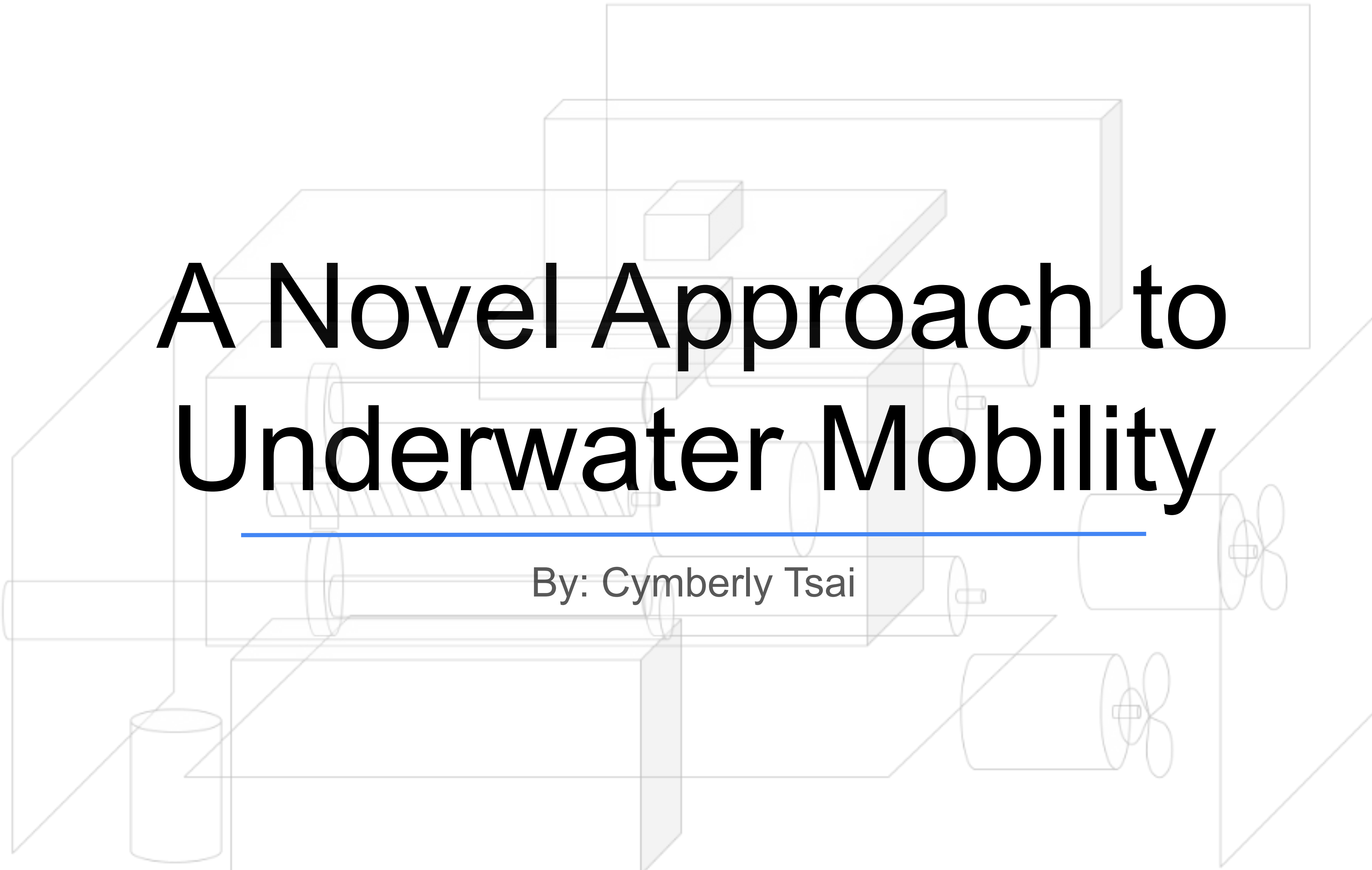
A Novel Approach to Underwater Mobility

By: Cymberly Tsai



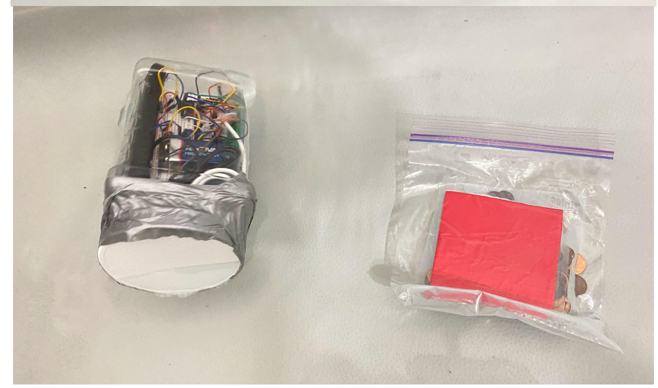
Introduction

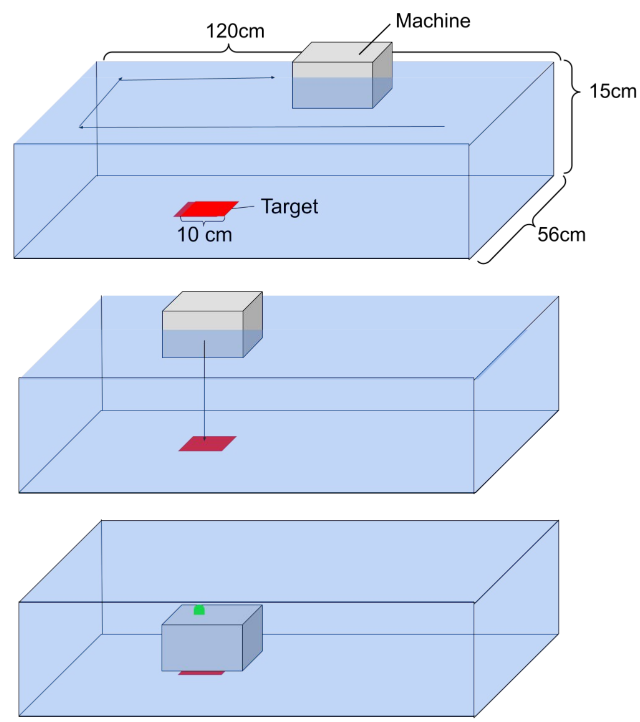
Rationale

- Challenges of aquatic environment
- Applications of submersible device
  - Marine life research
  - Underwater mechanical repair
  - Aquatic rescue
- Underwater Mobility Unit

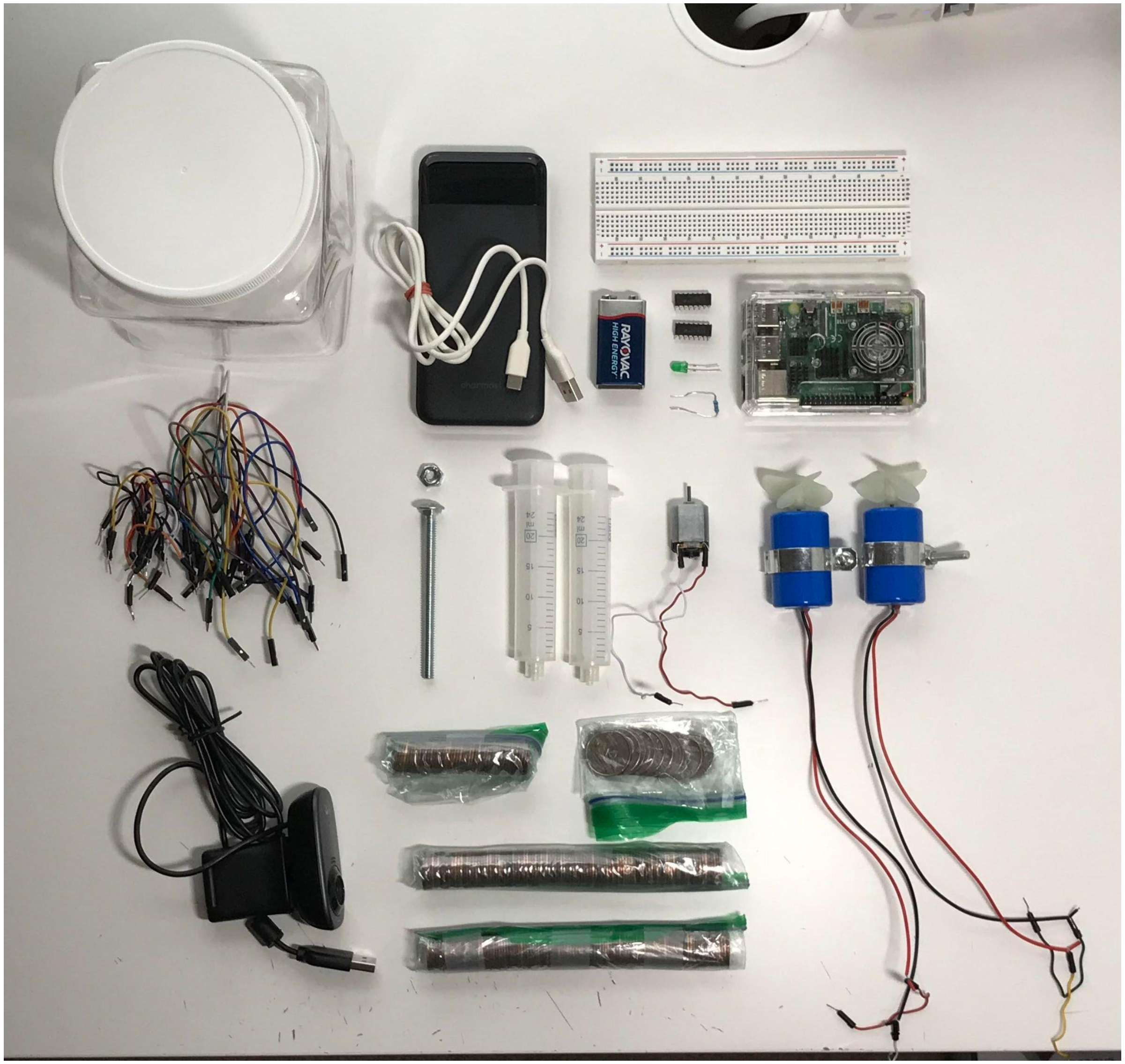
Engineering Goal: To create a machine

- Capable of 3-dimensional underwater movement
- Detect a red 10 cm^2 target in an 120x56 cm^2 area underwater area
- Land on target and signal LED light





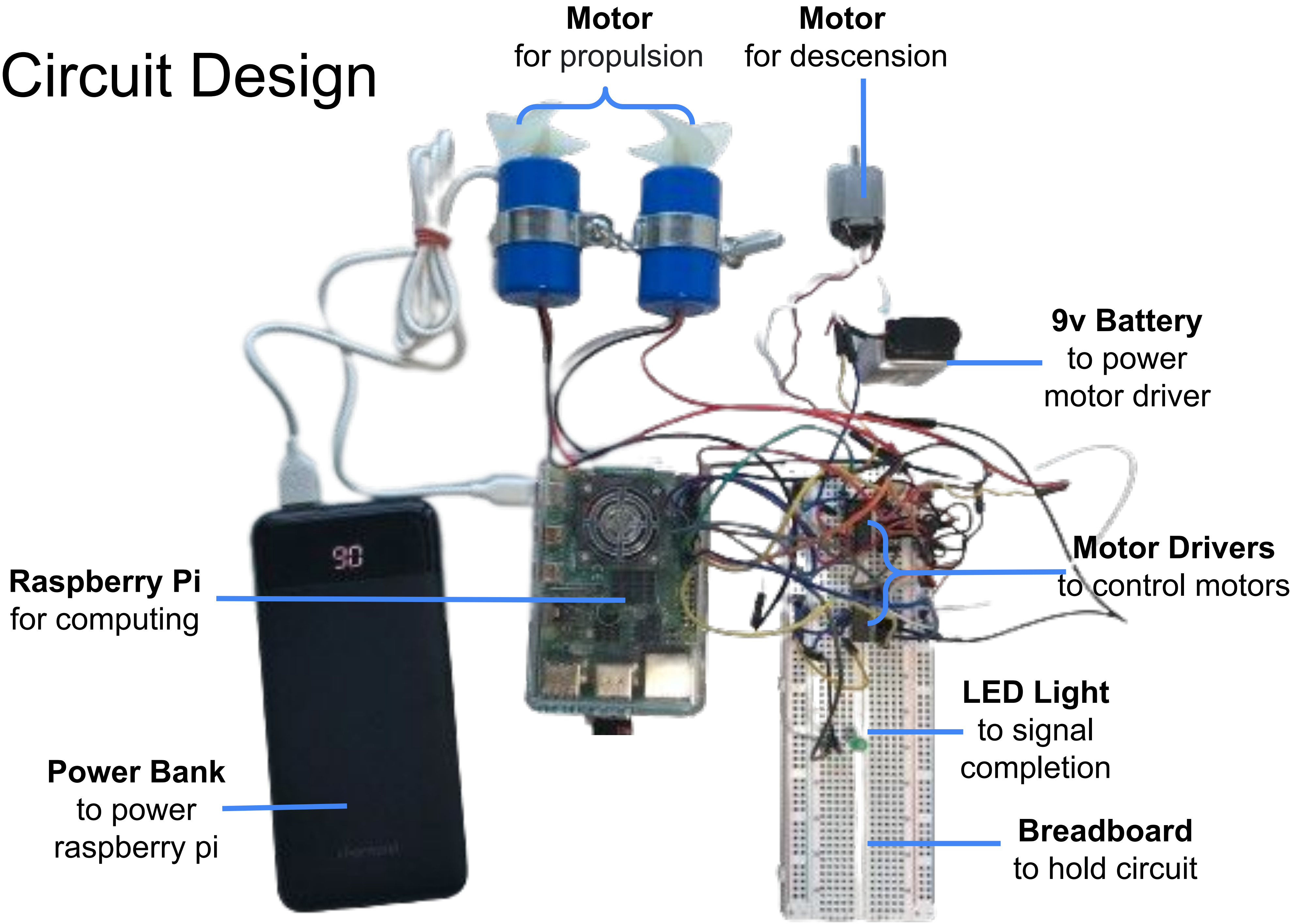
Materials



- Raspberry Pi 4
- Breadboard
- Motor Drivers (L293D)
- DC Motors
- Plastic Container
- Syringes
- Nut and Bolt
- LED Light
- 9v Battery
- Power Bank
- Webcam
- Coins

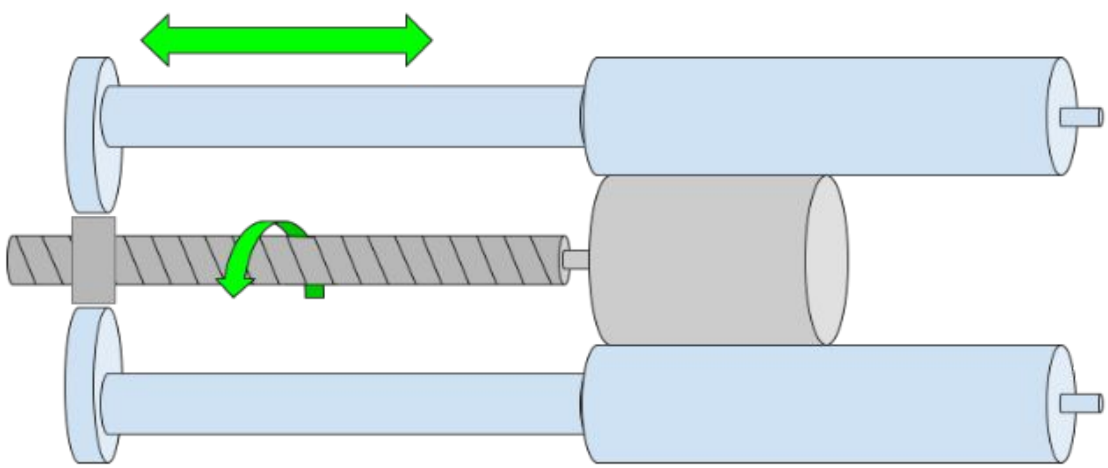
- Python 3.7
- Open CV
- NumPy

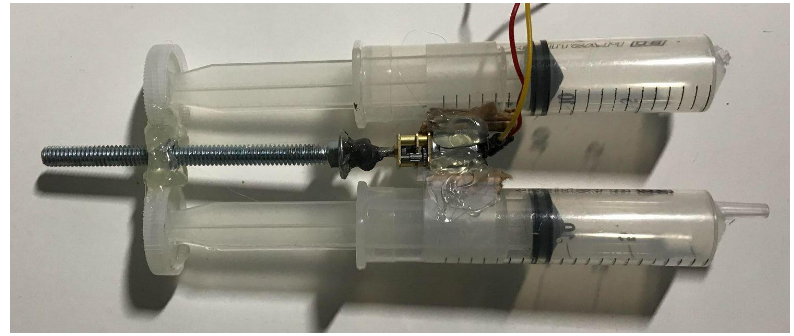
Circuit Design

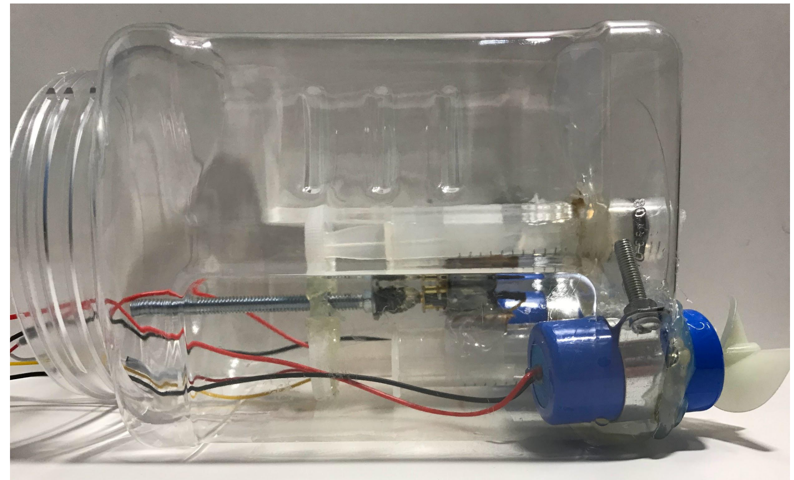


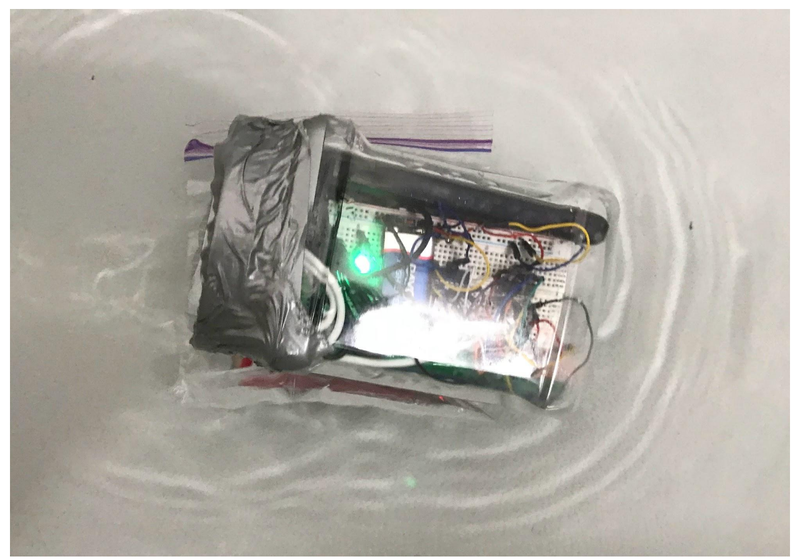
Descension Mechanism

- Density of object must be greater than density of water to sink
  - $D = M/V$
  - Density of Water ≈ 1.00 g/ml
- Original Density of Machine < 1.00 g/ml
  - Mass of Machine = 1780 g
  - Volume of Machine = 1815 ml
- Mass Added = 40 ml
  - New Density > 1.00 g/ml

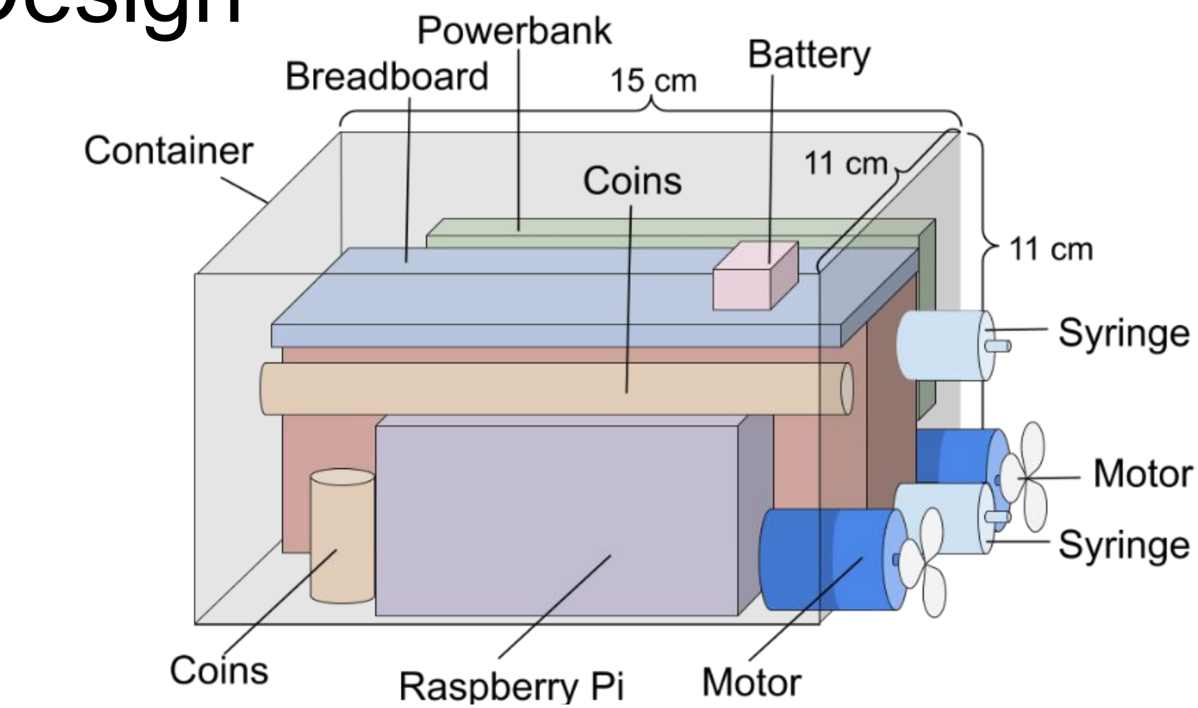


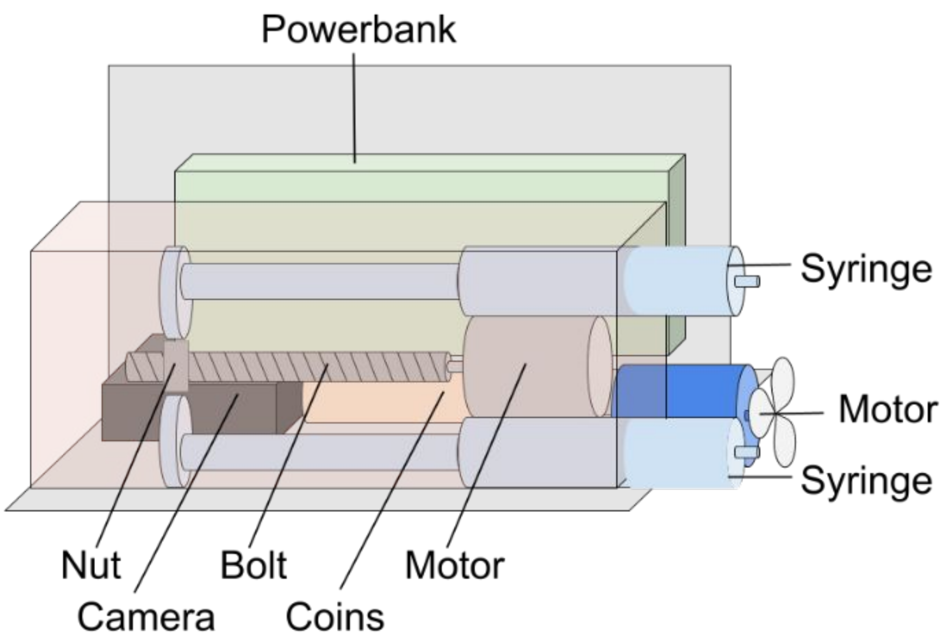


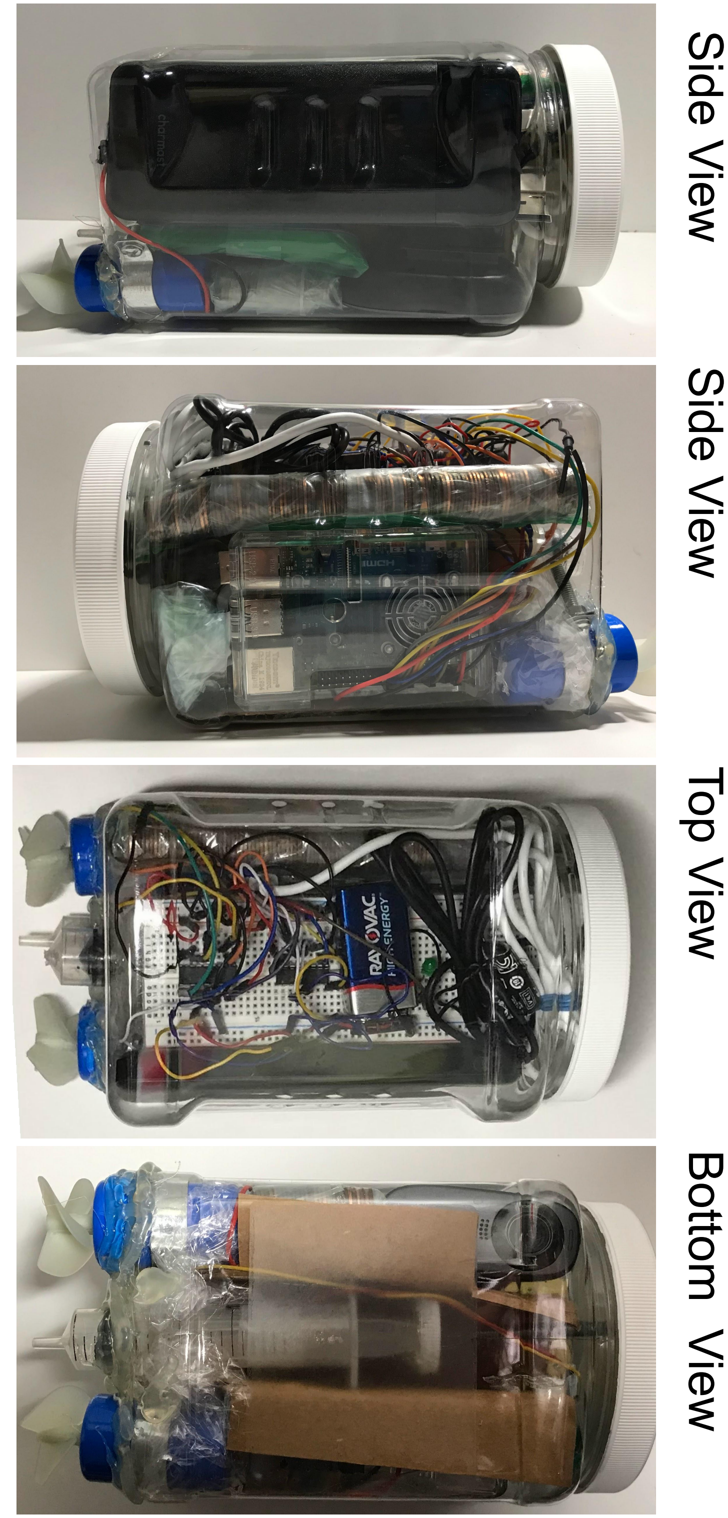




Design


Powerbank
Breadboard
15 cm
Battery
Container
Coins
11 cm
11 cm
Syringe
Motor
Syringe
Coins
Raspberry Pi
Motor


Powerbank
Syringe
Motor
Syringe
Nut
Bolt
Motor
Camera
Coins

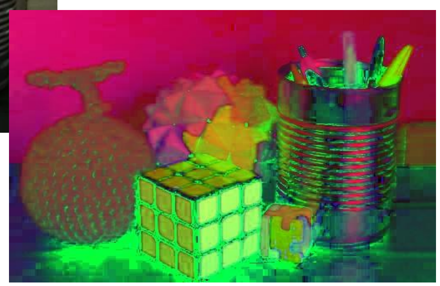

Side View
Side View
Top View
Bottom View

Detection Script

- Convert image to HSV values
  - Hue Saturation Value

Original Image

HSV Image



- Filter out values out of range
- Check for values within range

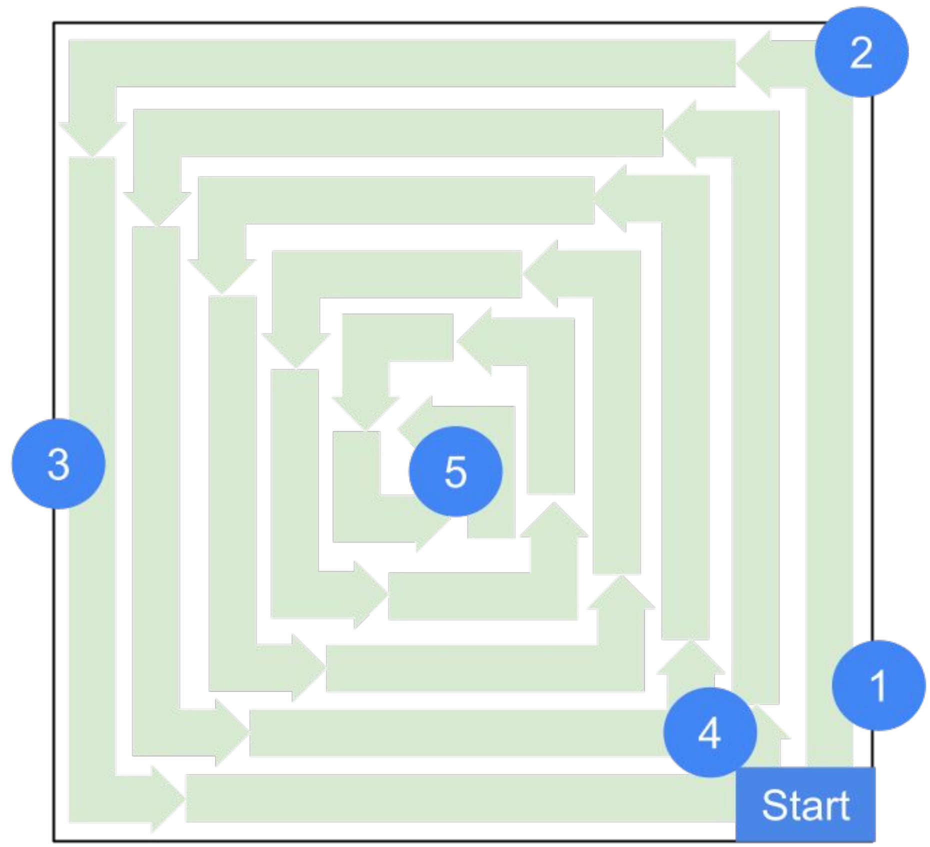
Masked Image

```python
# Define HSV values
redMin = np.array([0, 70, 50])
redMax = np.array([10, 255, 255])

# Set condition
found = False
while not found:

# Read image from camera
_,img = cam.read()

# Convert image to HSV
hsv = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)

# Filter for red in image
mask = cv2.inRange(hsv, redMin, redMax)

# Search for red in image
for i in range(0, len(mask), 50):
    for n in range(0, len(mask[i]), 50):
        if mask[i][n] == 255:
            found = True
```

Search Method

- Fastest pattern to cover area
  - 5 seconds per decimeter
  - 4 seconds per 90 degree turn
- Always choose next best move
- Start from close-right corner

1. Straight line along length
2. Single 90 degree turn
3. Repeat for three sides
4. Decrease length for fourth side
5. Repeat in concentric rectangles

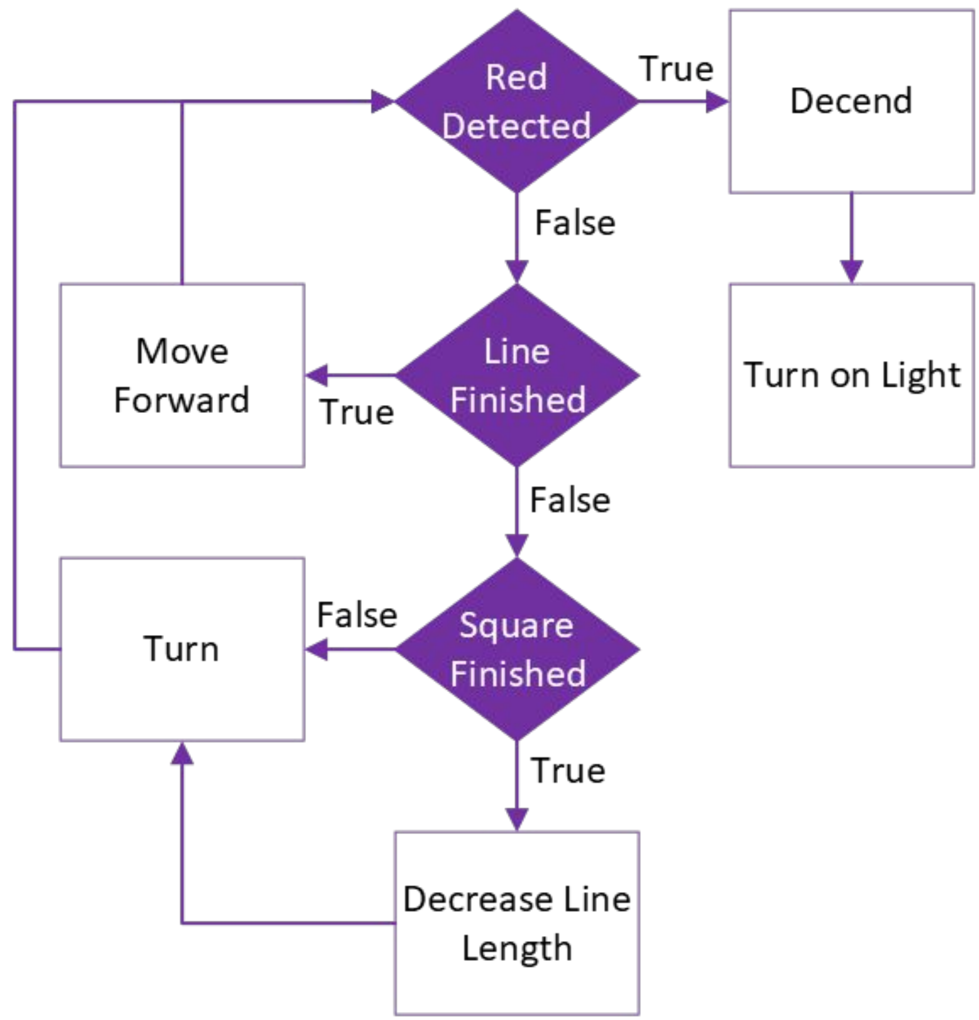


Implemented Process

Program Pseudocode

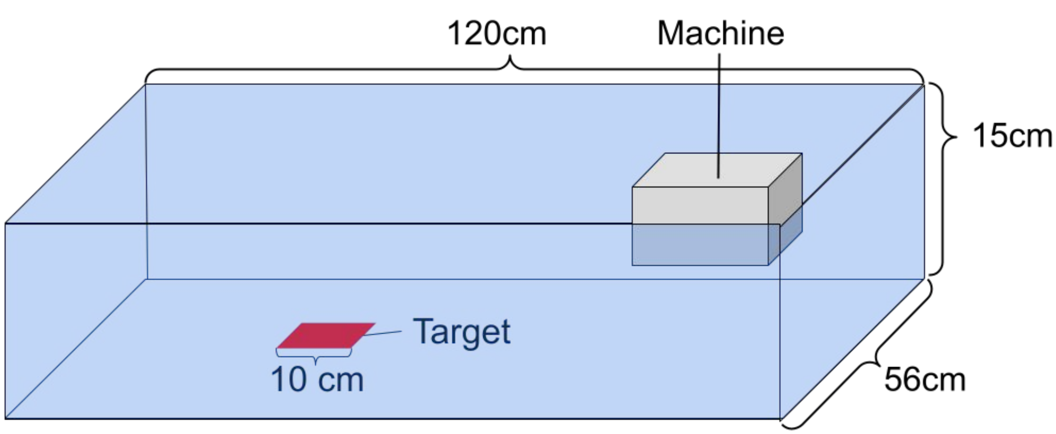
```
Setup output pins
Define variables for speed, lengths,
square side, line progress, found
status
While no red found
    Check for red
    If no red
        If line progress < length
            Both motors on
            Increase line progress
        Else
            If square side < 4
                One motor on
                Increase square side
            Else
                 One motor on
                 Set square side to 0
                 Decrease line length
            Set line progress to 0
Descension motor on
Light on
```

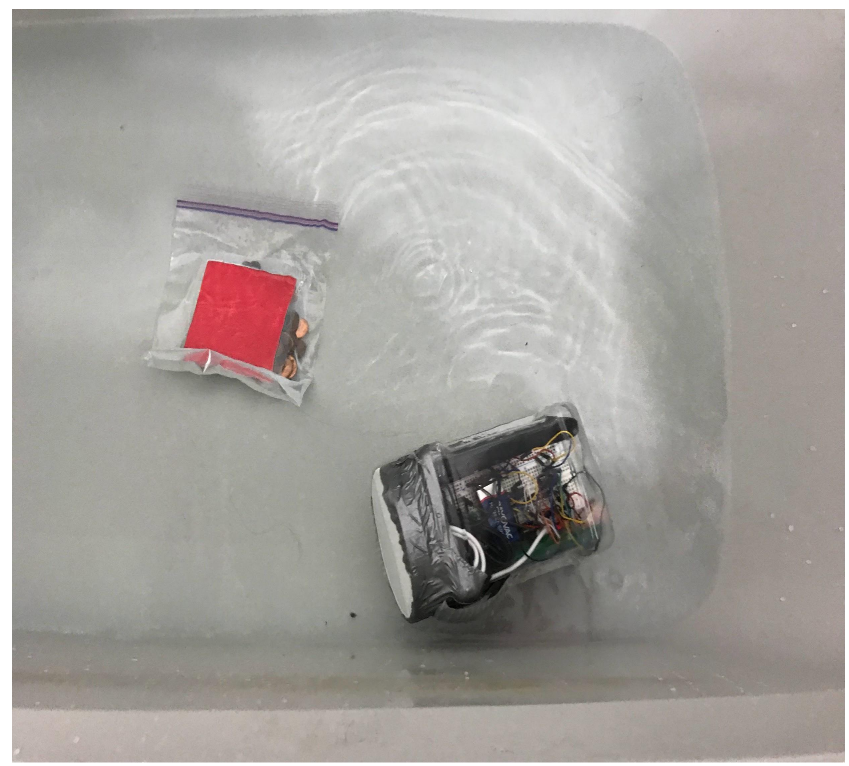
Program Flowchart



Procedure

1. Place target at random location at bottom of area
2. Place machine at close-right corner at surface of area
3. Initiate program
4. When light turns on, record machine contact with target
5. Repeat steps 1 through 4 ten times





Conclusion

Results

- 7 successes, 3 failure
    - Some water disturbance and poor turning
- Overall success

Limitations

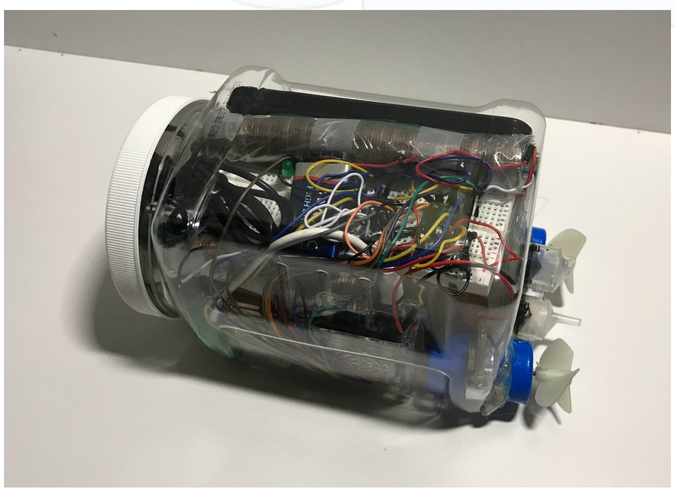
- Time consuming
- Poor turning mechanism

Possible Improvement

- Wider scope of camera
- More stability
- More efficient turning

Further Investigation

- Larger test area
- Varying target
- Faster methods of mobility



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