

Ball Balancing System

第五組

組員：張祐誠 蘇家弘

高坤宇 施君瀚

Reference



Result



Hardware

- MG996R * 2

- Control the plate
 - torque: 9.4kg*cm(4.8V)
 - Operating speed:
0.19sec/60degree (4.8v)



- Logitech c270

- Image recognition
 - resolution: 1280*720 [pixel]
 - fps: 30



- Flashlight ELF C2

- Enhance recognition accuracy



- DIY universal joint

- Made by 3D printer
 - Reduce 1 mobility comparing to ball joint

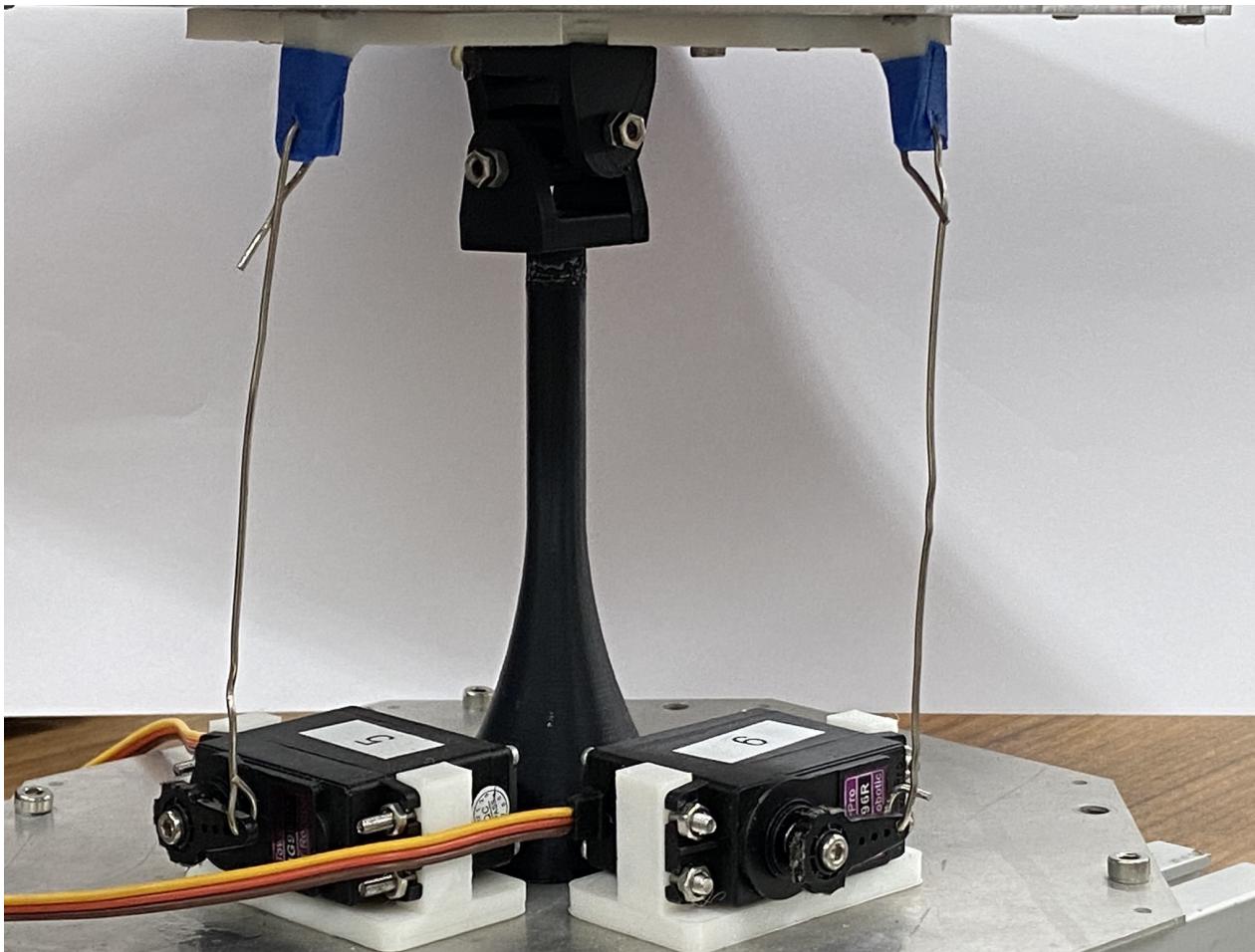


- Aluminum extrusion



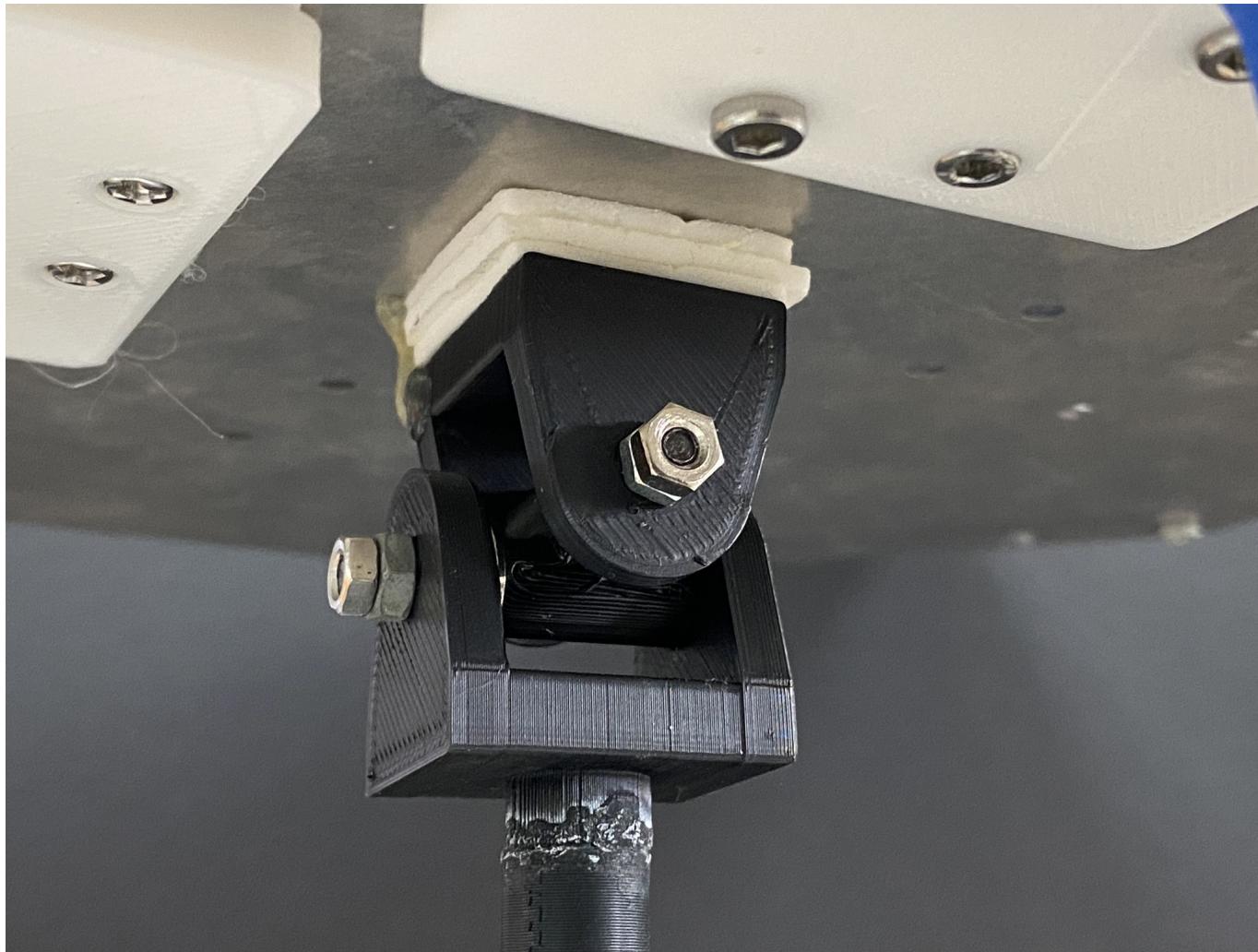
Detail

Instead of using glue and tape, we used screws to fix nearly every part in the system.

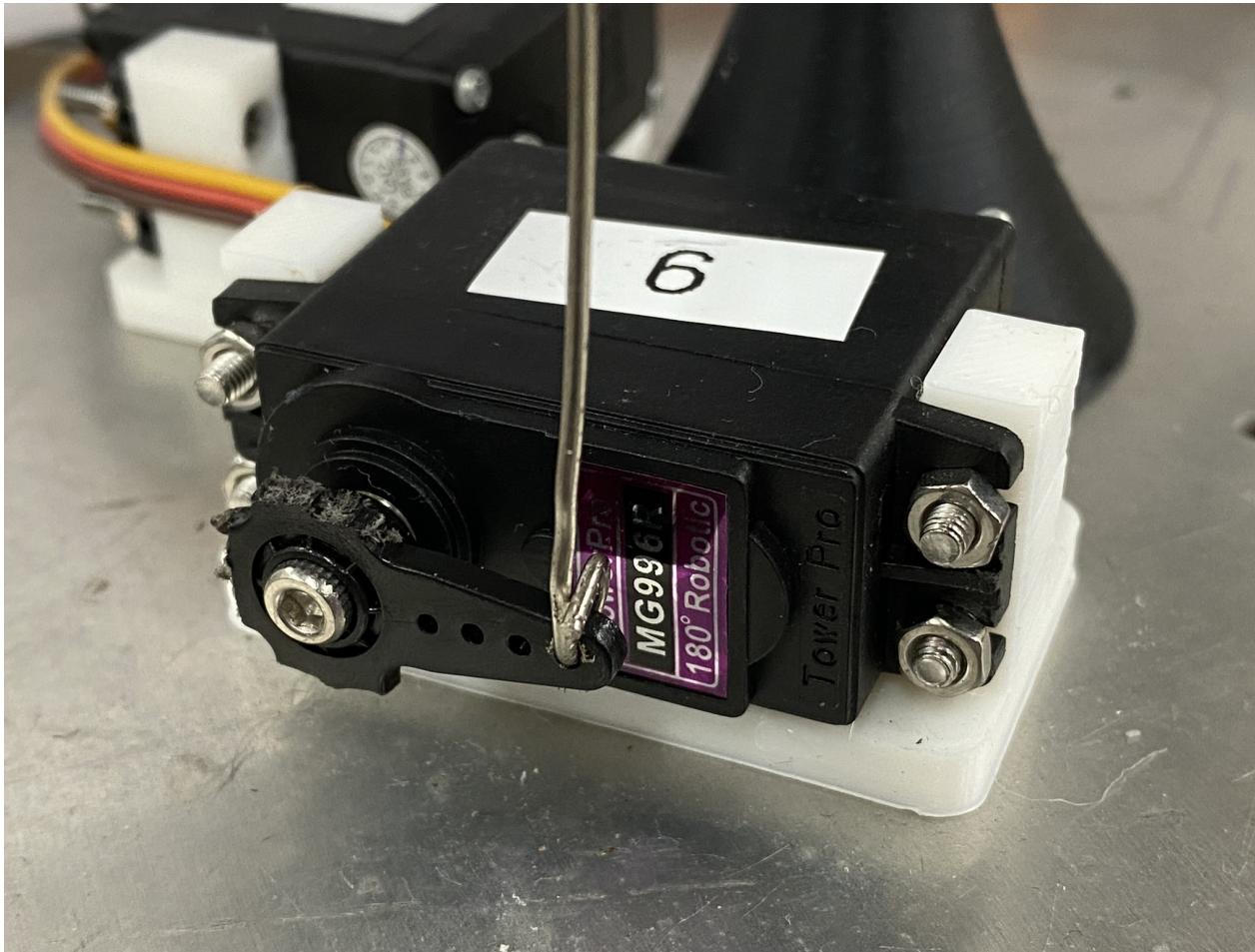


Detail

The bolt we used was attached with tape to reduce friction.

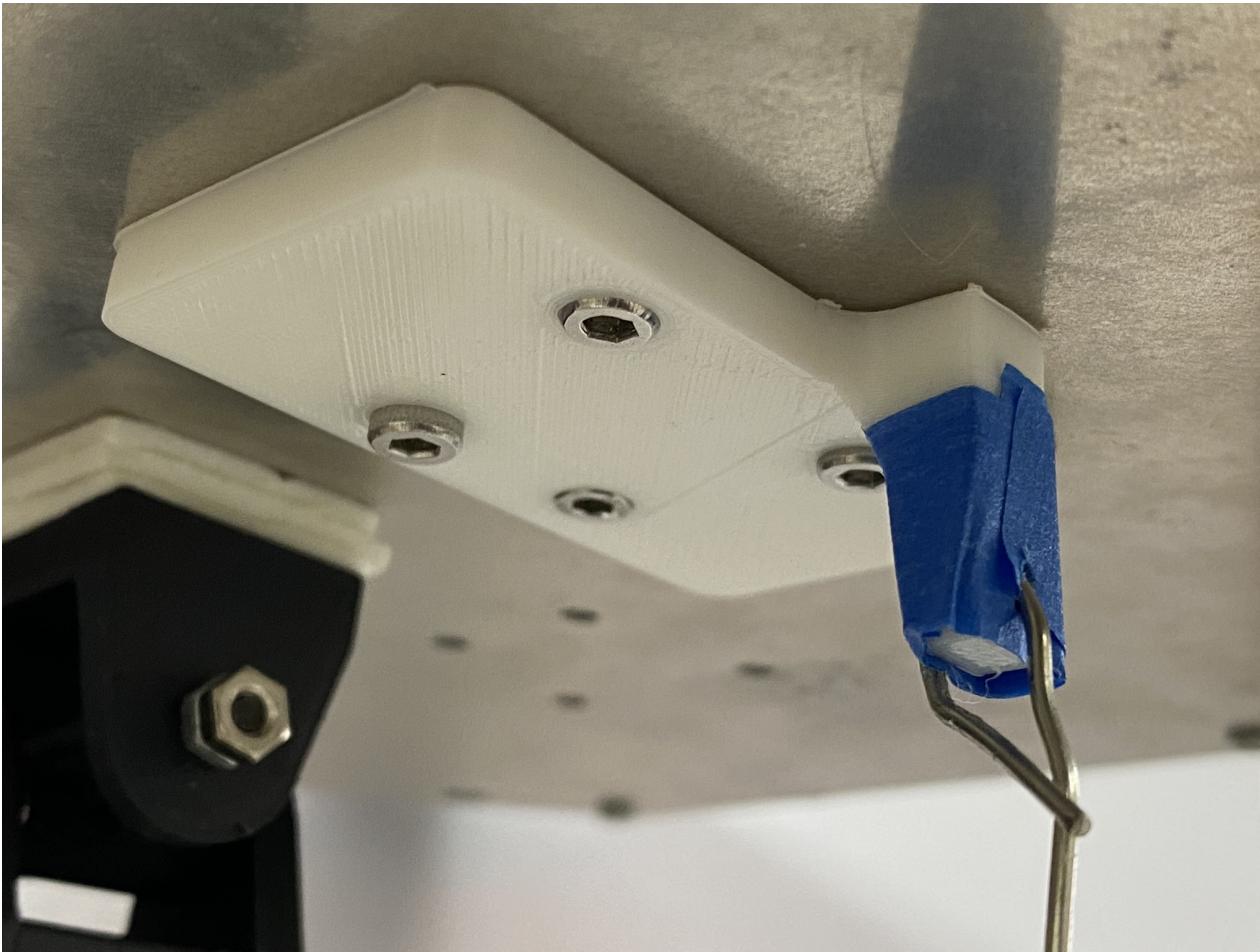


Detail



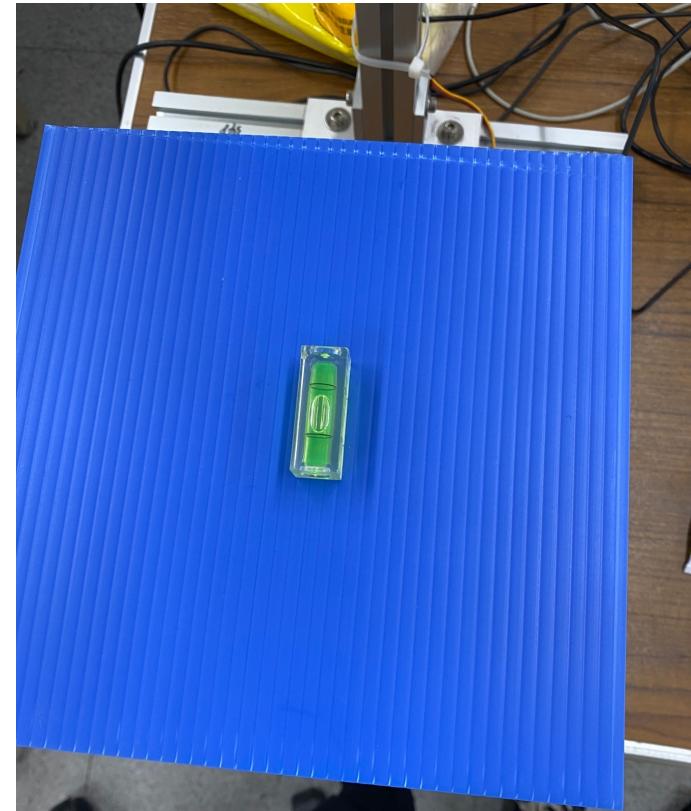
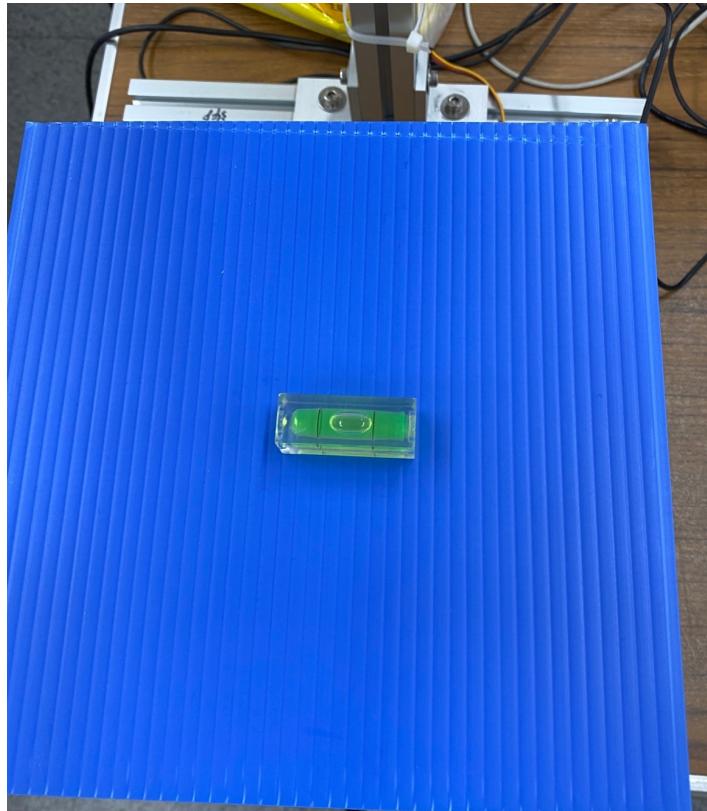
Detail

The tape is used to lower the friction and filled out the space of the clips and the joints.



Detail

The plate on each direction is carefully balanced by bending the clip connecting the servos and the plate.

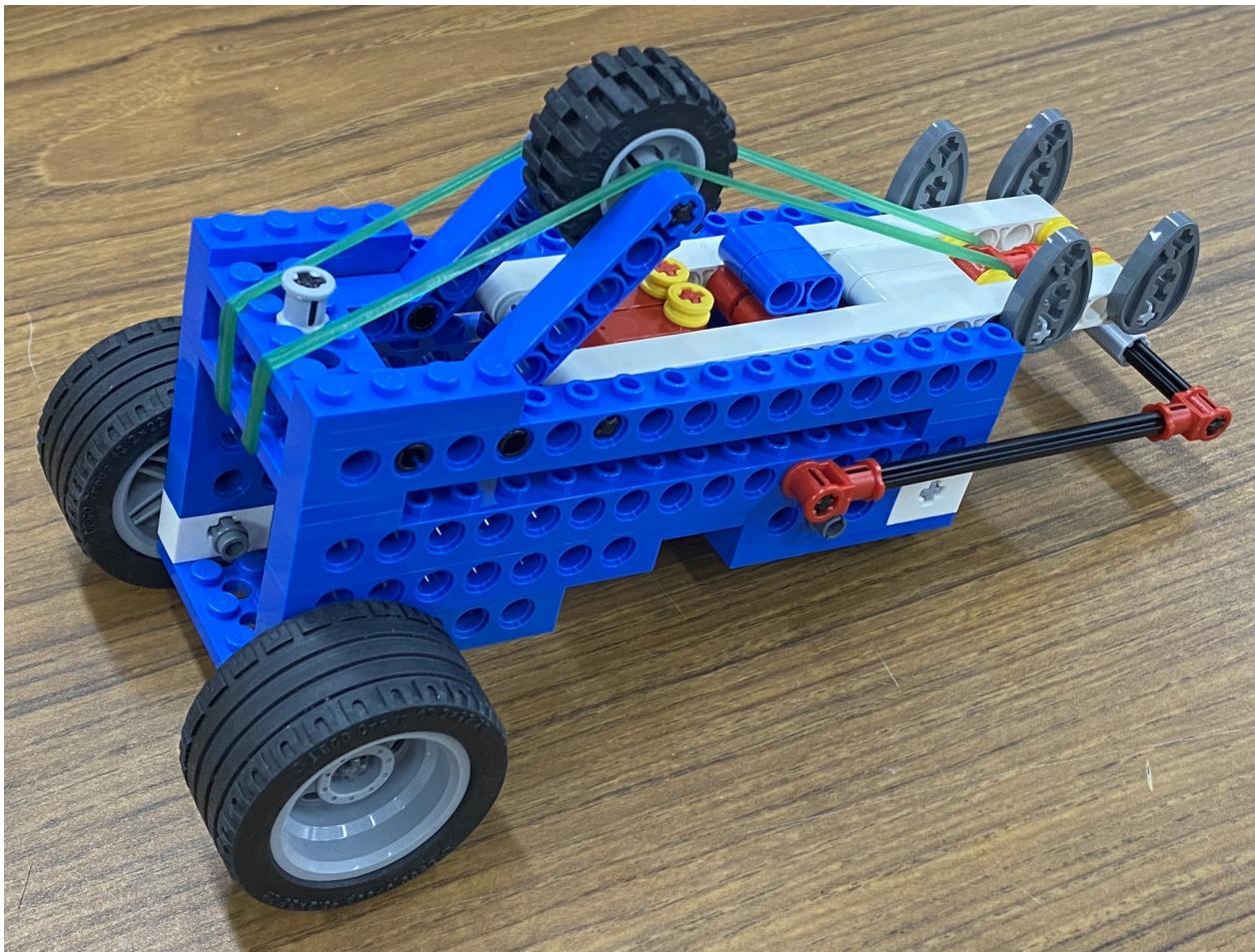


Detail

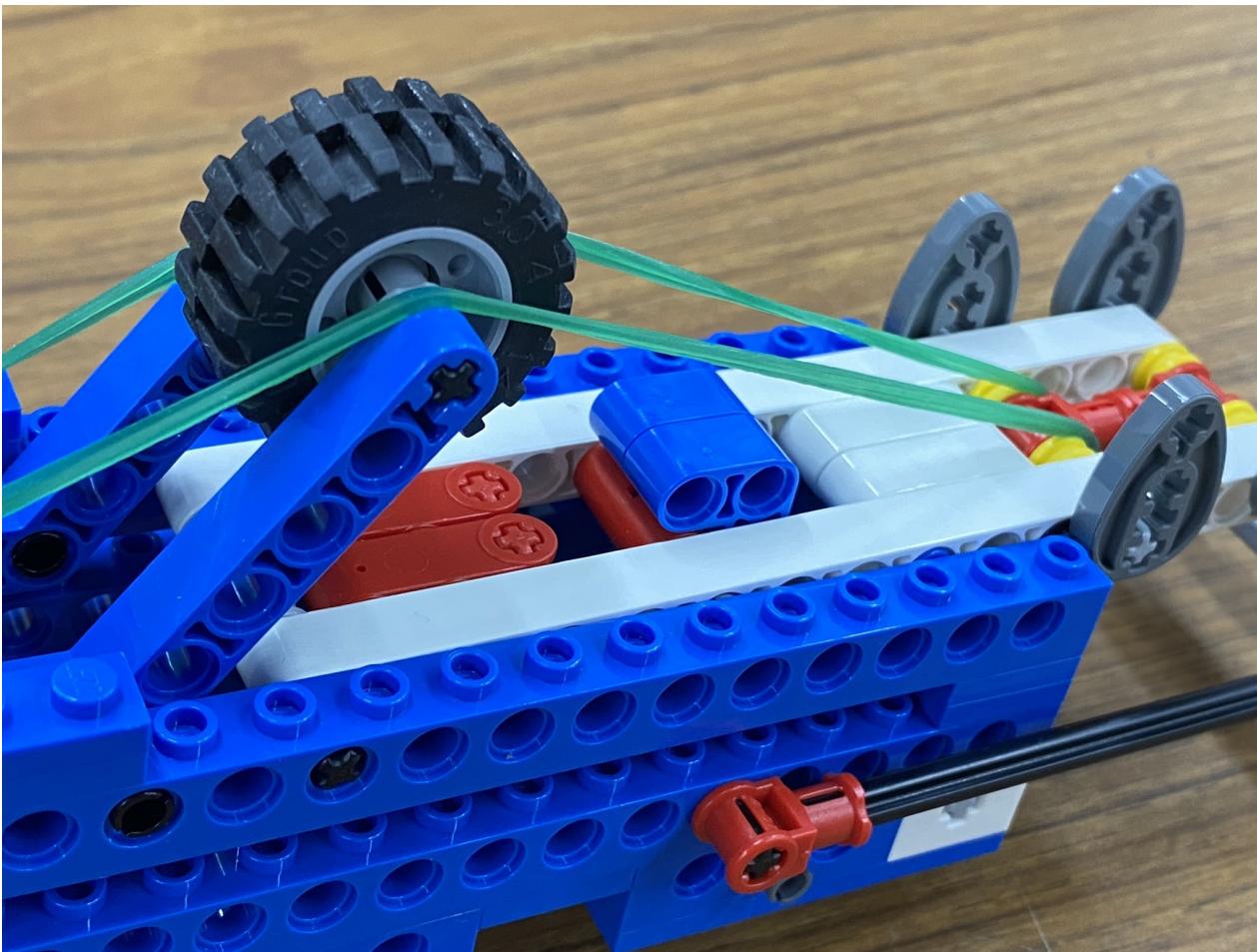
Flashlight is used to improve the precision of image recognition.



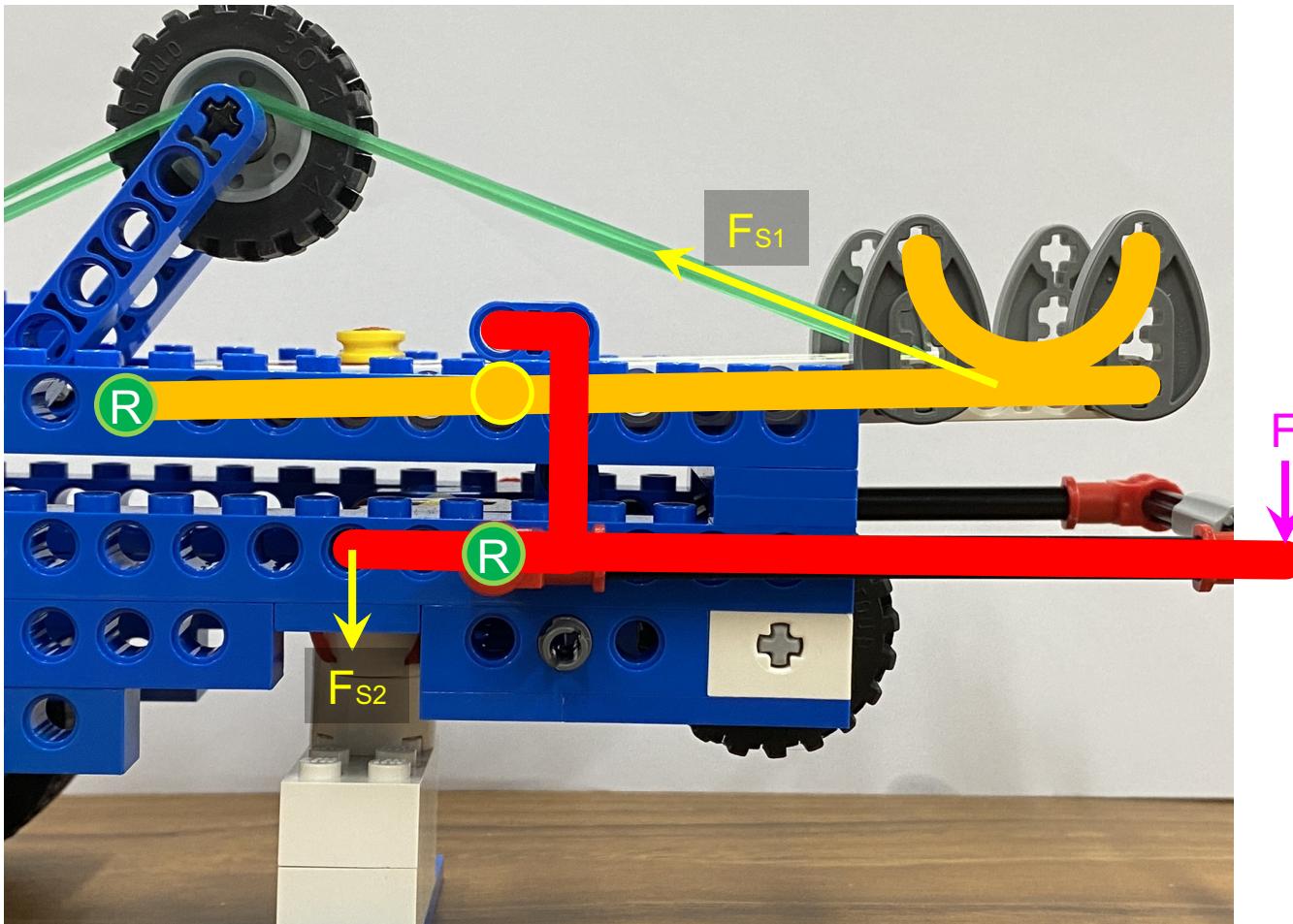
Ball Launcher



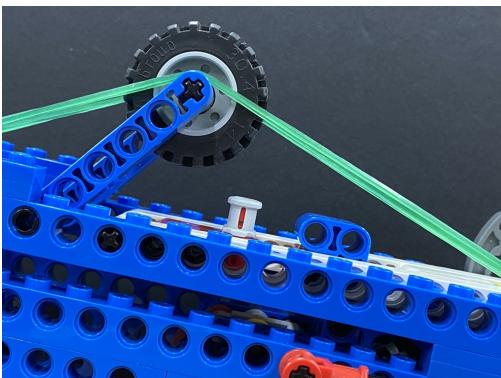
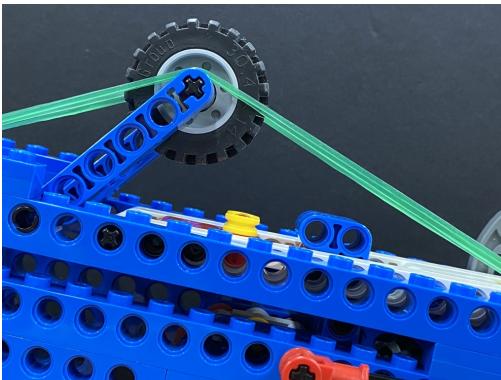
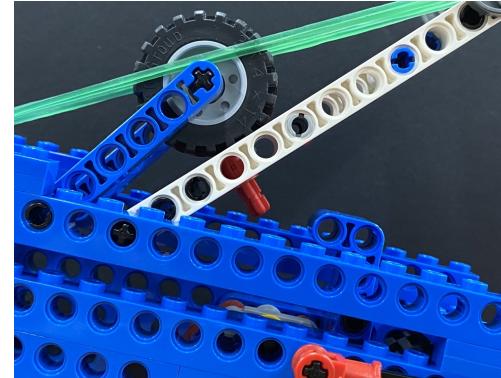
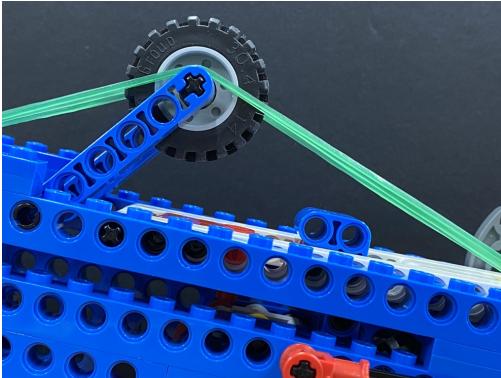
Ball Launcher



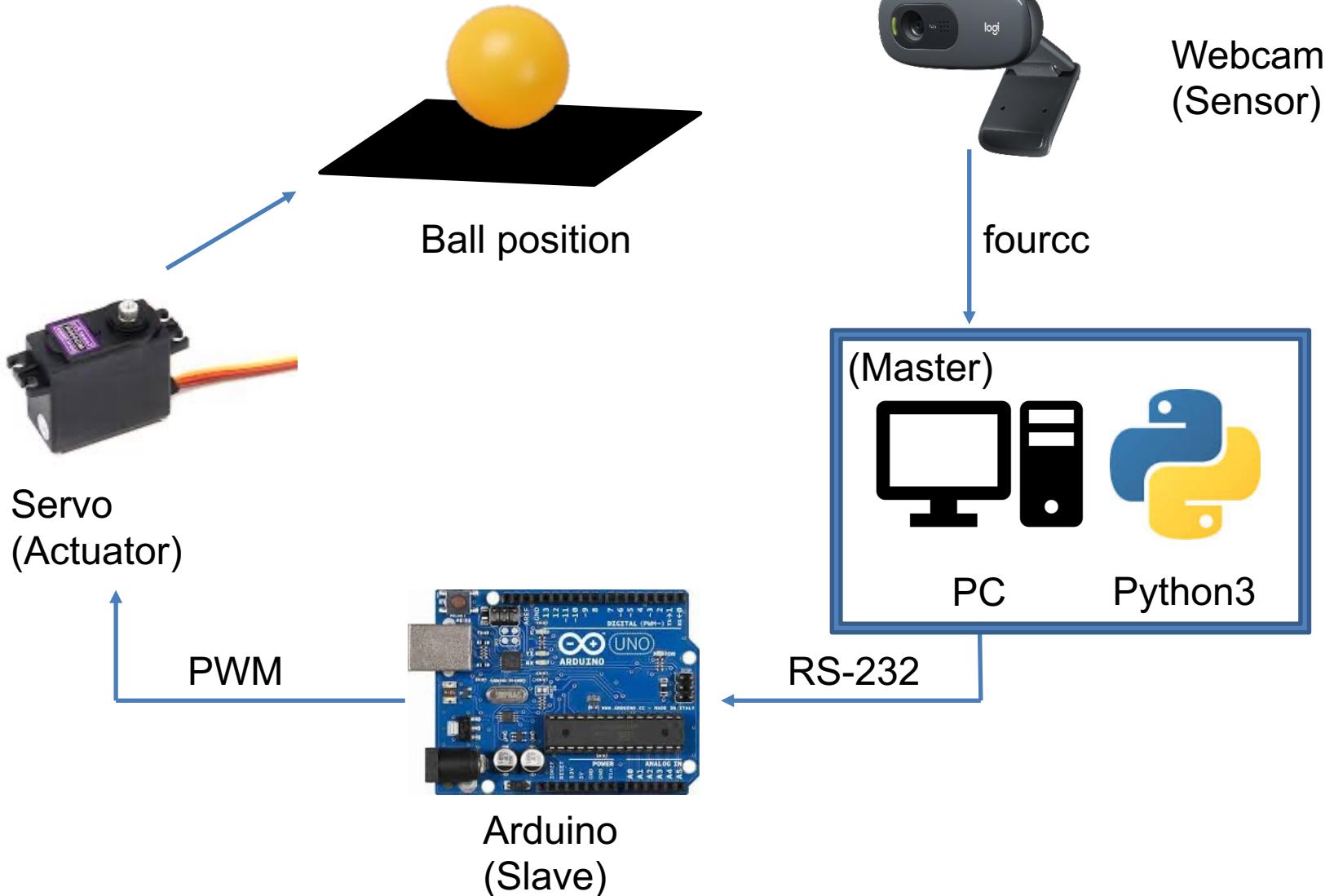
Ball Launcher



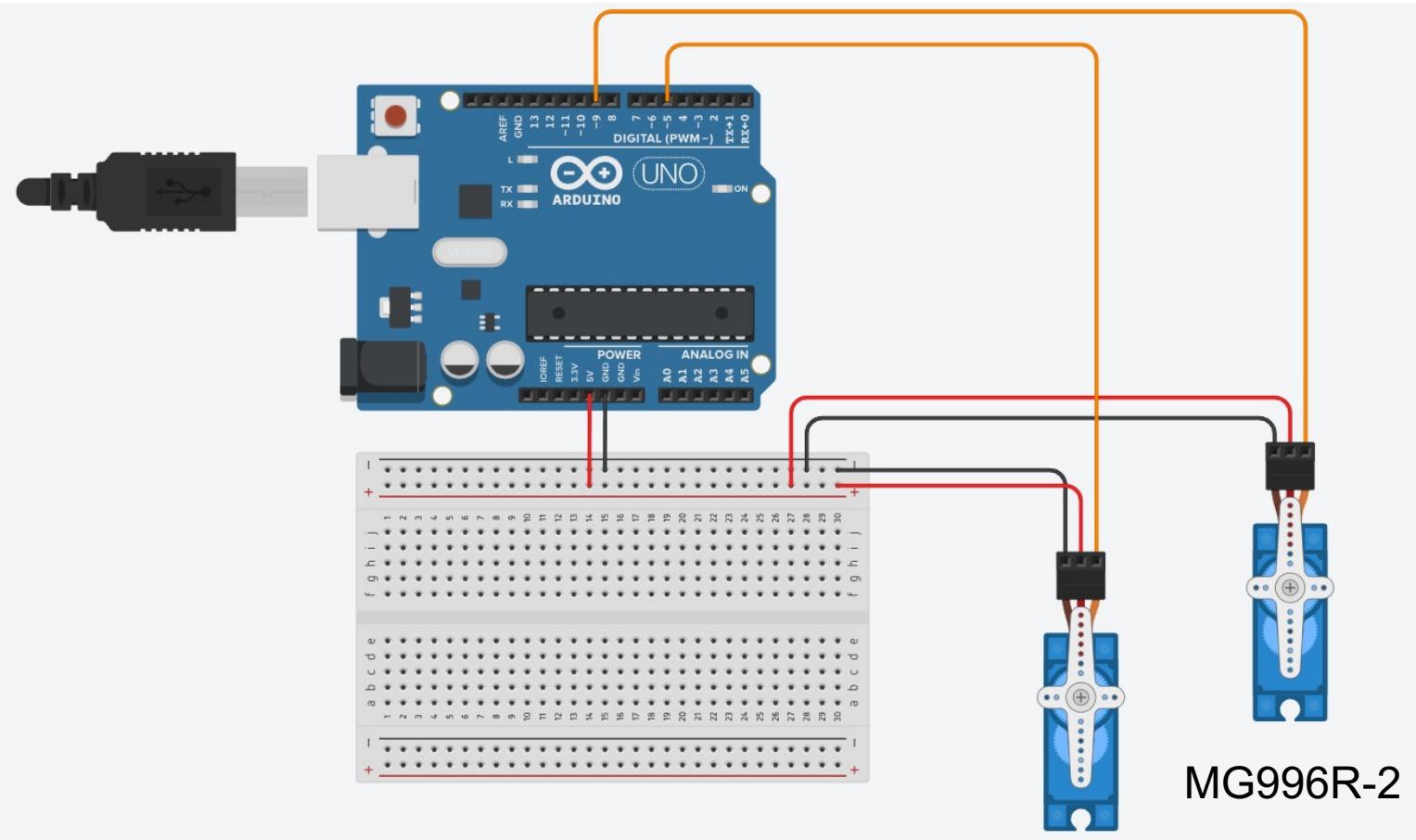
Ball Launcher



Setup



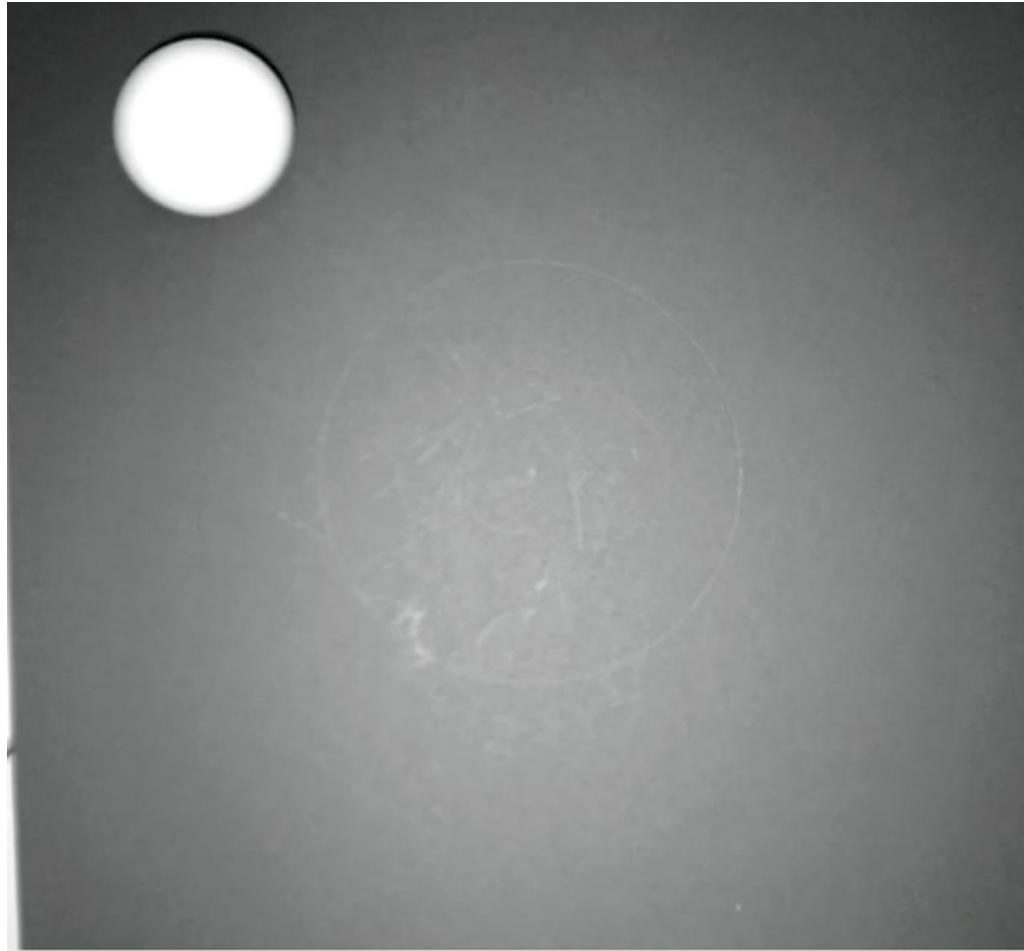
CIRCUIT



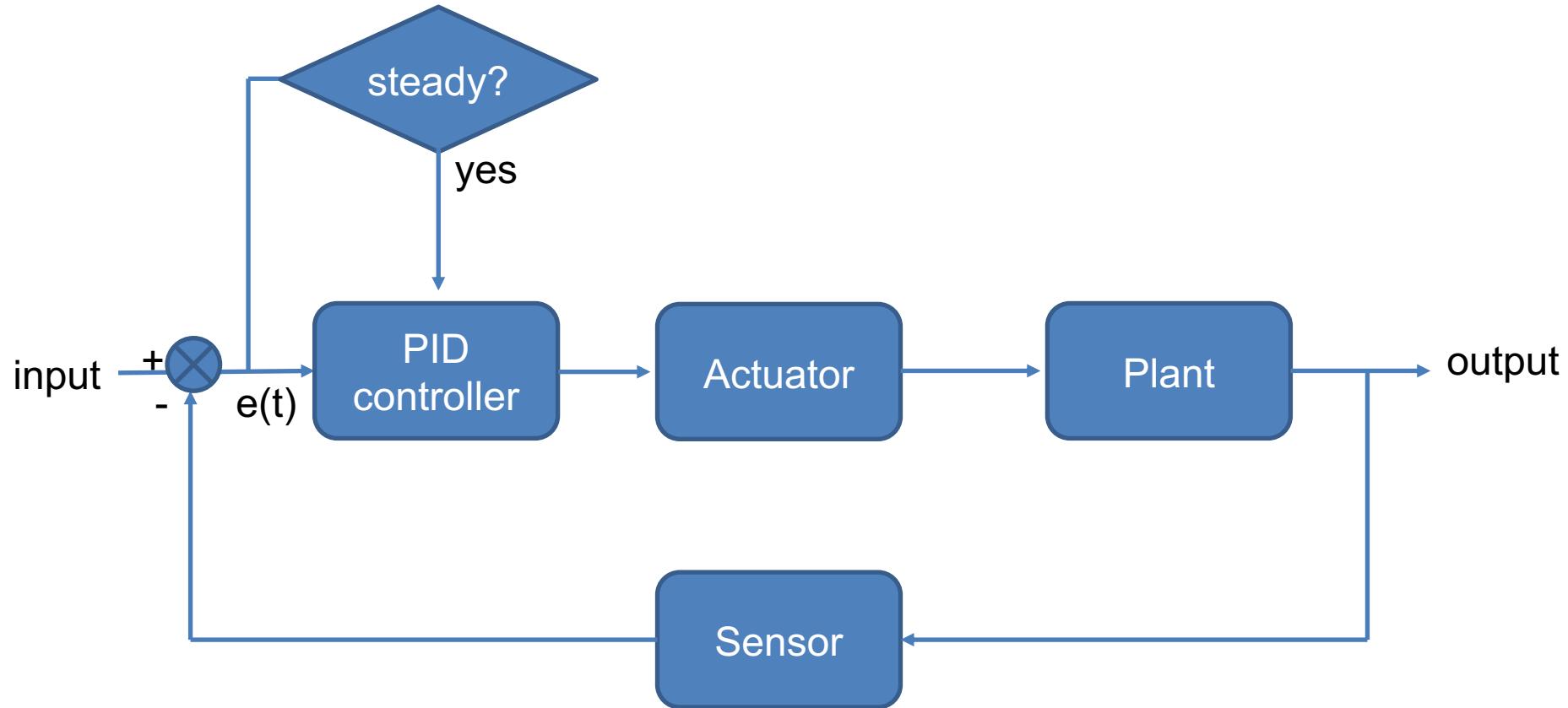
MG996R-2

MG996R-1

Convergence

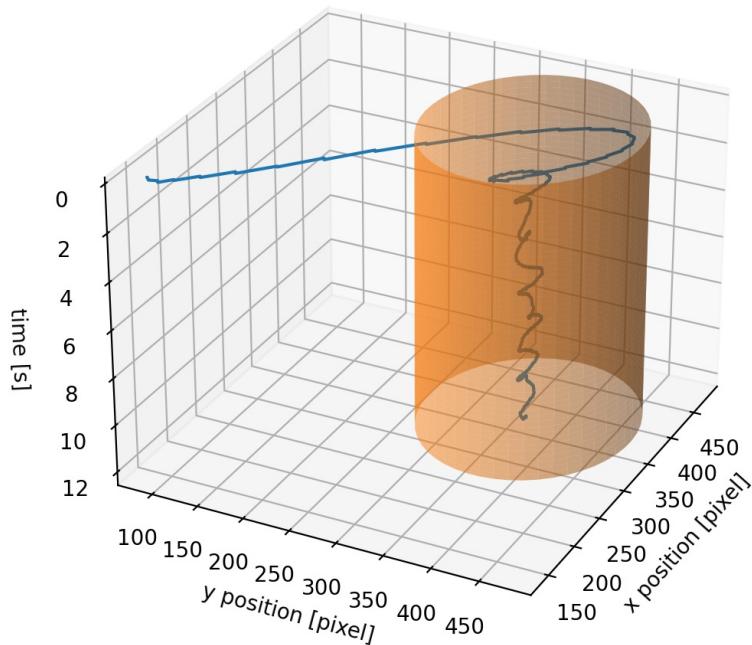


Strategy

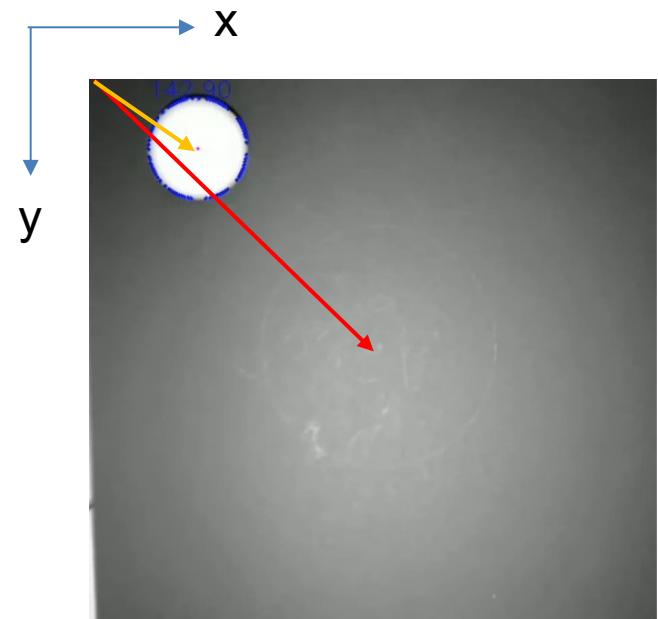
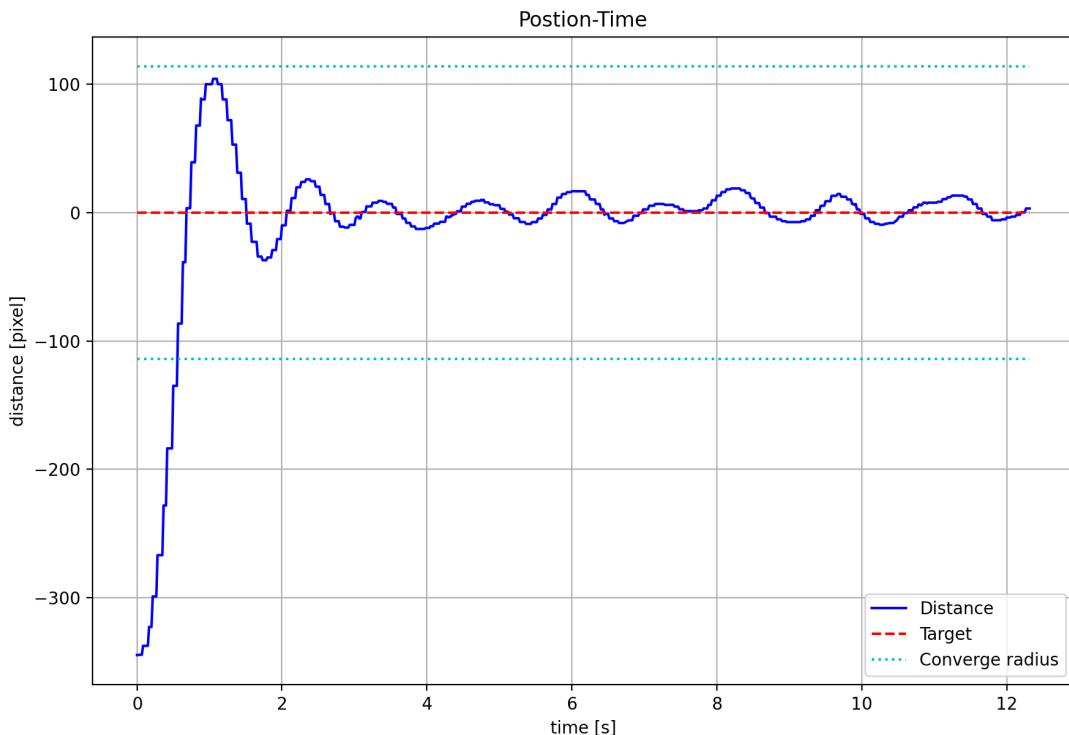


Result

Ball Trajectory



Result

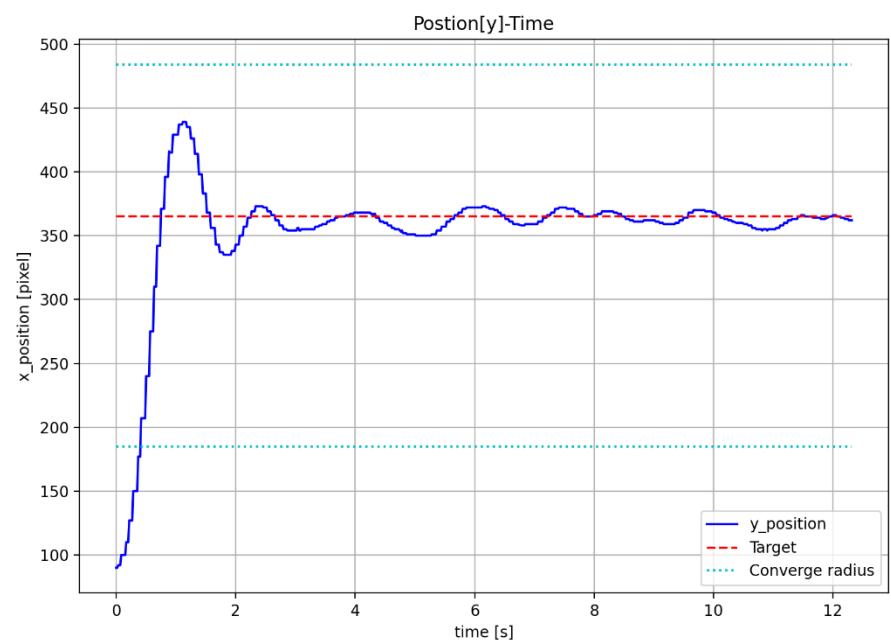
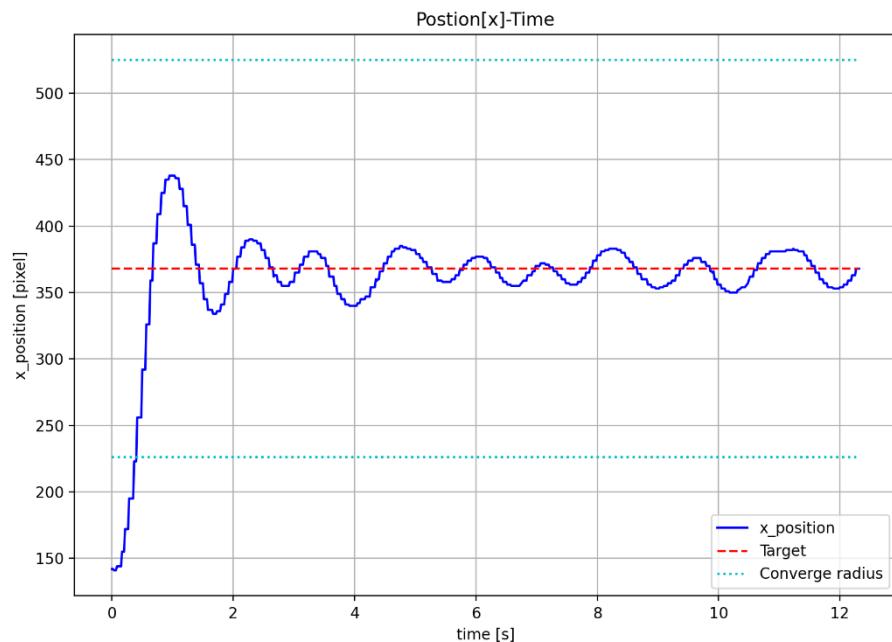


$$Mo = 30.2\%$$
$$tp = 1.05 \text{ s}$$

$$\xi = 0.358$$
$$wn = 2.041$$

$$\text{Distance} \equiv \| \text{ball} \| - \| \text{target} \|$$

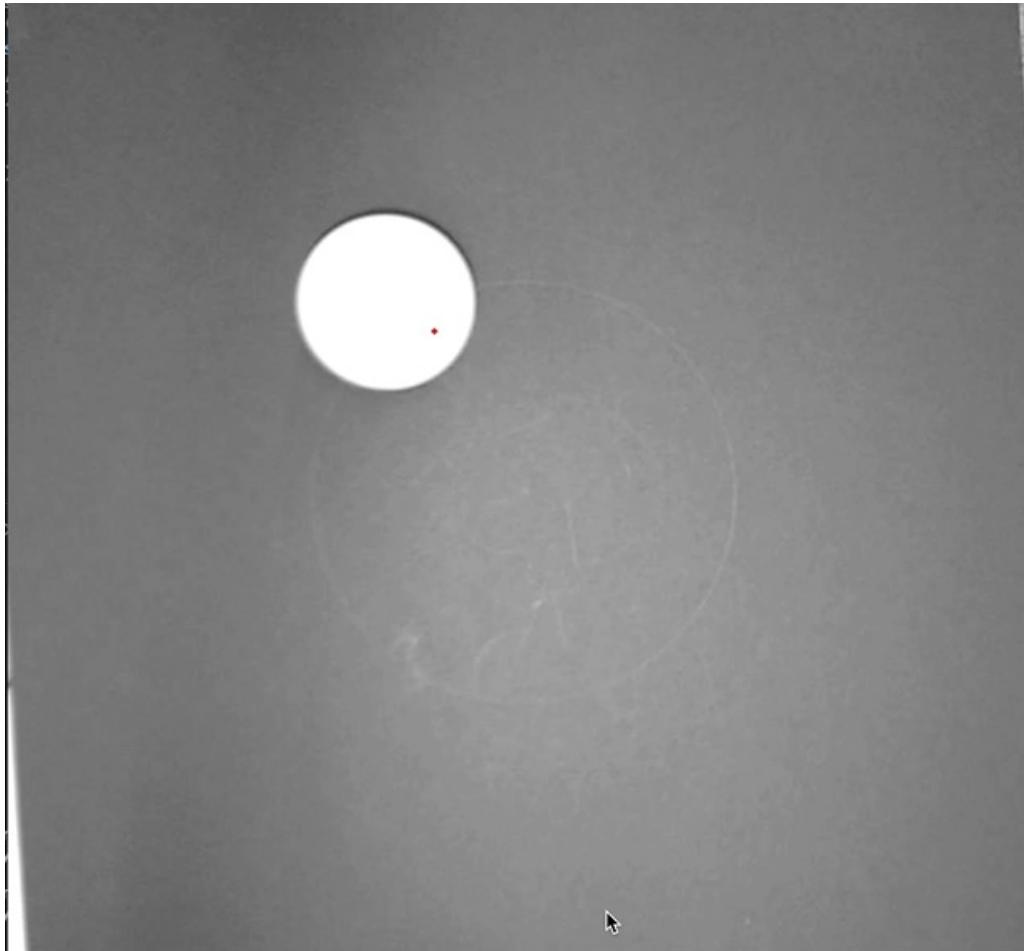
Result



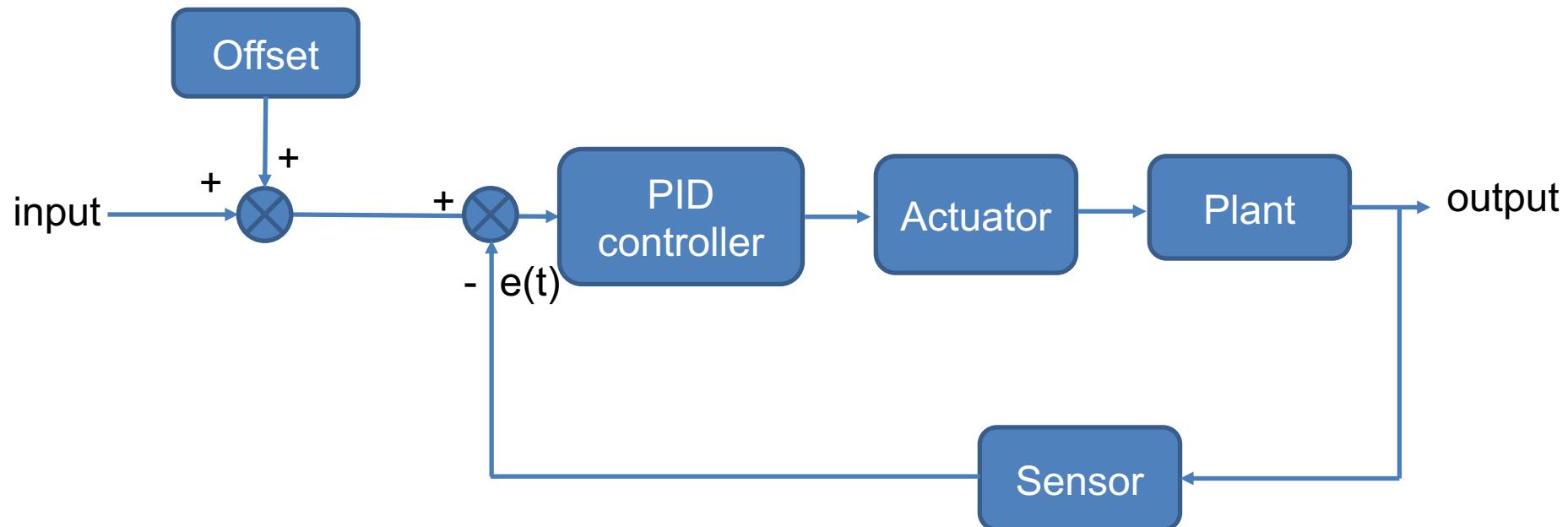
Discussion

- Improvements
 - Adding additional controller for servo on x axis
 - Reduce reaction speed to lower the ripple
 - Increase damping ratio
 - Adding one more controller before the existing one
 - Upgrade our hardware
 - Motor (actuator): precision and response
 - Image (sensor): resolution and FPS

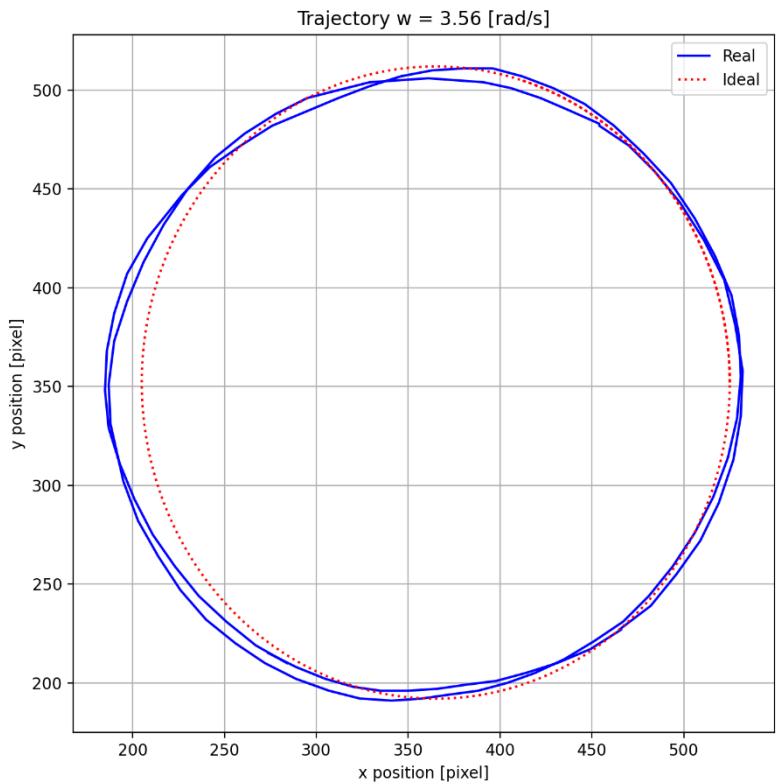
Circling



Strategy



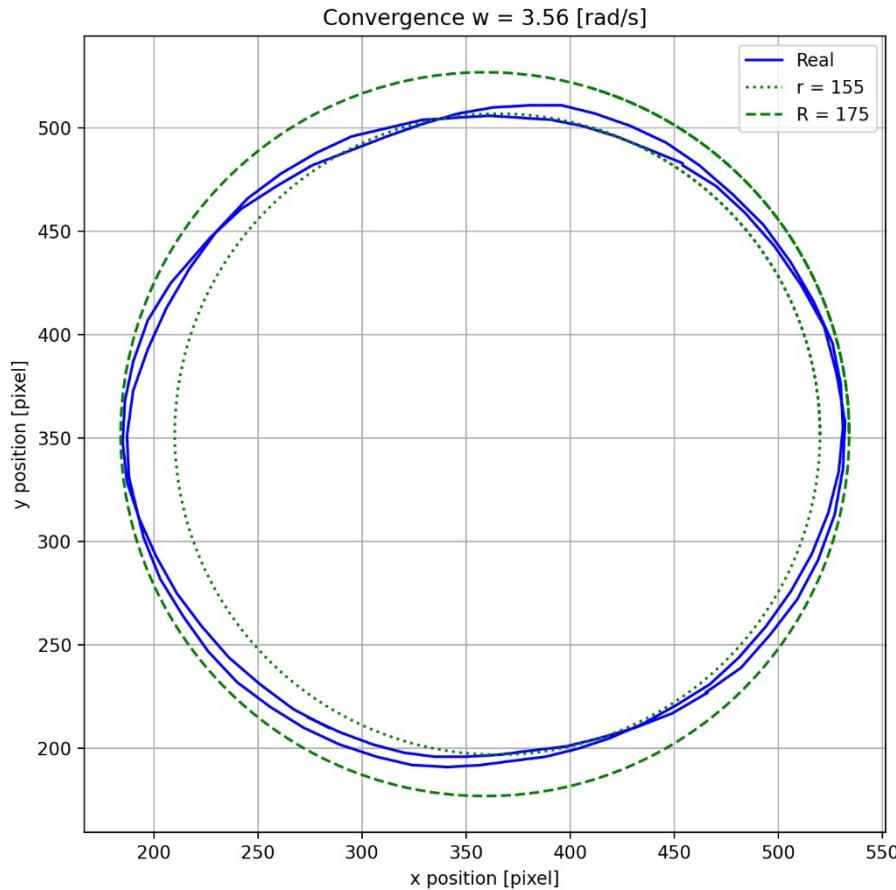
Result



mean error = 3.78 [pixel]



Result



内接圆半径 = 155 [pixel]
外接圆半径 = 175 [pixel]

Comparison

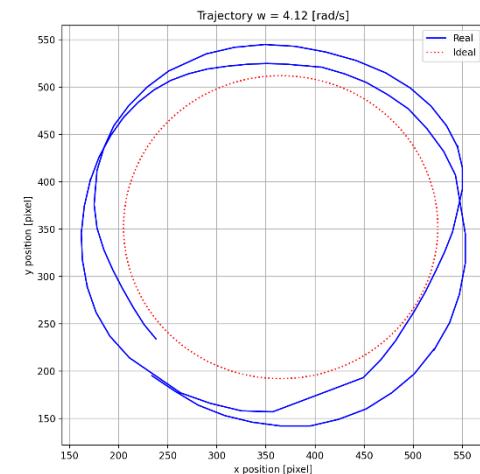
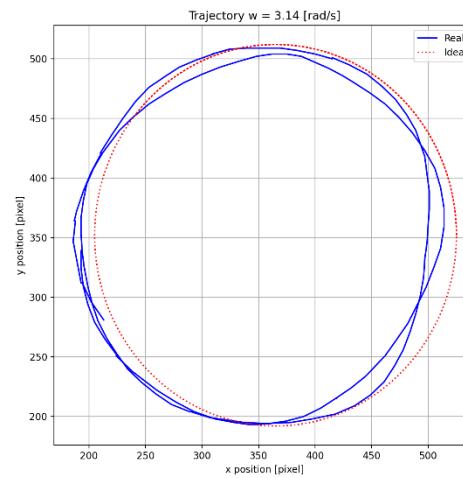
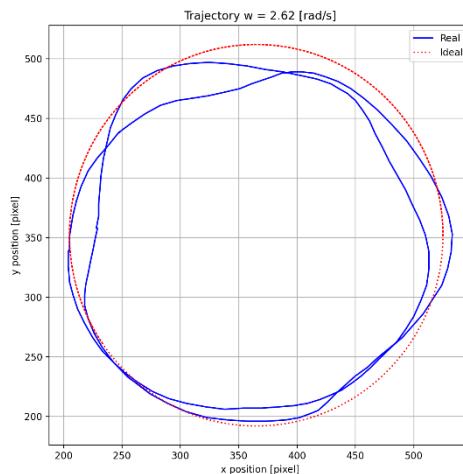
$w = 2.62 \text{ [rad/s]}$



$w = 3.14 \text{ [rad/s]}$



$w = 4.12 \text{ [rad/s]}$



Comparison

$w = 2.62 \text{ [rad/s]}$

$w = 3.14 \text{ [rad/s]}$

$w = 3.56 \text{ [rad/s]}$

$w = 4.12 \text{ [rad/s]}$

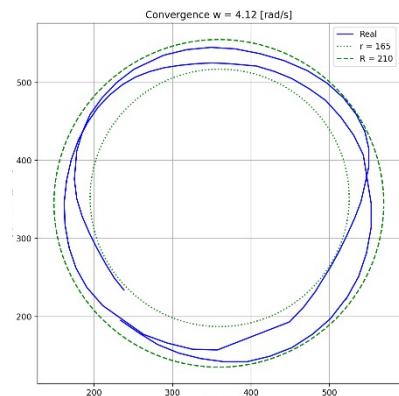
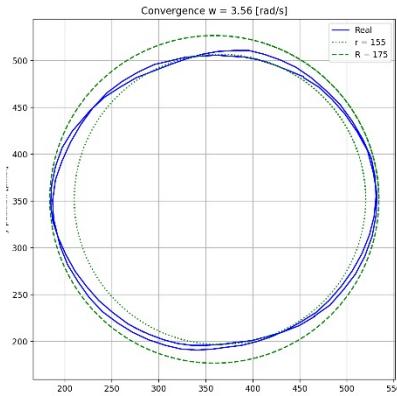
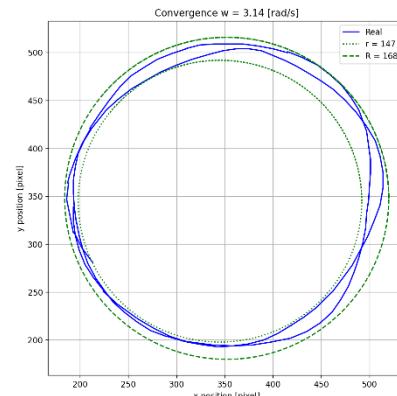
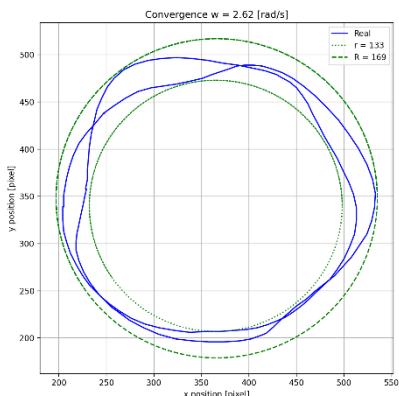
Mean
Error

-10.37 [pixel]

-1.87 [pixel]

3.78 [pixel]

30.98 [pixel]



$r = 133$
 $R = 169$

$r = 147$
 $R = 168$

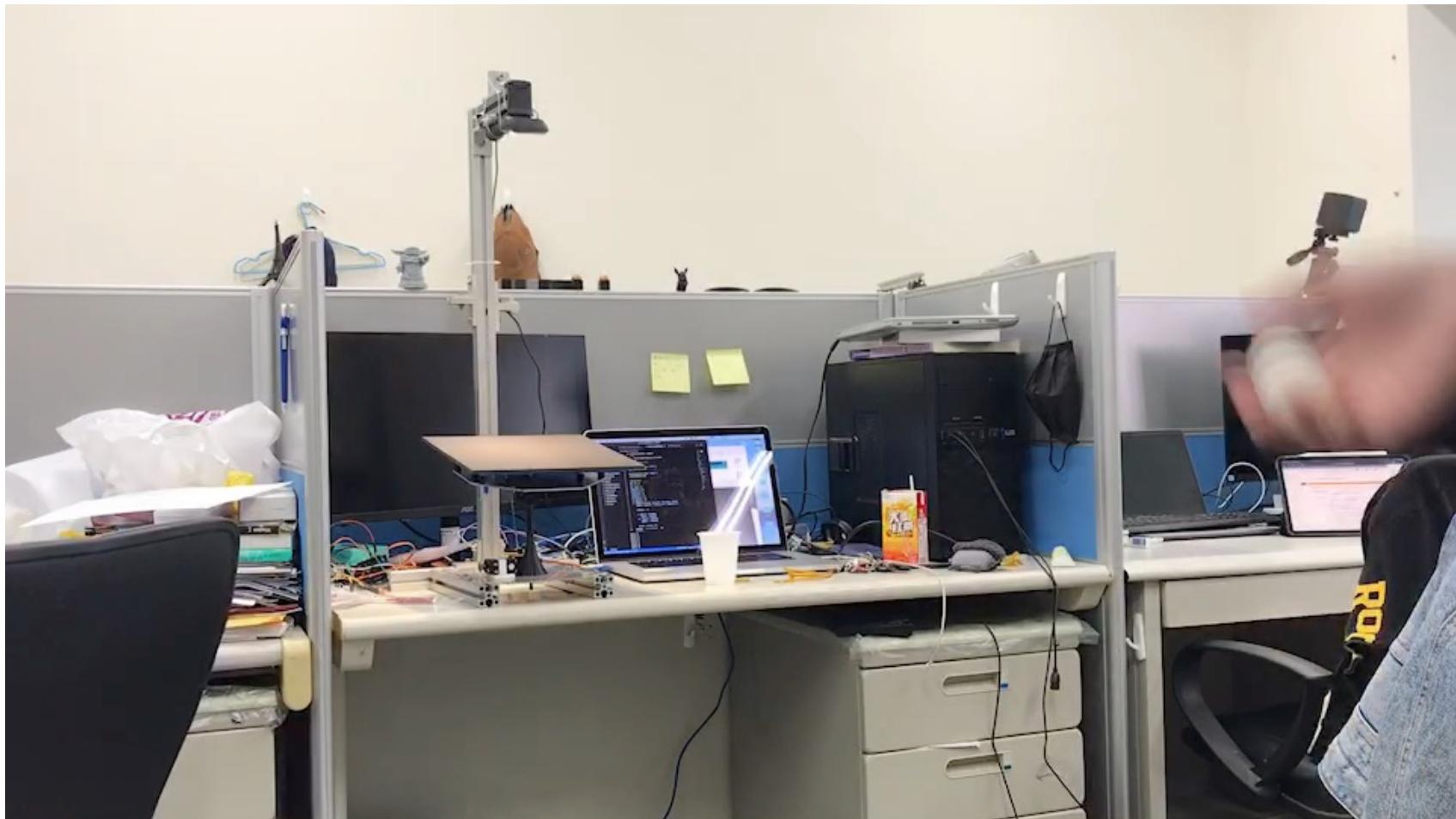
$r = 155$
 $R = 175$

$r = 165$
 $R = 210$

Discussion

- Improve method
 - Upgrade controller on x axis
 - Using different strategy to meet our goal
 - Controlling tangential velocity and radius
 - Upgrade hardware
- Increase angular velocity?

Catching ball



Catching ball

