ME 400
Creative Capstone Design

Team Buldozer

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Khalifa

solidworks

characteristic

Simple operation

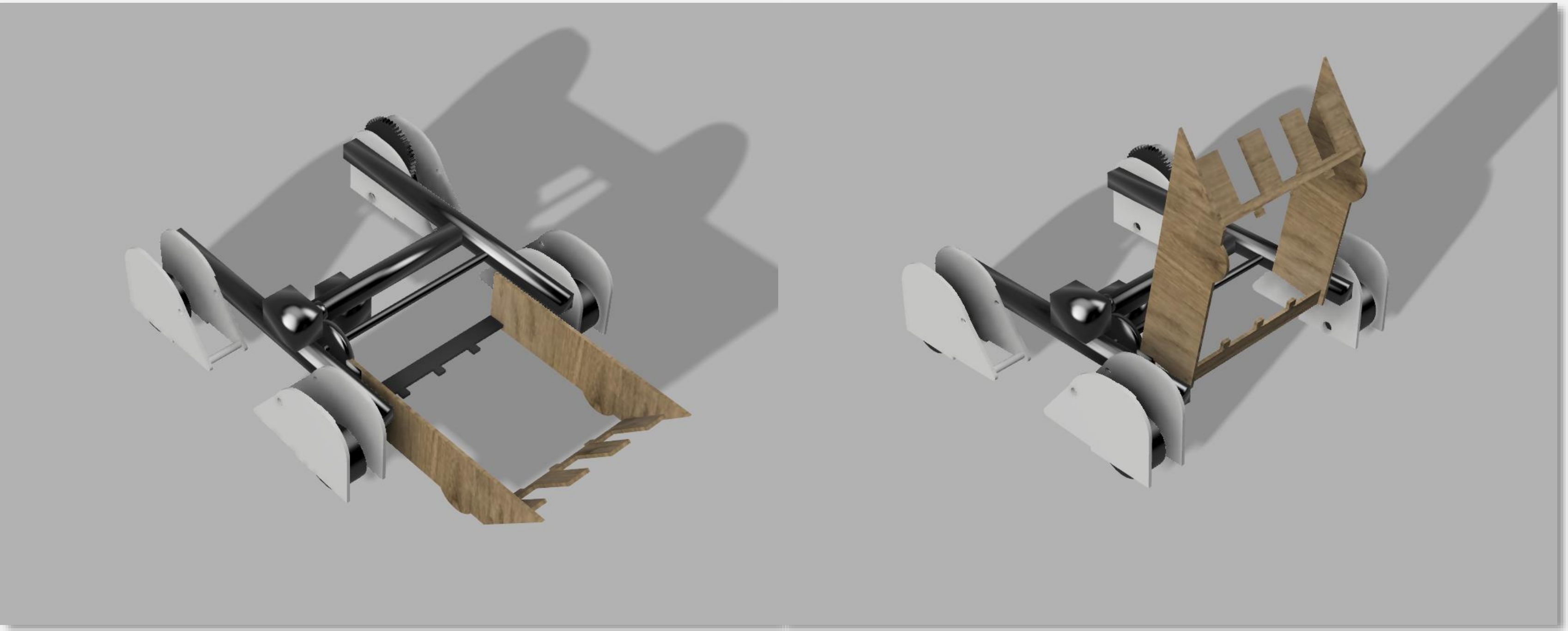
Compact size

Push away redball

Moduled components

Designed with flexibility

Detailed quality of design



Structure/Function

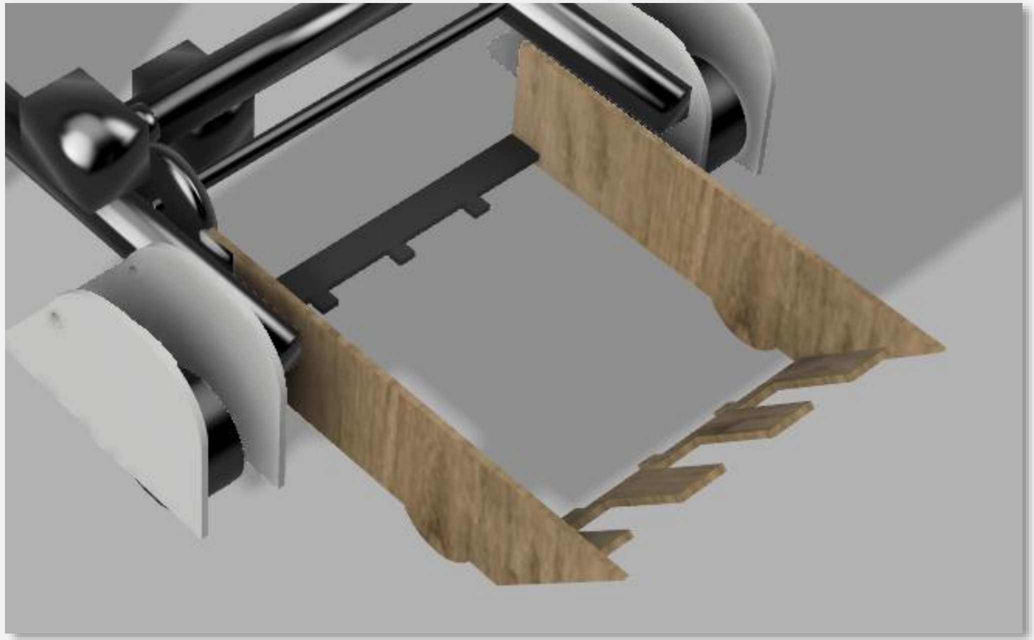
Simple operation

Our robot’s pick-up and release part can be operated by only one motor. This reduce heat, weight and error’s caused by complex code.

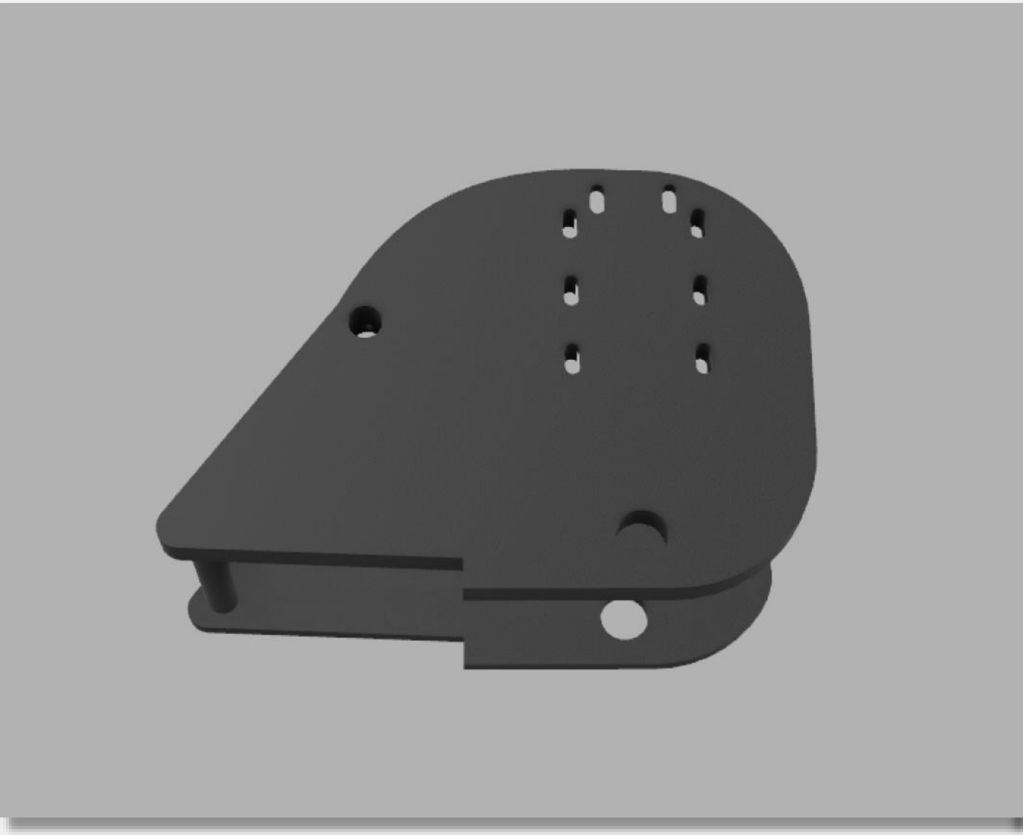
Also, we don’t need to change orientation to release at aligning stage

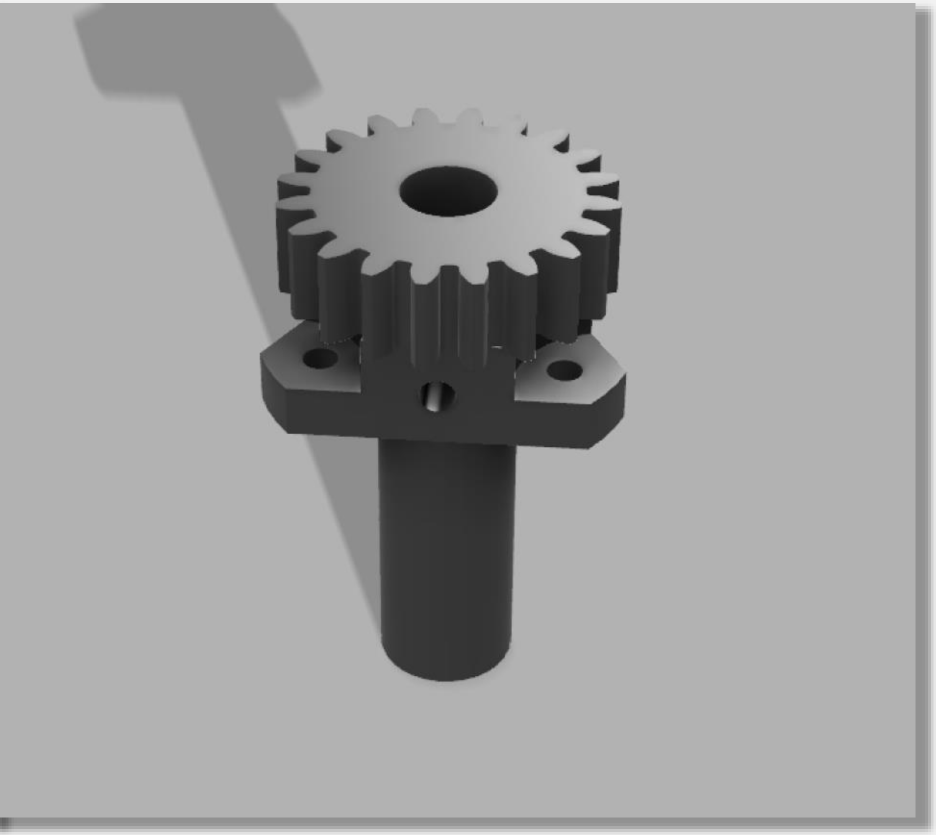
Structure/Function

Push away red-ball



By the characteristic of pick-up hardware structure, we don't have to avoid the red ball. Instead, we push away and stick the red ball around the robot's bumper which save a lot of time avoiding the red balls.



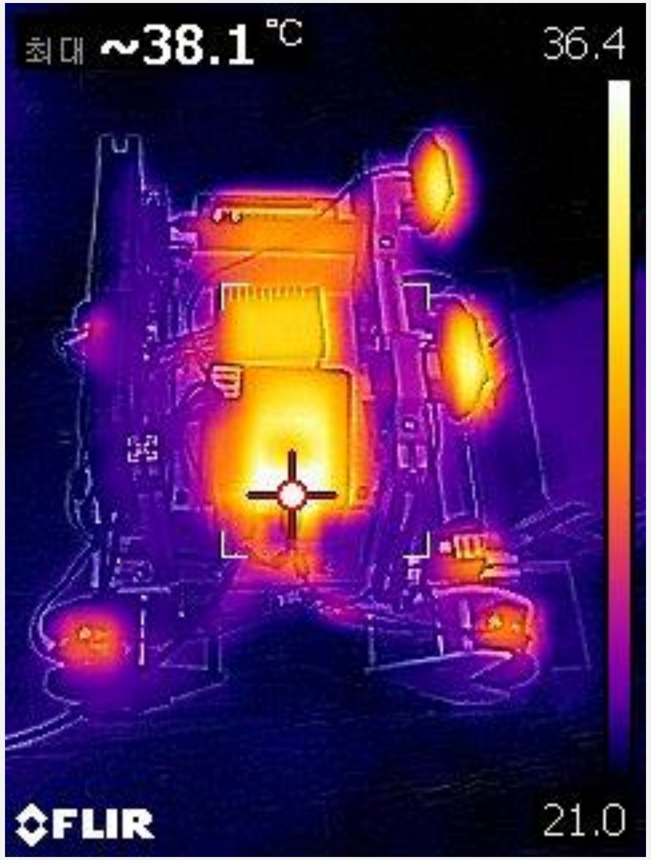


Structure/Function

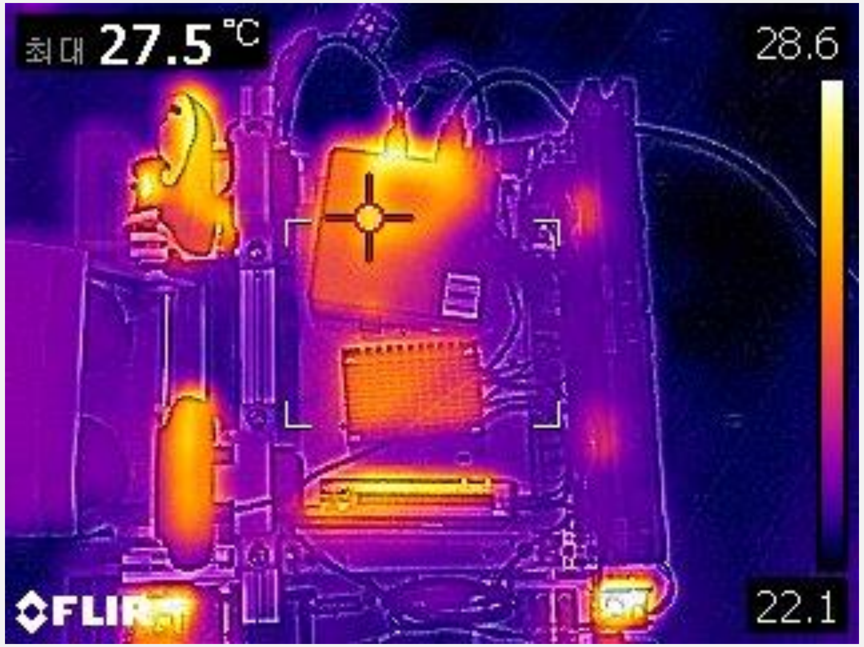
Design flexibility

We made longer holes to make the gears fit together even if there are some deformations. Also, we made parts which perfectly suit to our device environment like the second picture.

Heat



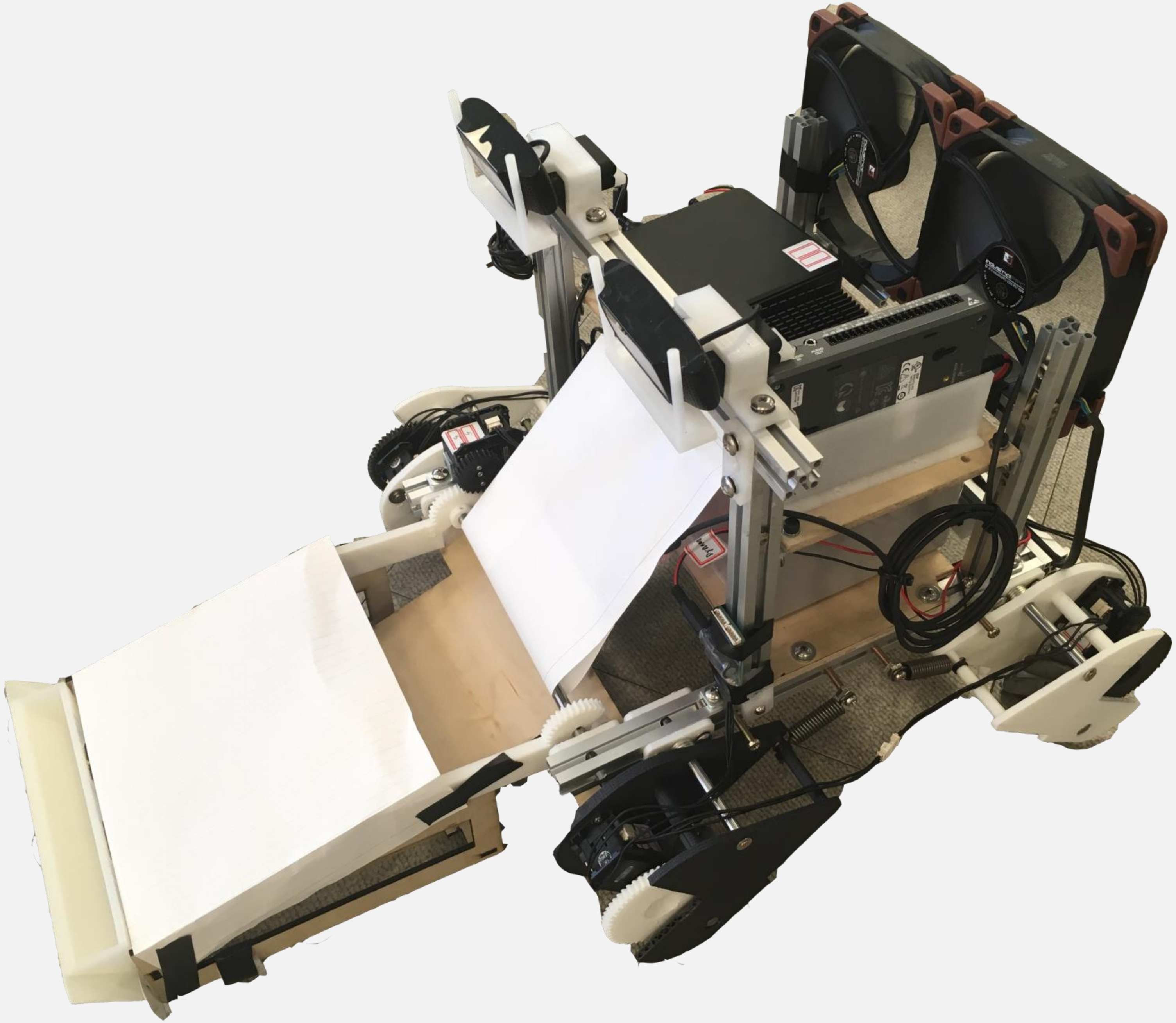
Without Fan



With Fan

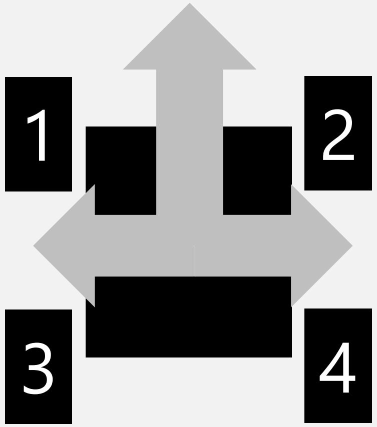
labview

- Motor configuration
- How to connect with ROS
- Vehicle movement motion
- Vehicle rotation motion
- Pick-up Motion



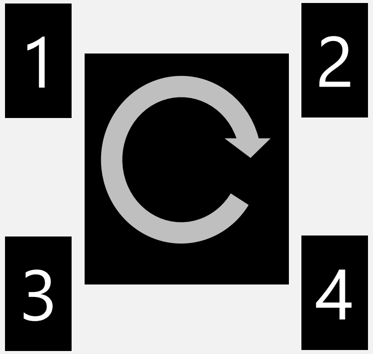
How to connect with ROS

Array



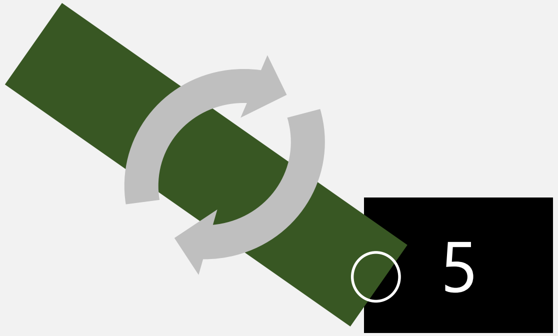
Vehicle translational motion

0 : stop
1 : forward direction
2 : right direction
3 : left directiona



Vehicle rotational motion

0 : stop
1 : fast clockwise rotation
-1 : fast counterclockwise rotation
2 : slow clockwise rotation
-2 : slow counterclockwise rotation



Pick-up and Release Motion

0 : stop
1 : going up
2 : going down

➡ **Send TCP message to ROS**

Vehicle movement motion

Mecanum Wheel

Forward direction

1	0	0

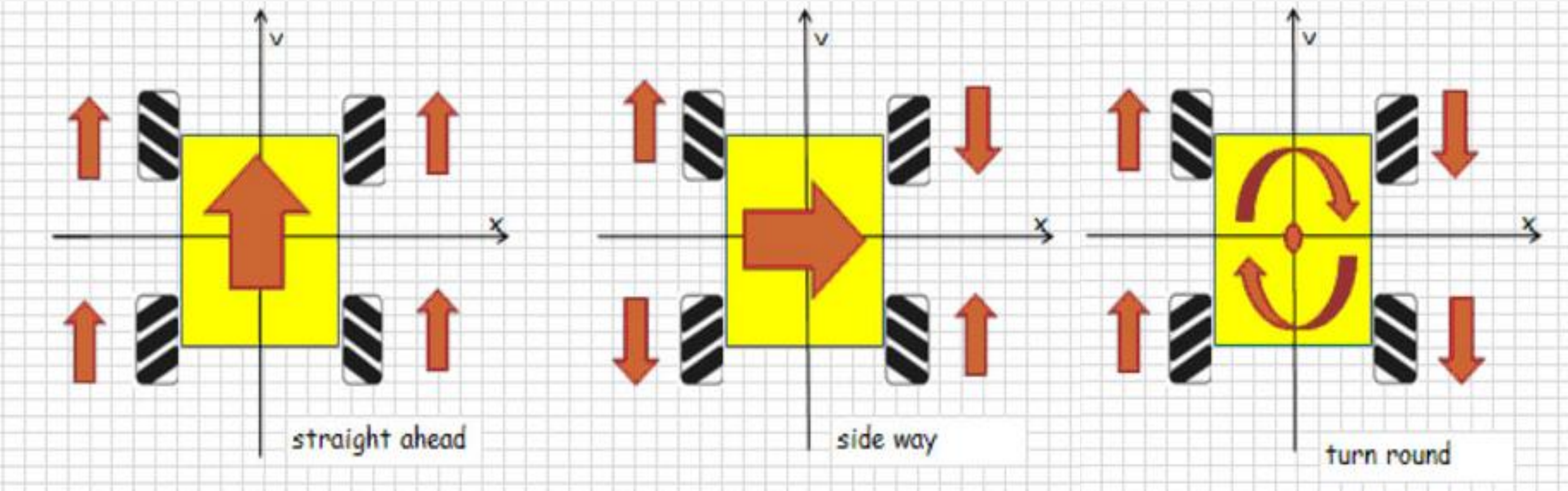
Right direction

2	0	0

Clockwise rotation

0	1	0

ROS command



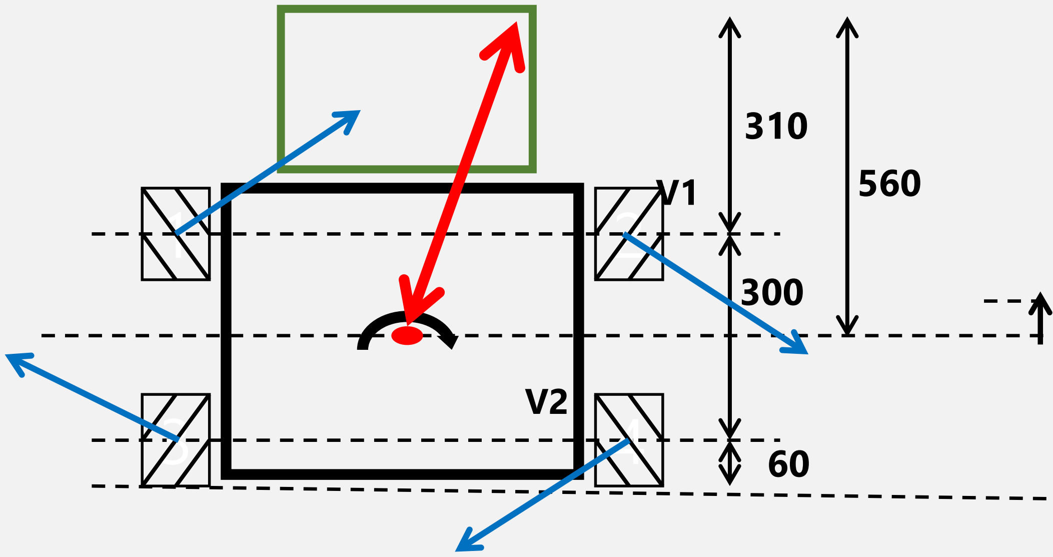
Appropriate rotation direction of each motor

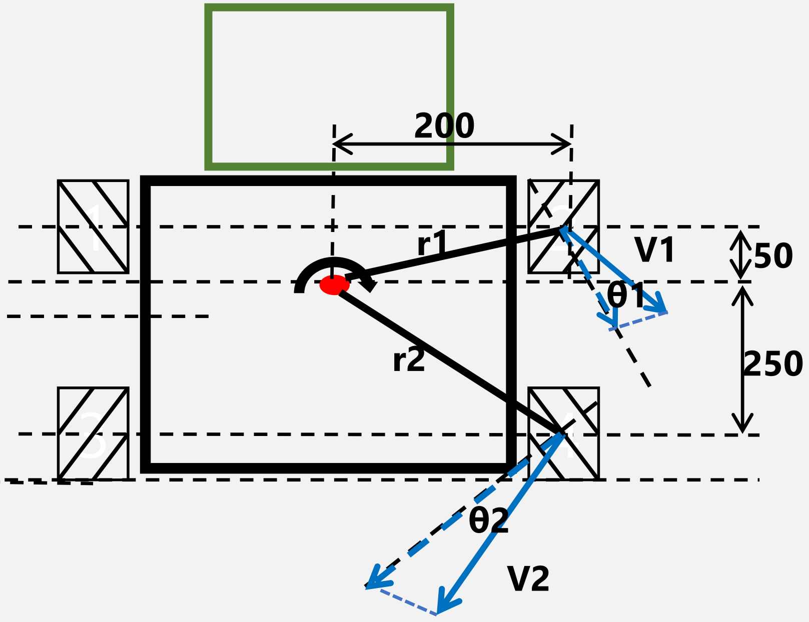
Vehicle rotational motion

maximum radius of gyration

$$V1 = V2$$

$$\frac{V1cos\theta1}{r1} = \frac{V2cos\theta2}{r2} \rightarrow \frac{V2}{V1} = 2.47$$





Initial radius of gyration

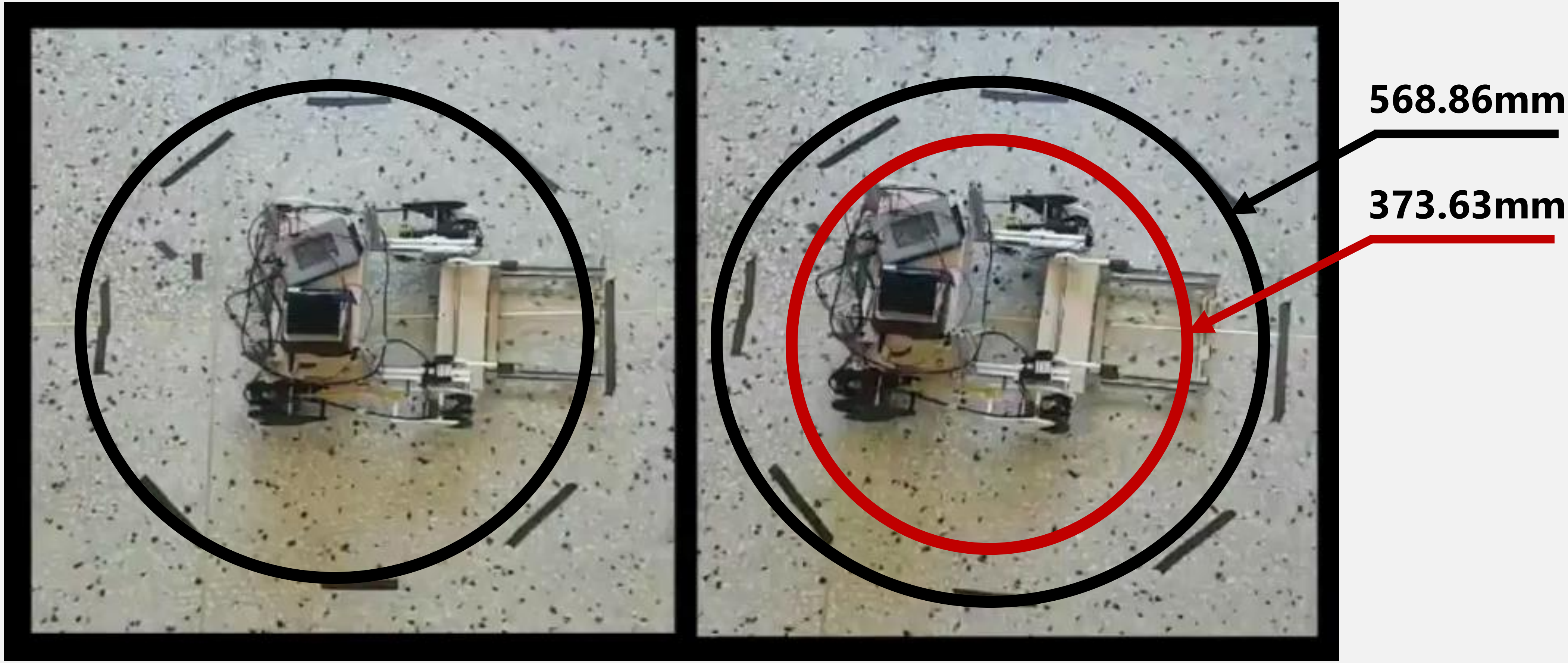
568.86mm

Changed radius of gyration

373.63mm

Vehicle rotational motion

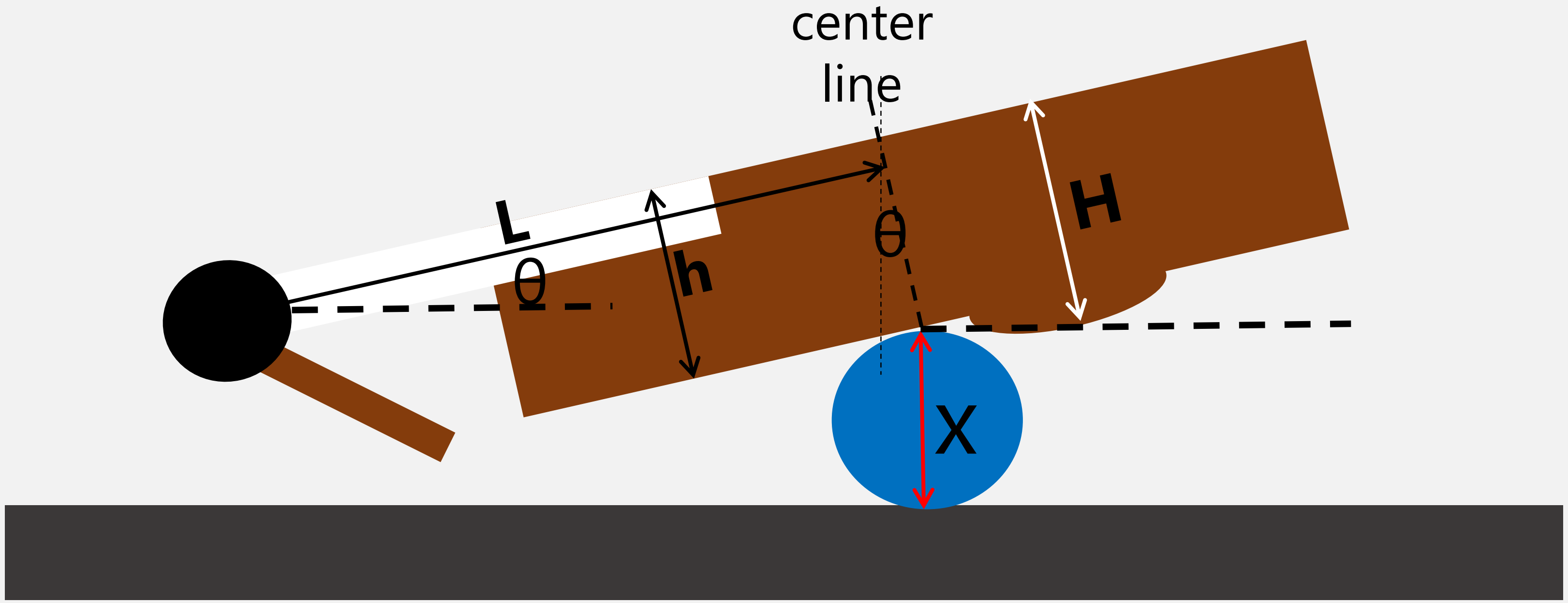
maximum radius of gyration



568.86mm

373.63mm

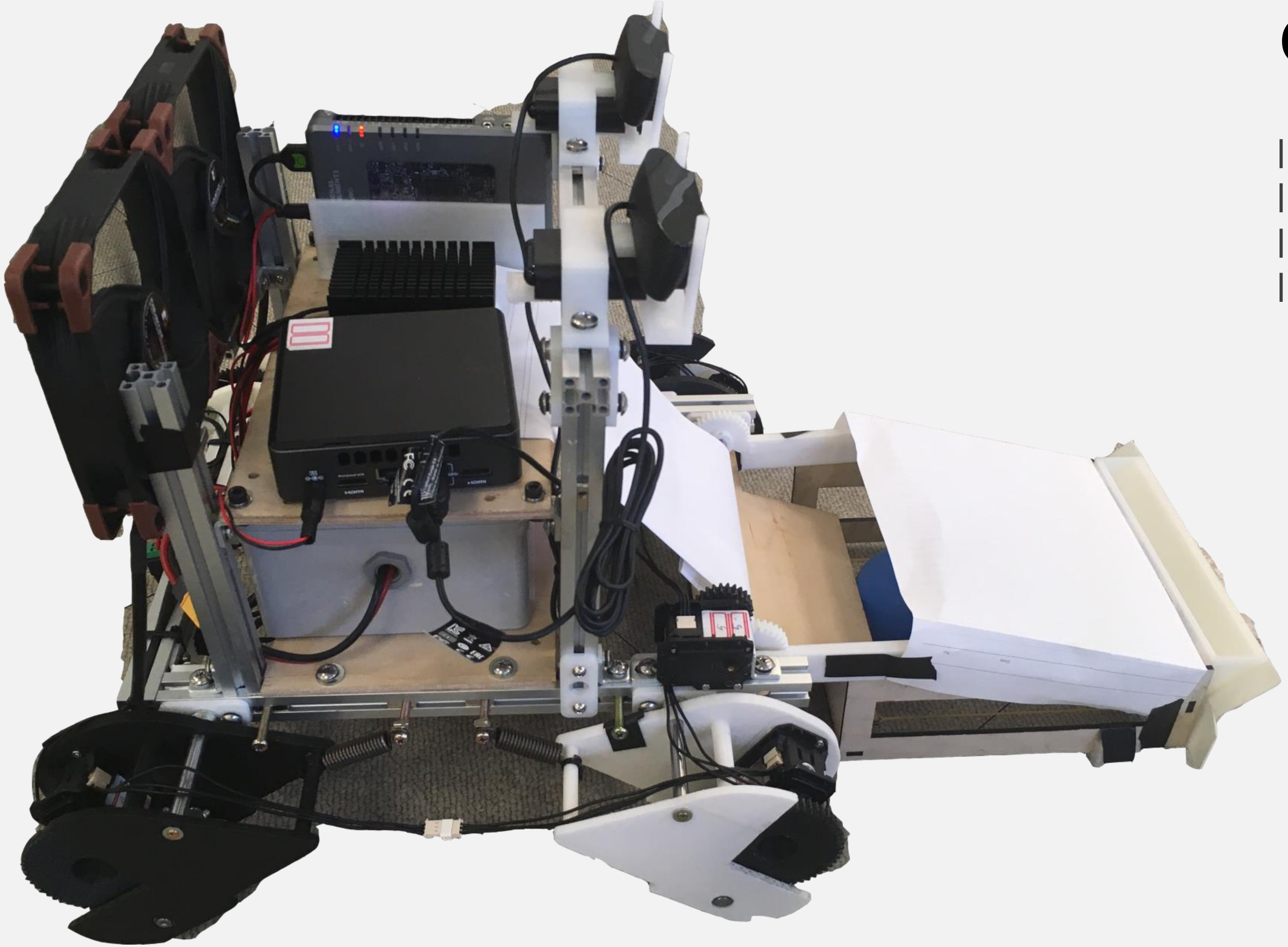
Pick-up Motion



$$x(\theta) = Lsin\theta + \mathrm{H} - \mathrm{hcos}\theta = D$$

$$H = 80.85mm, h = 68.85mm, D = 73.2mm$$

$$\theta \cong 23.31°$$

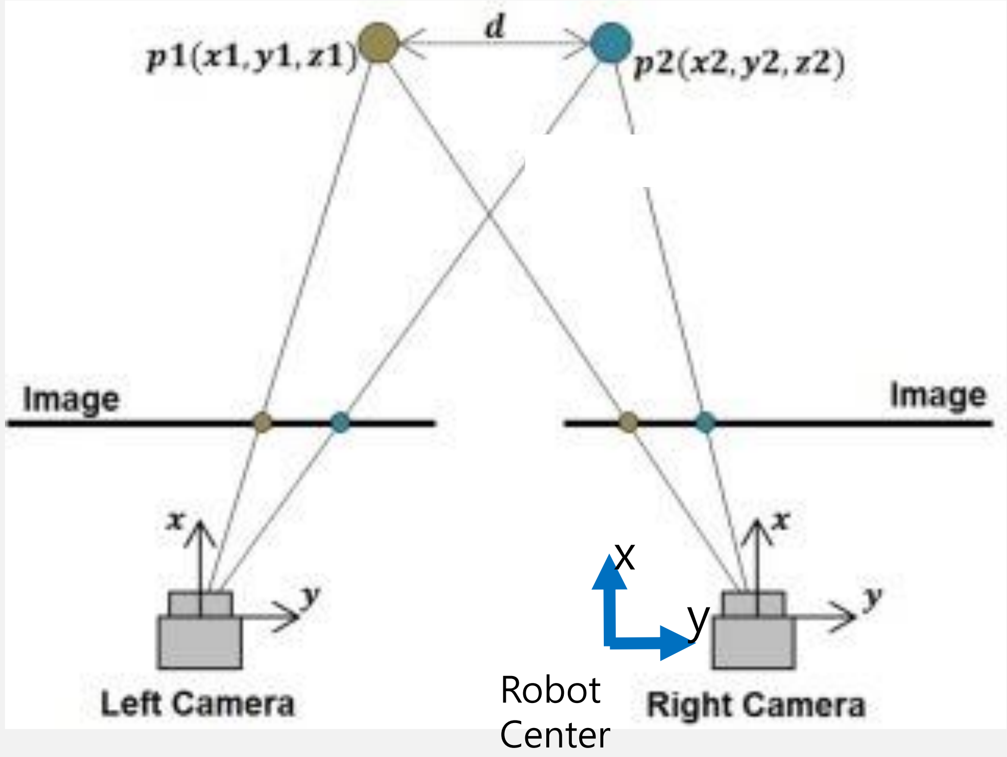


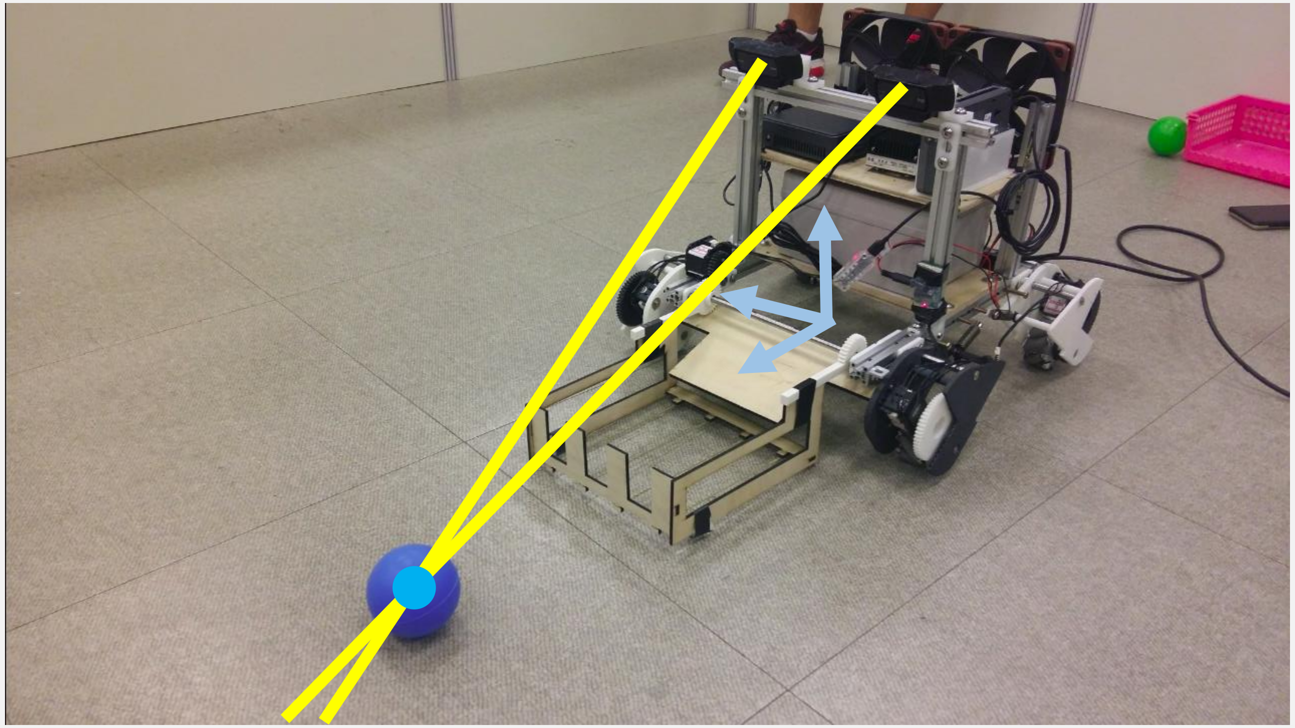
opencv

- Stereo Camera
- Calculating coordinate
- Accuracy
- Result

opencv

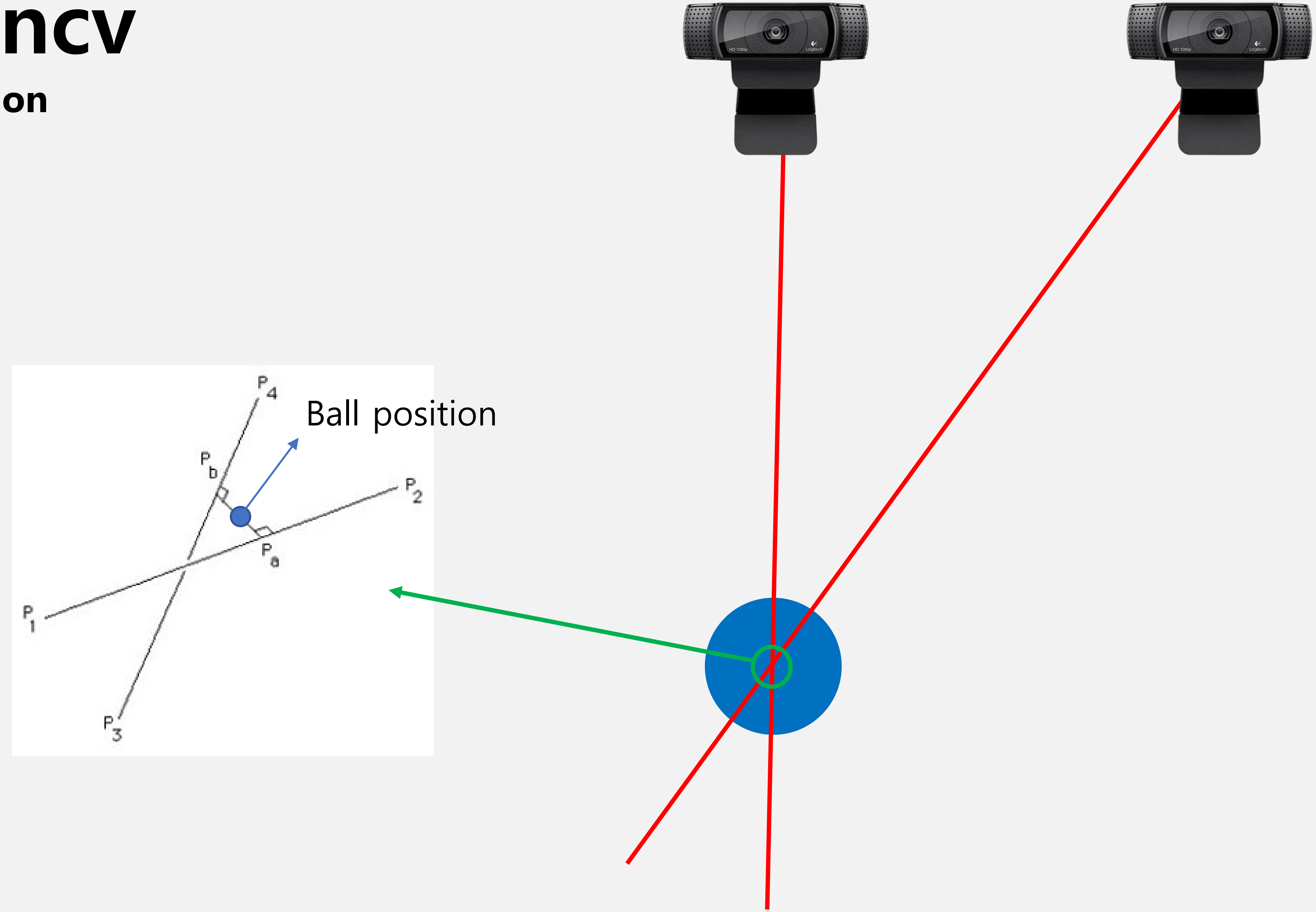
Calculating coordinate





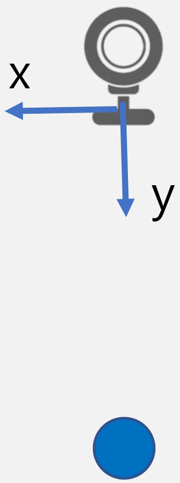
opencv

Calibration

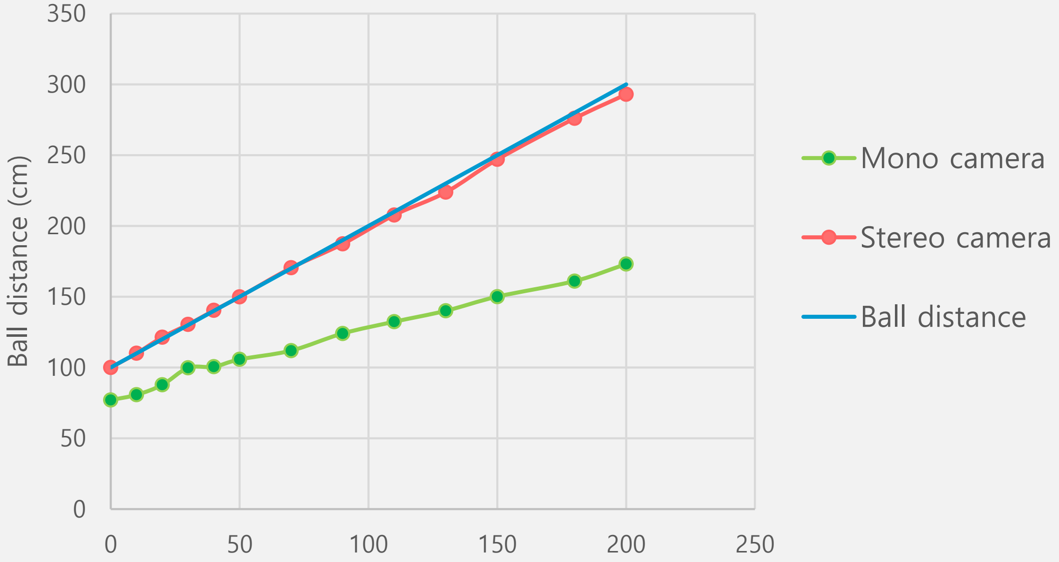


opencv

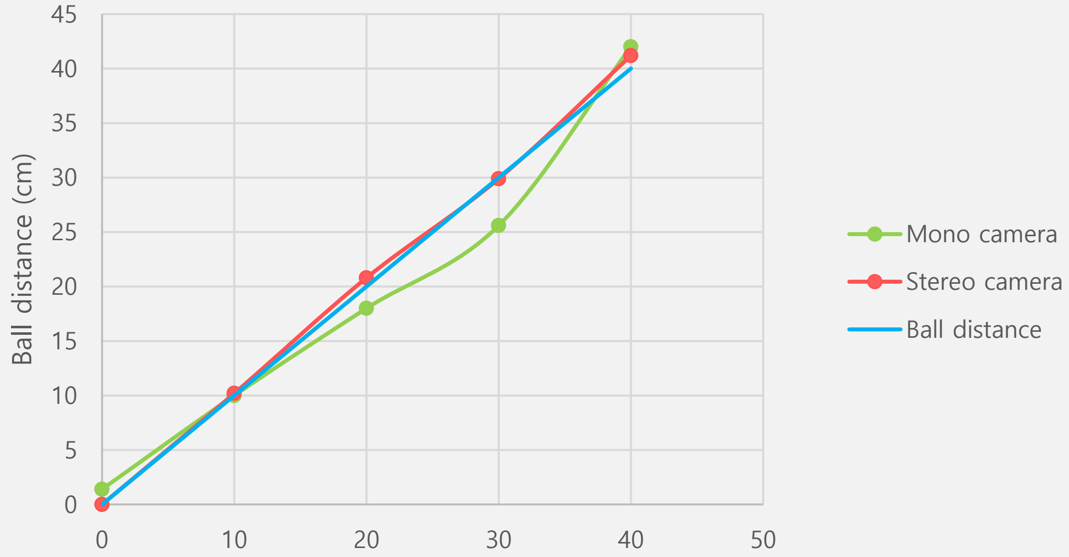
Accuracy



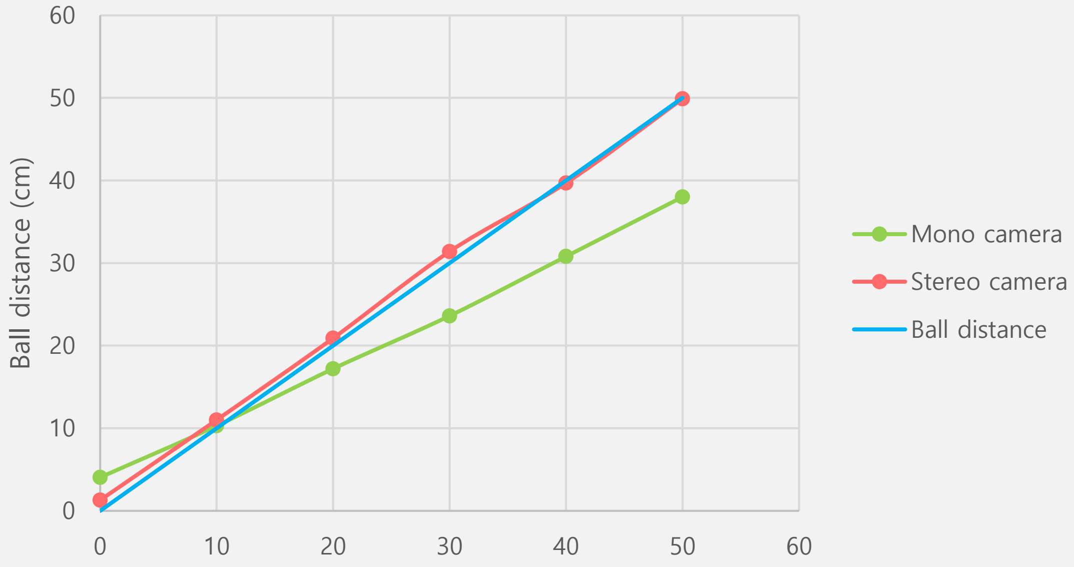
Distance error



x direction error at 1m

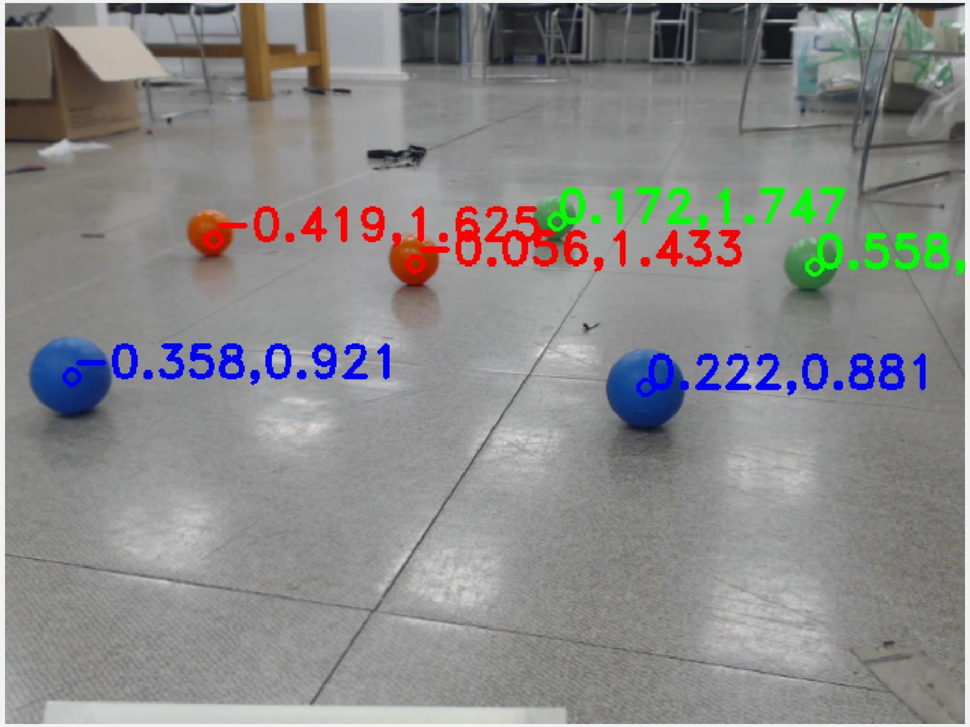


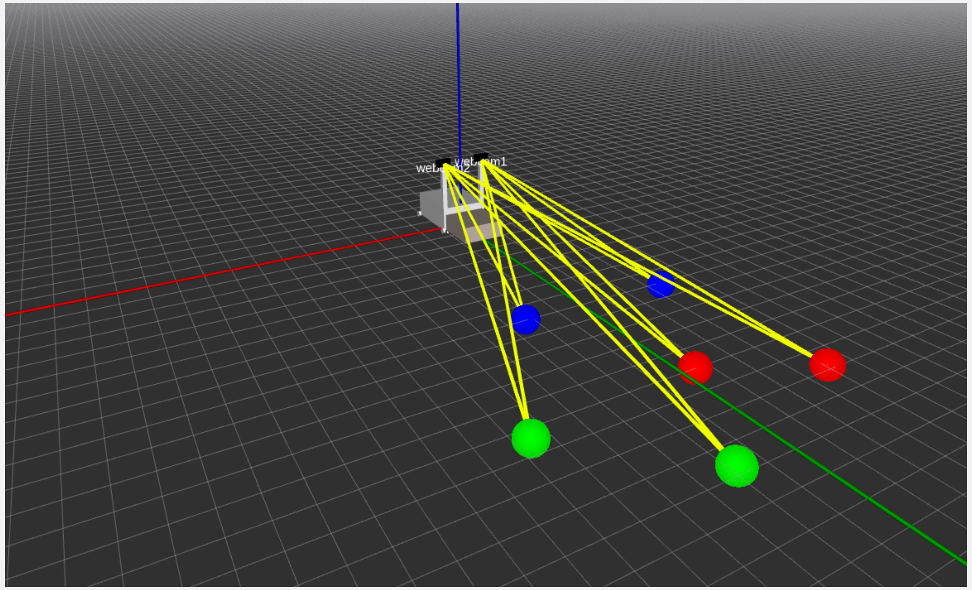
x direction error at 2m

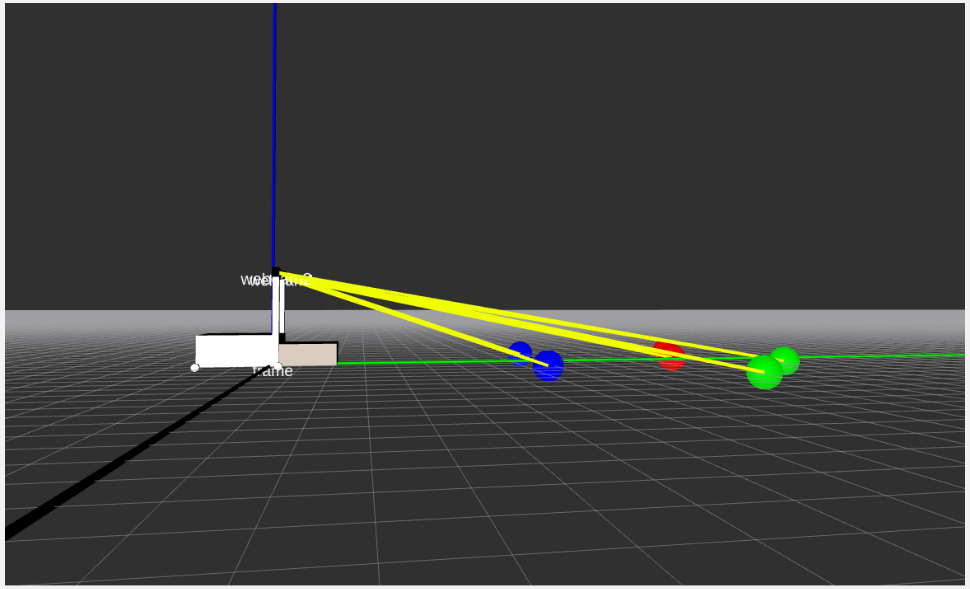


opencv

Result

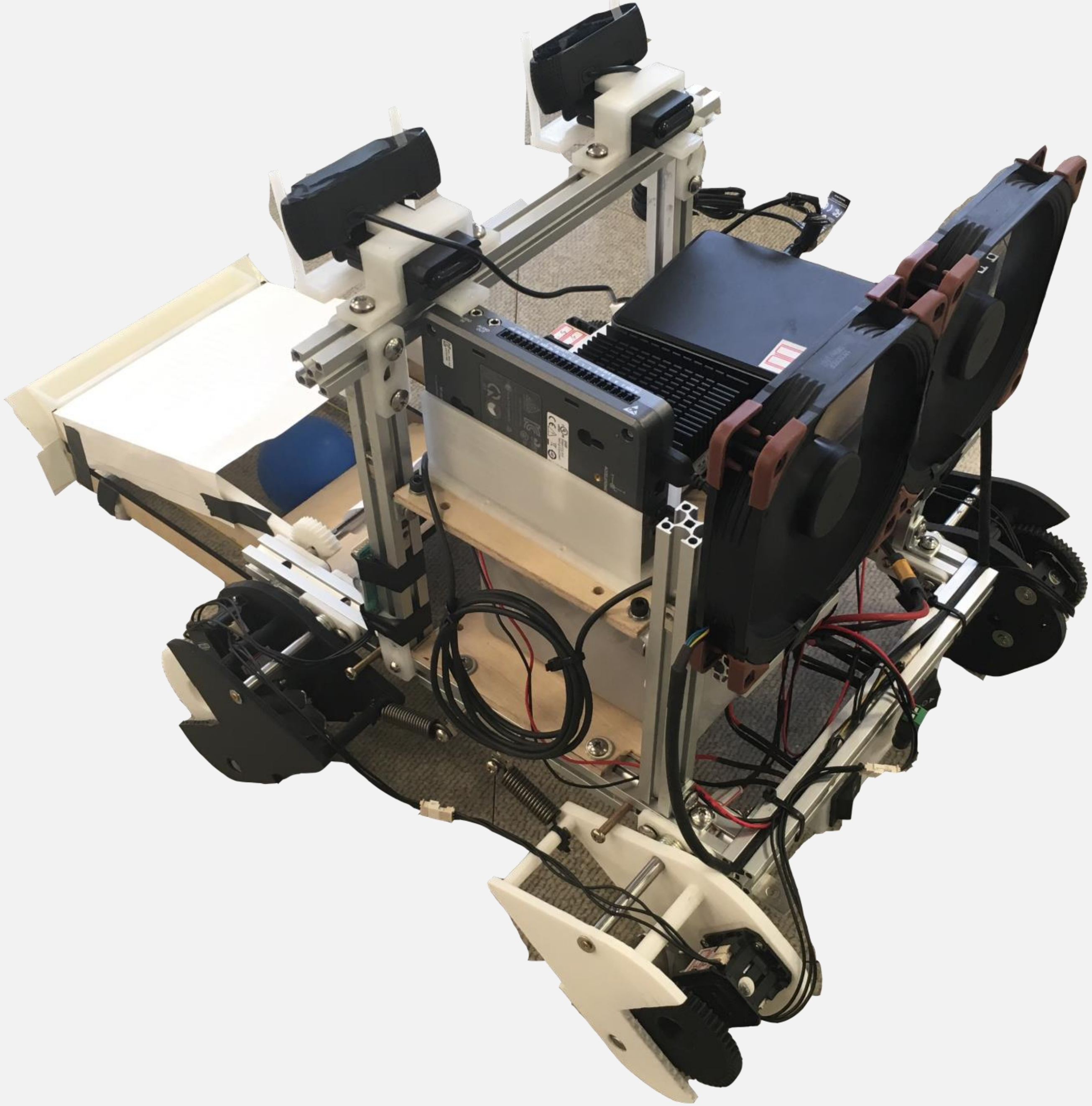




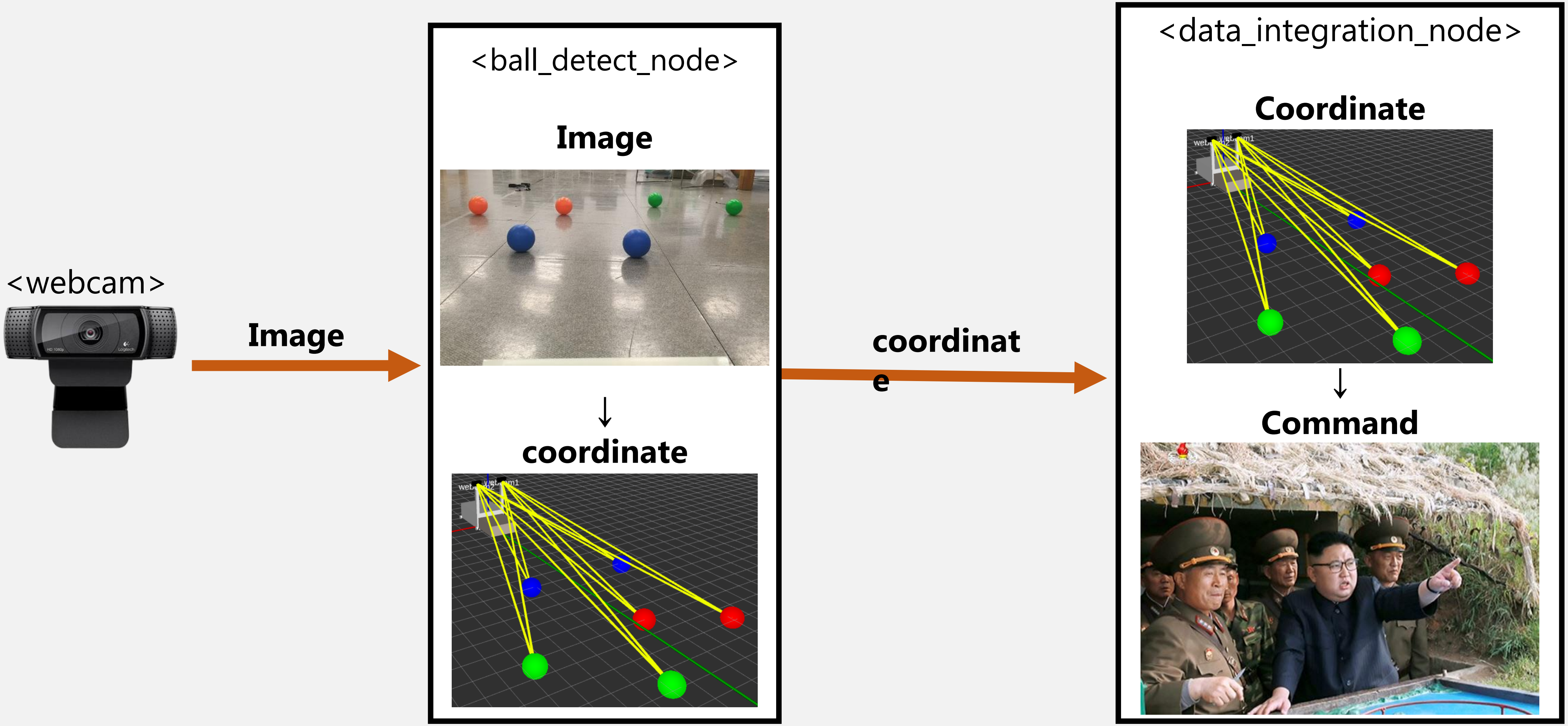


ROS

- Algorithm
- Solution
- About red balls
- Operation



Data Flow & Overview of Algorithm



<webcam>

Image

<ball_detect_node>

Image

↓

coordinate

coordinate

<data_integration_node>

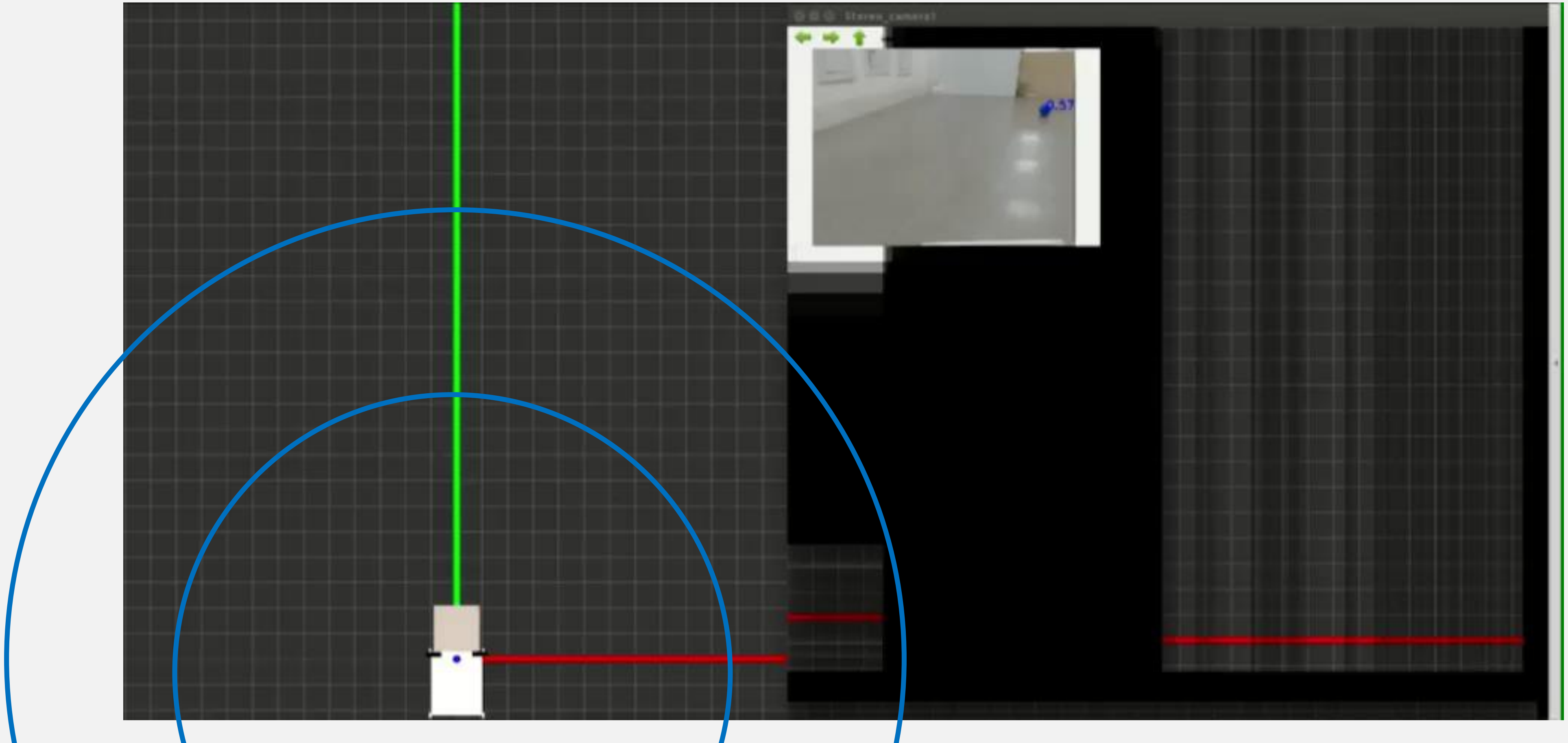
Coordinate

↓

Command

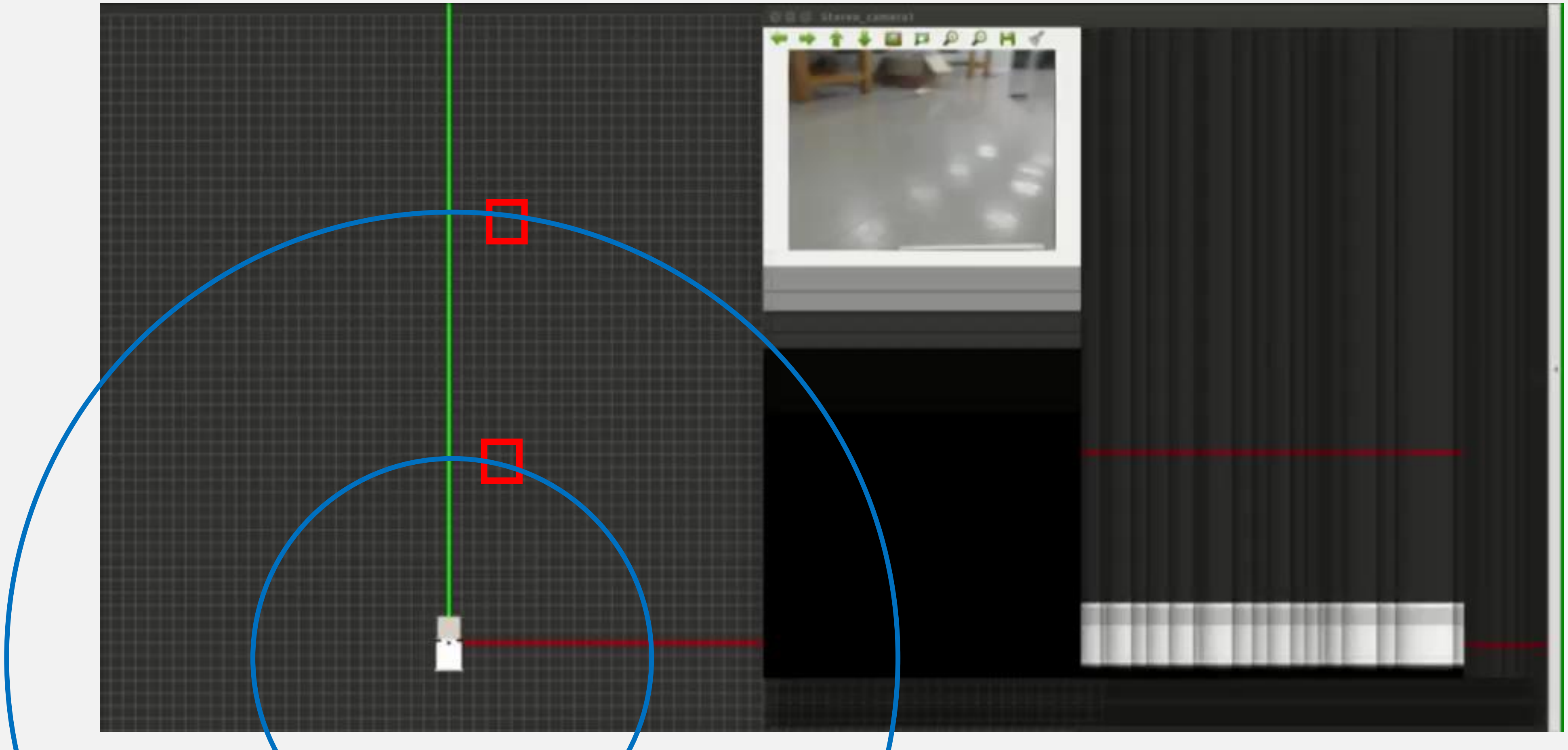
ROS improvements of OpenCV problems

Stereo camera -> too sensitive to vibration!



Solution - take_rest()

Stop for a short time to detect ball position accurately



Time issue - Longer operation time?

Stops 0.3 second per 1 takerest()

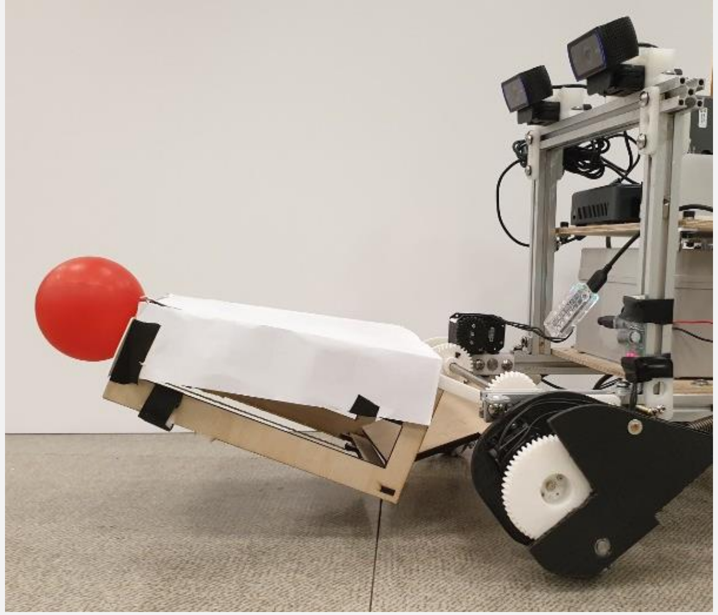
10 times of takerest() per operation – extra 3seconds

Lots of feedback + Failure >> extra 3 sec

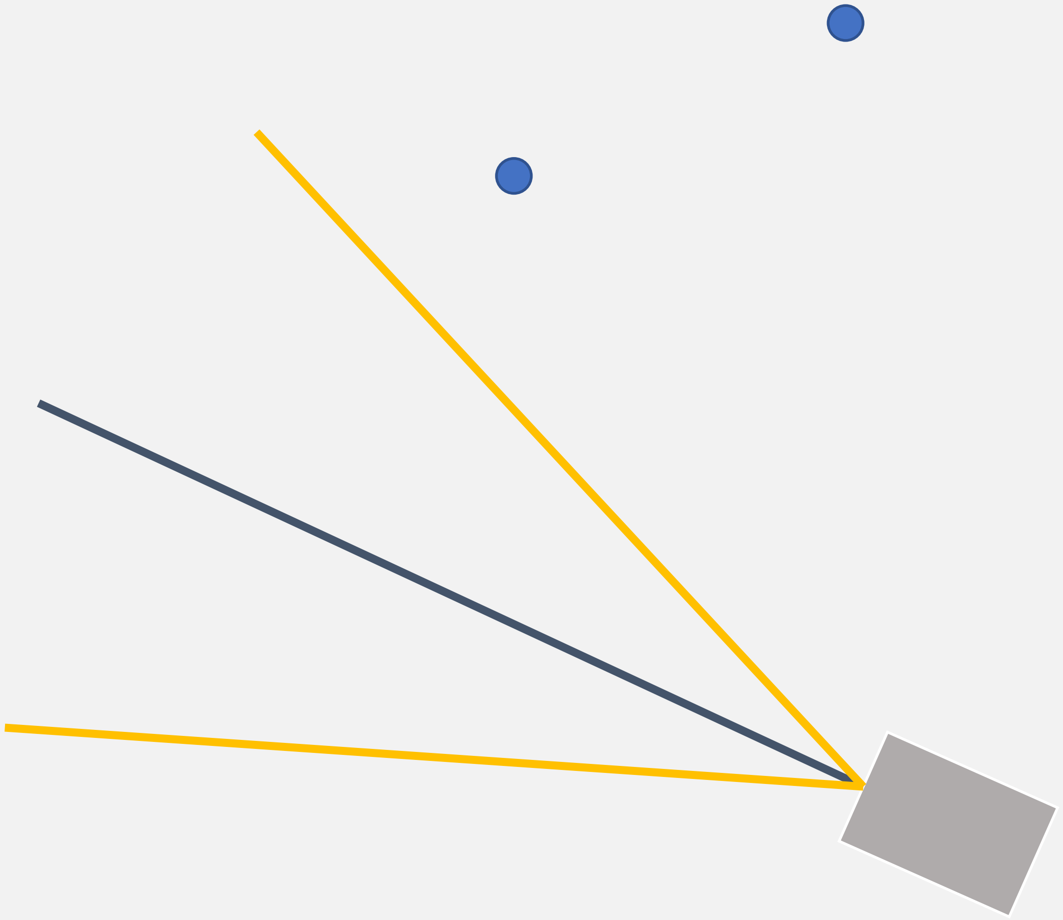
About red balls

Our hardware have a wall in front.

By attaching red balls on its way, we can reduce time.



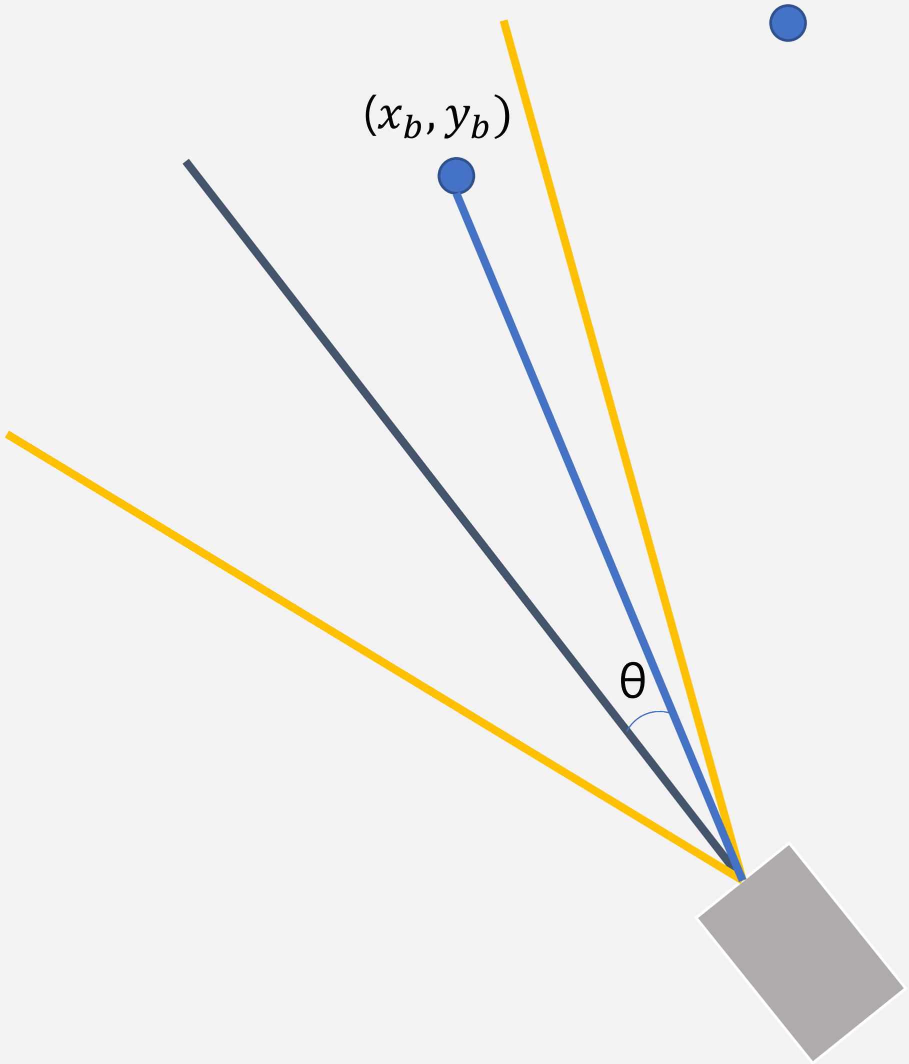
How do we collect blue balls?



No blue ball in sight!

Rotate CW

How do we collect blue balls?

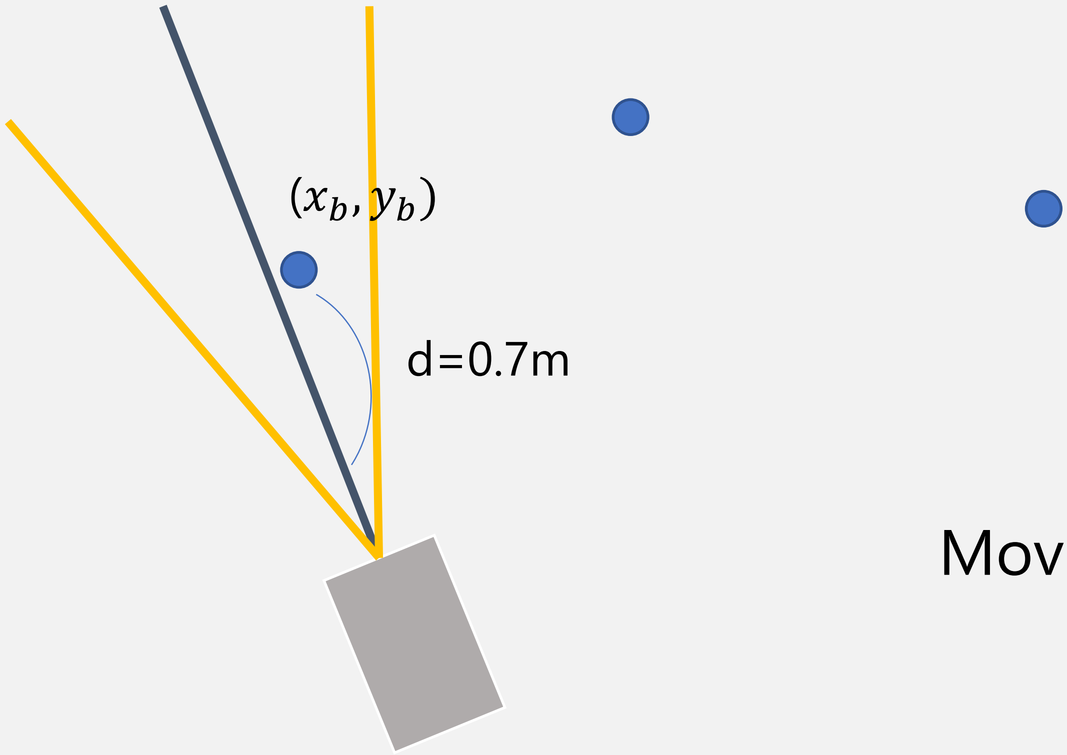


Check x coordinate size

If > 5cm -> Calculate θ and rotate

$$\theta = \tan^{-1}(\frac{y_b}{x_b})$$

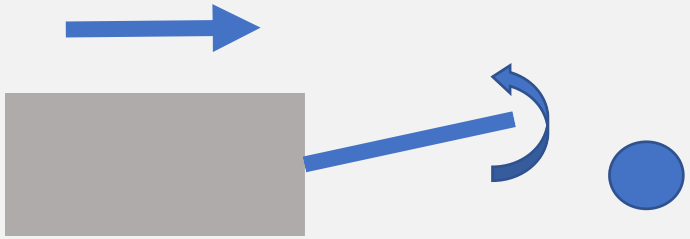
How do we collect blue balls?



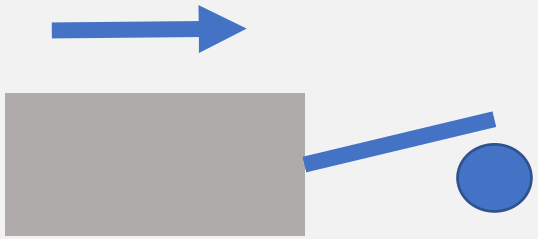
Move to point 0.7m away

How pickup is held?

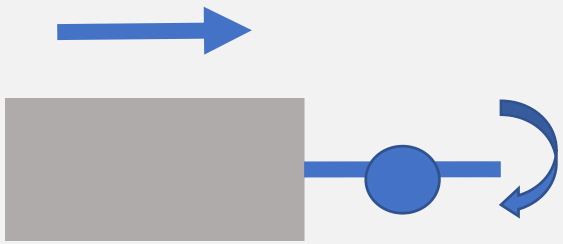
(When the device is in range of d=0.7m)



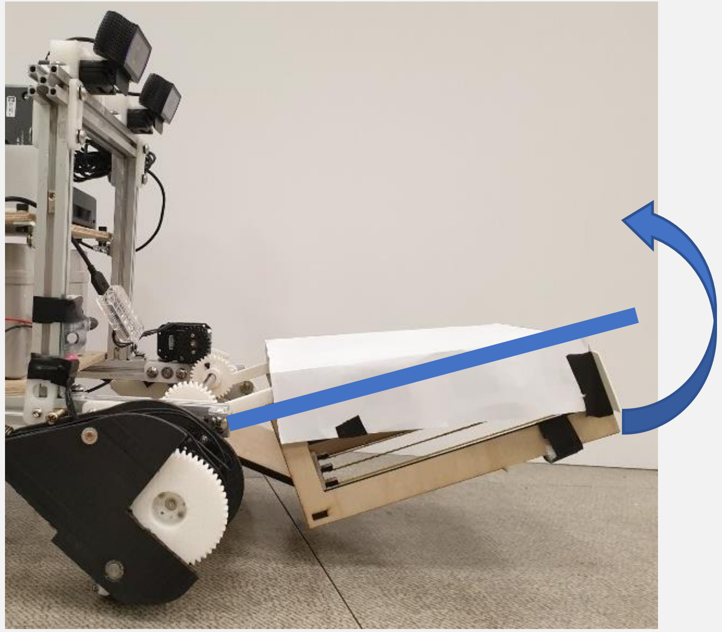
Move forward + lift the tray



Move forward
(Move 35cm)

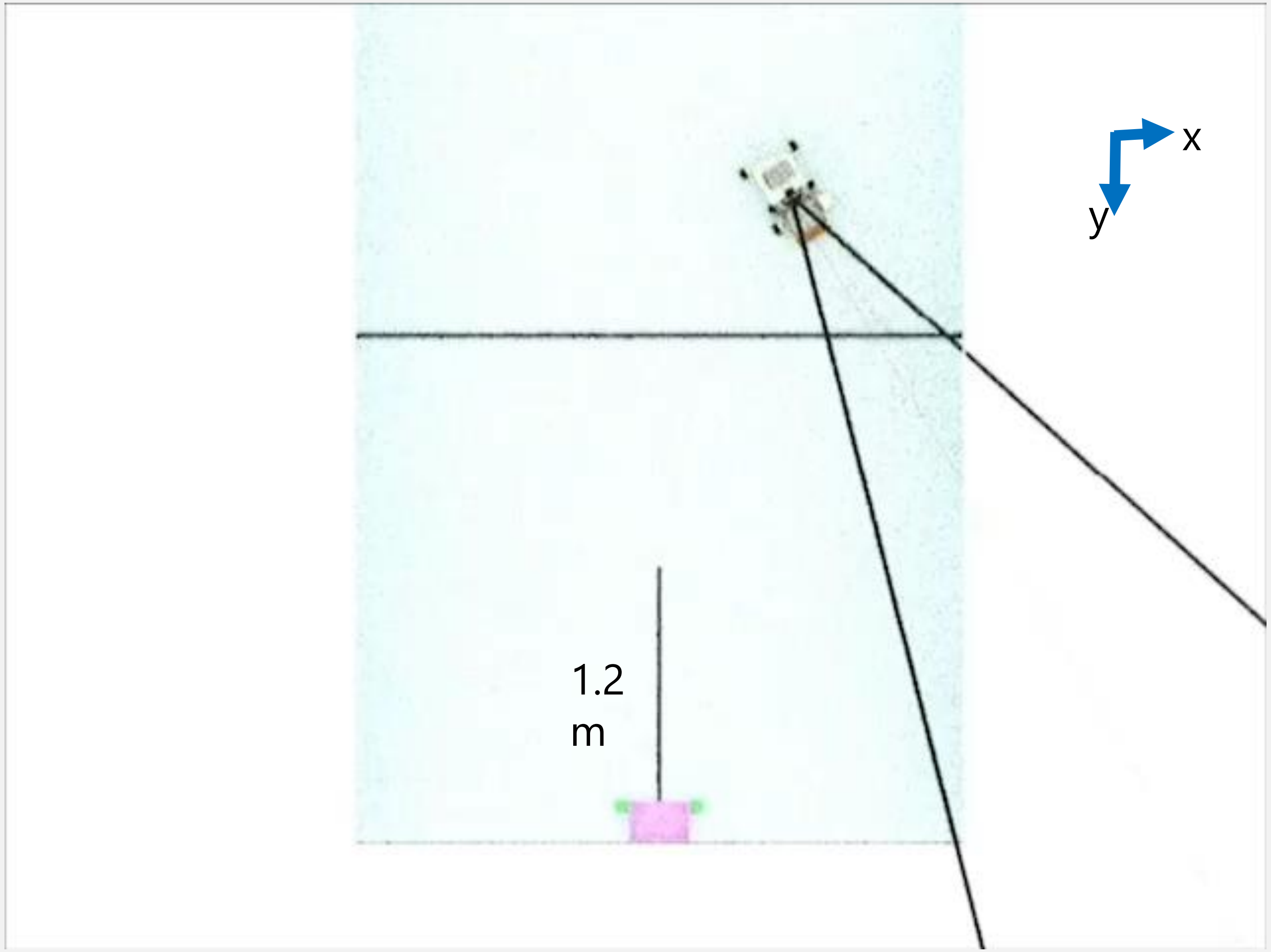


Move forward + lower the tray



How do we park?

Until two green balls are detected, Rotate!

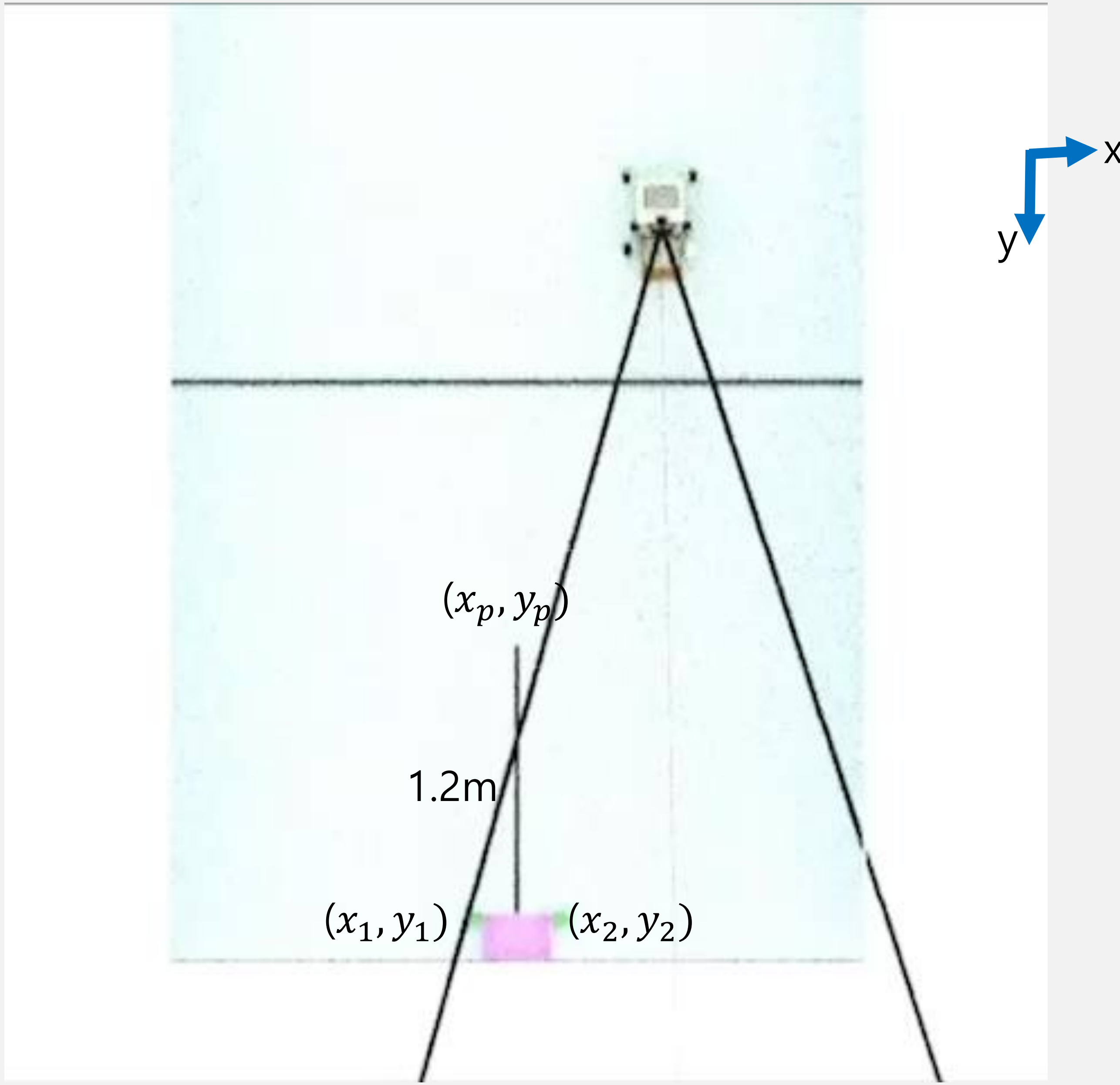


How do we park?

Calculate (x_p, y_p) and move to P

Calculate θ using $(x_p, y_p)\ and\ (x_{mid}, y_{mid})$

Rotate θ

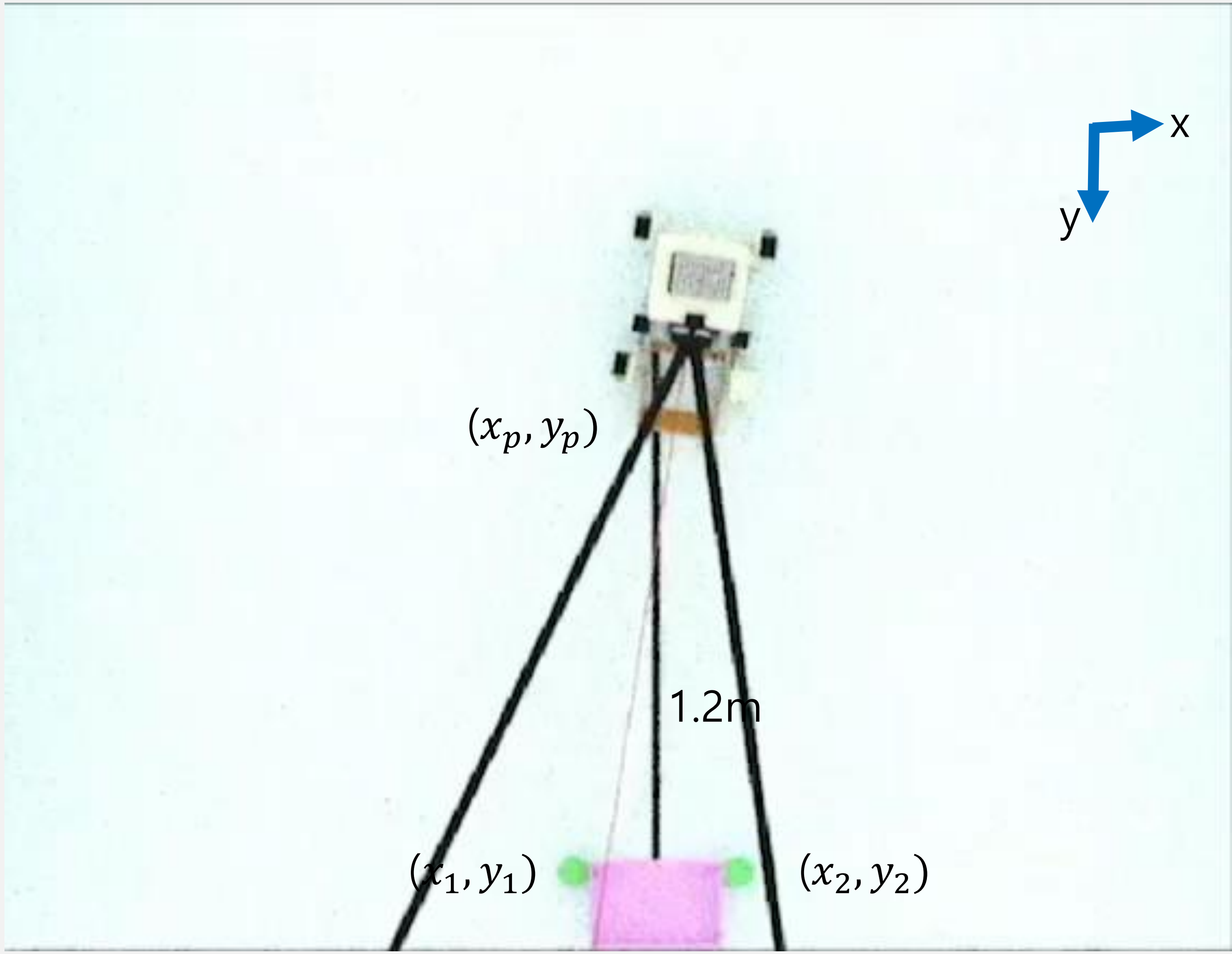


How do we park?

Case 1 – Perpendicular aligning

Perpendicular to basket
-> Rotate!

$|y_1 - y_2| < 0.01$: Angular aligned!

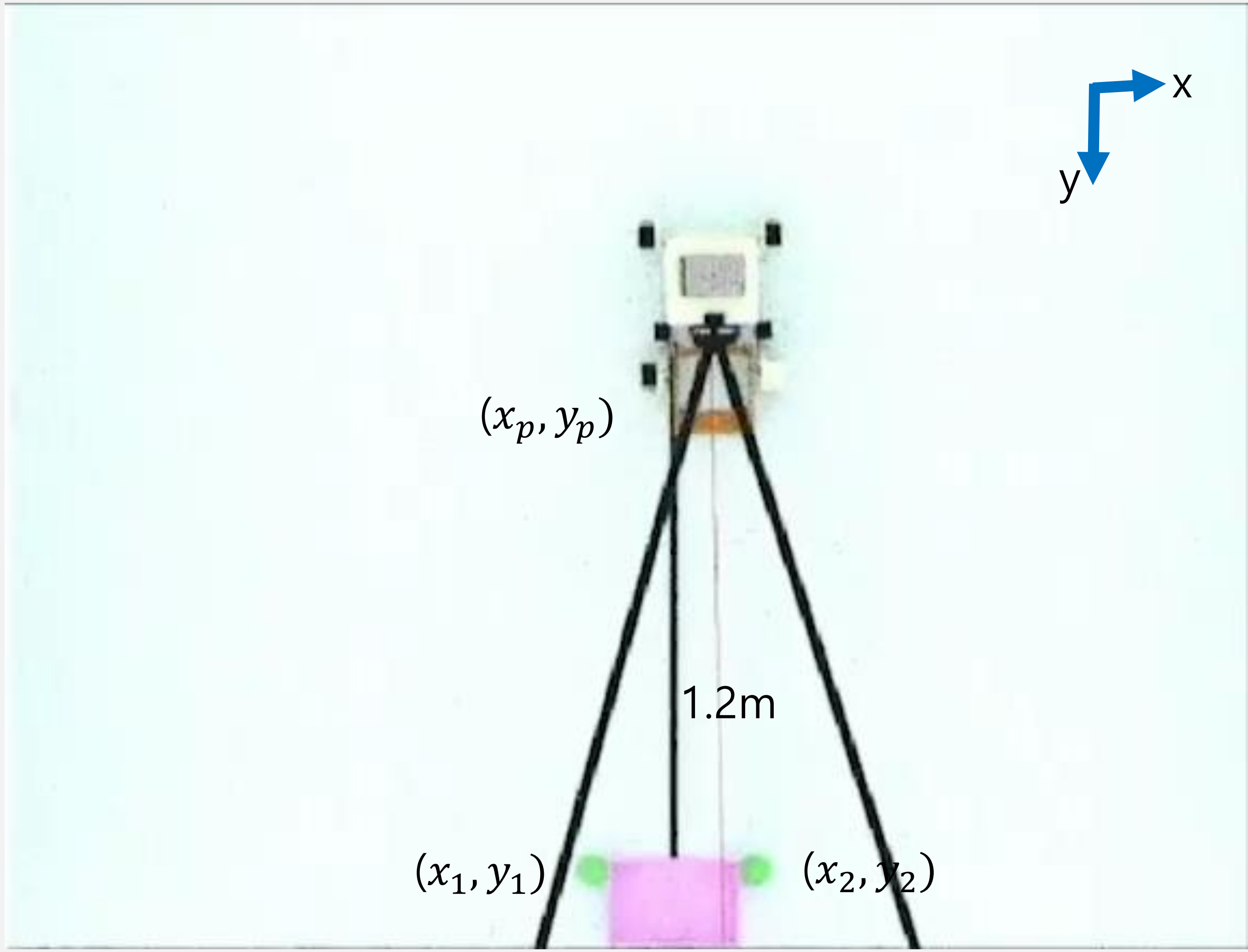


How do we park?

Case 2 – lateral alignment

Mid point alignment should be made!

$\left|\frac{x_1+x_2}{2}\right| < 0.02$: Aligned well in the middle!

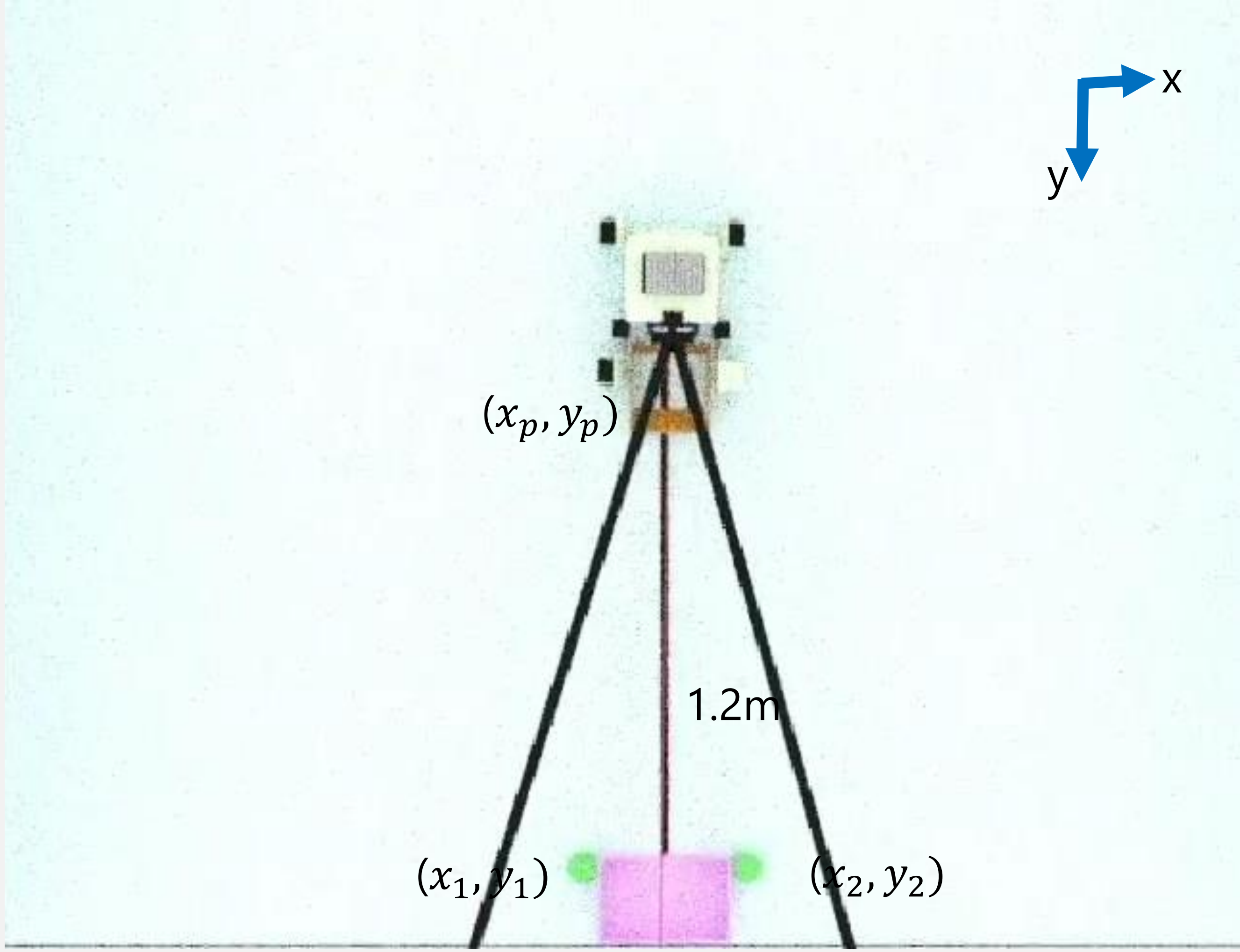


How do we park?

After two conditions are satisfied.

Move forward after alignment

Lift up tray to release balls!


x
y
(x_p, y_p)
1.2m
(x_1, y_1)
(x_2, y_2)