IR Tracking NERF Sentry Gun

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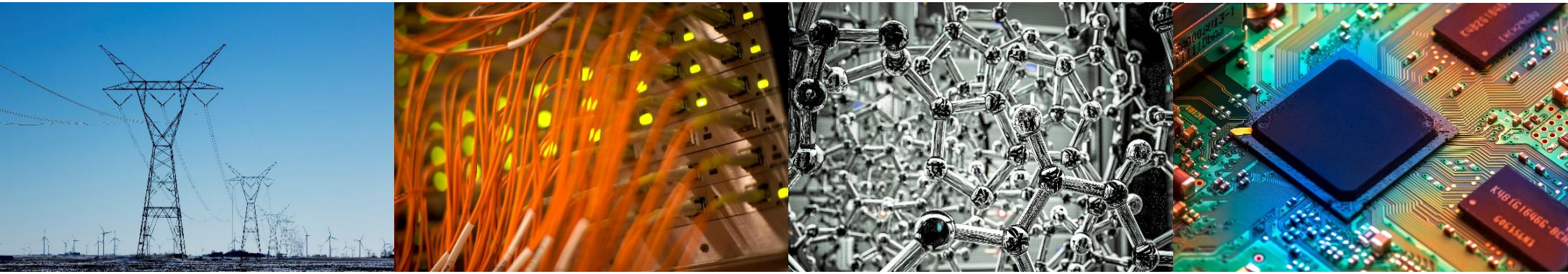
Team 13



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Introduction

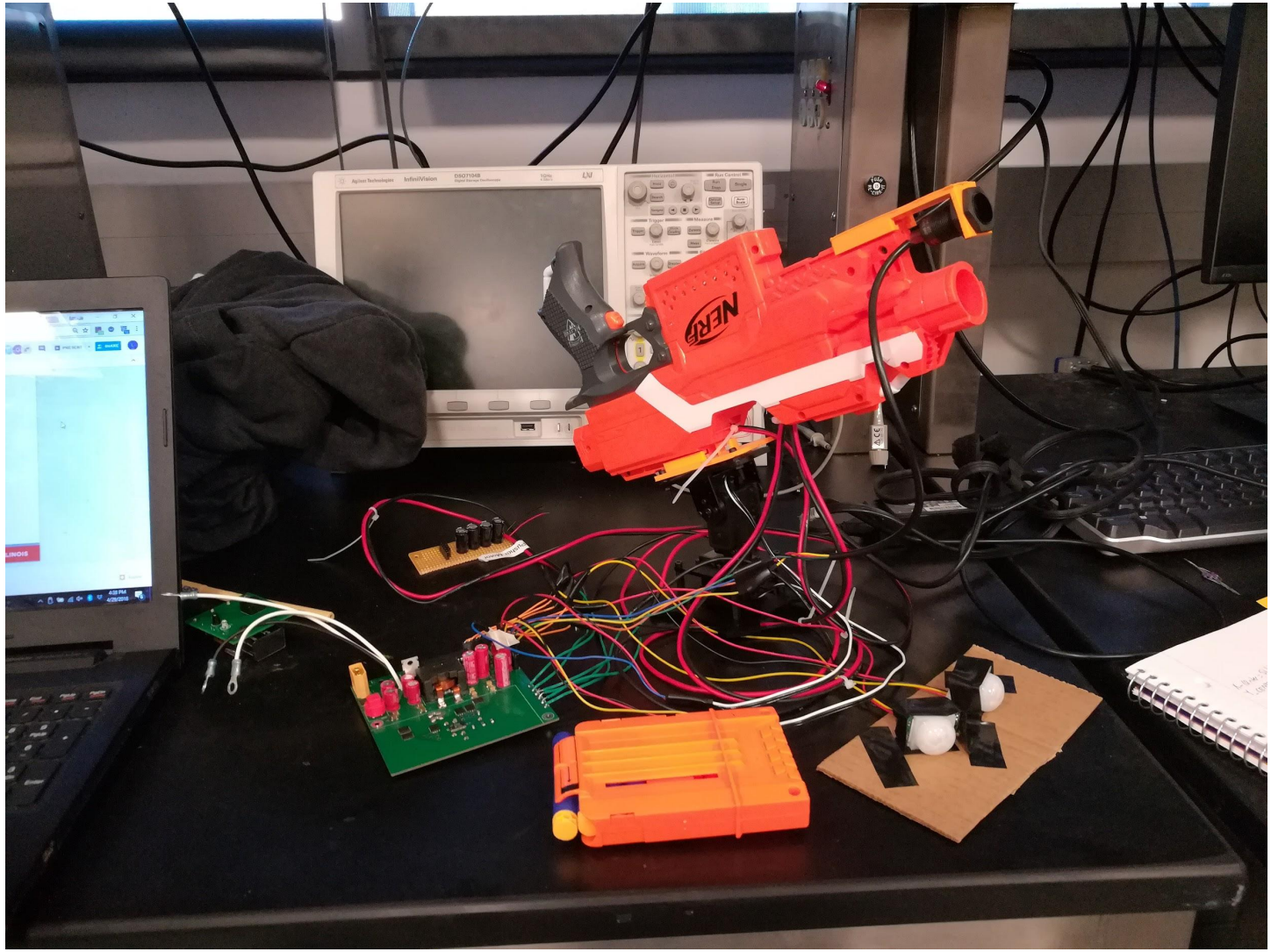
- Scans the surrounding area for a strong IR source
- Locks onto a target holding an IR emitter within 15 feet
- Fires NERF darts at the moving target as they approach 10 feet

Video

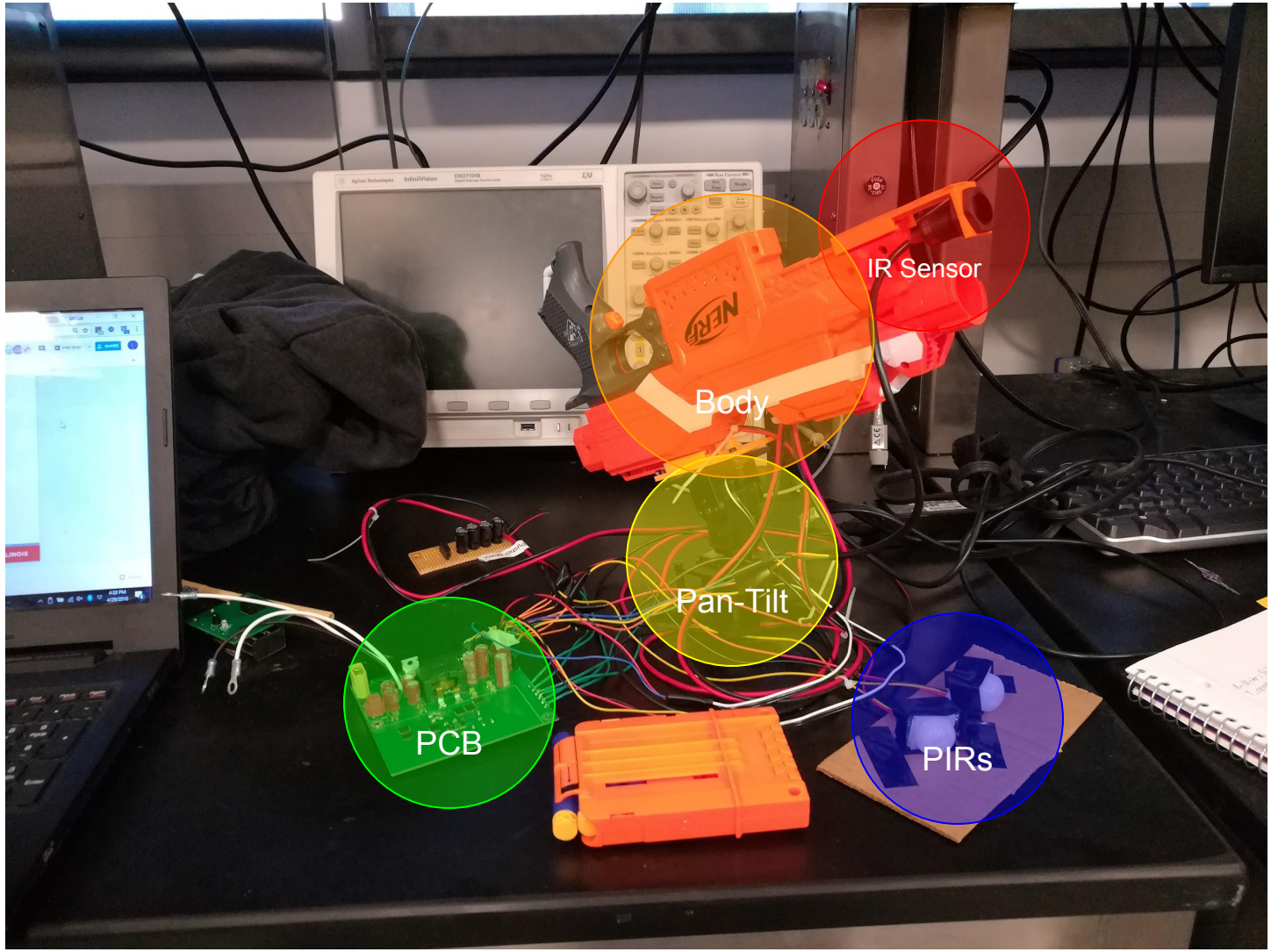
Objectives

- Portability
  - On board microprocessor
  - Powered with a Li-Po battery
  - Long run time
  - Compact design
- Accurate tracking
  - Wiimote IR sensor
  - PIR sensors

Physical Design

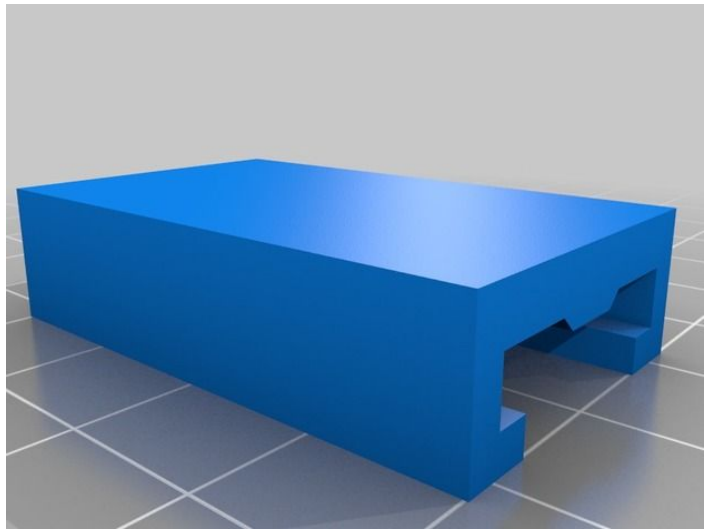


Physical Design

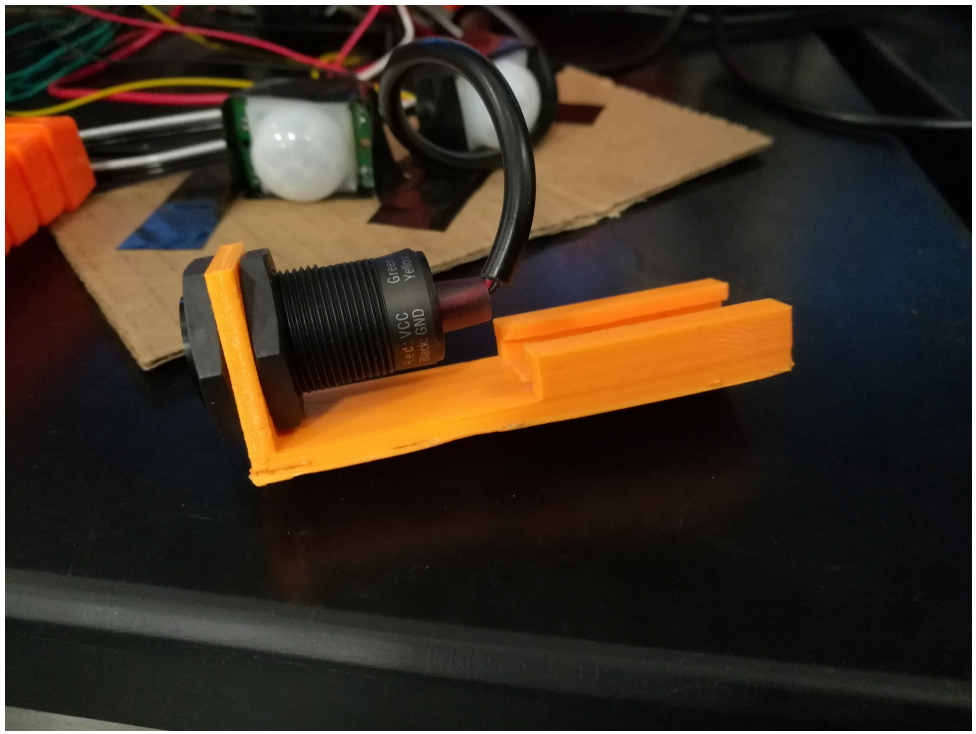


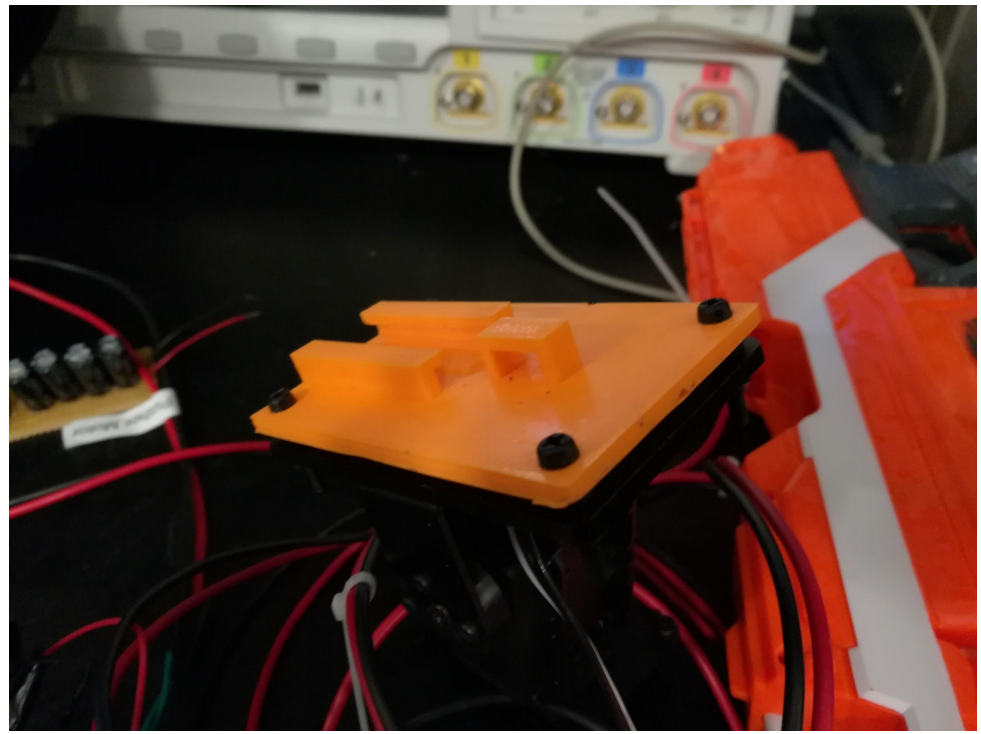
3D Printed Parts

- Used existing accessory rail system on body to create custom mounts
- Modified base NERF rail mount model in SketchUp to fit needs

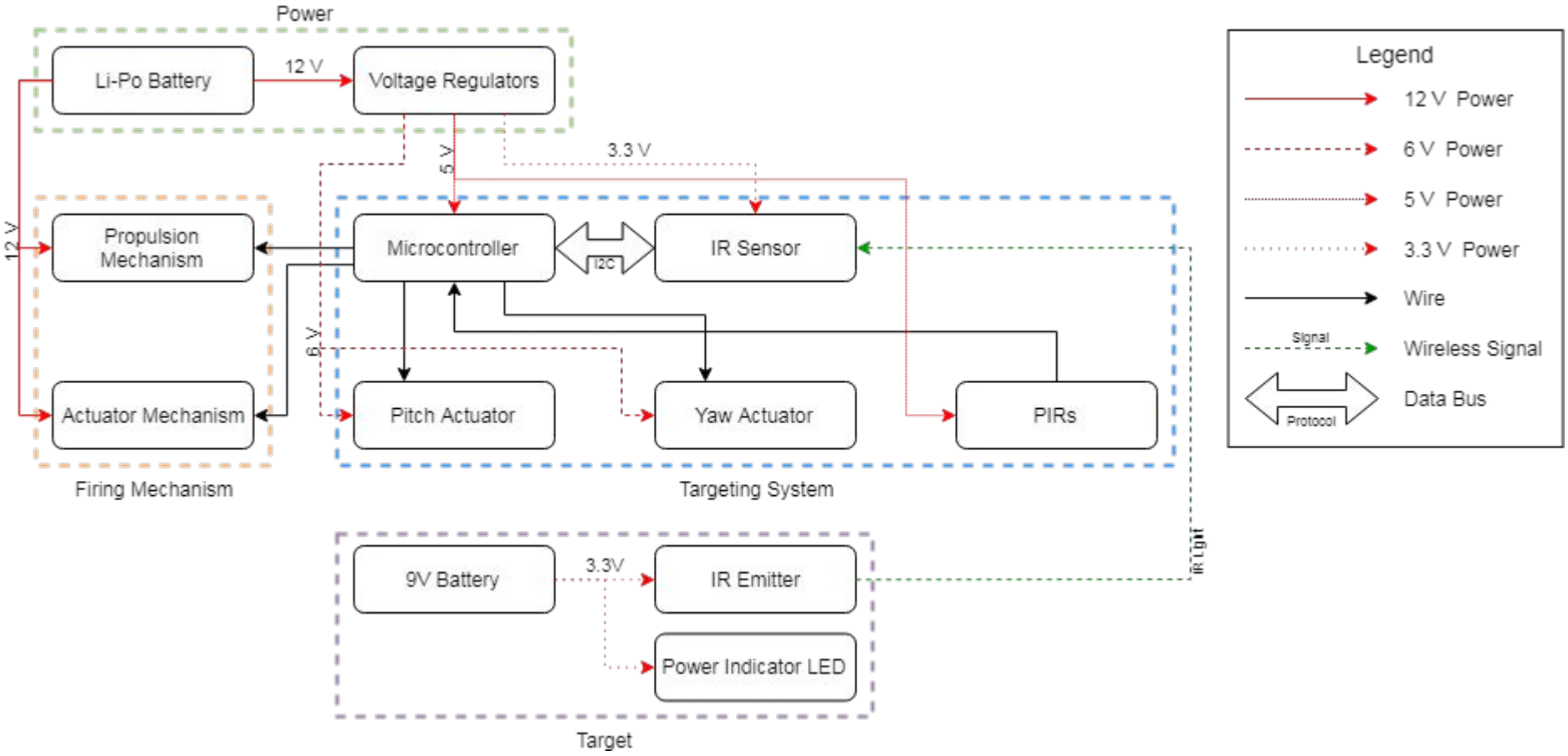


3D Printed Parts

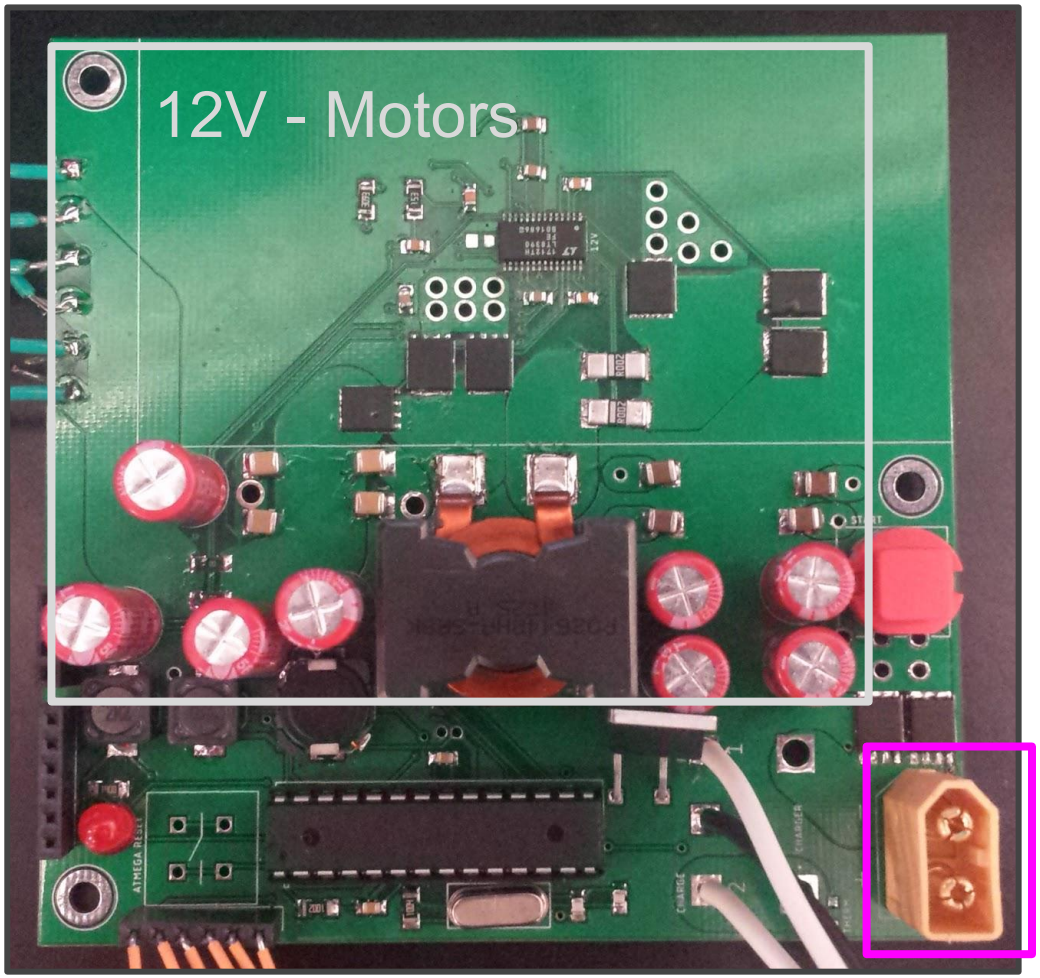


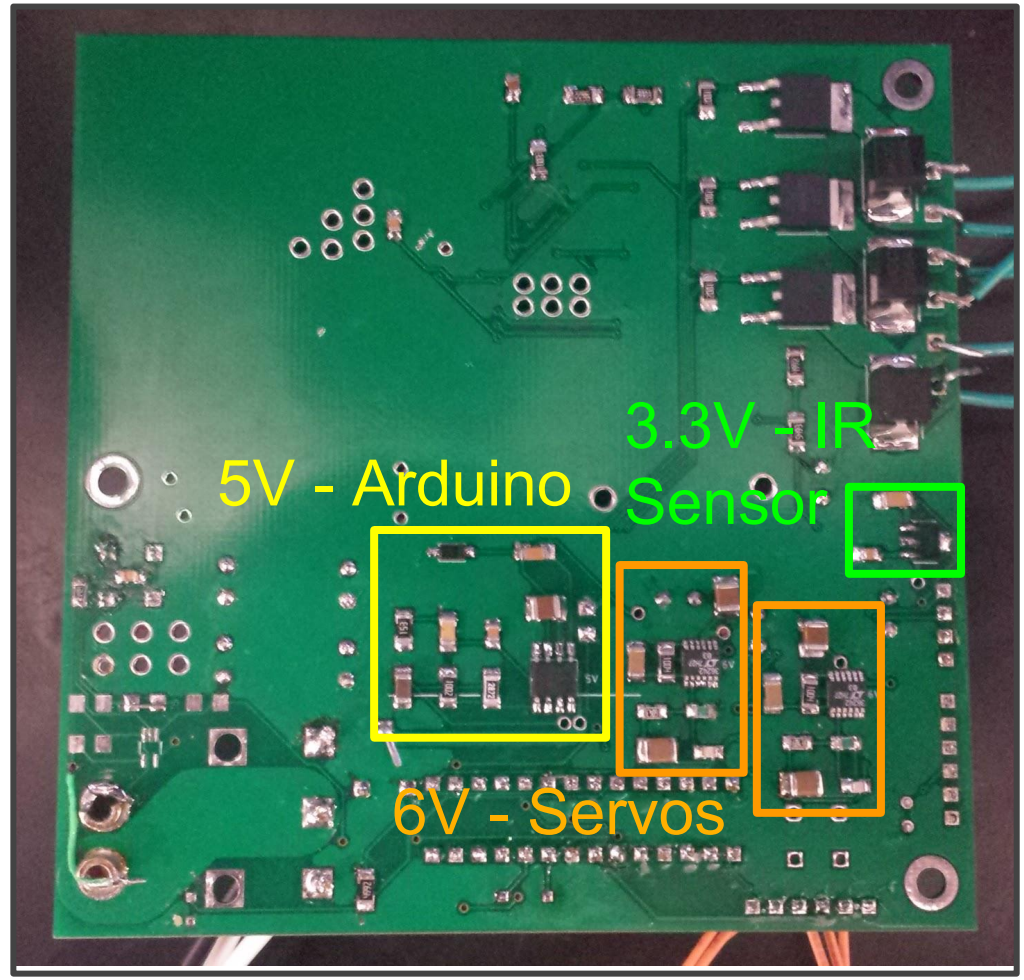


Block Diagram



Power: Regulators

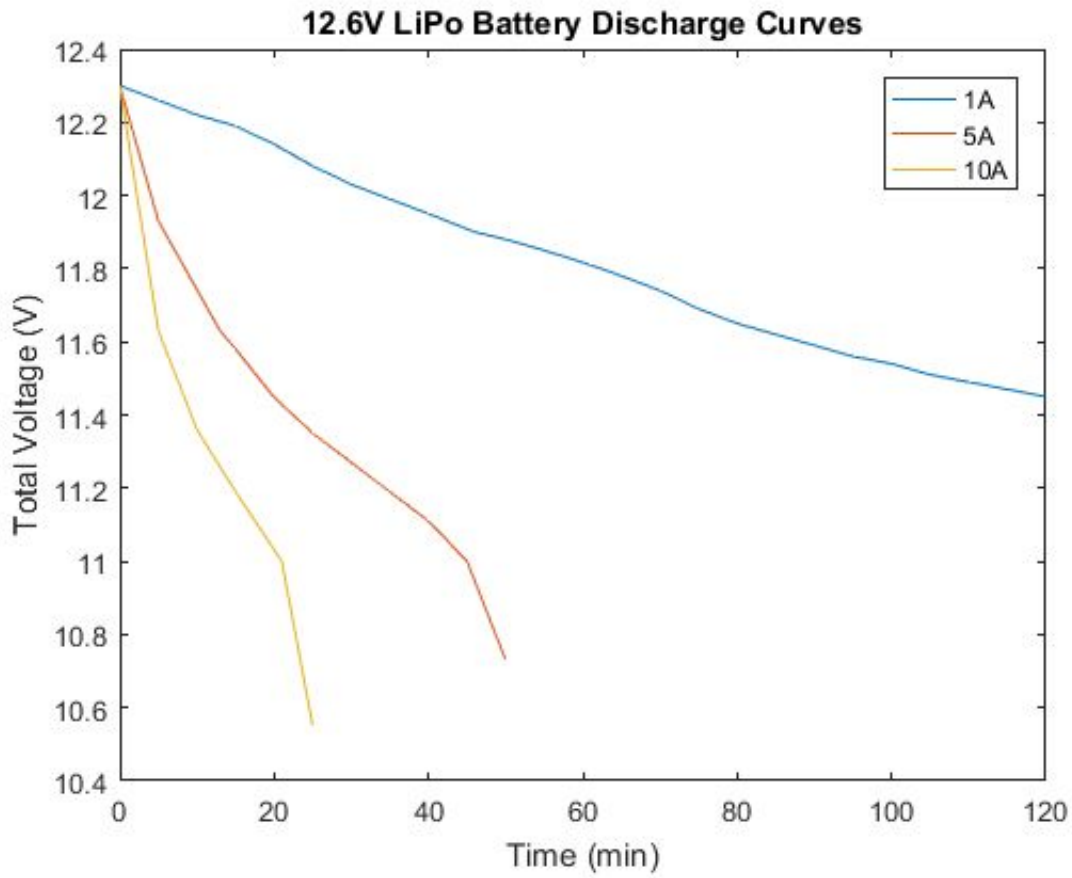




Power: LiPo Battery

Requirements

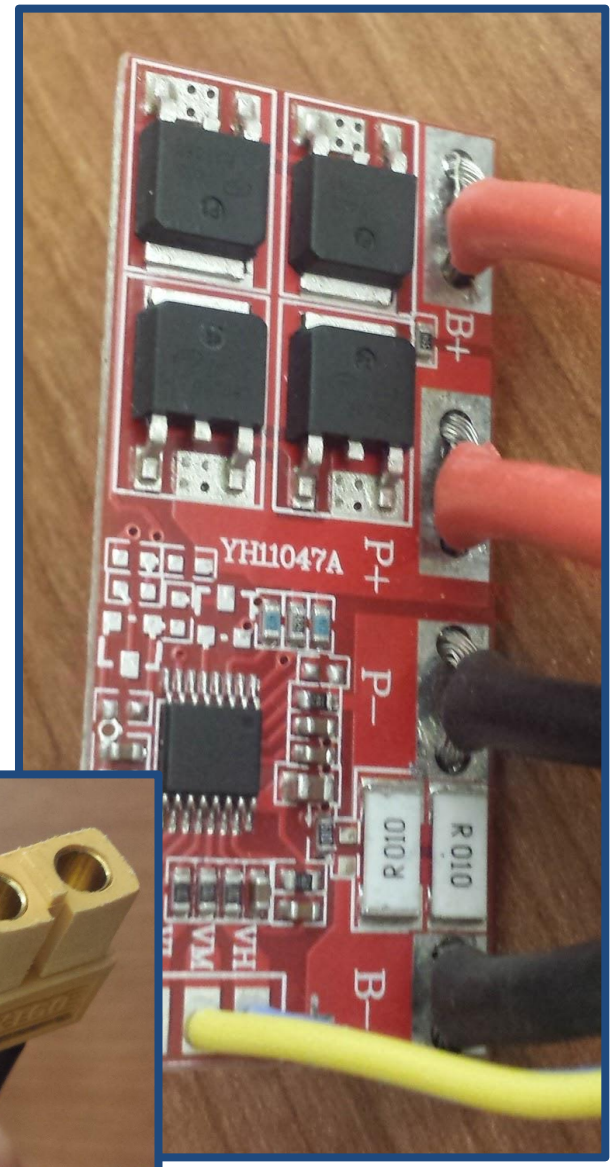
- 1A discharge for at least one hour
- Peak discharge of at least 28.2A

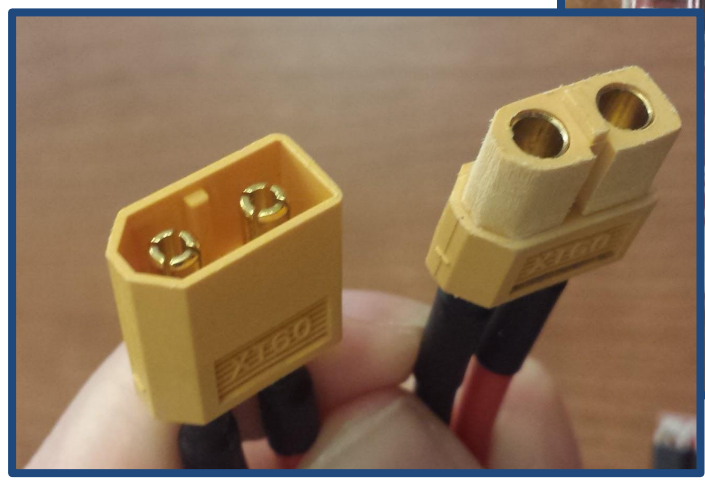


Power: LiPo Battery

Safety

- Charging circuit
  - Over charge
  - Over discharge
  - Over current
- Thermistor
  - Over heating
- XT60
  - Reverse polarity





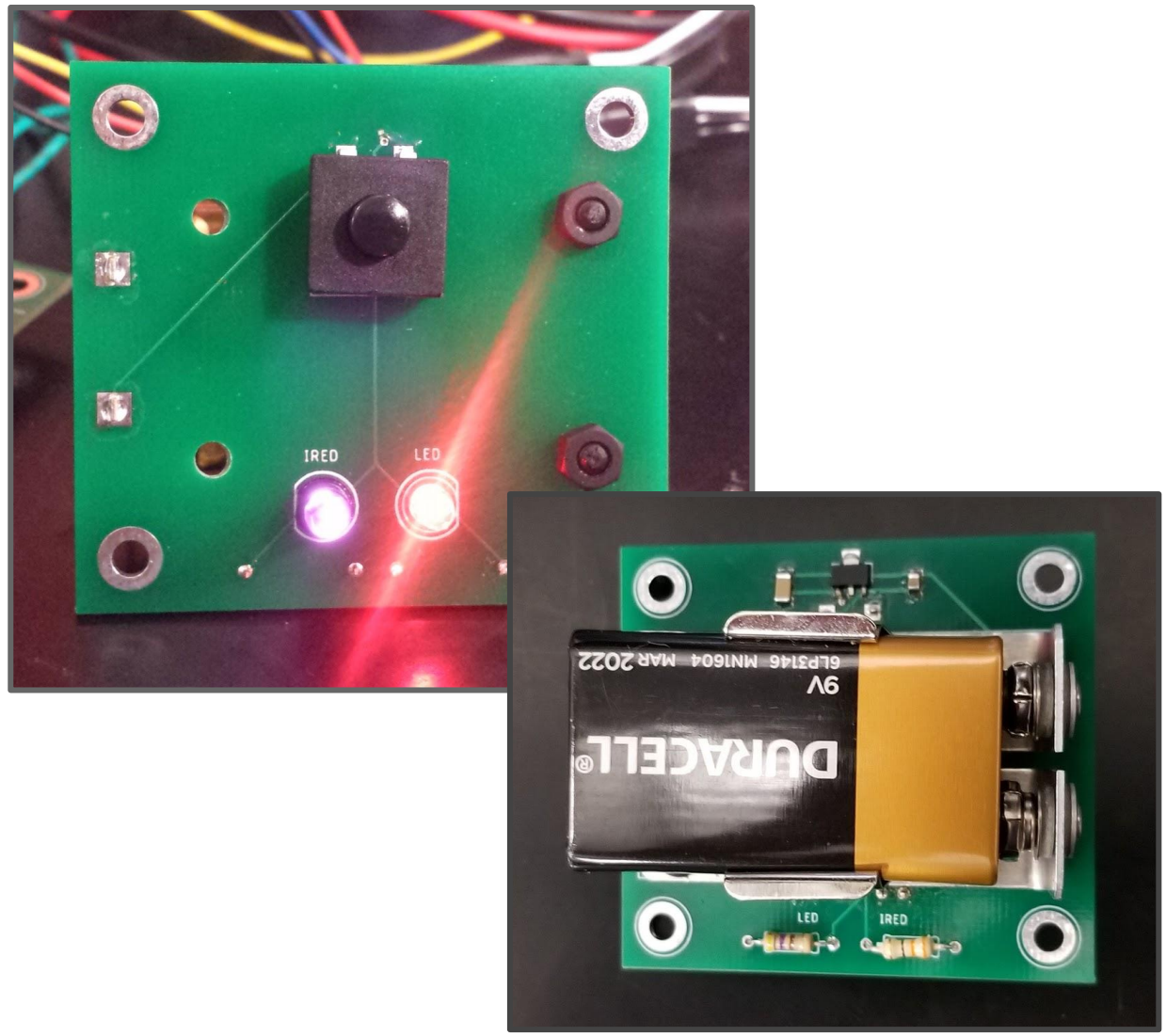
Target

Requirements

- Compact
- Long lasting

Elements

- 9V battery
- 3.3V regulator
- IR Emitter
- “On” LED



Target: IR Emitter

Requirements

- Detectable from 15 feet: 0.2028 W/sr

Concerns

- IR Eye Hazard
  - Exempt: 4 W/sr
- Retinal Thermal Hazard
  - Exempt: 18.12 W/sr

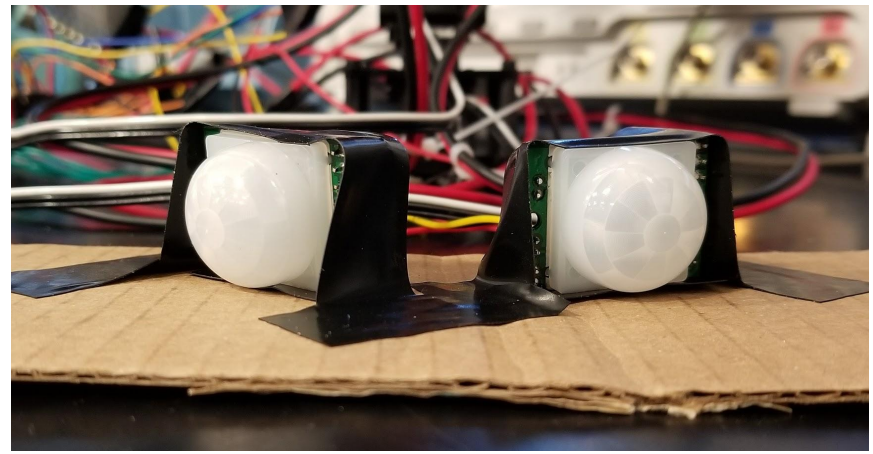
Actual Intensity: 0.297 W/sr

Tracking System Requirements

- Detect a target (IR Emitter) within 15 feet
- Signal the gun motors to fire a dart at the target once it is within 10 feet
- Be able to detect targets within a 180° horizontal range of motion

Orignal Tracking System Design

- Used the Wii Remote IR Sensor to detect the target/IR emitter
- Used PIR motion sensors to detect whether the target is within 10 feet



Math for IR Sensor

- Used linear interpolation to estimate angular displacement from a seen target's x-y coordinates
- Defined constants that related sensor's resolution with its horizontal and vertical field of view
- To find horizontal displacement:

$$\Delta\theta_h = \frac{33}{1024}(|x_{center} - x_{read}|)$$

- To find vertical displacement:

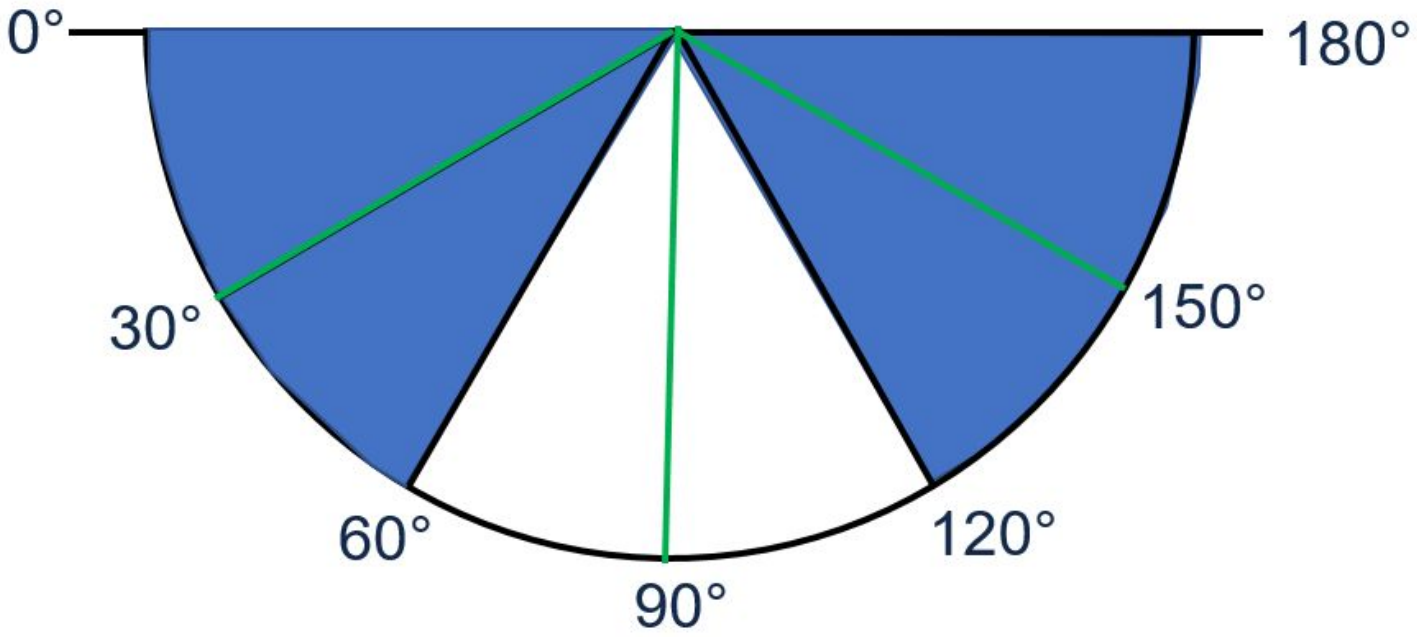
$$\Delta\theta_v = \frac{23}{768}(|y_{center} - y_{read}|)$$

Original Ideas for 180° Tracking System

- First idea: pan the 180° area looking for IR targets
  - Problem: does not detect target quick enough
- Second idea: use PIR motion sensors to detect motion in certain areas
  - Once motion is detected, signal to motors to move gun to that area

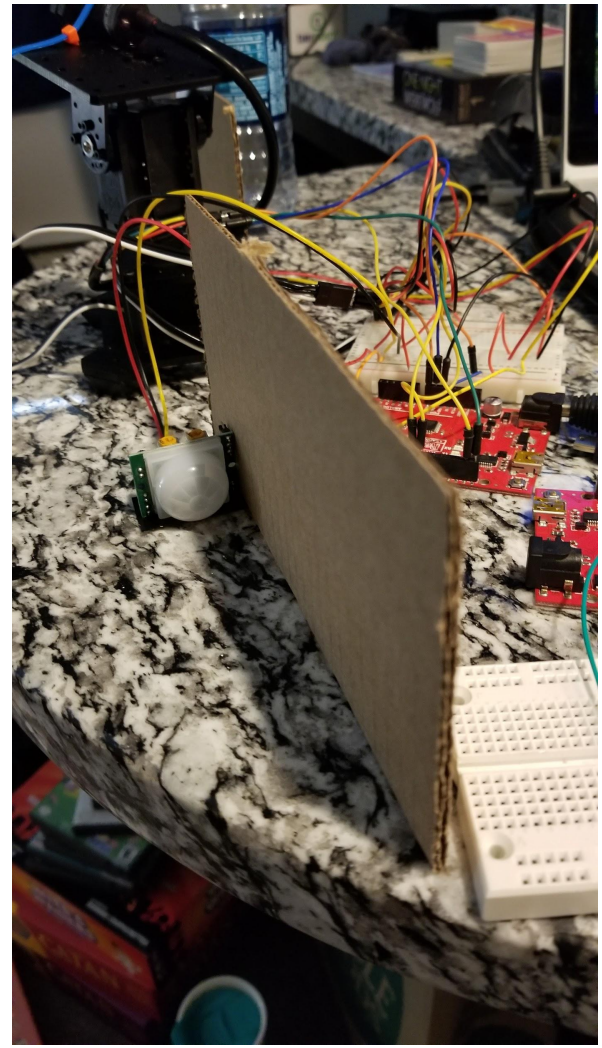
Original 180° Tracking System Setup

- Have 1 PIR Sensor on each side to cover 60° (blue areas)
- When motion is detected, move to middle of area (green lines)



Problems with Original 180° Tracking System

- PIR Sensors resulted in a lot of false positives
  - Had to build setup to limit FOV
  - Gun would get stuck in cycle of trying to go to both areas

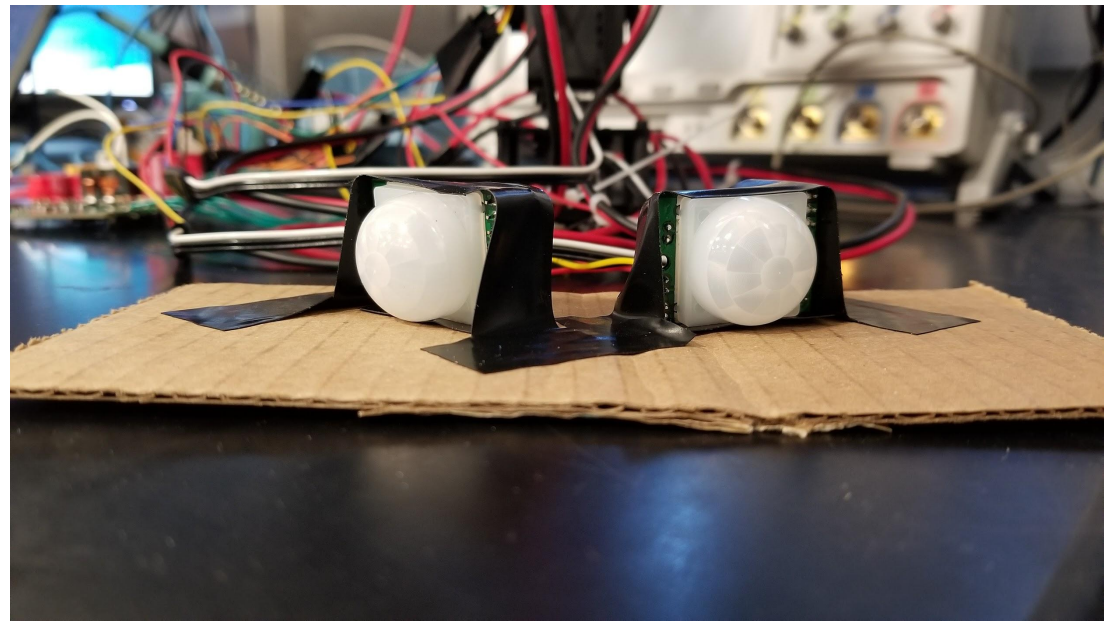


New Idea for 180° Tracking System

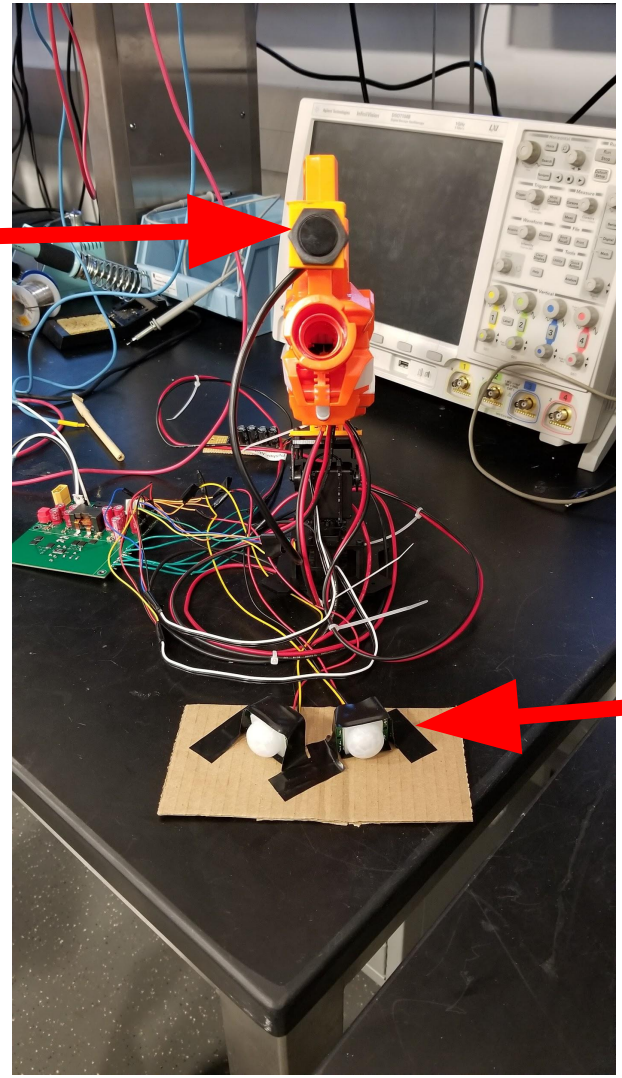
- Problem: Gun is heavy, very jerky movements
- Solution:
  - We chose accuracy over speed
  - Switched back to the panning solution
  - Pan the 180° area and stop when IR emitter is detected

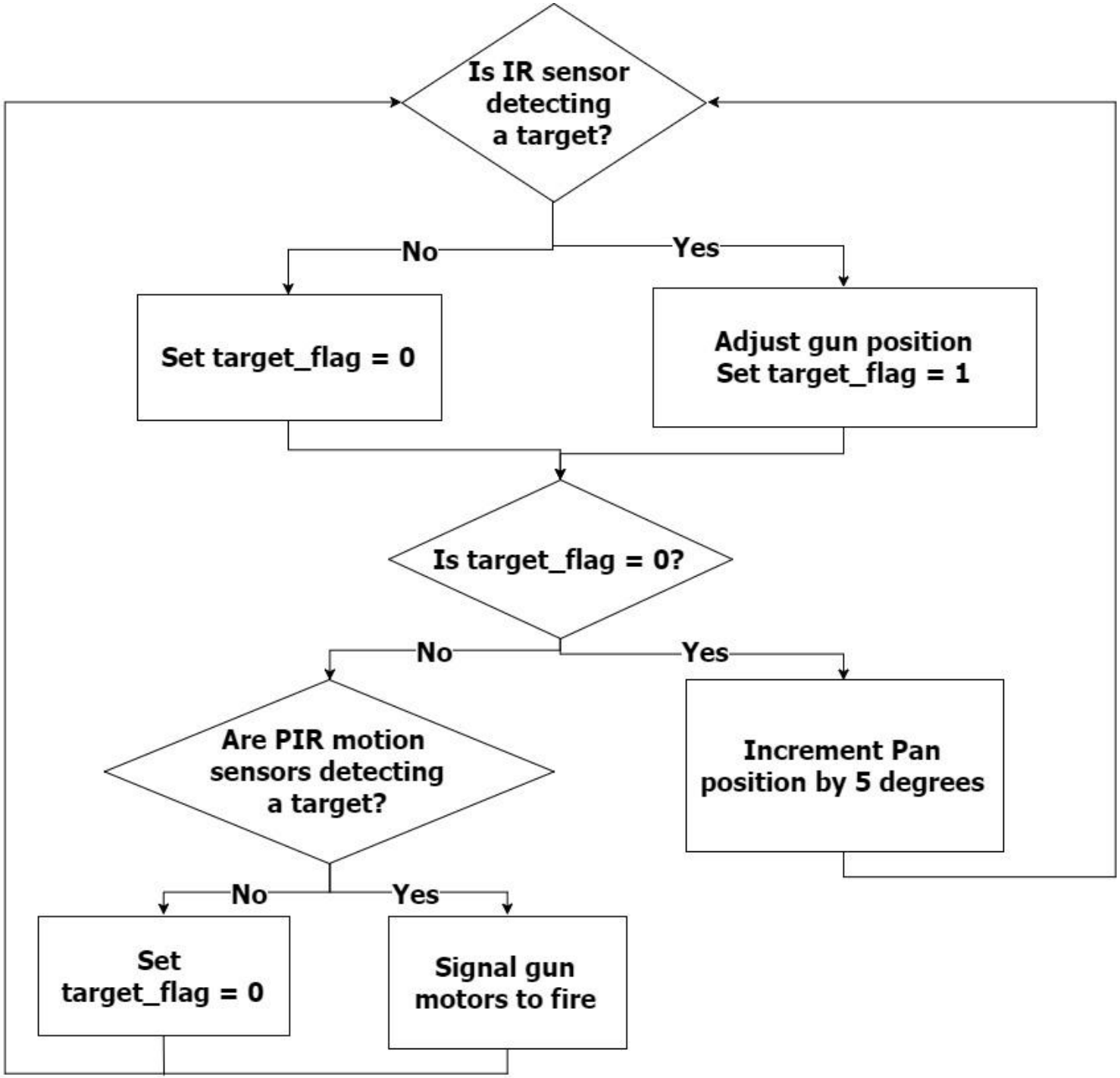
Final Implementation of PIR Motion Sensors

- Horizontal FOV is 110°, Vertical is 70°
- Used 2 Sensors to cover entire 180° range of motion
- Used minimum sensitivity and minimum timeout
  - Range ended up around 10 ft.

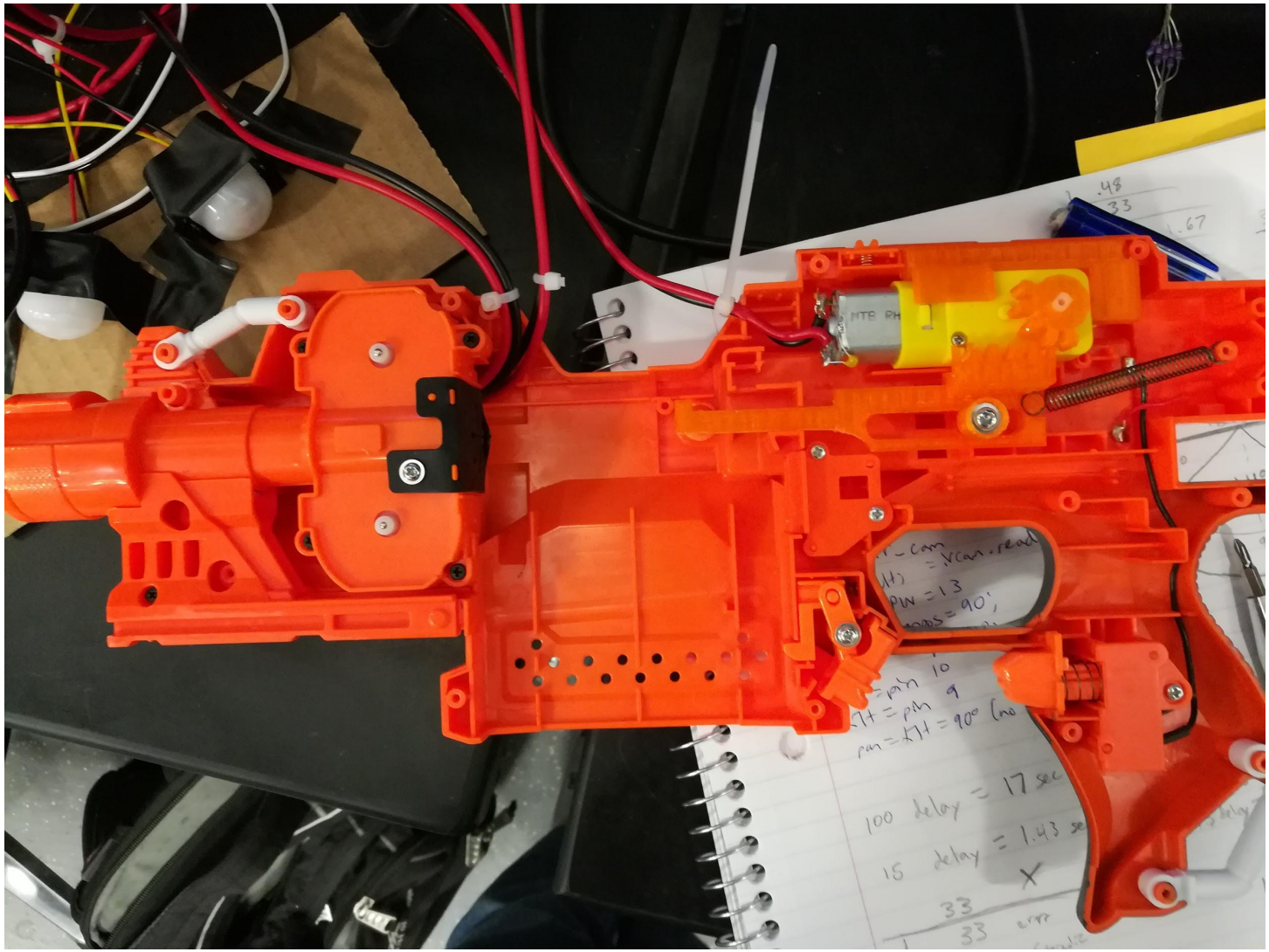


Final Tracking System Physical Design




Is IR sensor detecting a target?
No
Yes
Set target_flag = 0
Adjust gun position
Set target_flag = 1
Is target_flag = 0?
No
Yes
Are PIR motion sensors detecting a target?
Increment Pan position by 5 degrees
No
Yes
Set target_flag = 0
Signal gun motors to fire

Firing Mechanism



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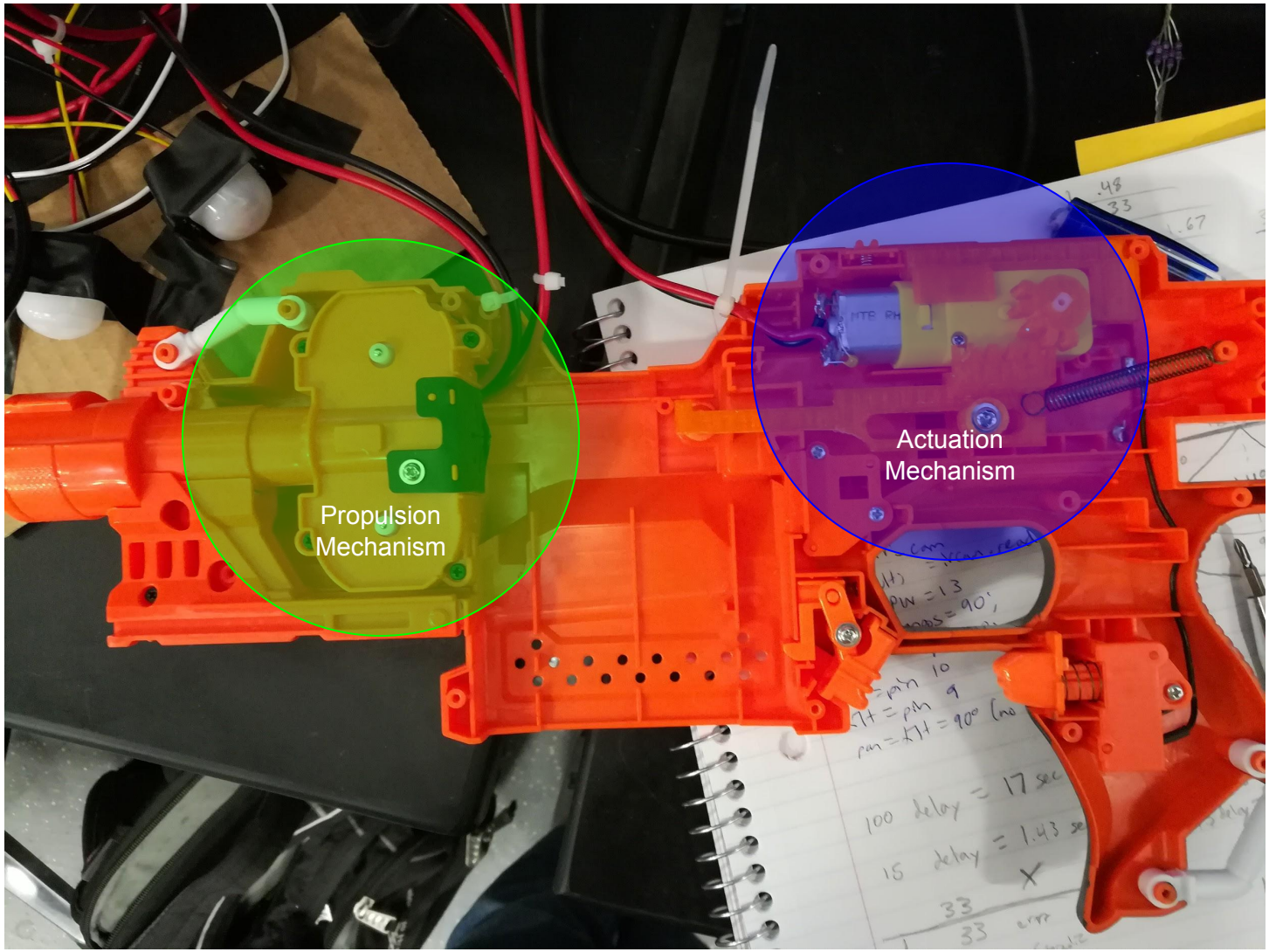

Firing Mechanism Rate of Fire Testing

Firing System Initial Test

Software for Firing Mechanism

- Once the target is detected within 10 feet:
  - Begin rotating top and bottom motors
  - Rotate pusher motor until exactly 1 dart is pushed out
  - Stop rotating top and bottom motors once dart is fired

Motor Interference Problem

- When running, DC motors generated electrical noise
- This noise interfered with the microcontroller, especially the servos
- To remedy this, we added noise-reducing capacitors to the motors and minimized run times of motors

Ethical Issues

- IEEE Code of Ethics #9
  - Projectile has potential to harm people
  - Solution: Clear area when using gun
- IEEE Code of Ethics #1
  - Dangers of moving parts including gun and motors
  - Solution: disclose possible dangers to user

Conclusion

- Capable of detecting and tracking the target at 15 feet
- Fires at the target as it approaches 10 feet
- Future improvements
  - Reduce size
    - Design original case for the firing mechanism
  - Improve accuracy
    - Use a different type of projectile
    - Implement more powerful servos
    - Replace the PIRs with a less noisy alternative

Thank You!