G Series | Laser Module, Laser Diode Module,Laser Diode, LD, RED, Green, IR*. [Online]. Available: https://www.quarton.com/content/Laser_Module_1/Red_Laser_Module_11/Adjustable focus Laser_32/157/. [Accessed: 14-Mar-2019].