ME400: Capstone Design

Final presentation

Team I:
창시구실로
Roller 가자!

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Members.

System design
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System integration
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Jinsik Kim

Vision processing
Chaeree Park

31 May 2019

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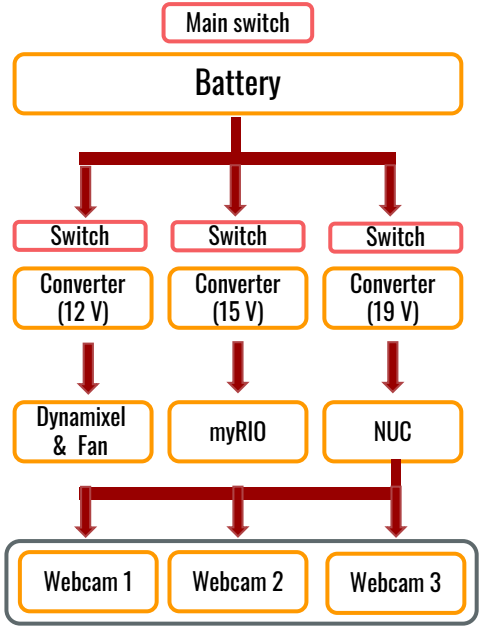
System design

“Work fast, but keep it cool”

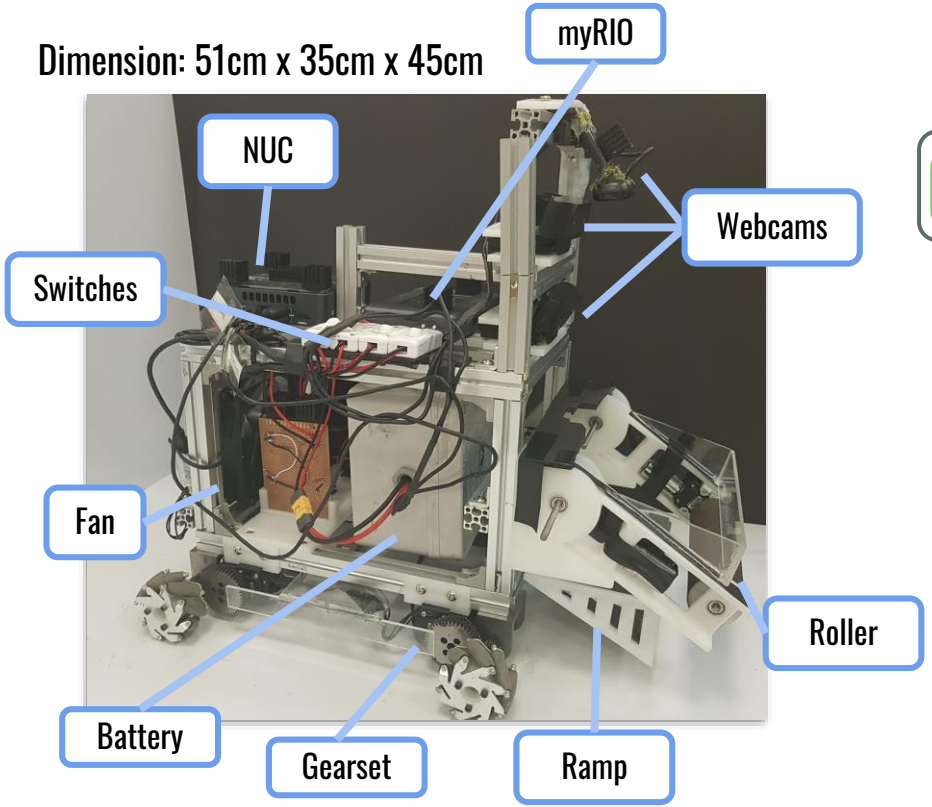
System design

Overall design

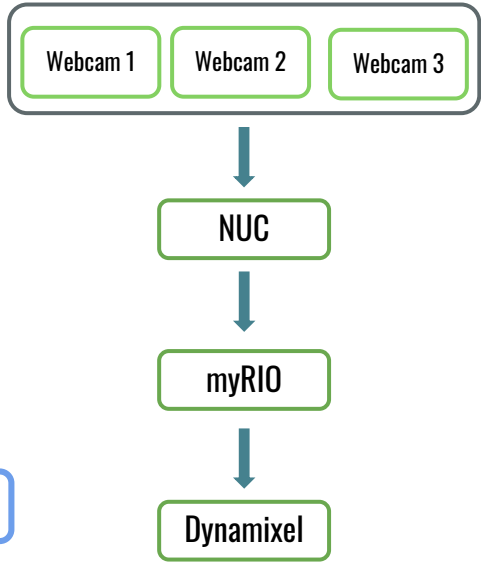
Power line



Dimension: 51cm x 35cm x 45cm



Data line

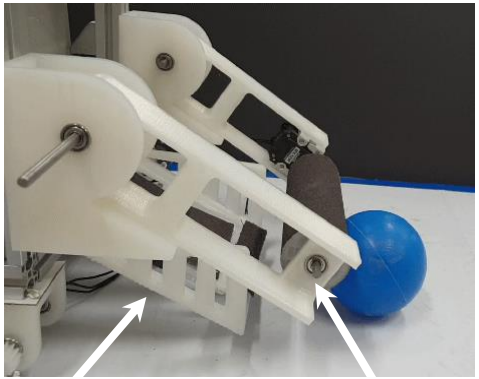


System design | Collecting system

Key feature

3-in-1 mechanism (pick up, storage, release)

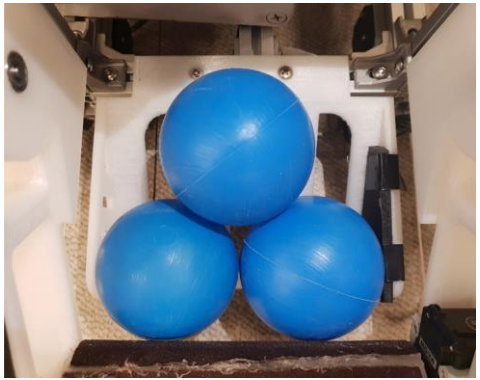
- **Fast** pick up speed (continuous forward movement)
- **Efficient** actuation by using a single motor for both pickup and release
- **Effective** storage space by sharing pick up inlet and release outlet (Ratio of ball area : ramp area = 0.7 : 1)



Storage

Pick up and release

Nonstop pick -up

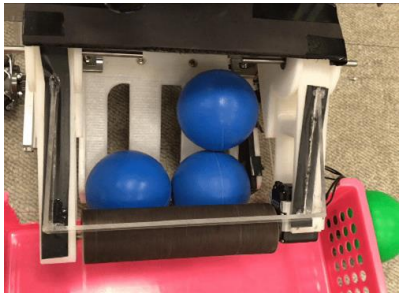


Storage area

System design | Detailed design | Ramp design

Problem definition

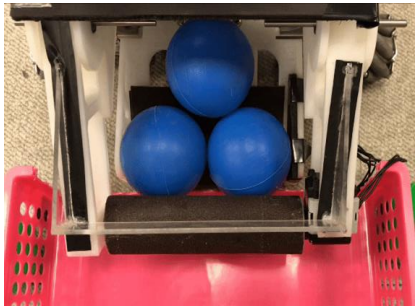
Ball release failure due to slipping



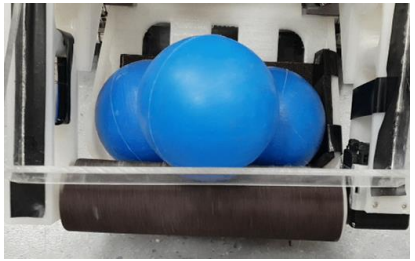
Ball climbing roller

Detailed design

Add sandpaper on ramp surface to prevent slipping



Build ball fence to prevent ball drop



System design Thermal Analysis

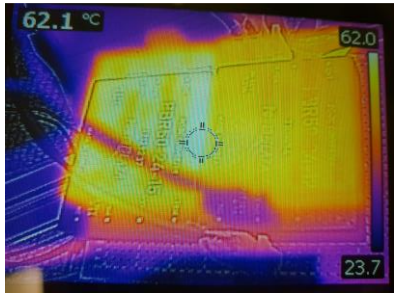
*Target temperature: 28~33°C
Ambient temperature: 23 °C

Overall temperature (before)

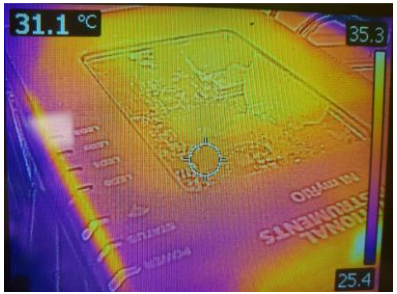
Part	Temperature(°C)
Converter	62.1
Dynamixel	25.6
myRIO	31.1
NUC	36.9
Battery	26.7
Webcam	31.9

Danger range
Potential danger range

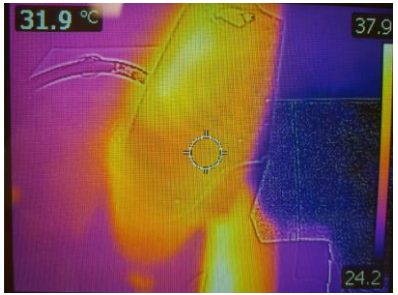
Converter



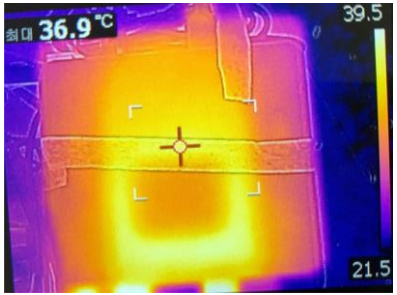
myRIO



Webcam



Nuc



System design Thermal Analysis

Goal: Keep all potential heat sources within target temperature range

1. Fan & Fin (Converter)

Our fan velocity + fin number:

8.276m/s / 300 fins

$$Q_{Emit} = Q_{Output}(\frac{1}{\varepsilon} - 1) = 49.2\,W(\frac{1}{0.93} - 1) = 3.7\,W$$

$$q_{Fin} = \sqrt{hPkA_c}\,tanhmL_c(L + \frac{t}{2}) = 4.427 \times 10^{-3}\,W$$

$$Q_{Emit} - 300q_{Fin} = 2.3716\,W = h_c A(T_s - T_\infty)$$

$$25.42\,W/m^2K \le h_c \le 38.13\,W/m^2K$$ → Target range

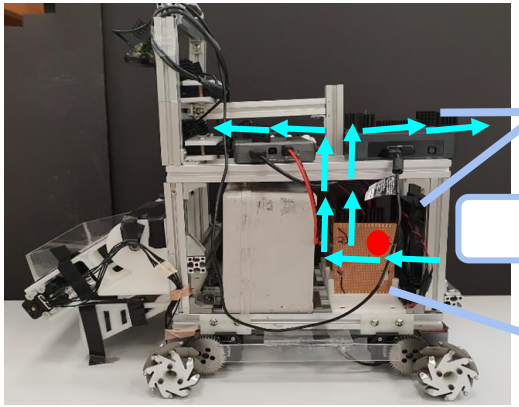
$$h_c = 10.45 - v + 10v^{0.5} = 10.45 - 8.276 + 10(8.276)^{0.5} = 31\,W/m^2K$$

→ Our convection coefficient

2. Component arrangement:

- Place the converter in front of the fan.

-Set up a layout so that the fan flow may reach all electronics



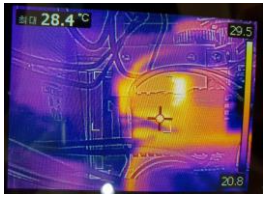
System design Thermal Analysis

*Target temperature: 28~33°C
Ambient temperature: 23°C

Overall temperature(After)

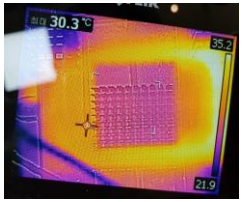
Part	Temperature(°C)
Converter	28.4
Dynamixel	23.2
myRIO	28.4
NUC	30.3
Battery	24.9
Webcam	29.7

Converter

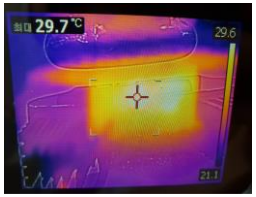


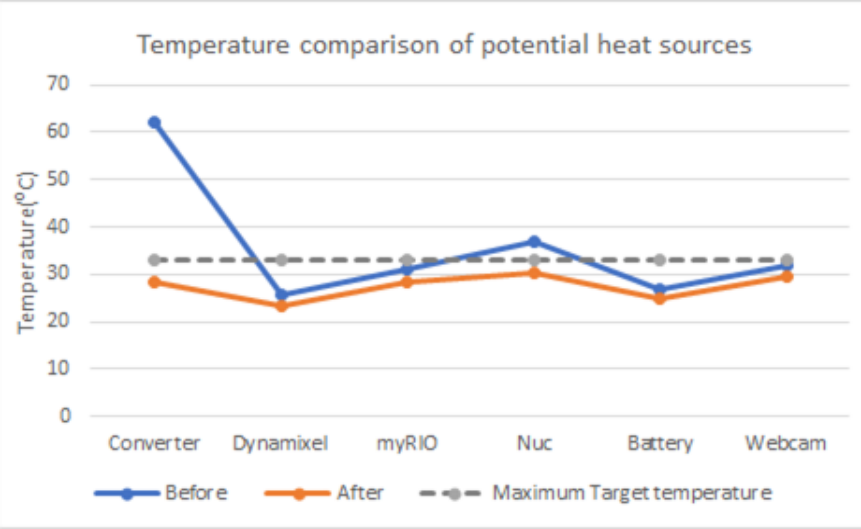
myRIO

Nuc



Webcam





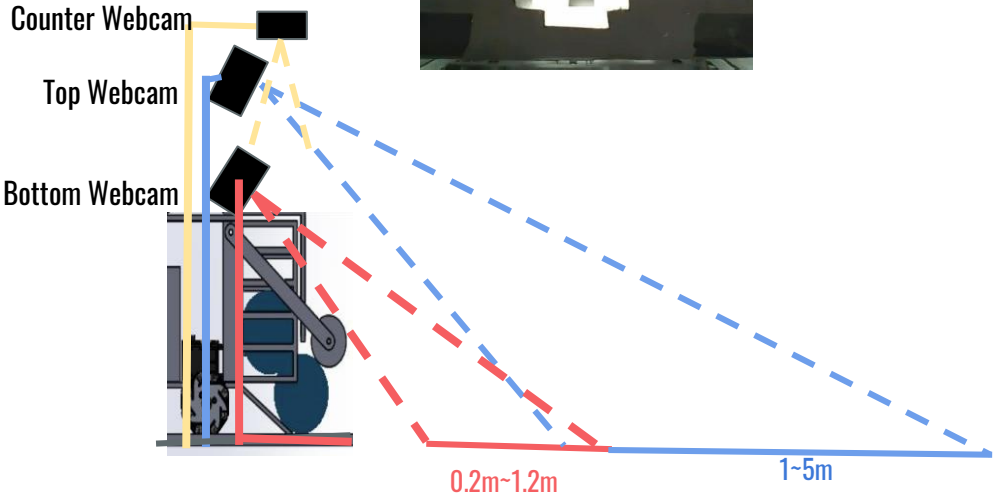
Vision processing (OpenCV)

“Increase pick up & release accuracy with three webcams”

OpenCV Webcam functions

Counter Webcam

Count the number of balls in the ramp

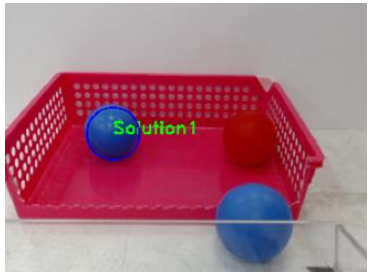


Top Webcam

Search for distant blue ball and green ball

Bottom Webcam

1. Search for close blue, red and green ball
2. Blue-ball-in-basket counter



OpenCV Troubleshooting

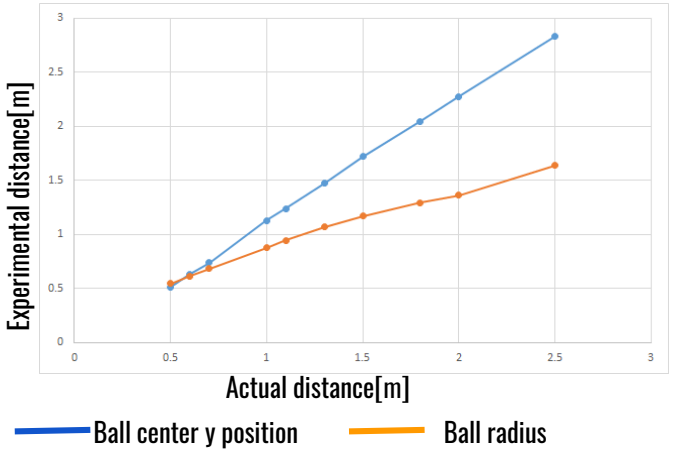
Problem

Inaccurate distance measurement using ball radius

Solution

Matching ball center y-pixel position and actual distance

Distance measurement with ball radius and center y-position

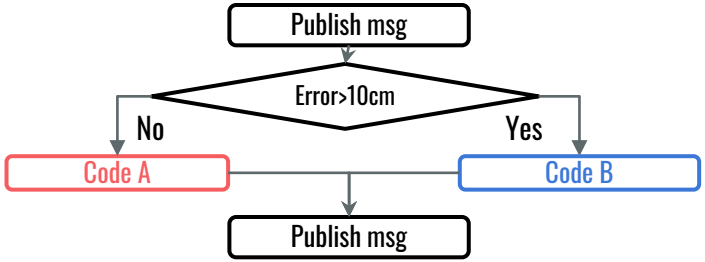


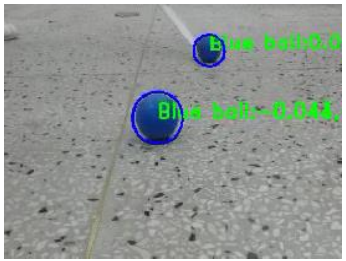
Problem

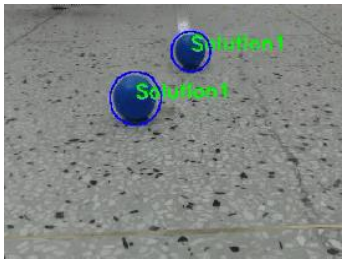
Two blue seen as single blue during ball overlap

Solution

Hybrid integration of two different Codes A & B







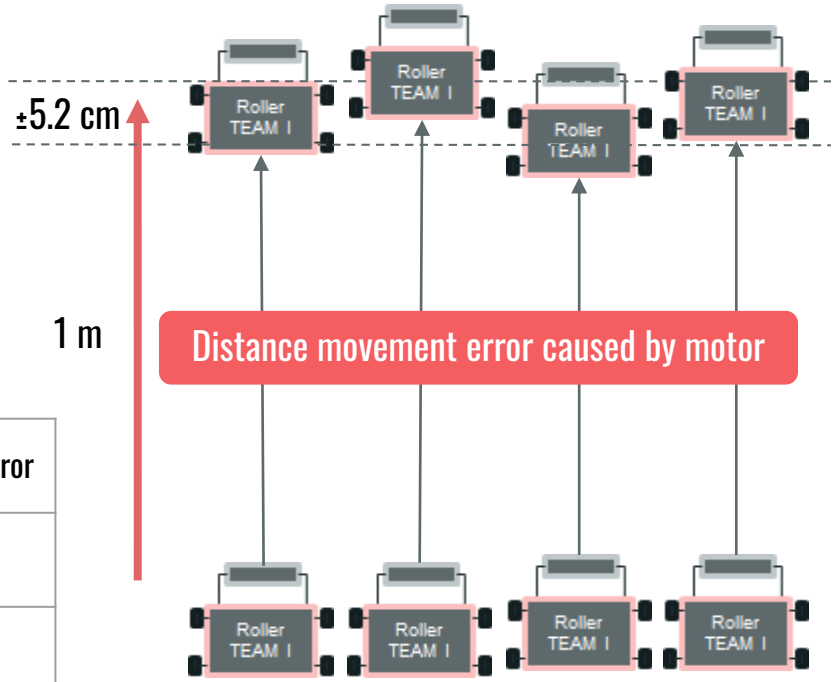
Vision processing

Vibration analysis

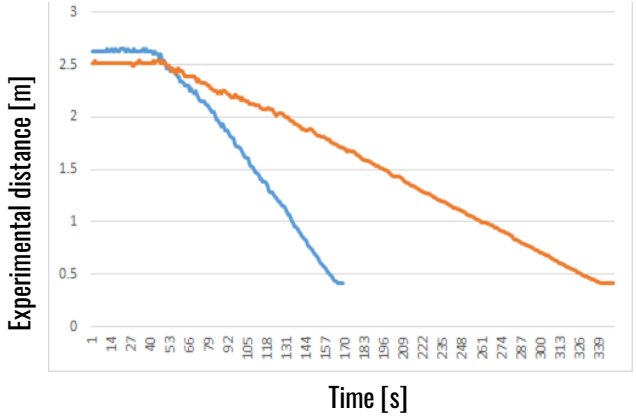
Problem

Analysis

- Vibration analysis with fast and slow vehicle movement (compare mecanum wheel caused error and dynamic vibration caused error)



Distance estimation variation due to vibration



	Peak to peak error
Slow	±5cm
Fast	±6cm

Conclusion: OpenCV distance measurement is not significant, suspension design is not mandatory

Motor control

“Time is gold”

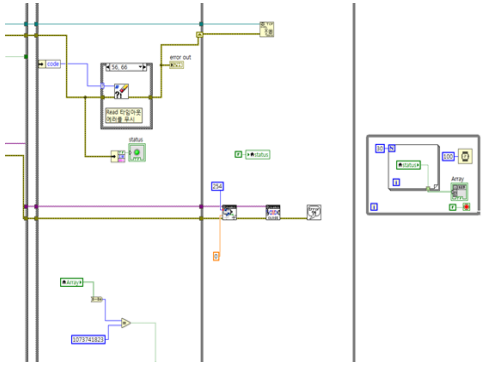
Motor control

Reducing debugging time

Previous procedure (3 mins)

- Node finished
- Myrio turn off
- Myrio turn on
- Wait until wifi become activate
- NUC wifi connecting
- rosrun

Time required : 3 mins



Totally saved time (for 100 cycles):
about 4 hrs 55 mins

Modified procedure (3 seconds)

- Node finished
- Myrio turn off
- Myrio turn on
- Wait until wifi become activate
- NUC wifi connecting
- rosrun

Time required : 3 seconds

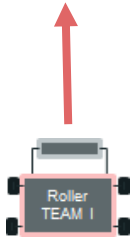
Motor control

Autonomous system

Receive 7x1 array from ROS

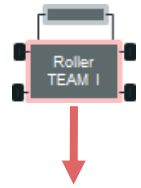
1st
2nd
3rd
4th
5th
6th
7th

1
0
0
0
0
0
0



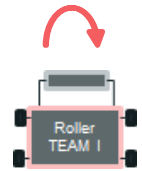
Mode 1 : Go forward

0
1
0
0
0
0
0



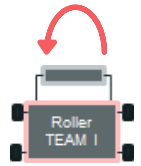
Mode 2 : Go backward

0
0
1
0
0
0
0



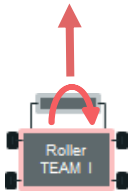
Mode 3 : Turn right

0
0
0
1
0
0
0



Mode 4 : Turn left

0
0
0
0
0
1
0

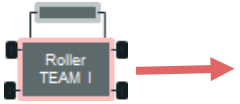


Mode 5 : Roller pick up & go forward slowly

0
0
0
0
0
1
0

Mode 6 : Drop out

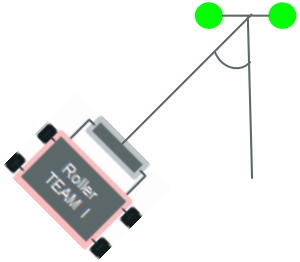
0
0
0
0
0
0
1



Mode 7 : Go right

Motor control

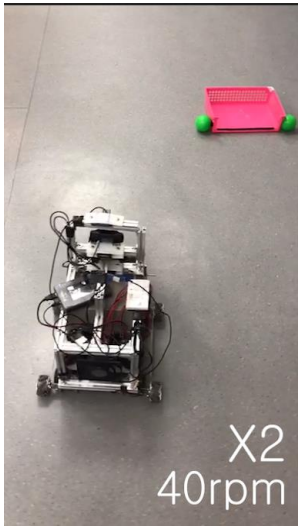
Lateral motion optimization

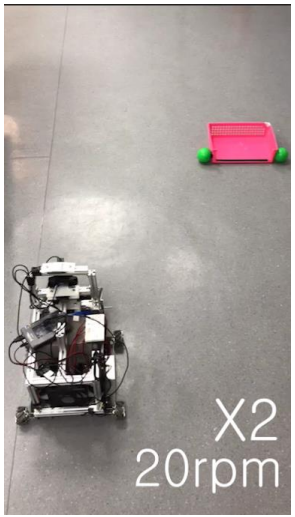


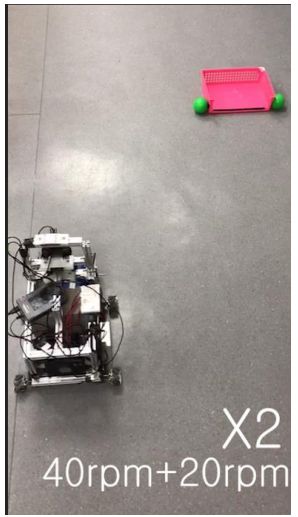
40 rpm
Fast movement but high overshoot & vibration

20 rpm
Low vibration but slow movement

If θ > 20°: 40 rpm
If θ < 20°: 20 rpm
Fast and low vibration

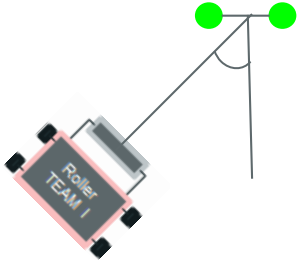




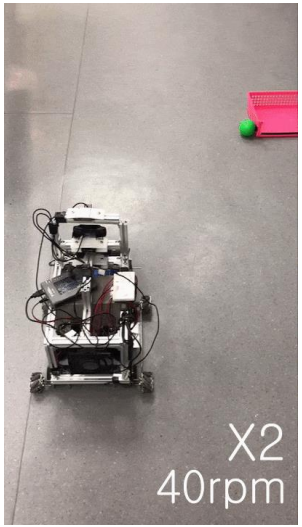


Motor control

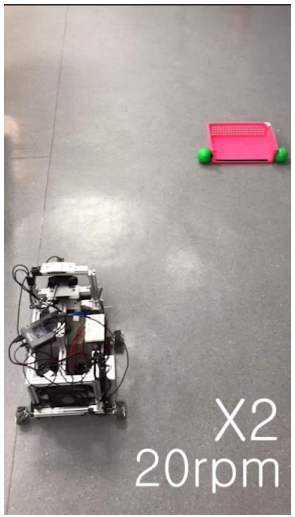
Lateral motion optimization



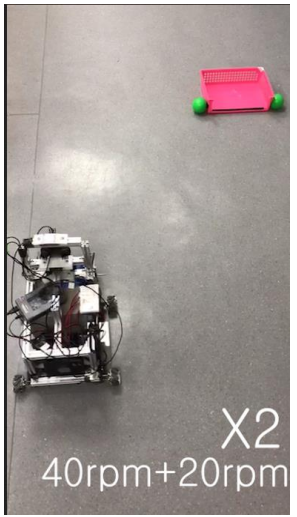
40 rpm
Fast movement but high overshoot & vibration
time : 21s



20 rpm
Low vibration but slow movement

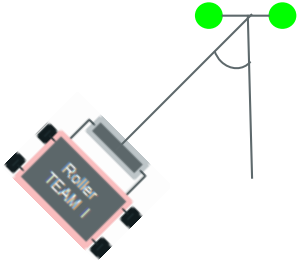


If θ > 20°: 40 rpm
If θ < 20°: 20 rpm
Fast and low vibration

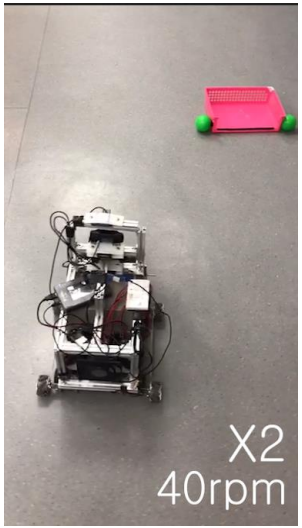


Motor control

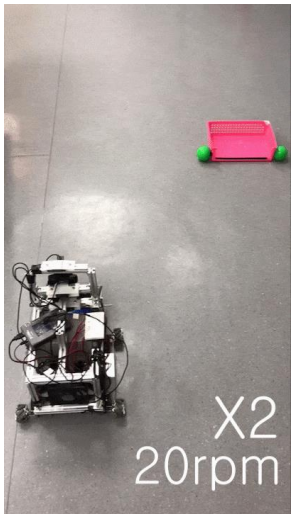
Lateral motion optimization



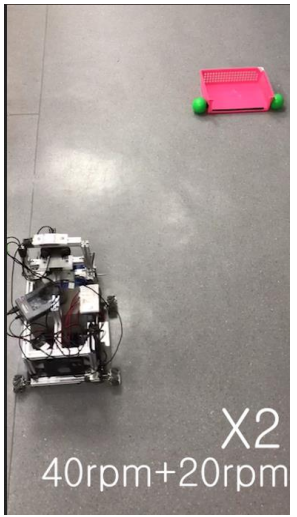
40 rpm
Fast movement but high overshoot & vibration
time : 21s



20 rpm
Low vibration but slow movement
time : 18s

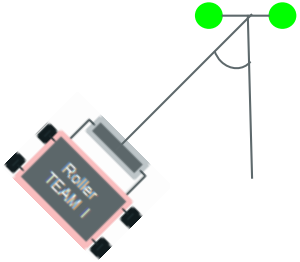


If θ > 20°: 40 rpm
If θ < 20°: 20 rpm
Fast and low vibration

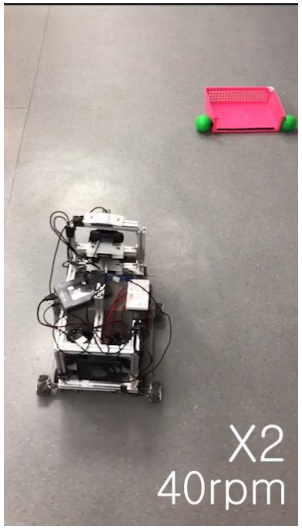


Motor control

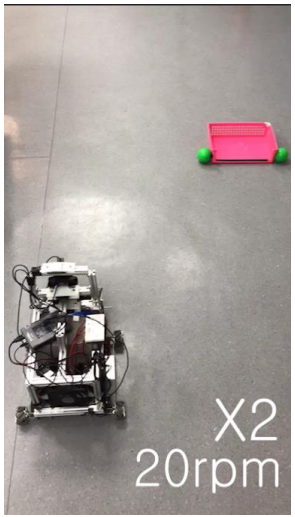
Lateral motion optimization



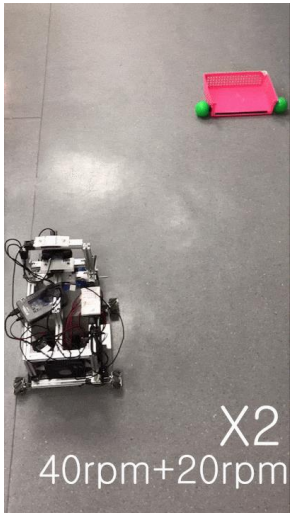
40 rpm
Fast movement but high overshoot & vibration
time : 21s



20 rpm
Low vibration but slow movement
time : 18s



If θ > 20°: 40 rpm
If θ < 20°: 20 rpm
Fast and low vibration
time : 15s

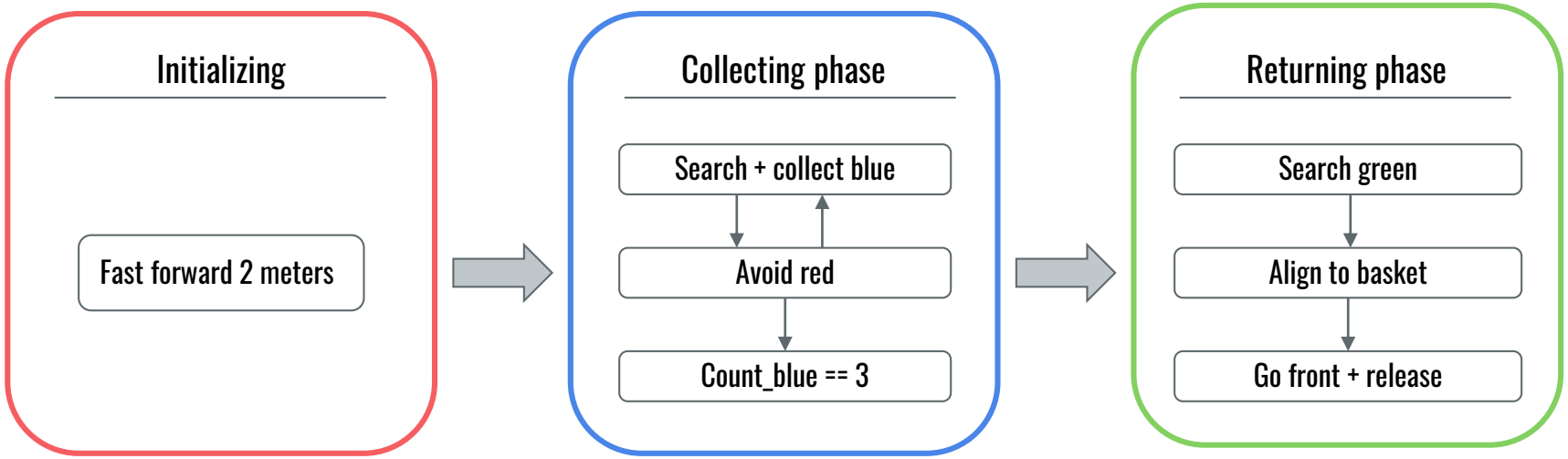


ROS TEAM

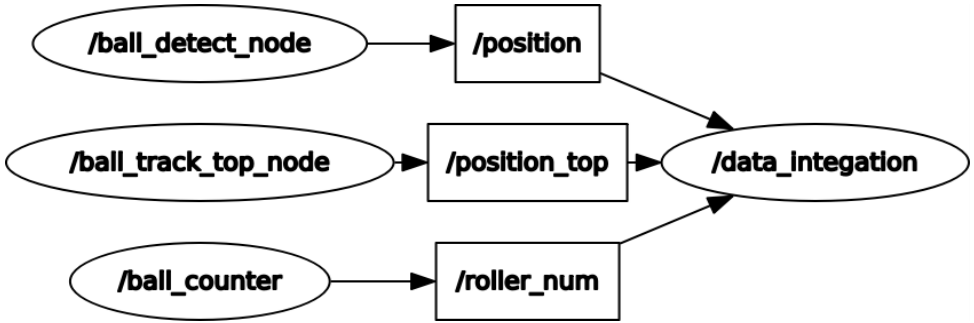
“Guarantee complete pick up and release”

ROS

Overall system (revisit and addition)



Rqt_graph:



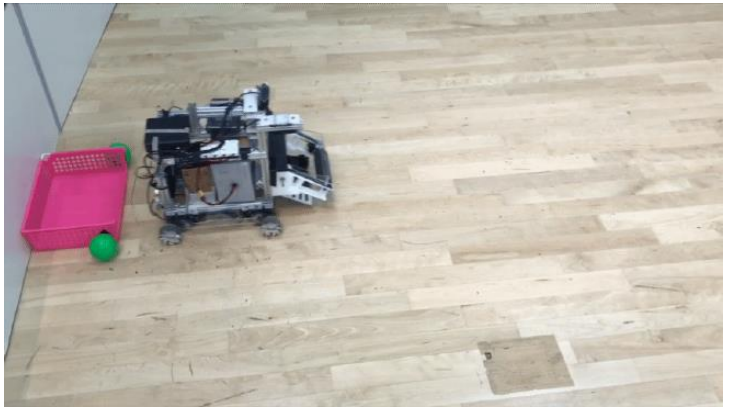
ROS Collecting phase

Problem definition

SEARCH:
Unstable blue detection at far distance
⇩
Infinite loop (turning left ⟺ right)

Solution

Moving forward 2 meters
⇩
Ensuring stable blue detection



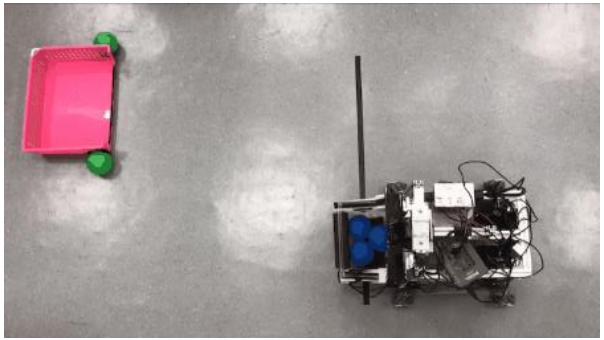
ROS

Returning phase - Alignment to green balls

Problem definition

Inaccurate lateral motion causing:

1. Imprecise alignment to basket with open loop movement
2. Unable to detect two green balls



↑ Commanded to move right direction, but it moves forward

↑ Unable to detect two green balls together due to imprecise lateral movement

ROS

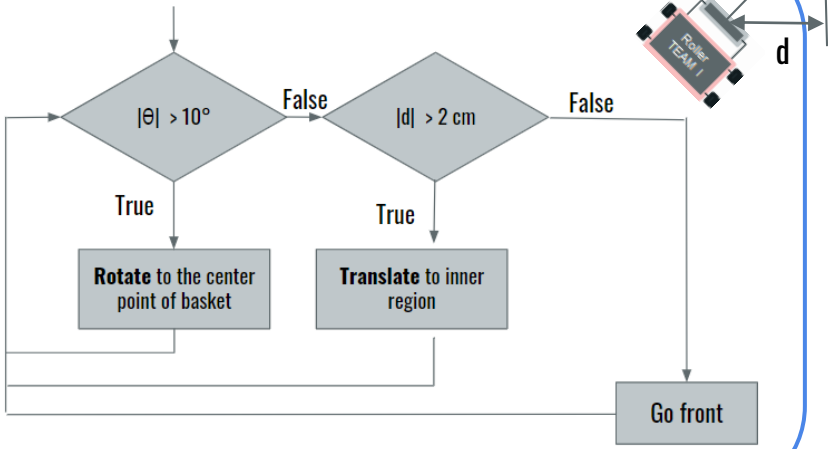
Returning phase - Alignment to green balls

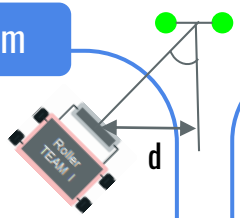
Problem definition

Inaccurate lateral motion causing:

1. Imprecise alignment to basket with open loop movement
2. Unable to detect two green balls

Solution: Adding position feedback algorithm

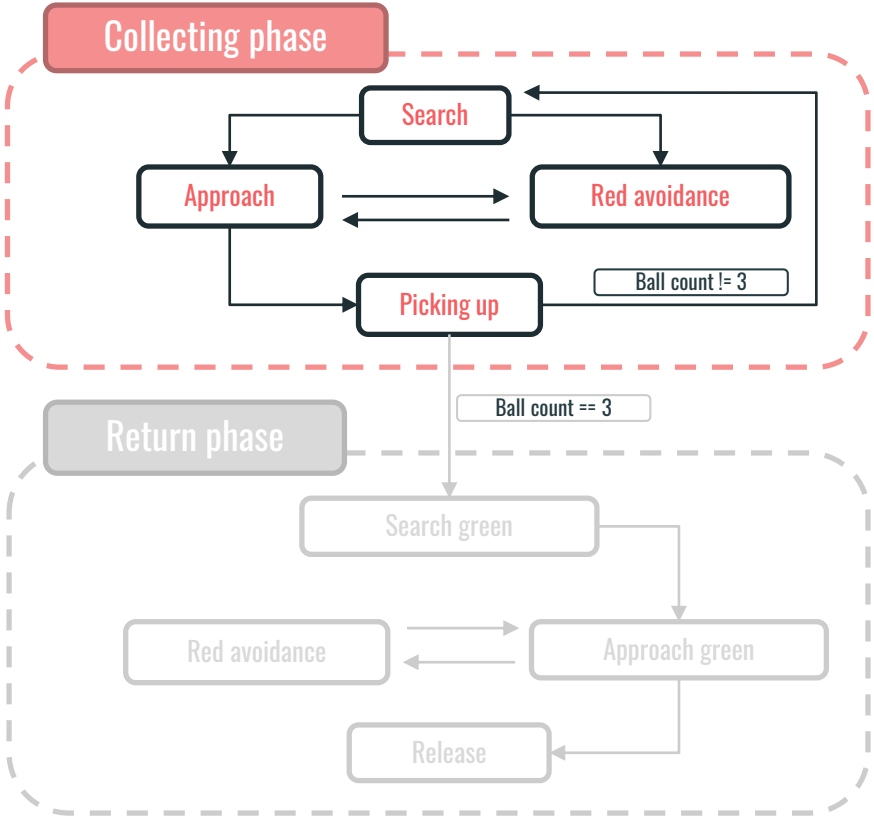


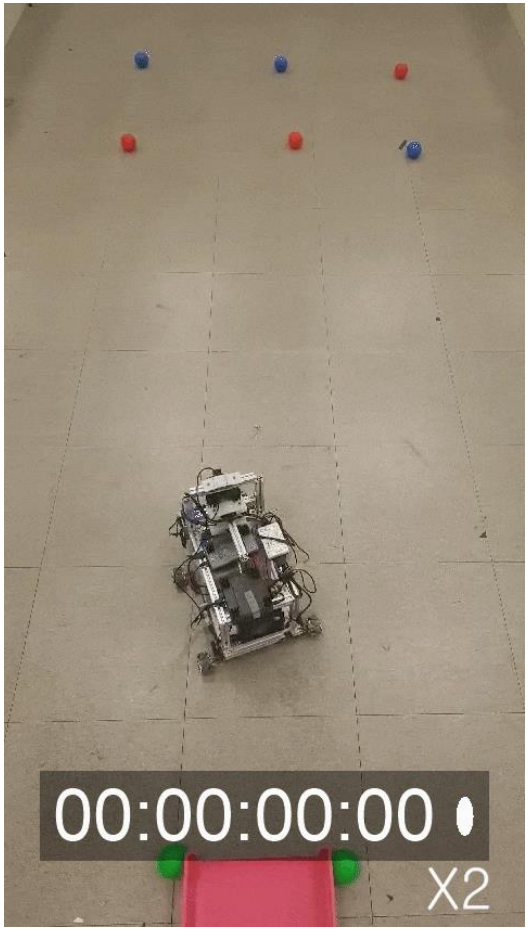


Solution: Aligning at further distance

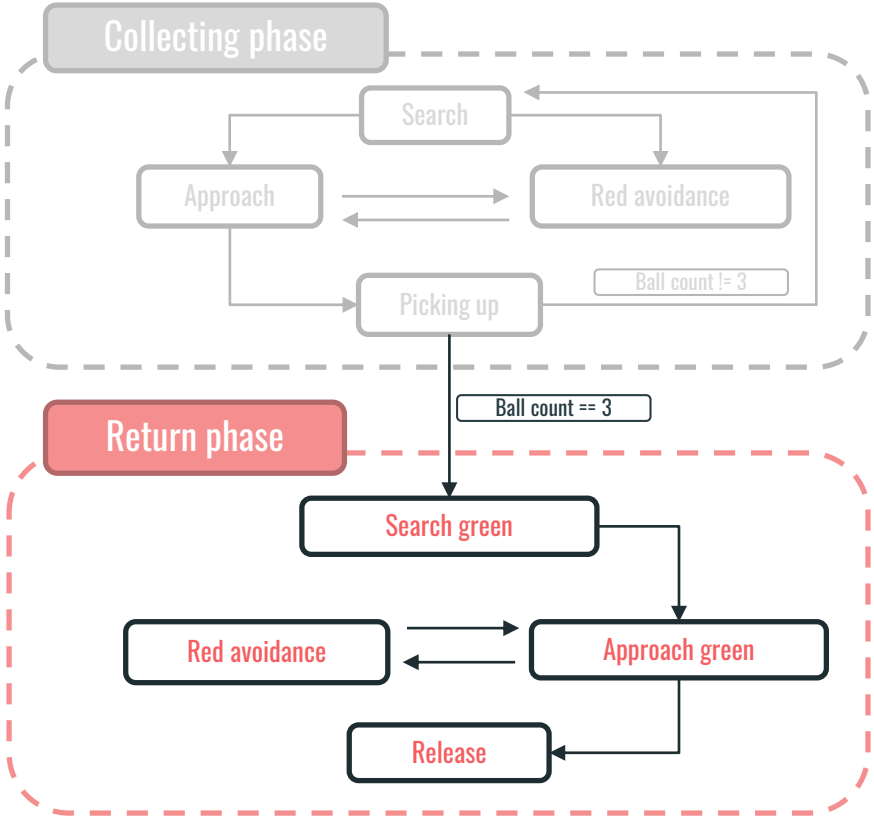
Guarantee perfect alignment!

ROS Finalized algorithm





ROS Finalized algorithm



Prototype Demo video

Q&A

THANK YOU CAPSTONE DESIGN I