ME400
CAPSTONE DESIGN 1

FINAL PRESENTATION

BAM

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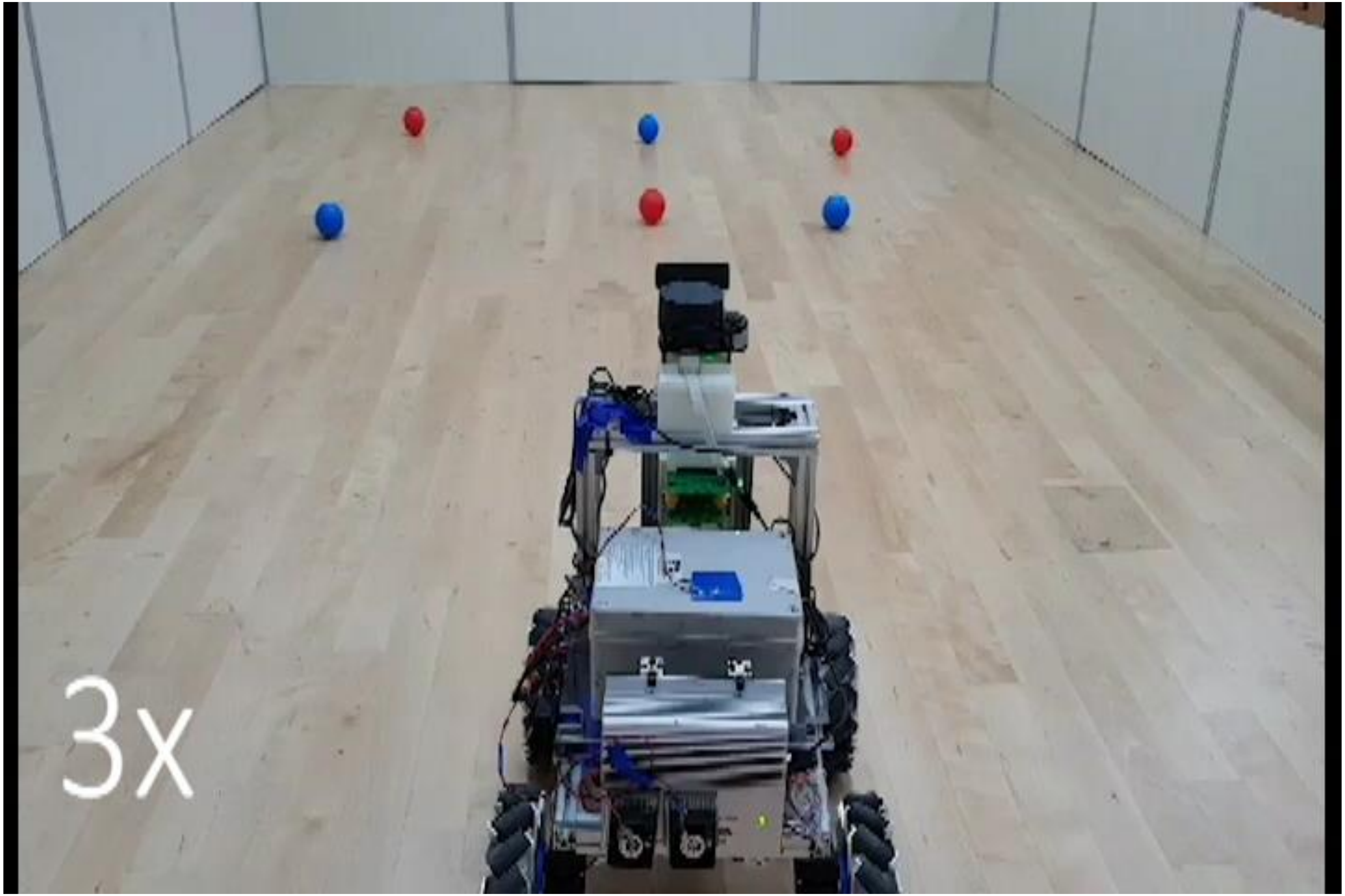
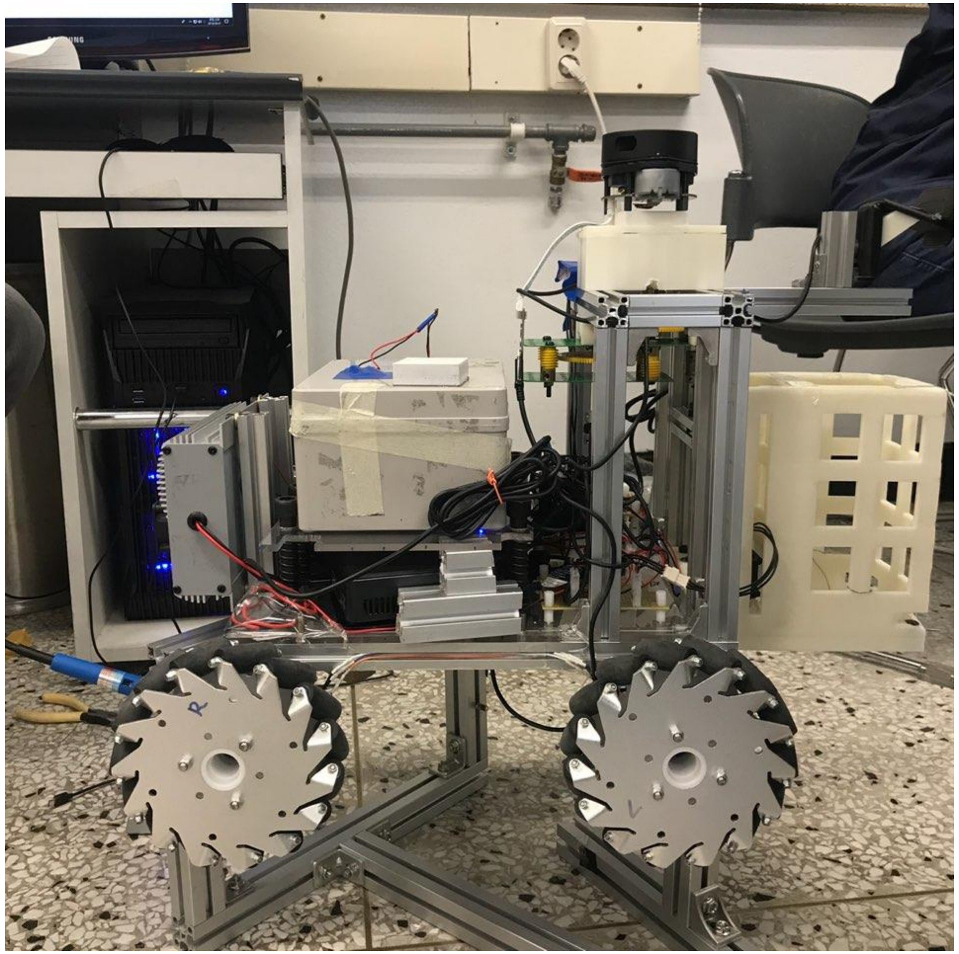

3x

Our Namsame-2 has...



HEAT MONITORING SYSTEM

UNIQUE PICK-UP MECHANISM

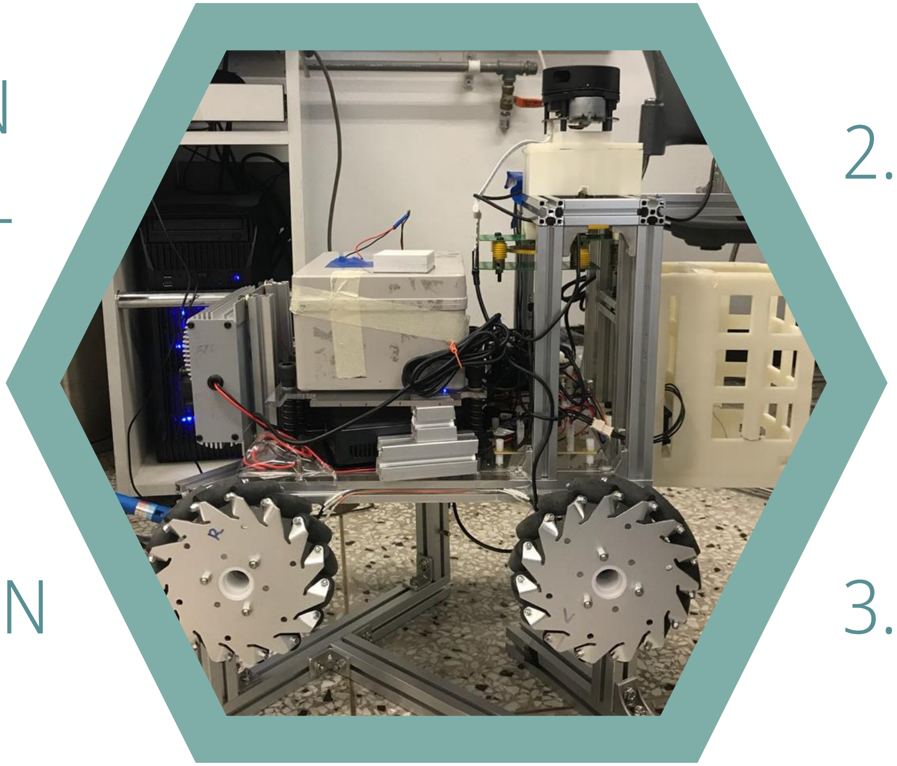
CREATIVE WAY TO AVOID RED BALL

ACCURATE CONTROL SYSTEM

1. HEAT MANAGEMENT

6. MOTOR OPERATION AND CONTROL

2. VIBRATION REDUCTION



5. ROS INTEGRATION

3. PICK-UP PART

4. VISION RECOGNITION

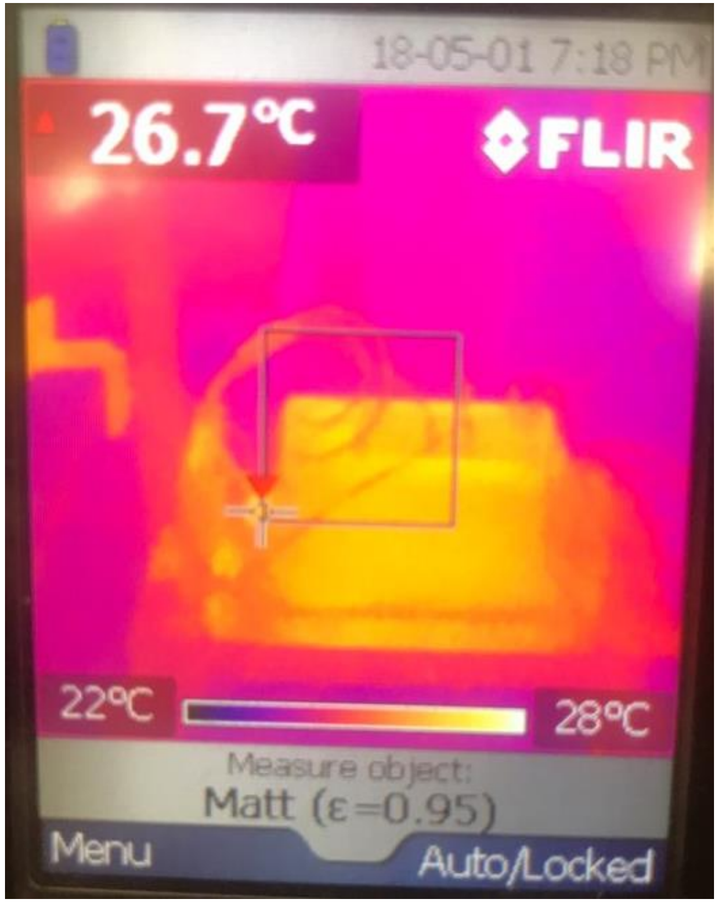
CONTENTS

COOLING SYSTEM

Related criteria:

1. HEAT MANAGEMENT
6. MOTOR OPERATION AND CONTROL

PROBLEM DEFINITION

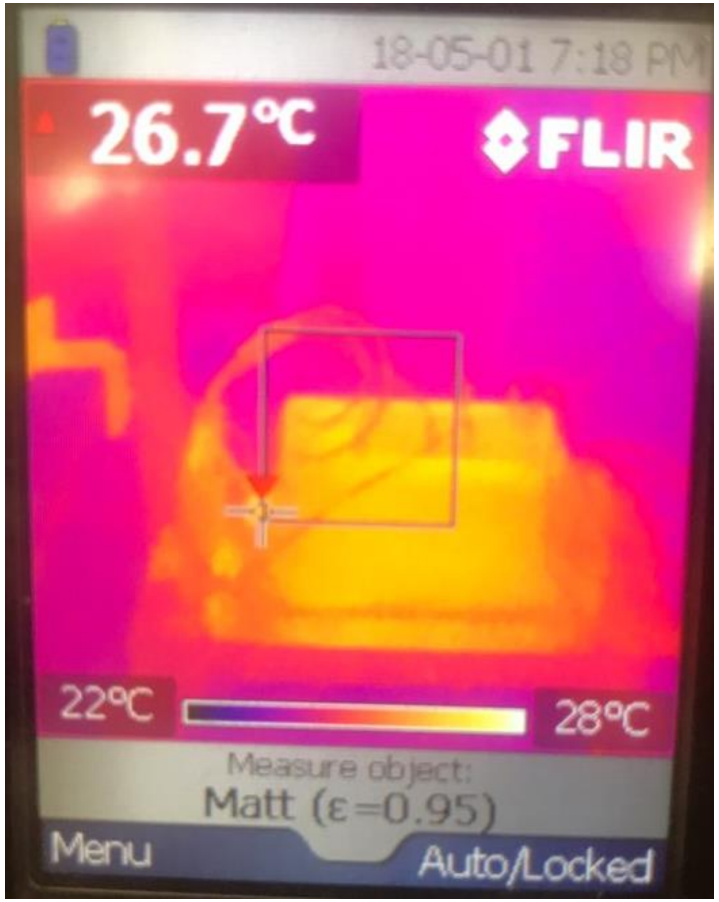


Before operating

COMPONENT	OPTIMUM TEMPERATURE
myRIO	0 ~ 70 °C
Converter	-40 ~ 85 °C
NUC	0 ~ 50 °C
Motor (MX 64)	-5 ~ 80 °C
Motor (MX 28)	-5 ~ 80 °C

Optimum temperature

EXPERIMENT

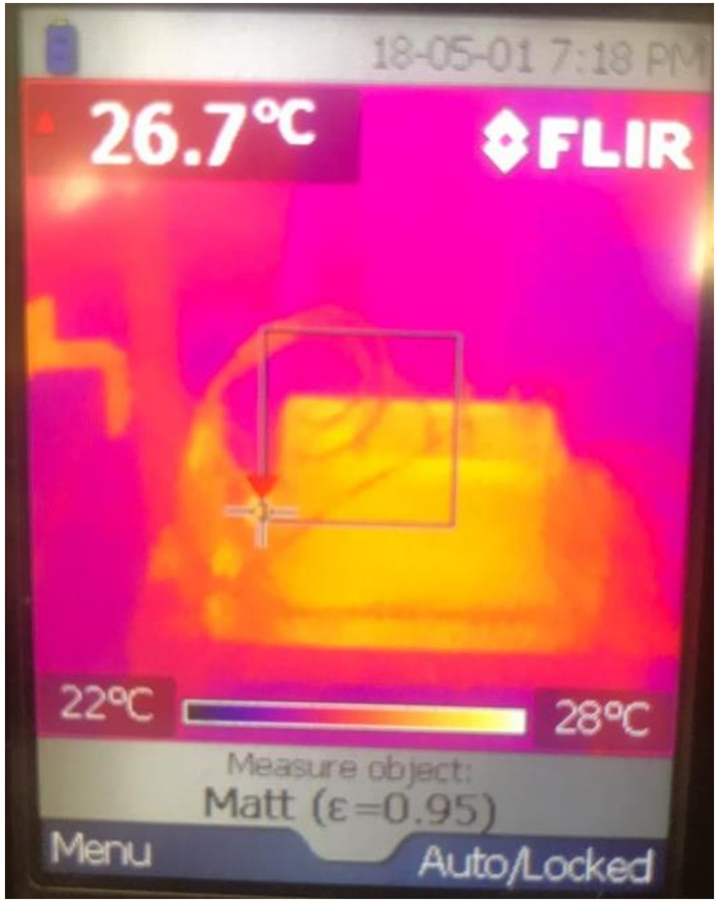


Before operating

COMPONENT	TEMPERATURE
myRIO	43.2 °C
Converter	37.3 °C
NUC	28.7 °C
Motor (MX 64)	34.2 °C
Motor (MX 28)	39.1 °C

After operating 2hr

RESULT

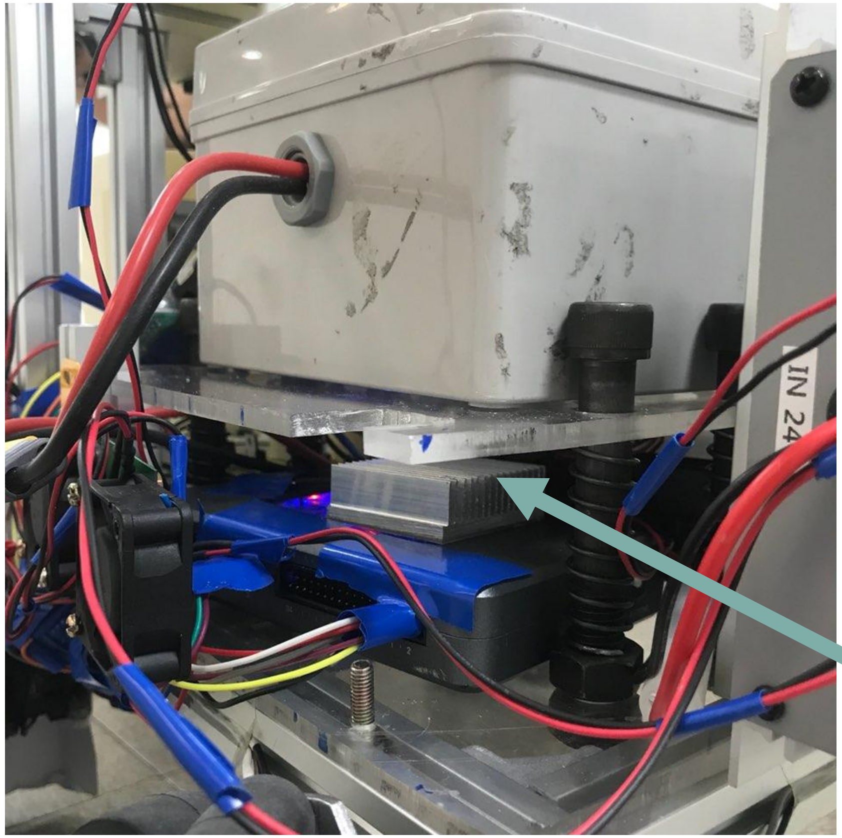


Before operating

COMPONENT	TEMPERATURE	
myRIO	43.2 °C	< 70 °C
Converter	37.3 °C	< 85 °C
NUC	28.7 °C	< 50 °C
Motor (MX 64)	34.2 °C	< 80 °C
Motor (MX 28)	39.1 °C	< 80 °C

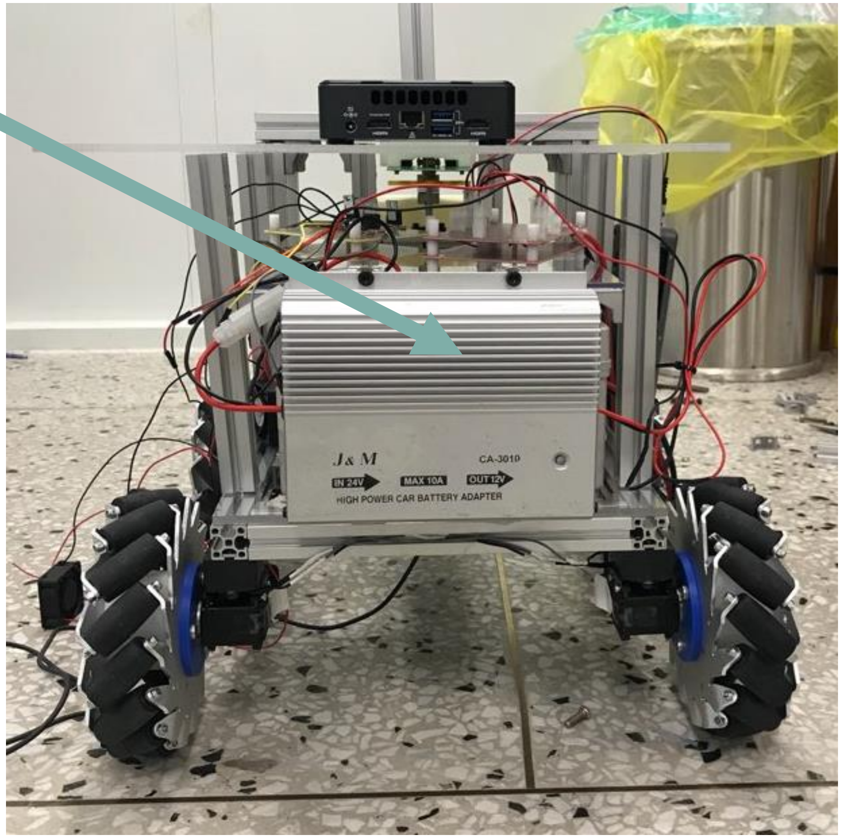
After operating 2hr

1. STRUCTURAL SOLUTION

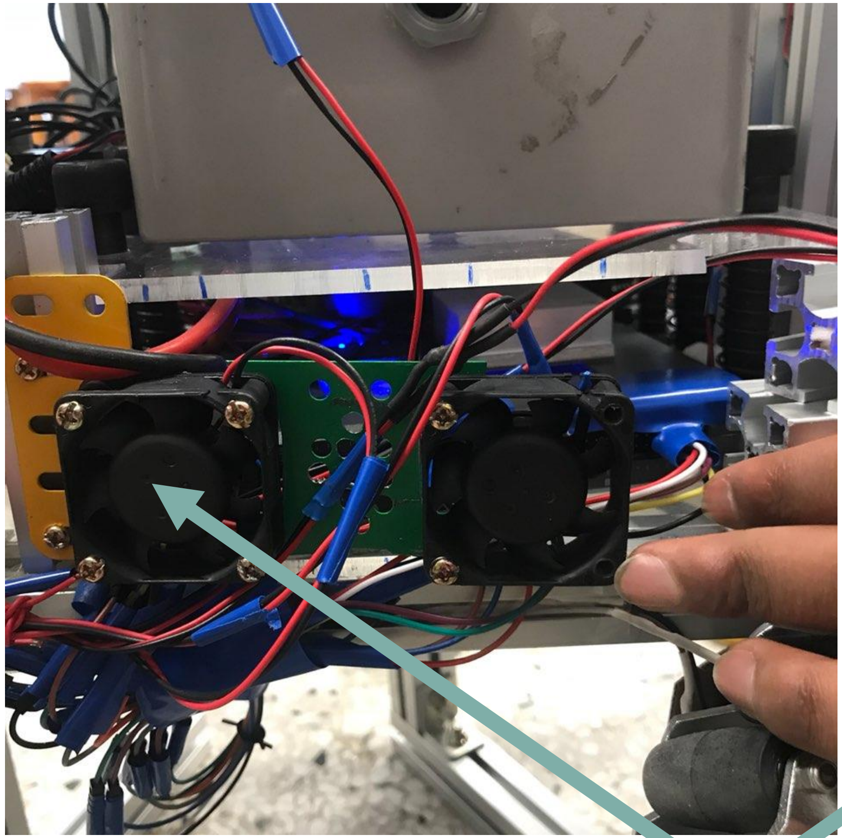


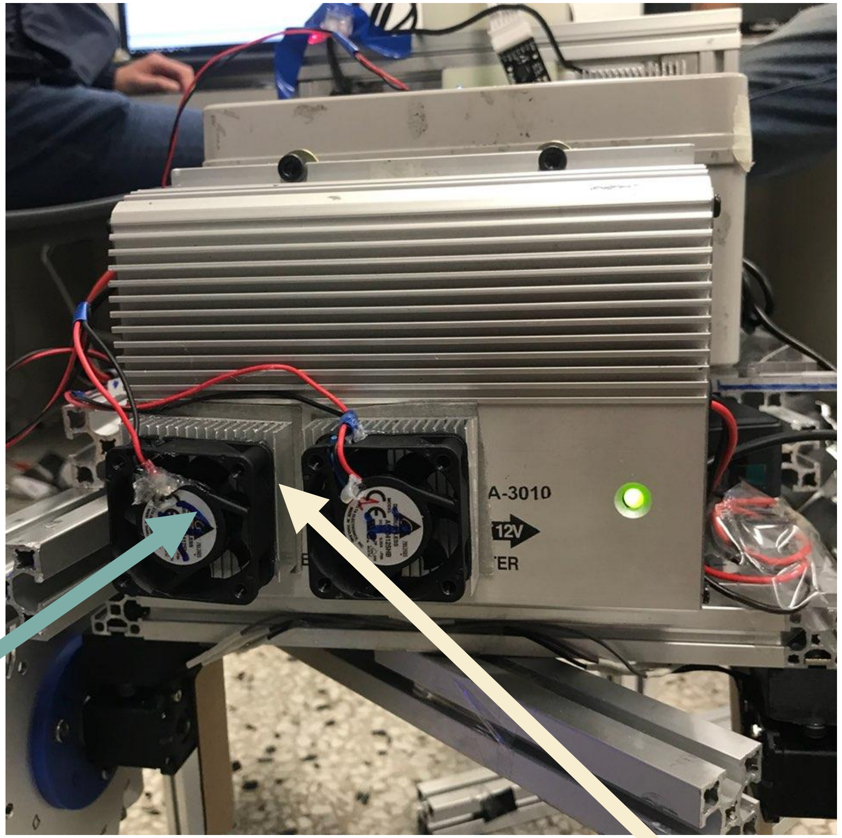
Space between each component and base

Maximum contact area with the air



2. DESIGN SOLUTION





Fan

Heatsink

3. SELECTIVE CONTROL SOLUTION

MEASURING → MONITORING

IF NEEDED

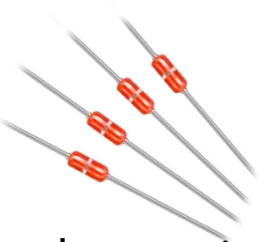
CONTROLING → COOLING

POWER EFFICIENCY!!

3. SELECTIVE CONTROL SOLUTION

Use analog output and GND from myRIO

FAN control



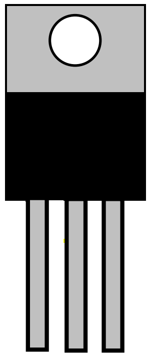
myRIO

Temperature read by thermistor and thermometer in dynamixel

If over 40 °C

5V: ON

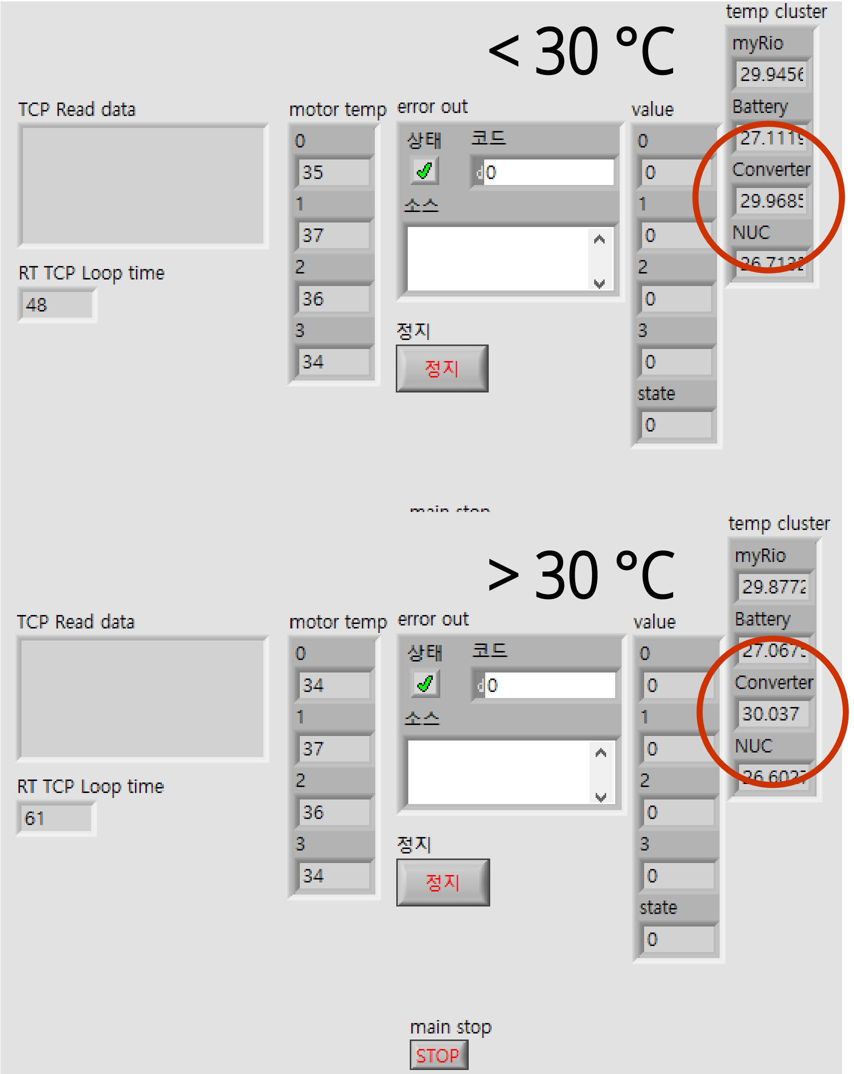
0V: OFF



MOSFET (switch)

3. SELECTIVE CONTROL SOLUTION

Example with threshold of 30 °C

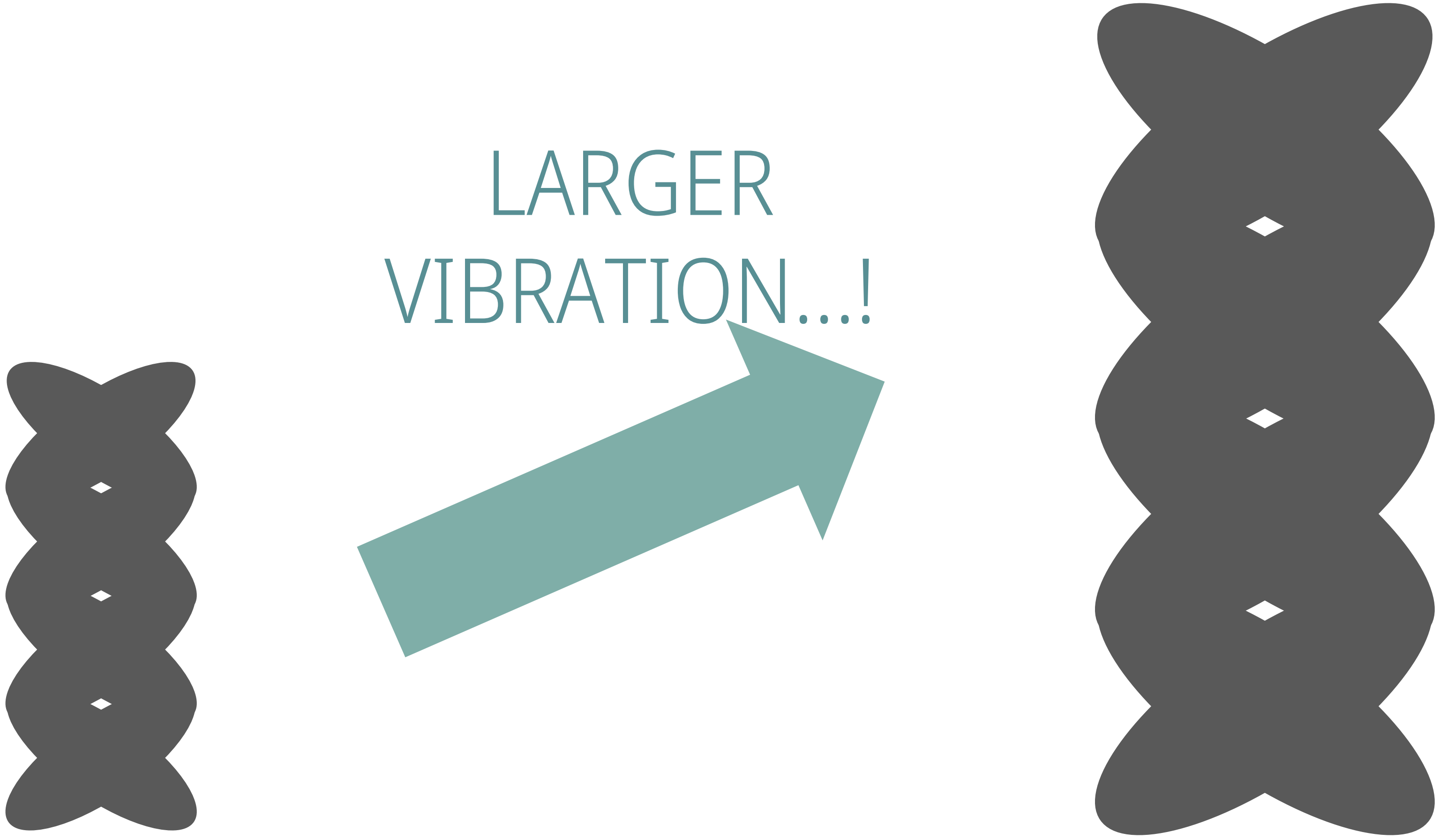


VIBRATION REDUCTION

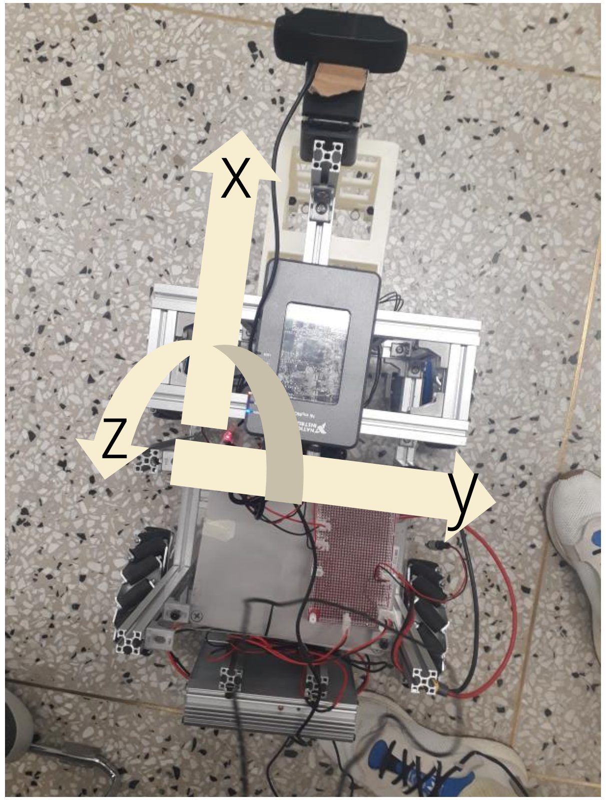
Related criteria:

2. VIBRATION REDUCTION

PROBLEM DEFINITION



EXPERIMENT



Accelerometer: built in myRIO

Velocity: 5~55 RPM (increment of 5 RPM)

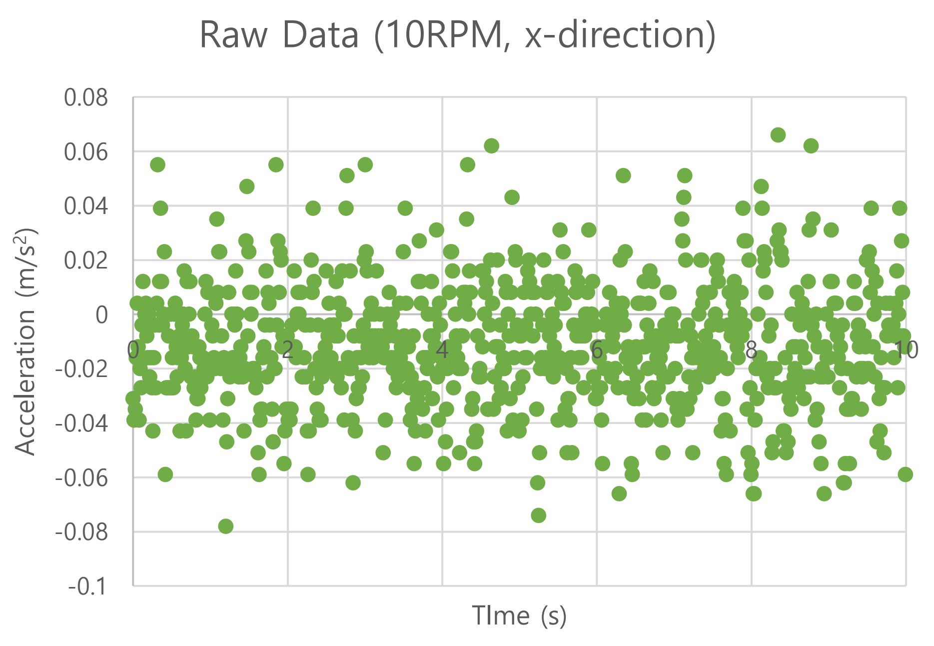
Weight : 8.2kg

Shape of the wheel: pentadecagon

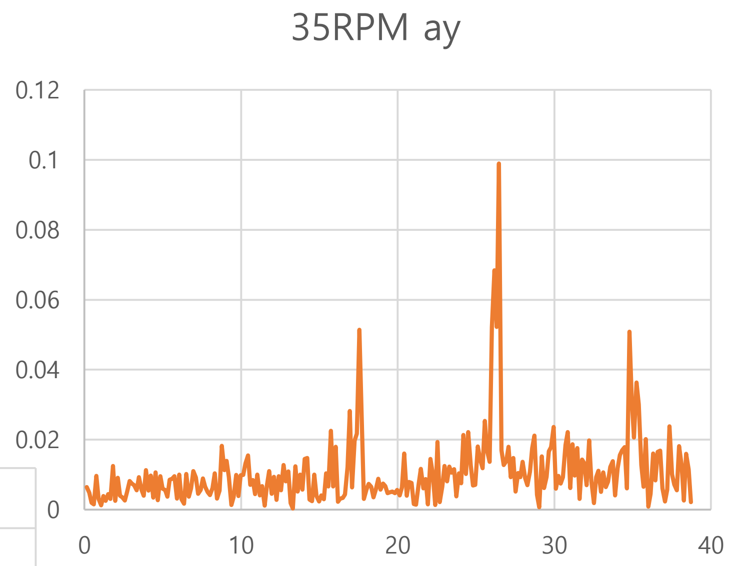
(regular polygon with 15 side)

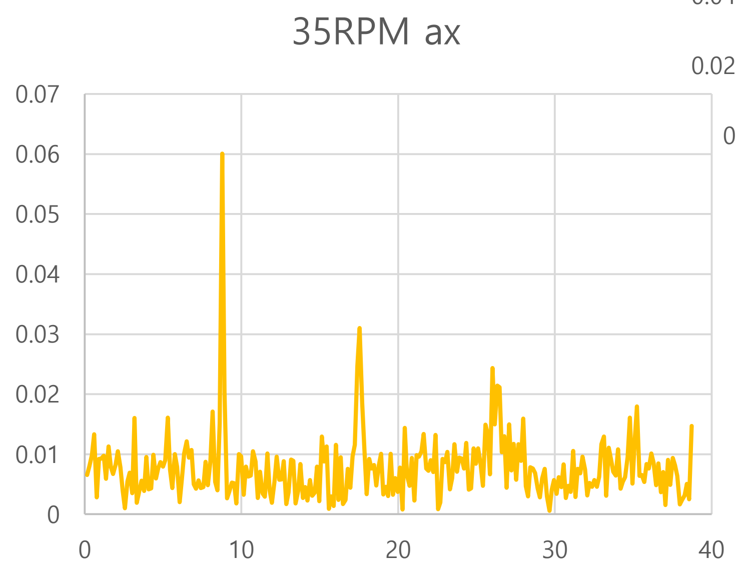
RESULT

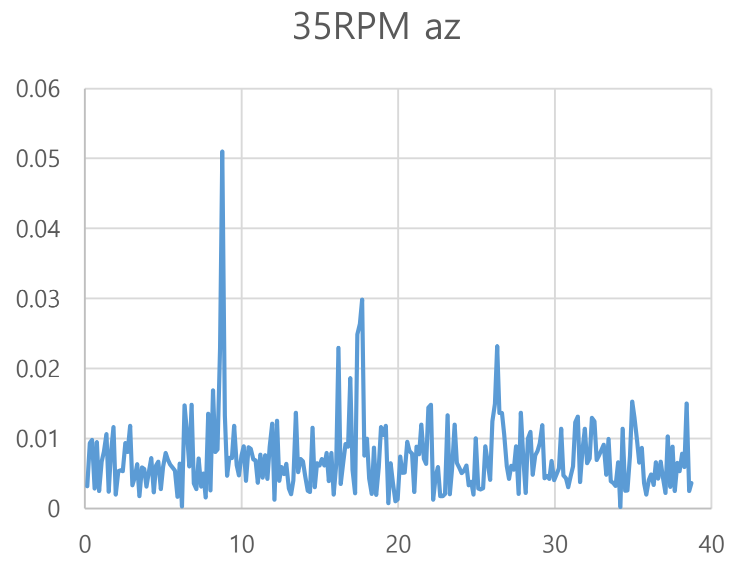
Raw data



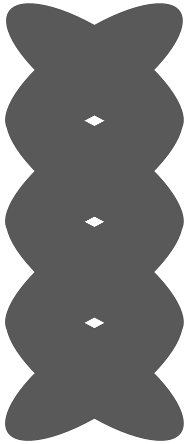
Major Vibration Analysis by Discrete FFT







ANALYSIS



pentadecagon

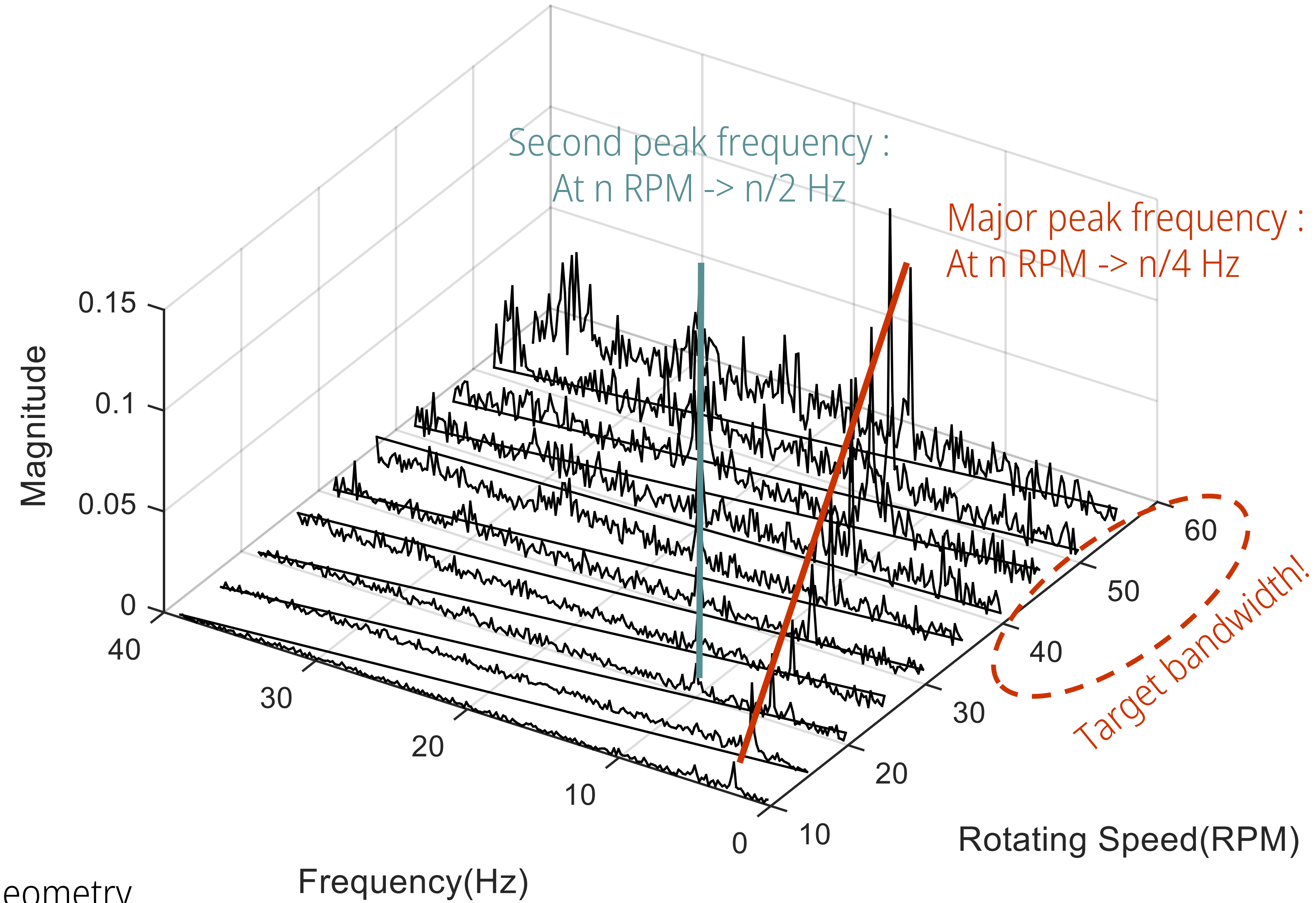
(regular polygon with 15 side)

Ex) 60 RPM

→ 1 revolution per 1 sec

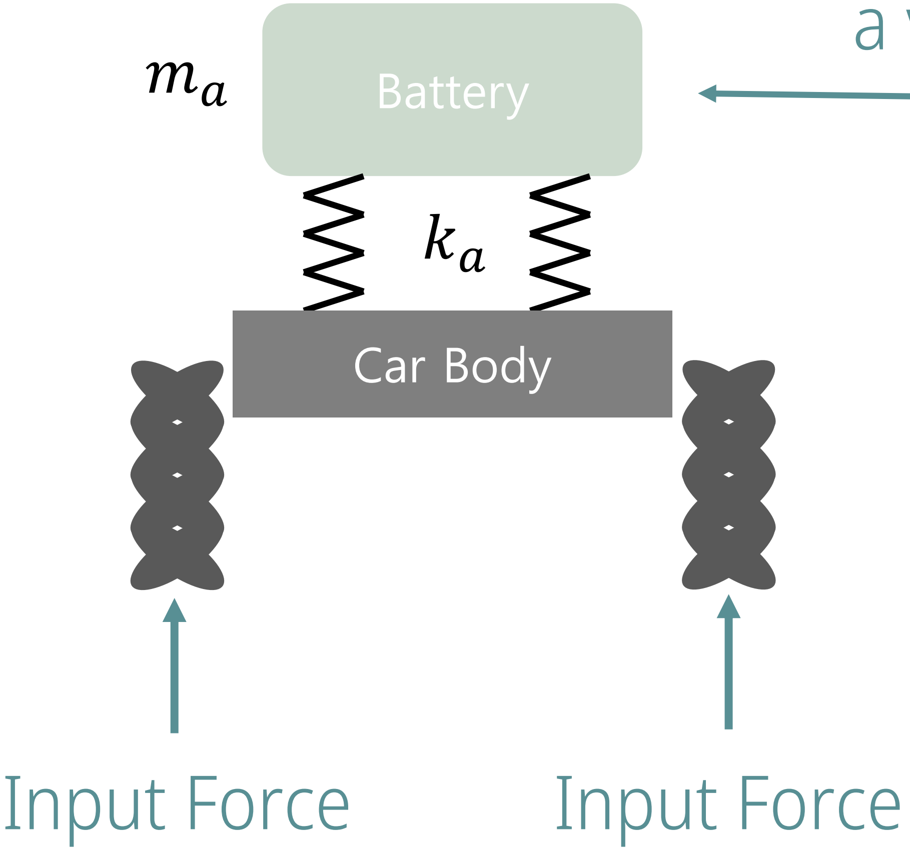
→ 15 impulses per 1 sec due to wheel geometry

→ Main input frequency of 15 Hz

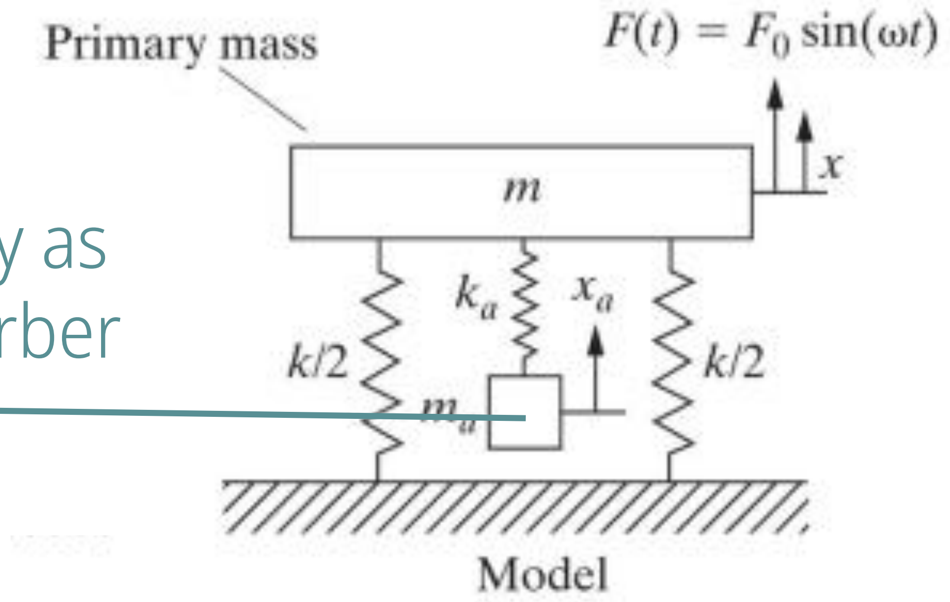


Fit with our hypothesis!!

DESIGN SOLUTION



Consider battery as a vibration absorber



Primary mass → Car body except Battery : 8kg
Added mass → Battery : 2kg
∴ mass ratio: 0.25

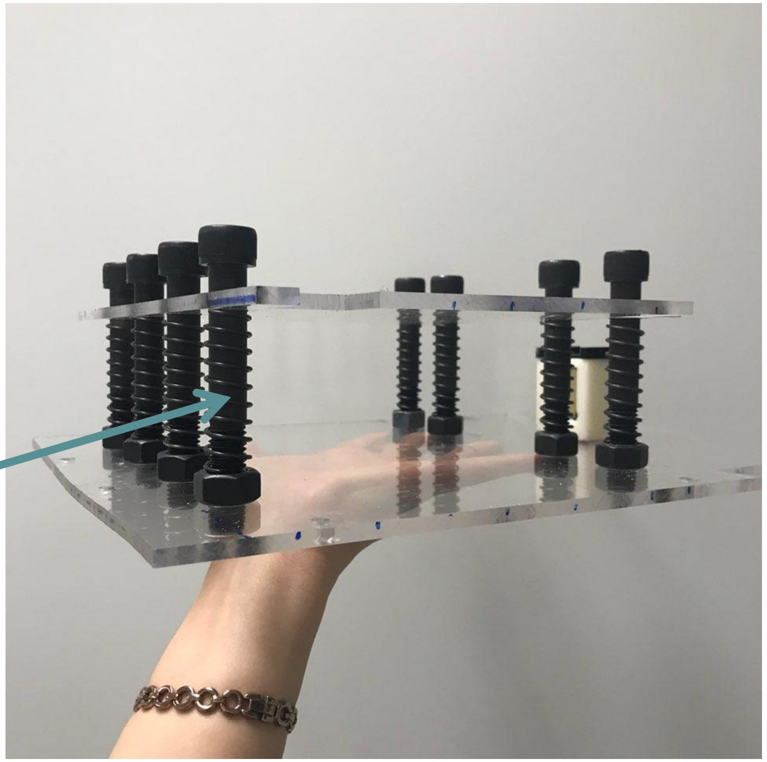
$$2\pi f_a = \sqrt{\frac{k_a}{m_a}} \rightarrow k_a \approx 12337\ \mathrm{N/m}$$

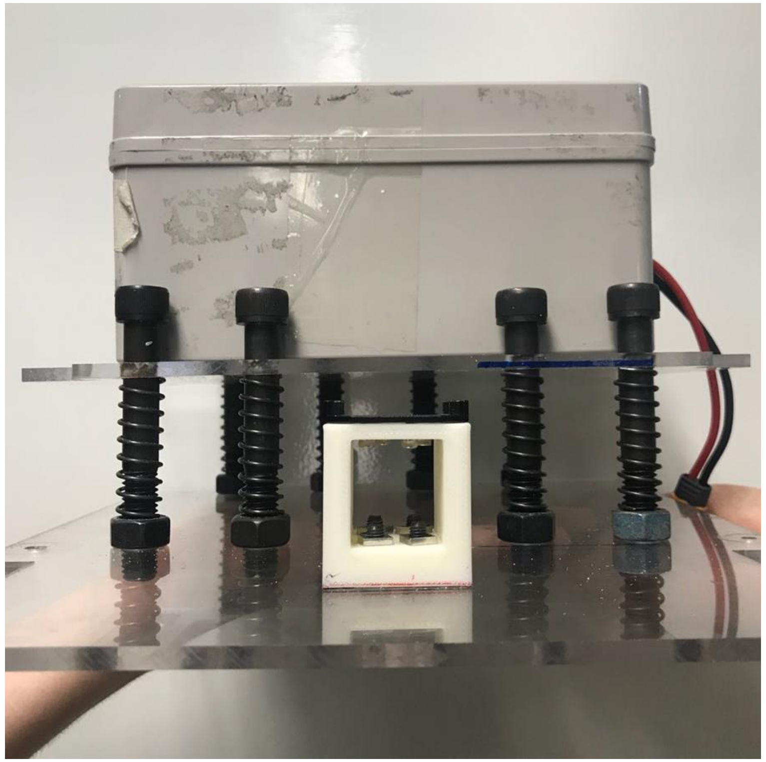
Target stiffness!!!

DESIGN SOLUTION

Target stiffness:
12337 N/m

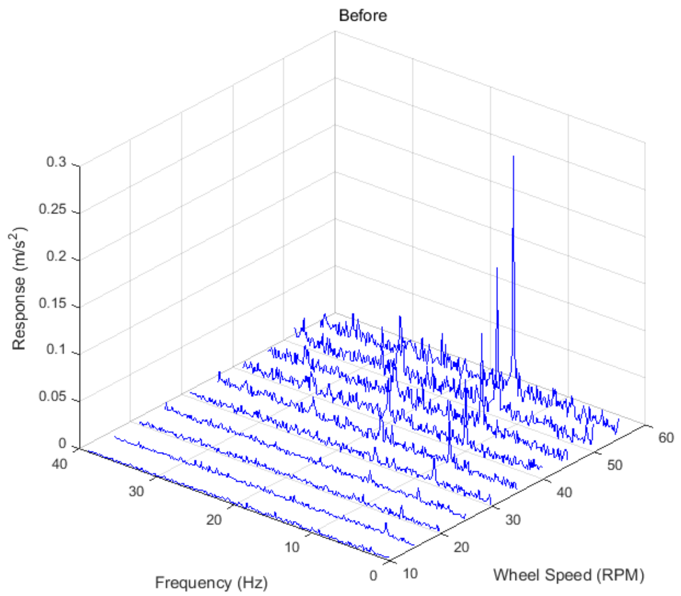
8 x Spring with stiffness of 1,500 N/m connected parallel

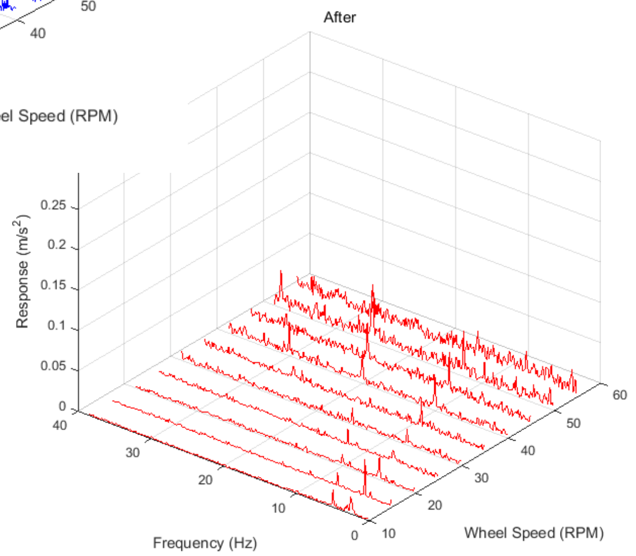




→ result stiffness: 12000 N/m

VIBRATION REDUCTION SYSTEM





OPERATION MECHANISM

Related criteria:

3. PICK-UP PART
4. VISION RECOGNITION
5. ROS INTEGRATION
6. MOTOR OPERATION AND CONTROL

OPERATION MECHANISM – Pick-up Part, Vision Recognition, ROS Integration & Motor Operation and Control

PICKING UP

DRIVING

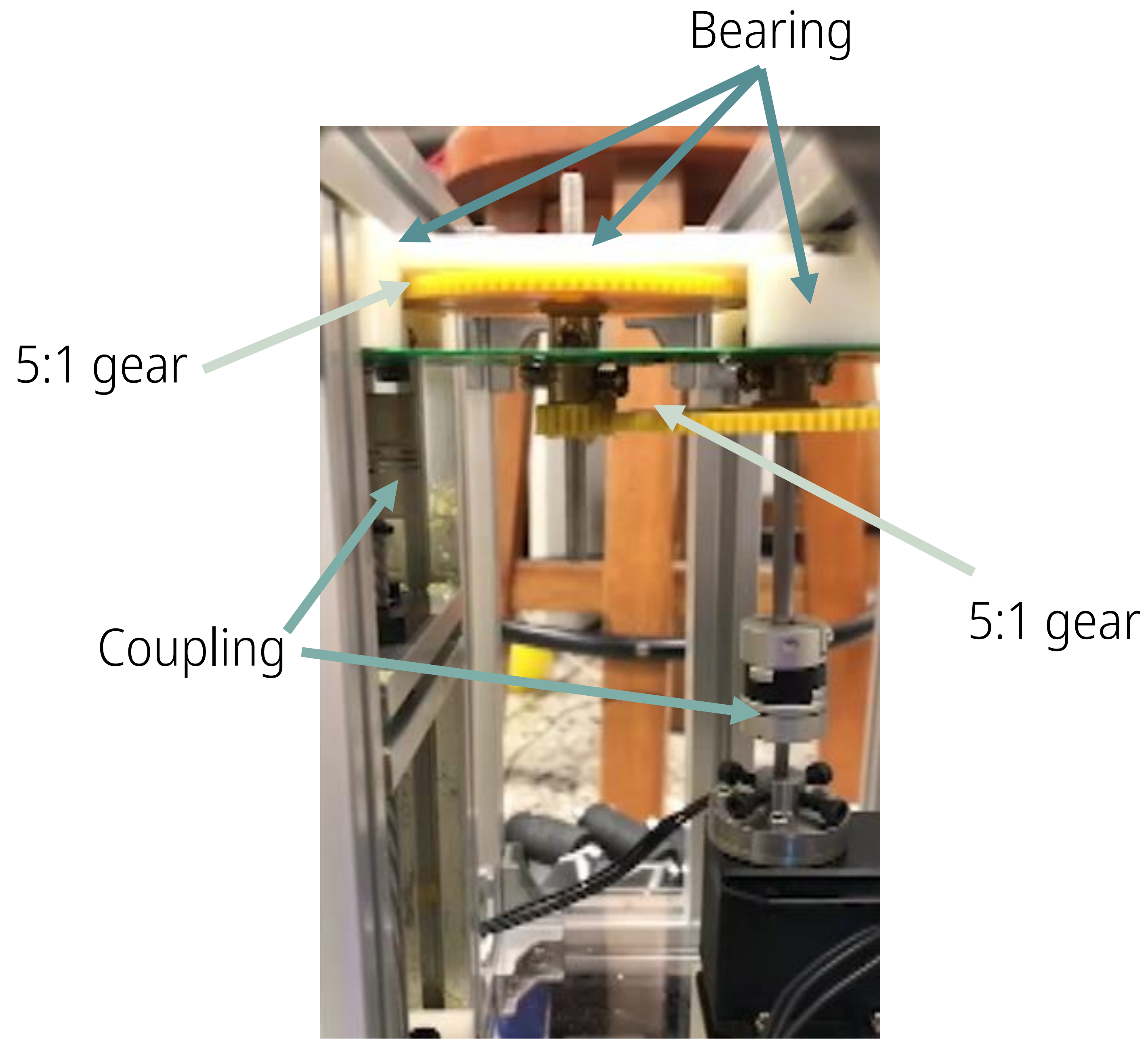
DUMPING

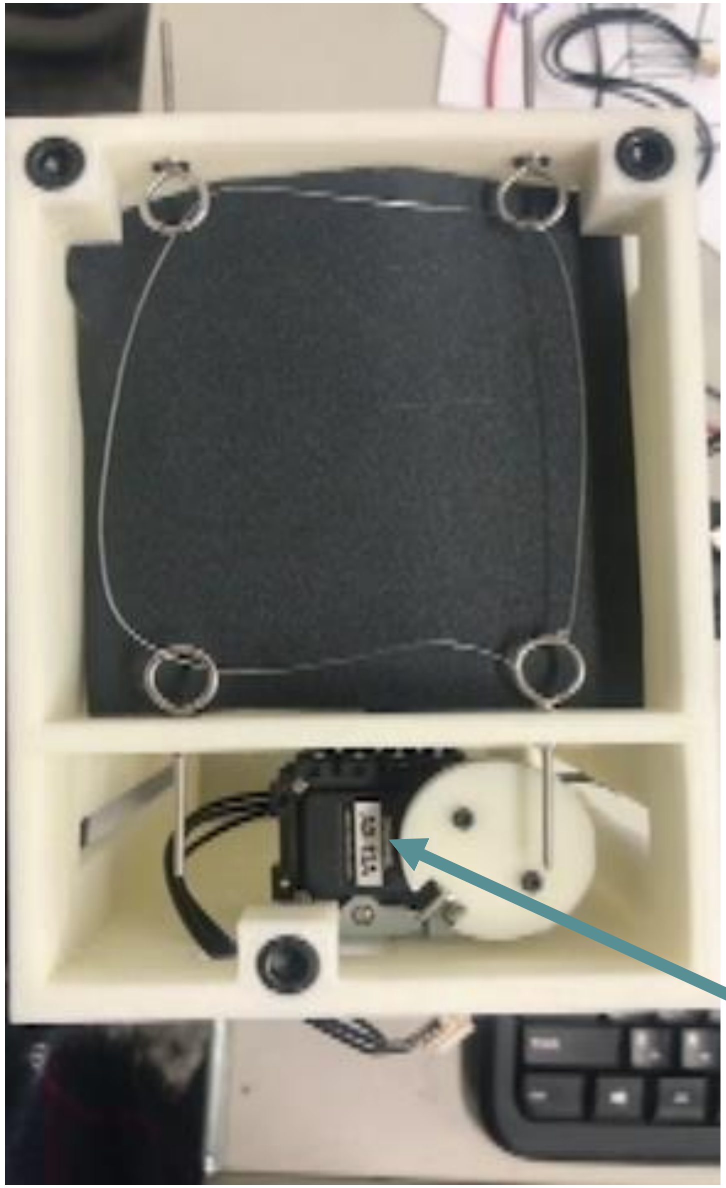
PICK UP PART

- Picking up
- Storing
- Dumping

25:1

GEARBOX





AX12
Dynamixel

ADJUSTABLE
STRING

FEEDBACK

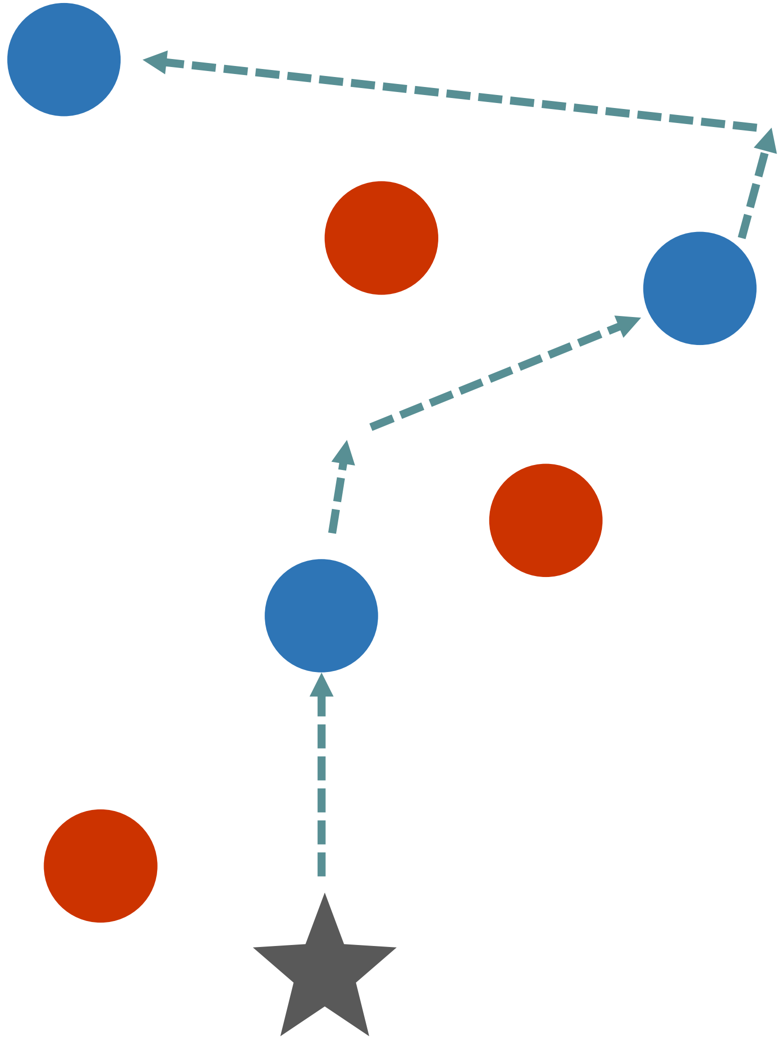
"Pick-up mechanism is still slow"

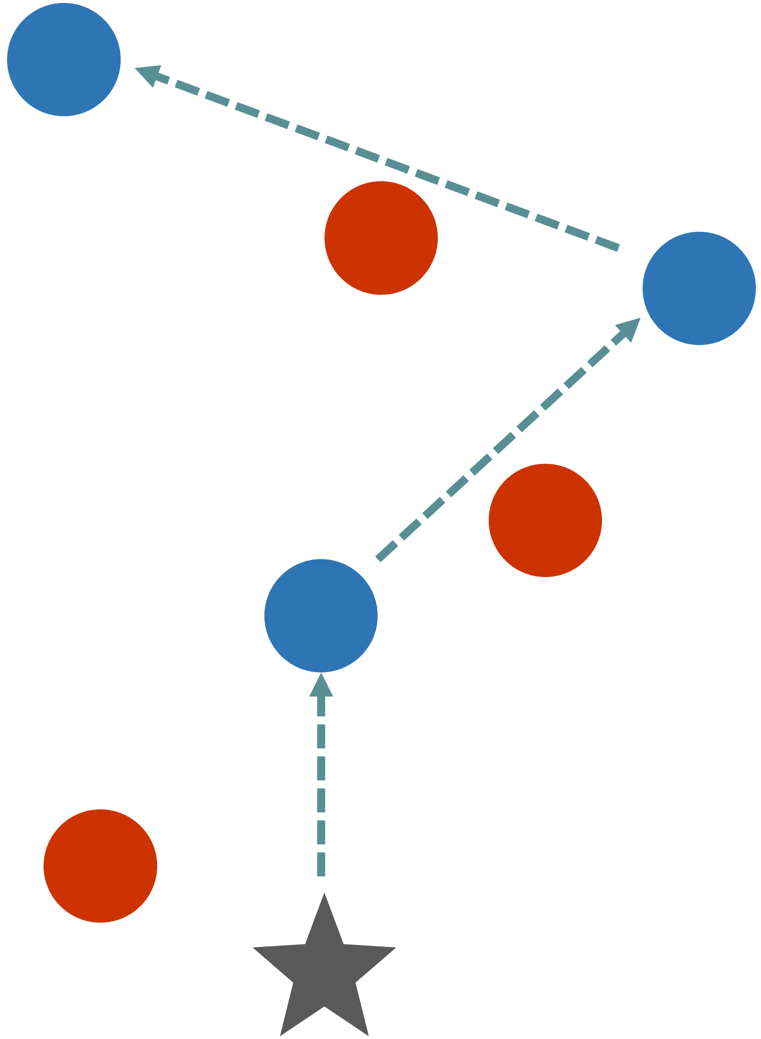
How can we improve our speed problem?

1. FIND THE OPTIMIZED ROUTE TO PICK UP THE BLUE BALL

2. REDUCE THE TIME OF STANDSTILL

1. FIND THE OPTIMIZED ROUTE TO PICK UP THE BLUE BALL

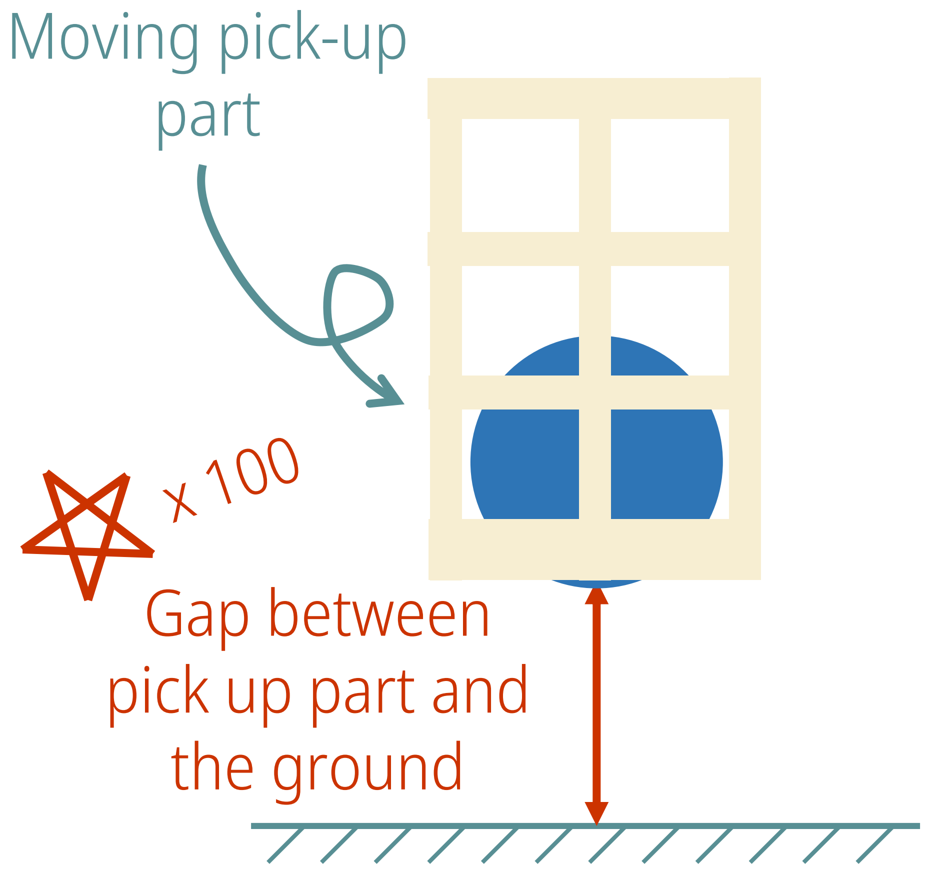


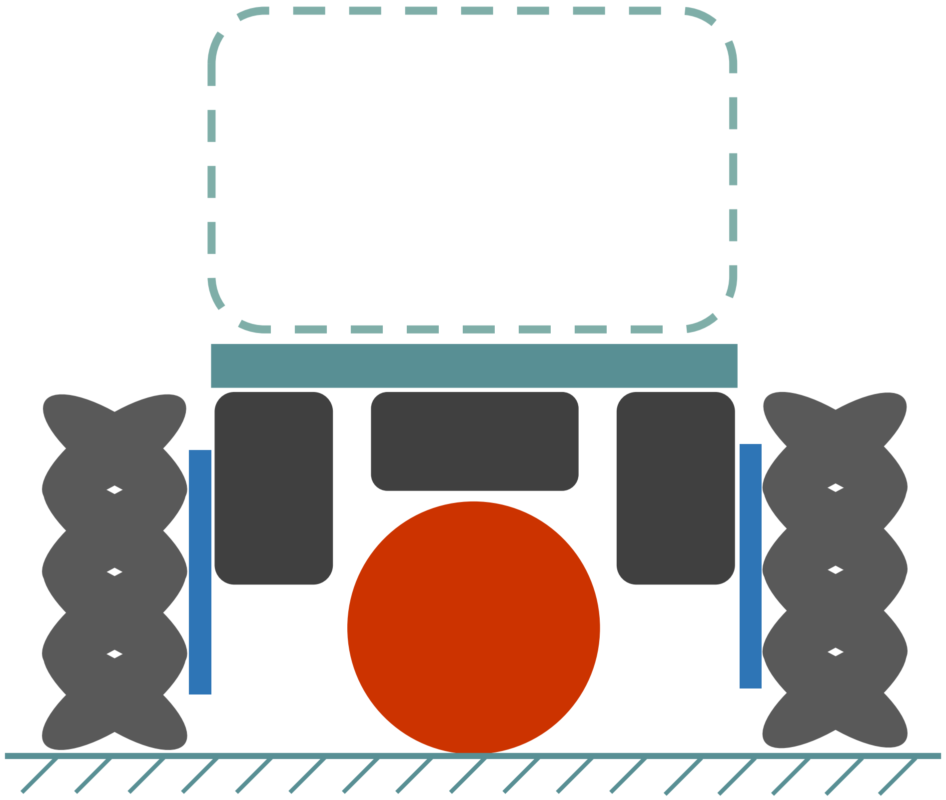


UNIQUENESS OF OUR PICK UP MECHANISM

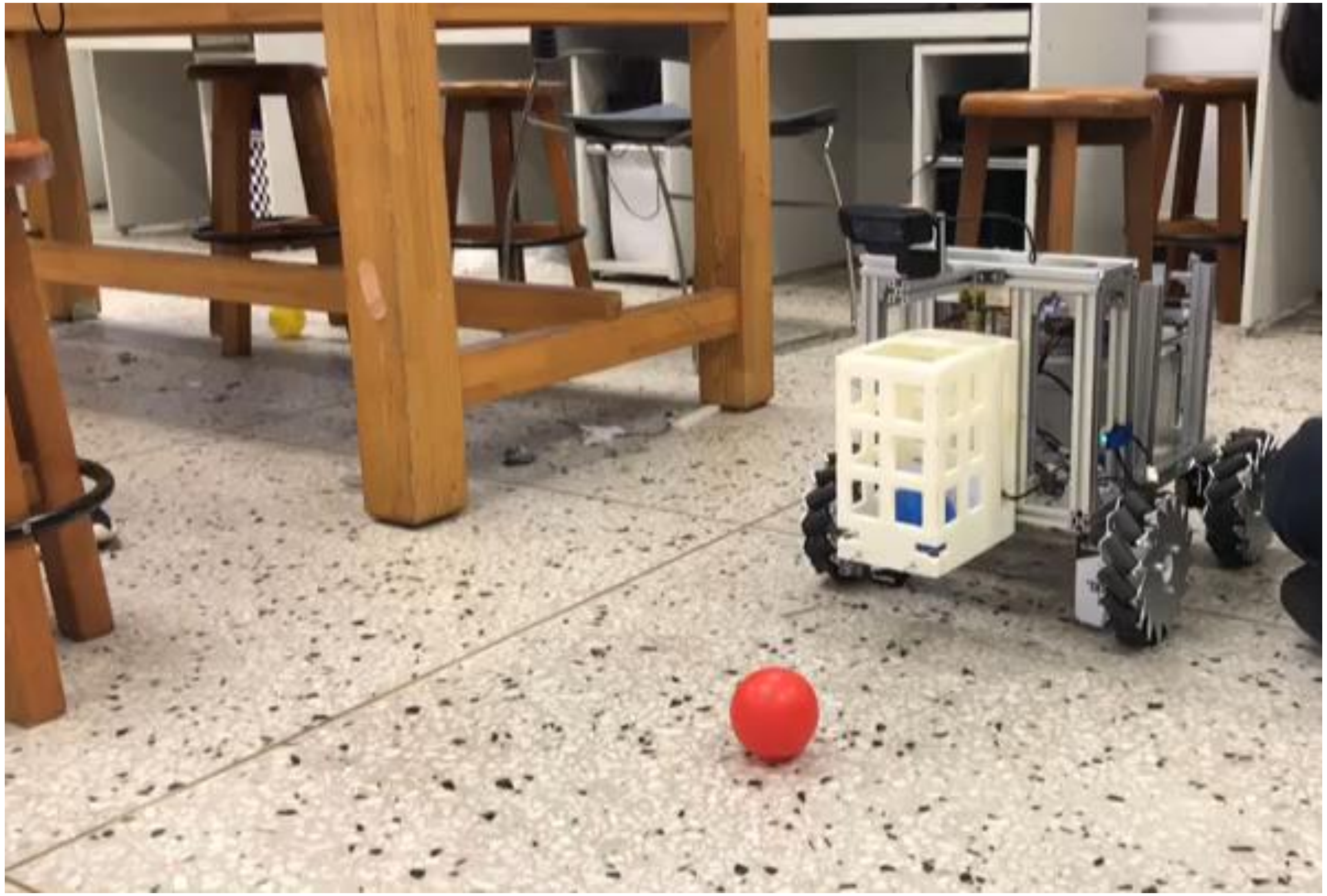
+

BIG WHEEL AND HIGH CAR FRAME





WHAT A REVOLUTION!!



2. REDUCE THE TIME OF STANDSTILL

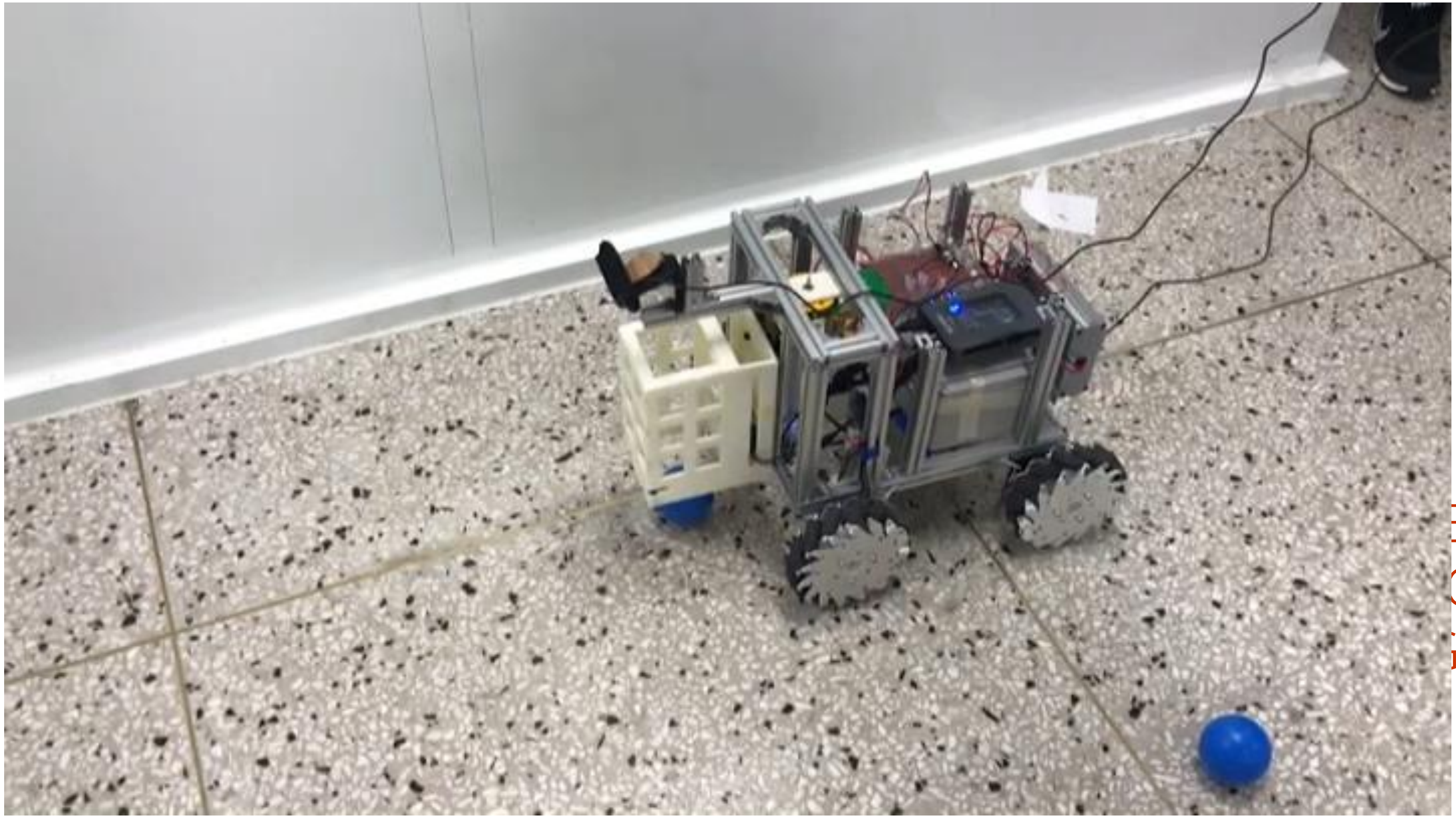
PICK-UP

- MOVE DOWN
- LOSSEN THE STRING
- CATCH THE BALL
- TIGHTEN THE STRING
- MOVE UP

START RE-SEARCHING AND MOVING TOWARD THE BLUE / GREEN BALL

2. REDUCE THE TIME OF STANDSTILL

PICK-



EARCHING
G TOWARD
GREEN BALL

Strengths

Adaptable to various environments
- balls closer to each other
- higher basket height
- other target shapes

Picking up, dumping, storage in one subsystem

Solving the Problems

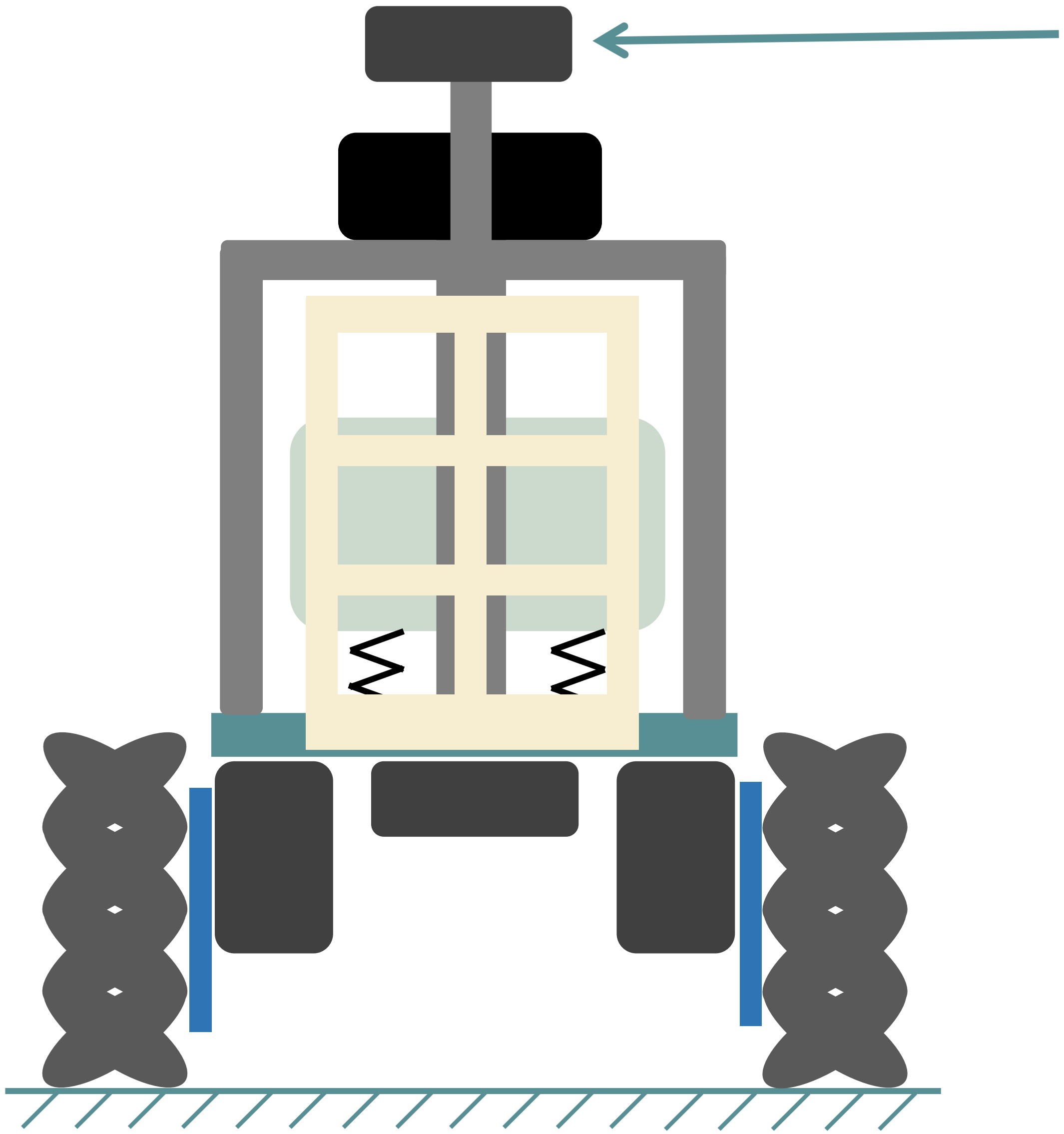
Require higher accuracy

Picking up time

DRIVING MECHANISM

- 1st webcam
- 2nd webcam
- Rplidar

DRIVING MODE



1st webcam:

Set the target using wide sight view

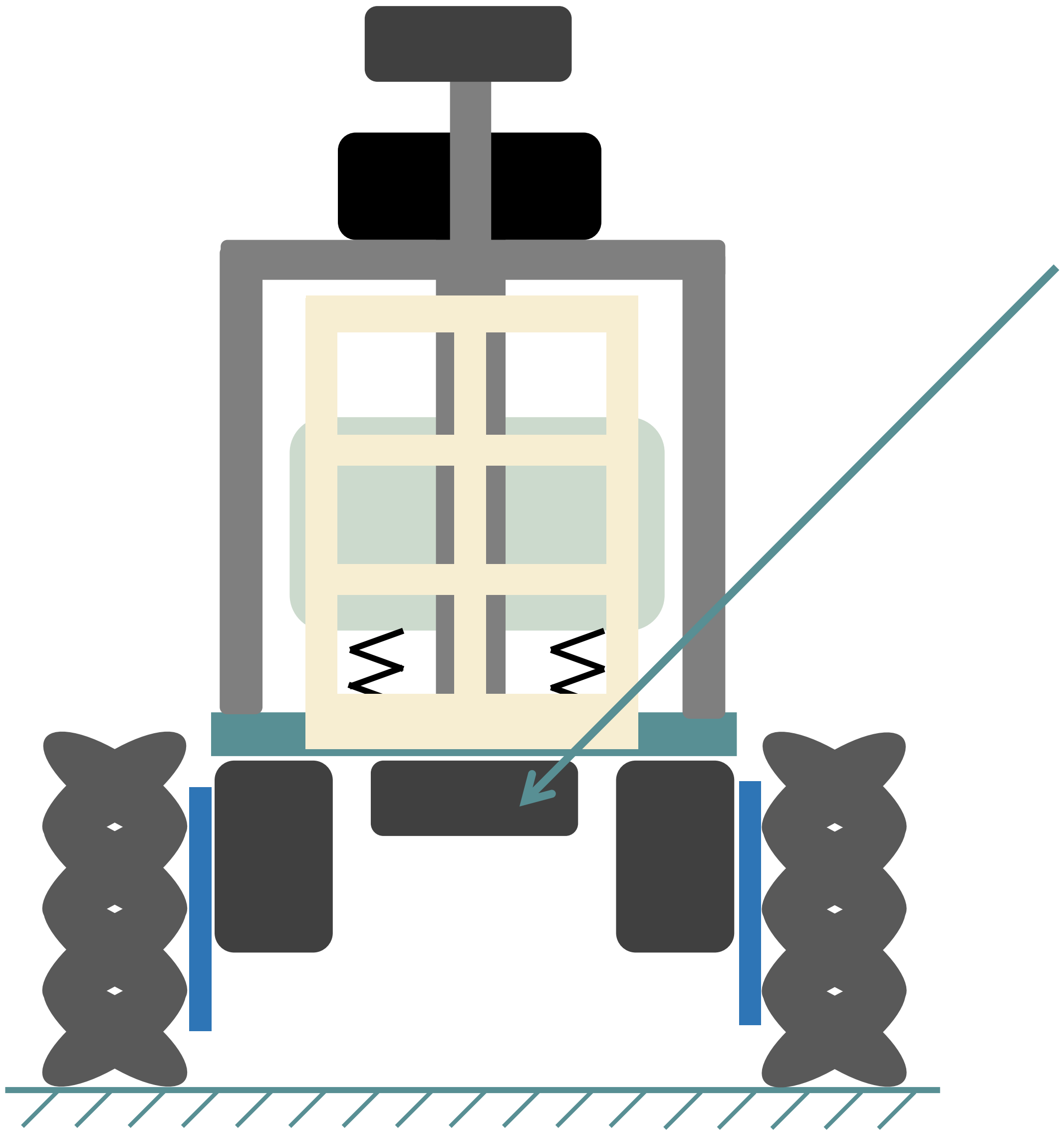
2nd webcam:

When the object is no longer detected by 1st camera, 2nd camera takes over the control

Rplidar:

Measures the distance from the wall to place mobile platform in front of the basket

DRIVING MODE



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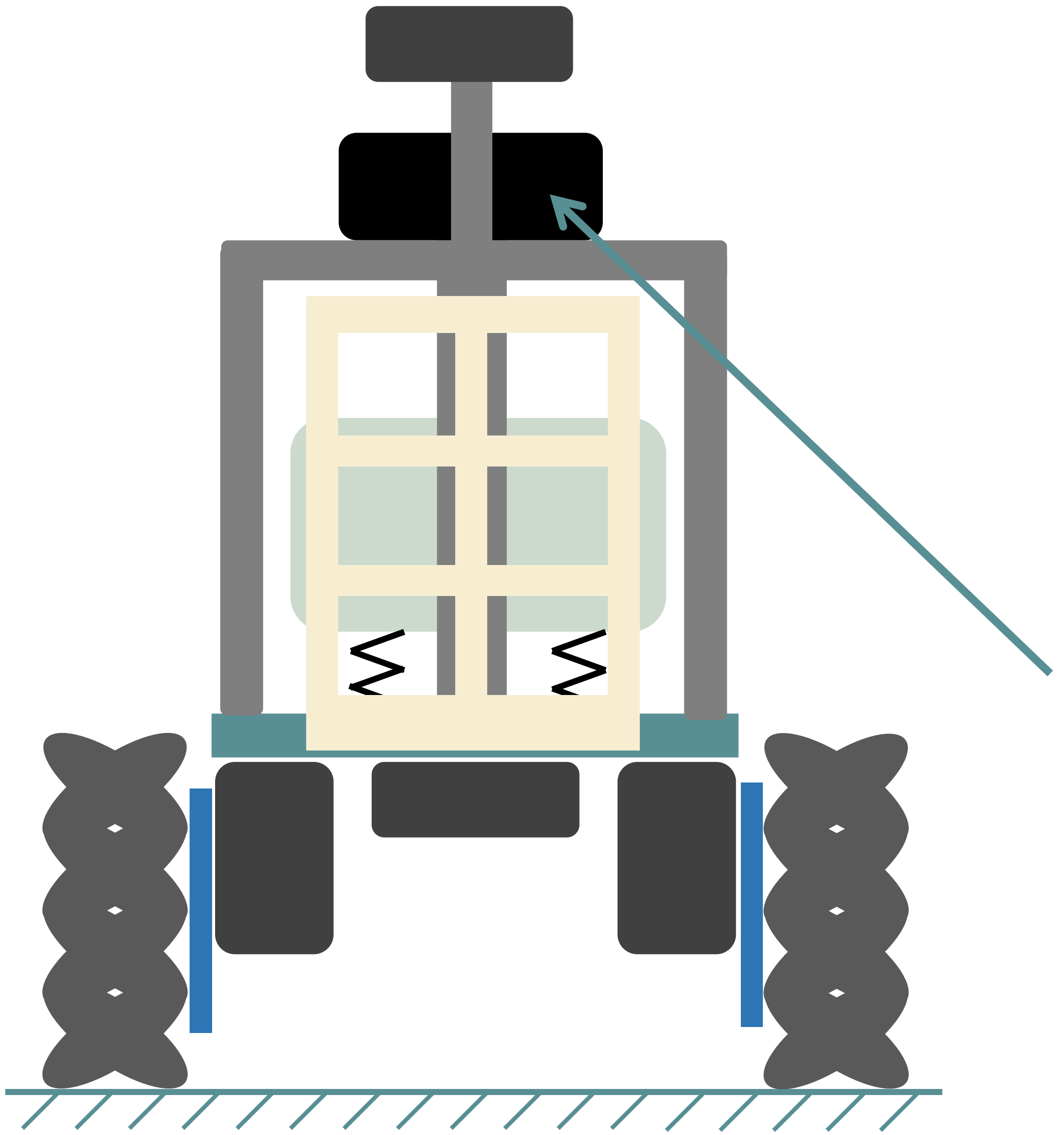
DRIVING MODE



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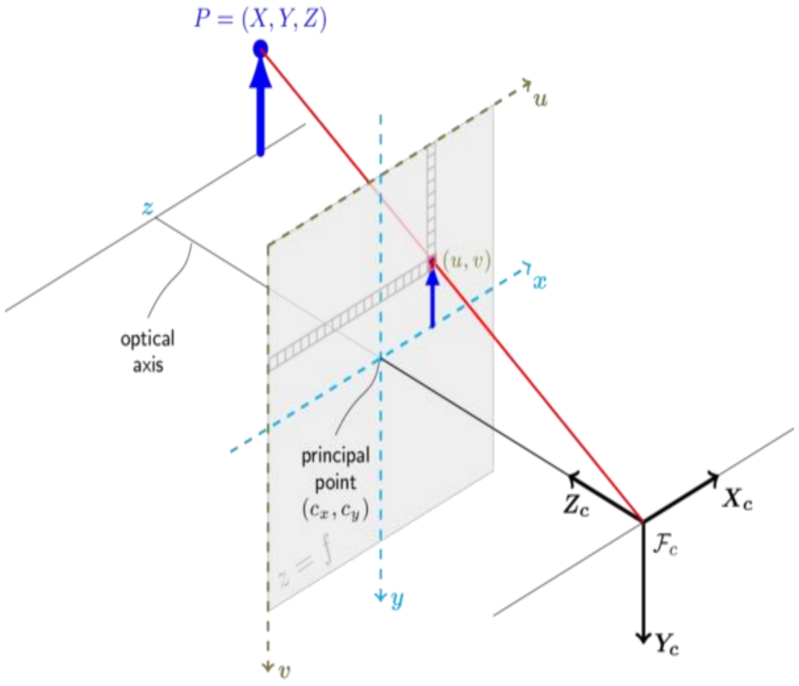
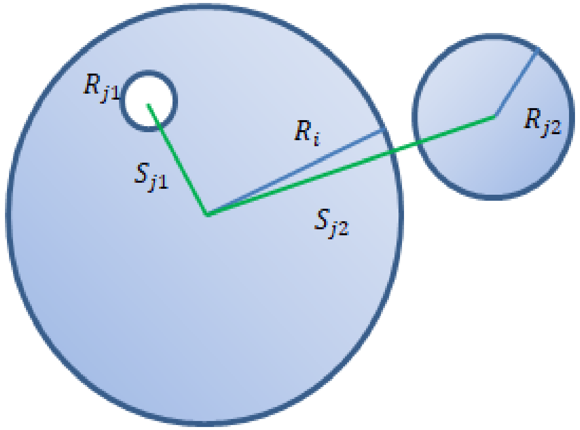
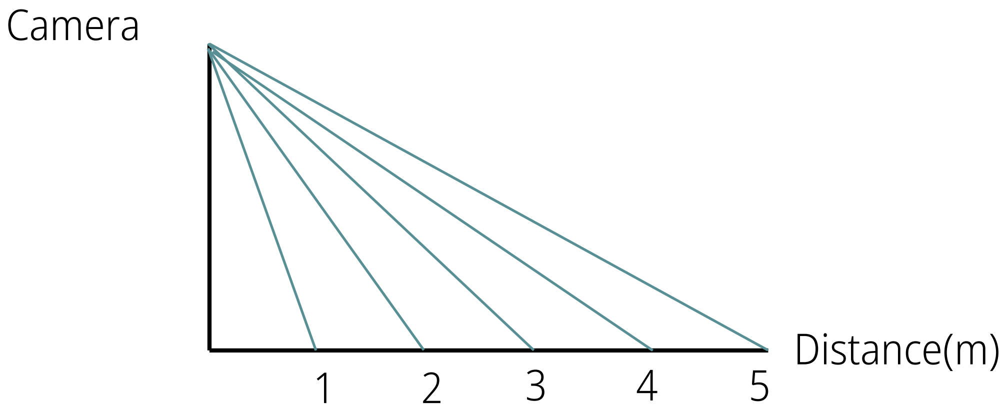
Measures the distance from the wall to place mobile platform in front of the basket

VISION RECOGNITION







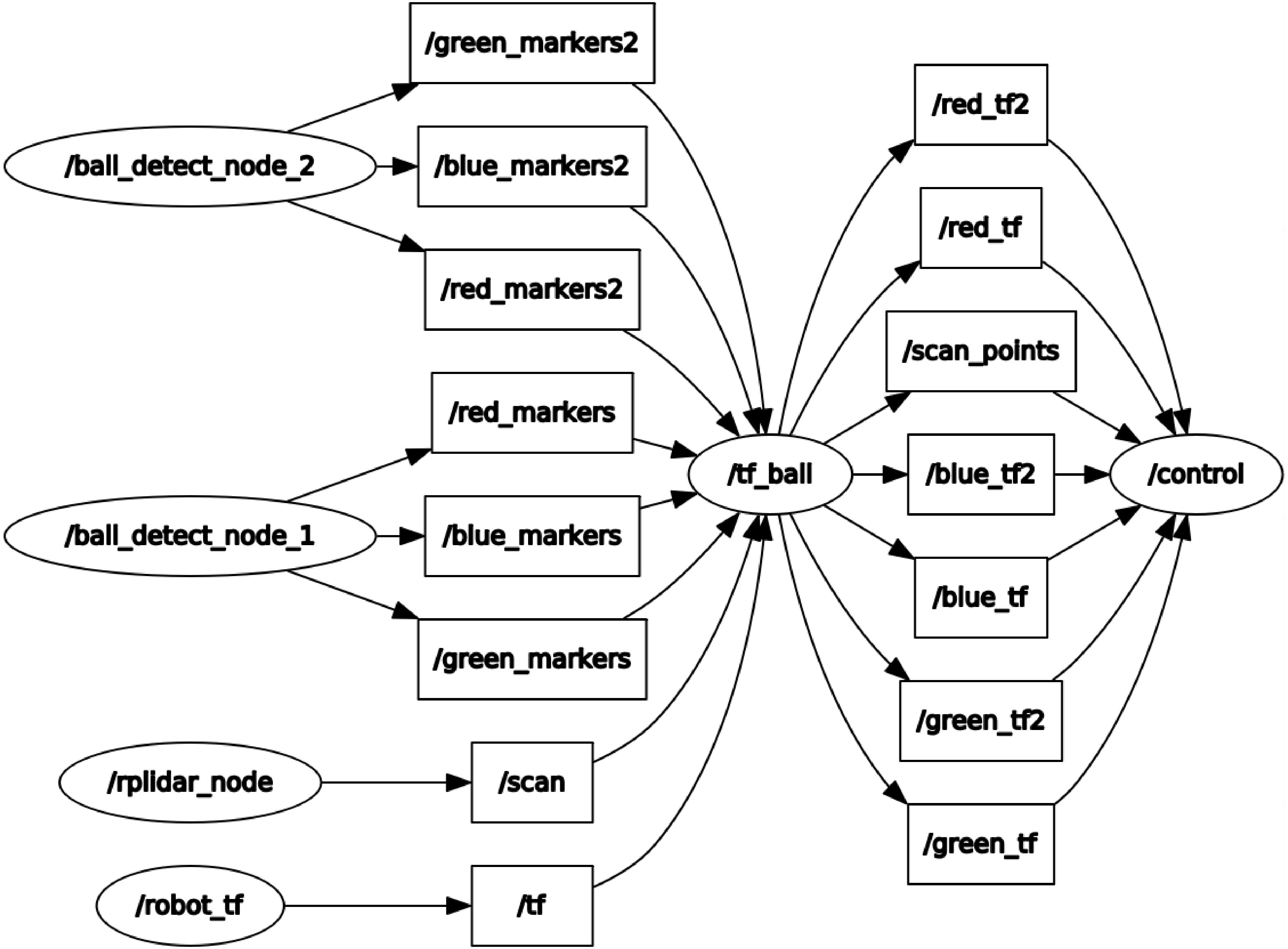
Position (m)	5	4	3	2	1
Fraction	1/5	2/5	3/5	4/5	5/5
Correction	0.2x10	0.4x10	0.6x10	0.8x10	1x10

Ball coordinates

Reflection problem

Trial and errors

OPERATION MECHANISM – Pick-up Part, Vision Recognition, ROS Integration & Motor Operation and Control



STATE INFORMATION

1. Findblue
2. Gofar
3. Gonear
4. Pickup
5. Gomid
6. Findgoal
7. Goalfar
8. Goalnear
9. Goallidar
10. Trash
11. Trashend
12. End

Webcam x 2
Rplidar
myRIO

We reduce the time of approaching by not considering the red ball

STATE INFORMATION

1. Findblue
2. Gofar
3. Gonear
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11. Trashend
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1st webcam

1st ,2nd webcam

$$u(x) = (1-w)\left(\frac{\sqrt{2x}-a}{\sqrt{2d}}\right)$$

$$v(x) = (1-w)\left(\frac{\sqrt{2y}-b}{\sqrt{2d}}\right)$$

$$w = \frac{\theta}{\pi/8}$$

Lower jerk

Decrease while approaching
Target value for accuracy

STATE INFORMATION

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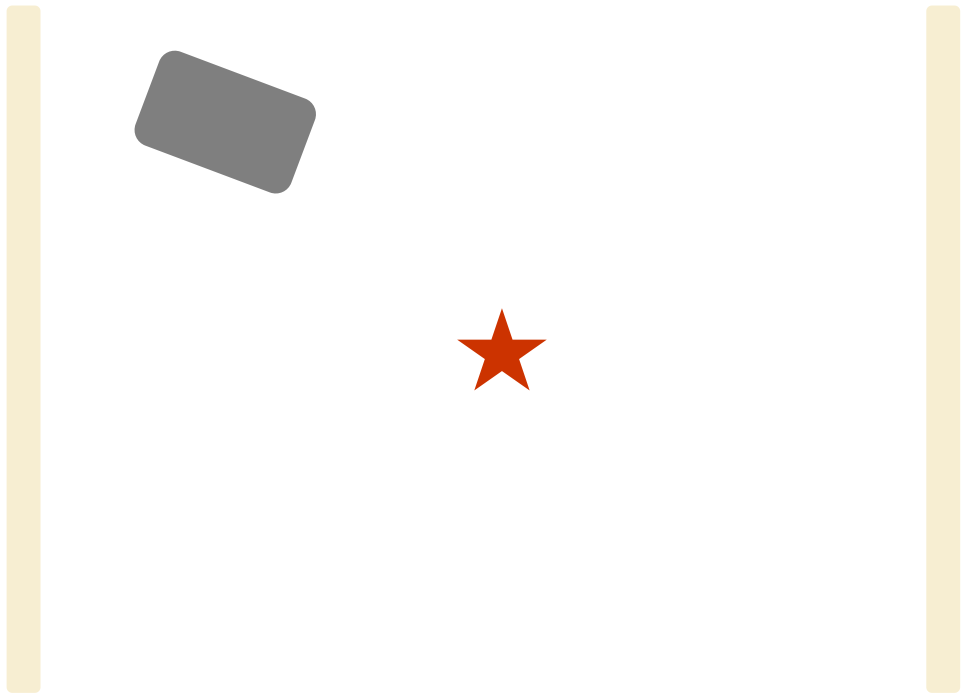
4. Pickup
5. Gomid
6. Findgoal
7. Goalfar
8. Goalnear
9. Goallidar
10. Trash
11. Trashend
12. End

rplidar

After picking up all three blue balls

Use rplidar to get to center of the field



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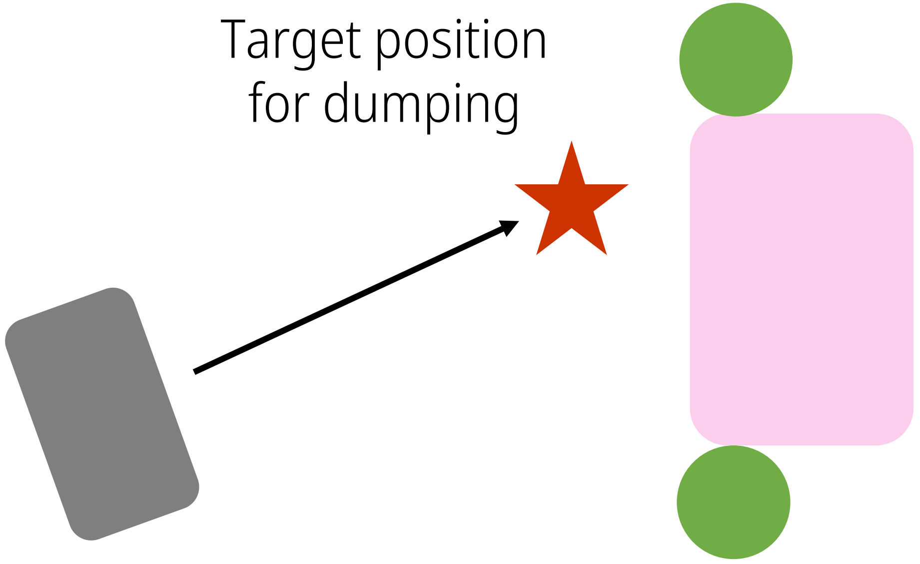
10. Trash
11. Trashend
12. End

1st webcam

2nd webcam



Reach target position

STATE INFORMATION

1. Findblue
2. Gofar
3. Gonear
4. Pickup
5. Gomid
6. Findgoal
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8. Goalnear
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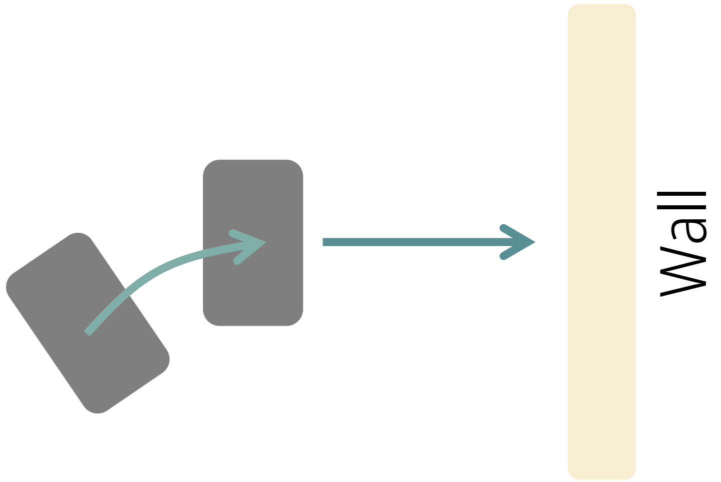
10. Trash
11. Trashend
12. End

Rplidar

Align with the wall and approaching



Calculate wall distance

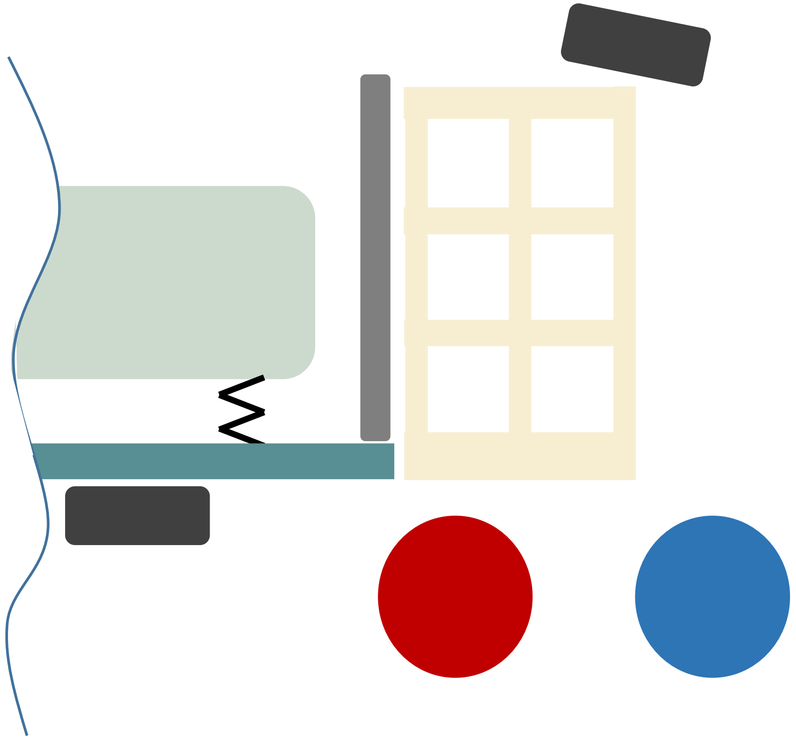
$$y = ax + b$$

$$a = \frac{(2n+1)\sum xy - \sum x \sum y}{(2n+1)\sum x^2 - \sum x \sum x}$$

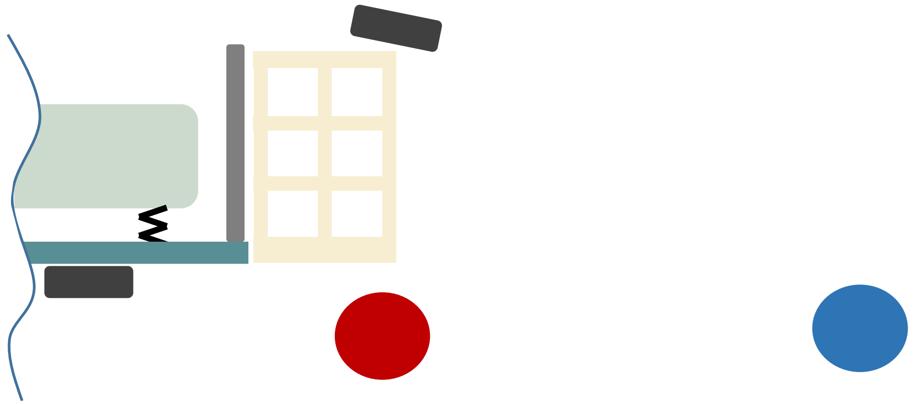
$$b = \frac{\sum x^2 \sum y - \sum x \sum xy}{(2n+1)\sum x^2 - \sum x \sum x}$$

CONSIDERING EXCEPTIONAL CONDITIONS

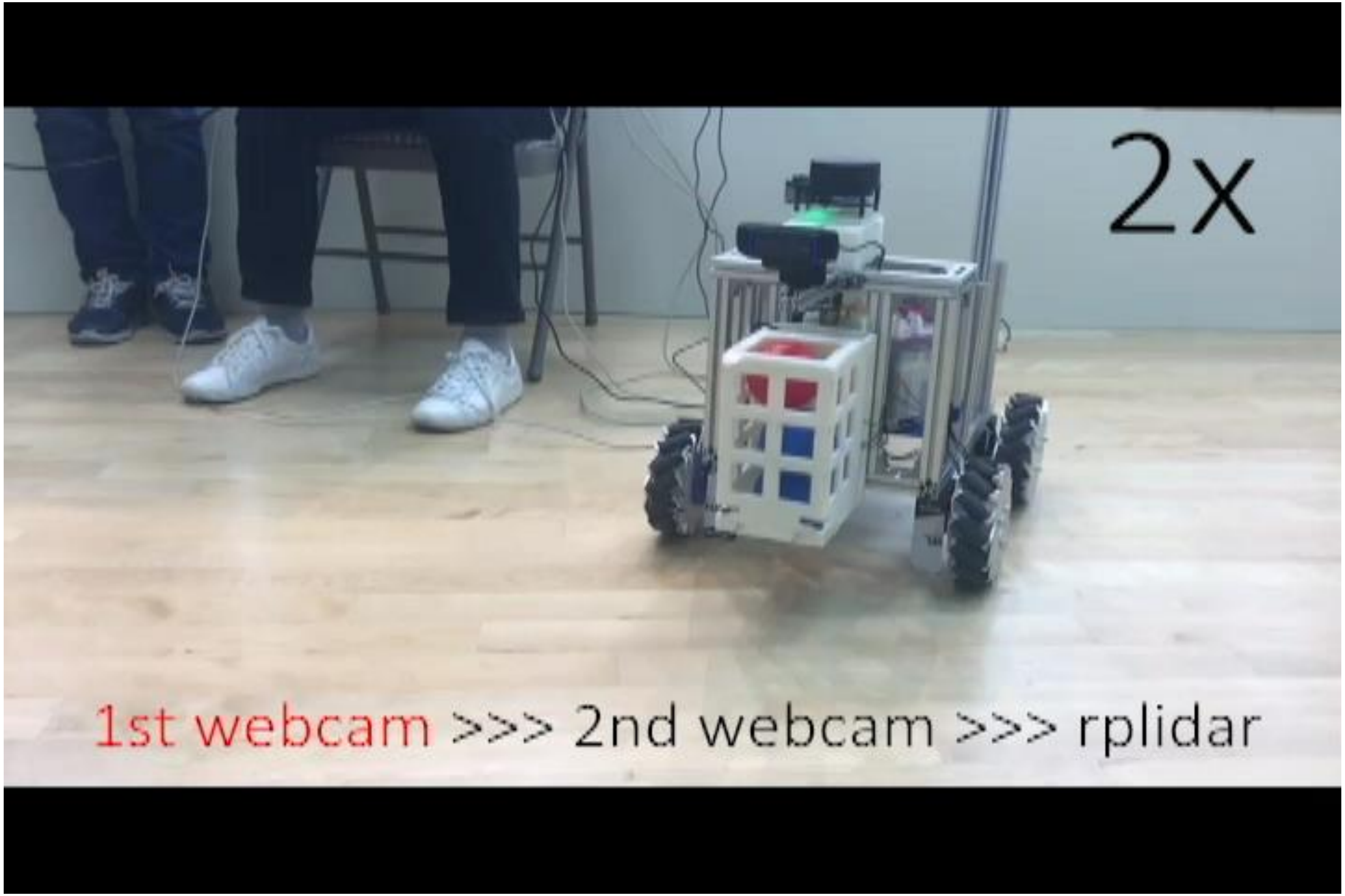
1. Red ball blocking the last blue ball



2. First webcam detects but second can't detect



OPERATION MECHANISM – Pick-up Part, Vision Recognition, ROS Integration & Motor Operation and Control

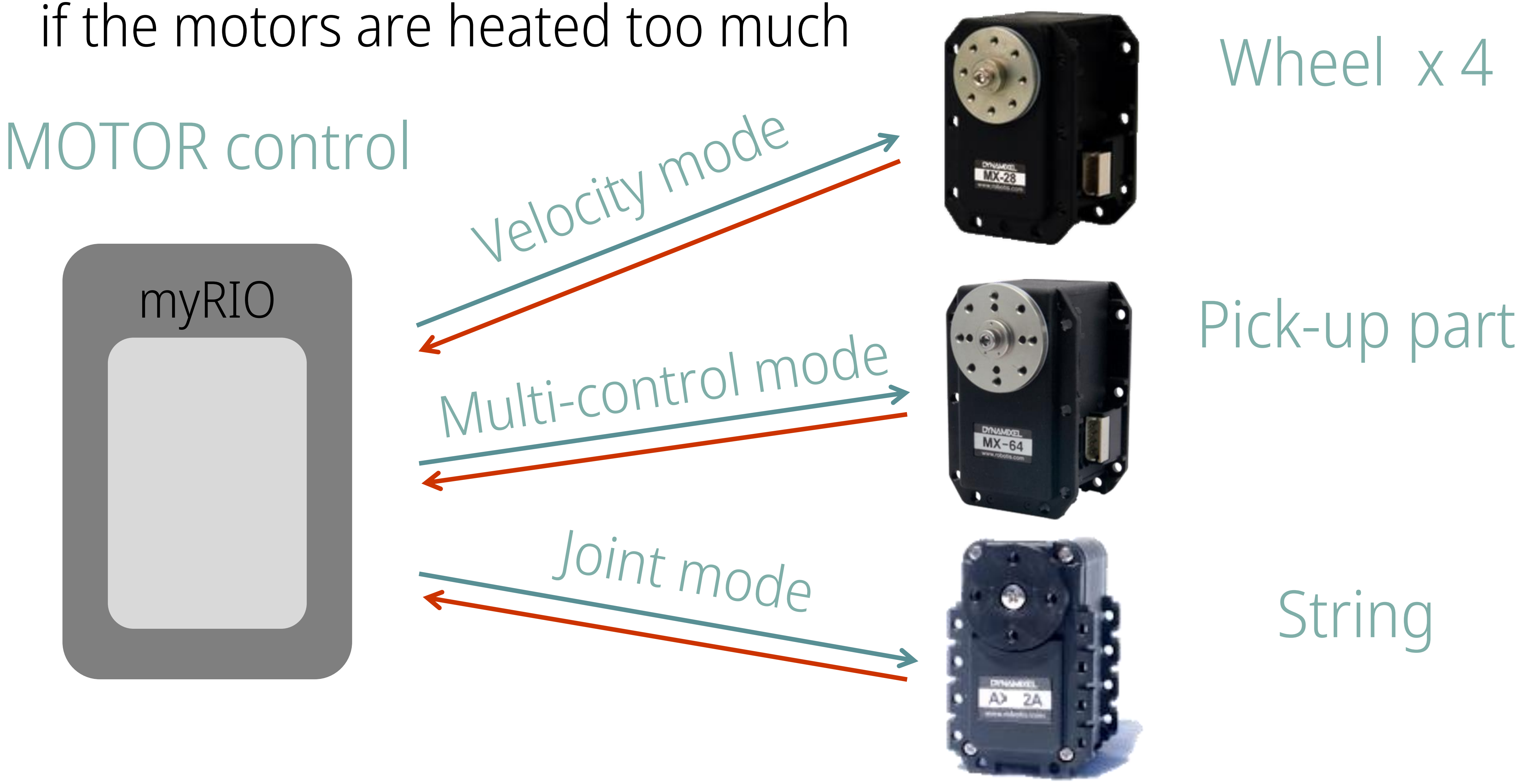


MOTOR OPERATION AND CONTROL

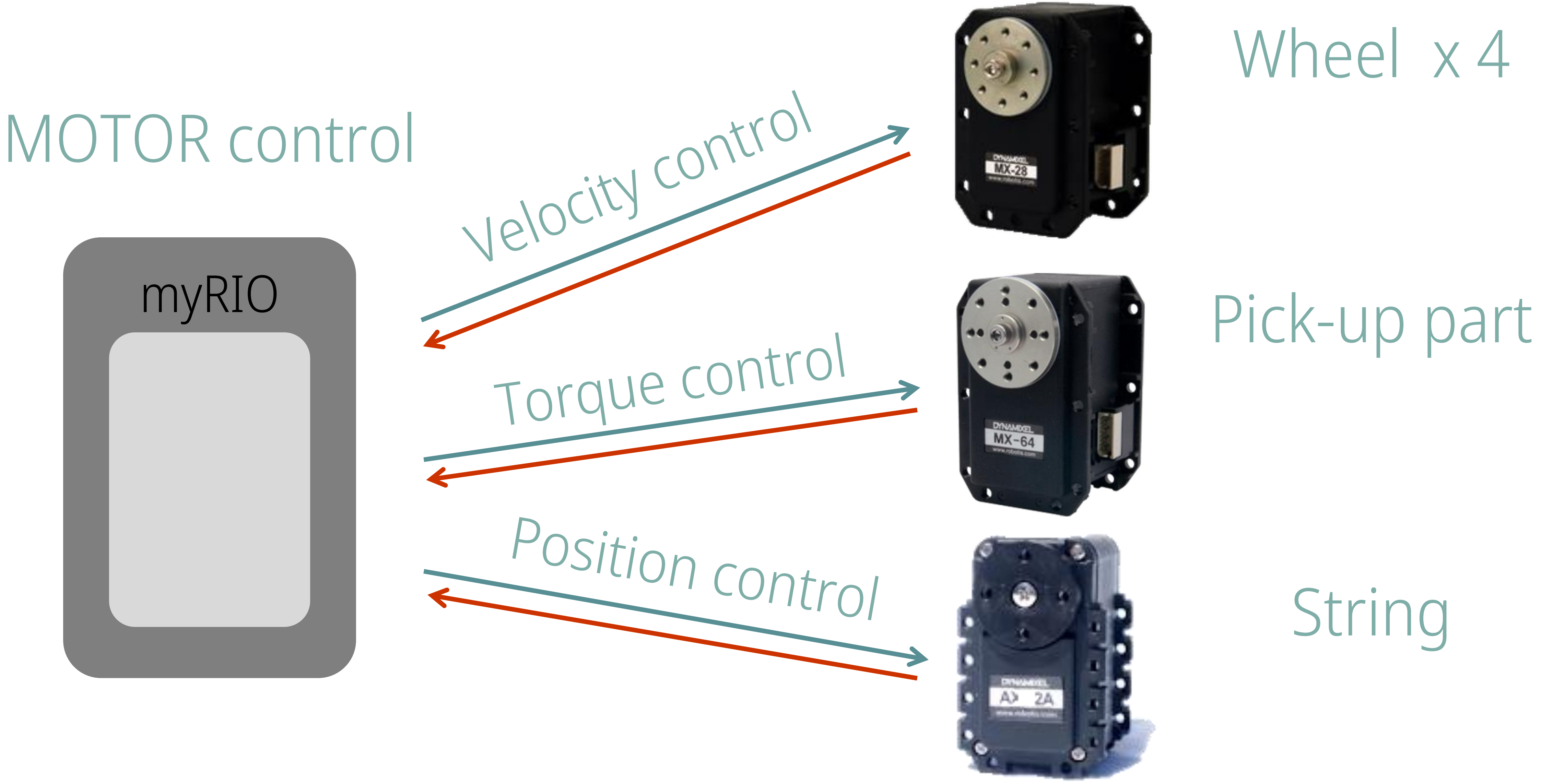
Related criteria:

6. MOTOR OPERATION AND CONTROL

Temperature to cut the maximum speed if the motors are heated too much

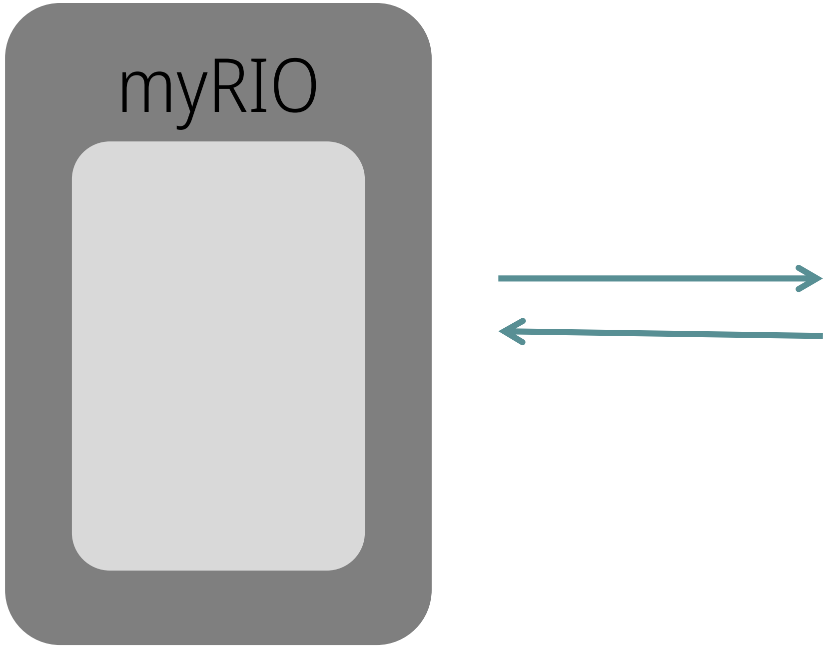


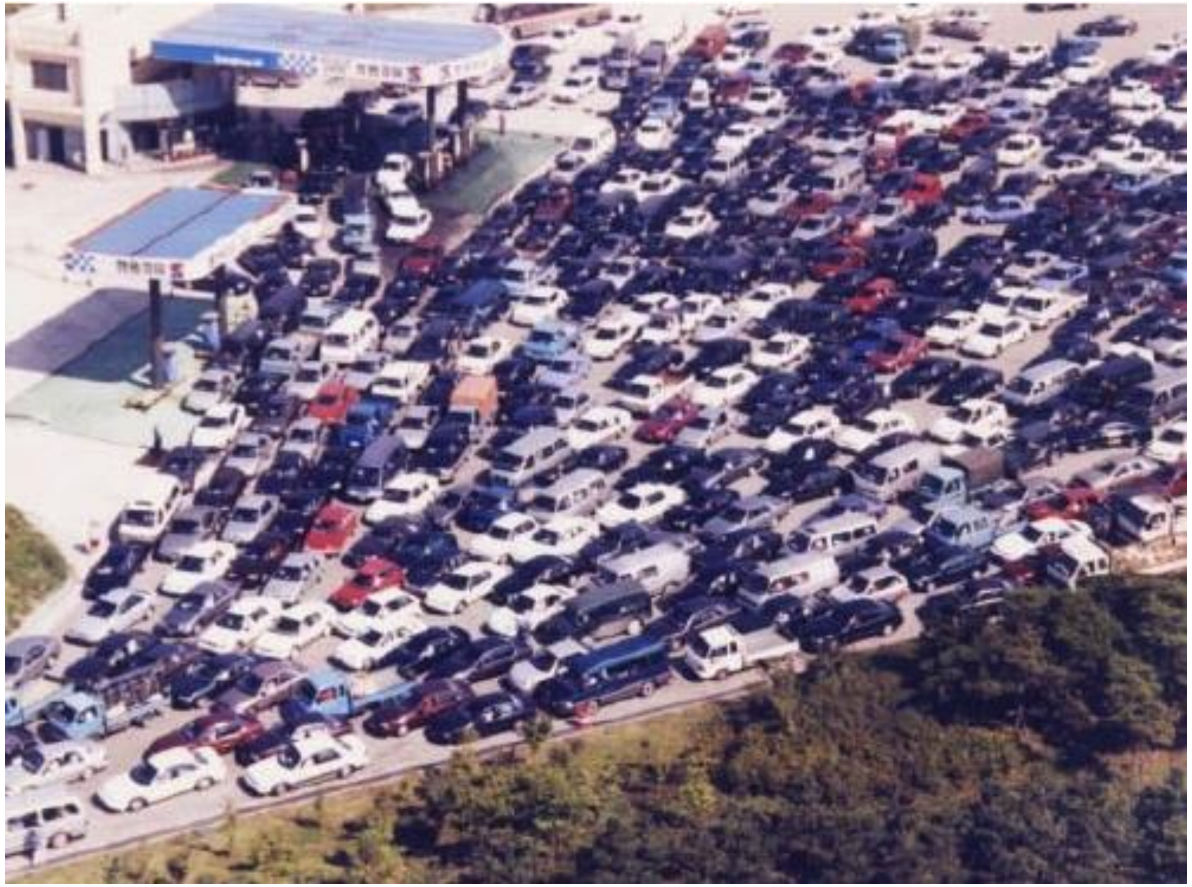
Torque control to prevent damage on gears



We also prevent Bottle-neck effect to remove delay

TCP Communication





Embedded system that we do not need to use external computer

Code written inside

SUMMARY

Summary

Heat Monitoring System

Unique Pickup System

Creative optimum route

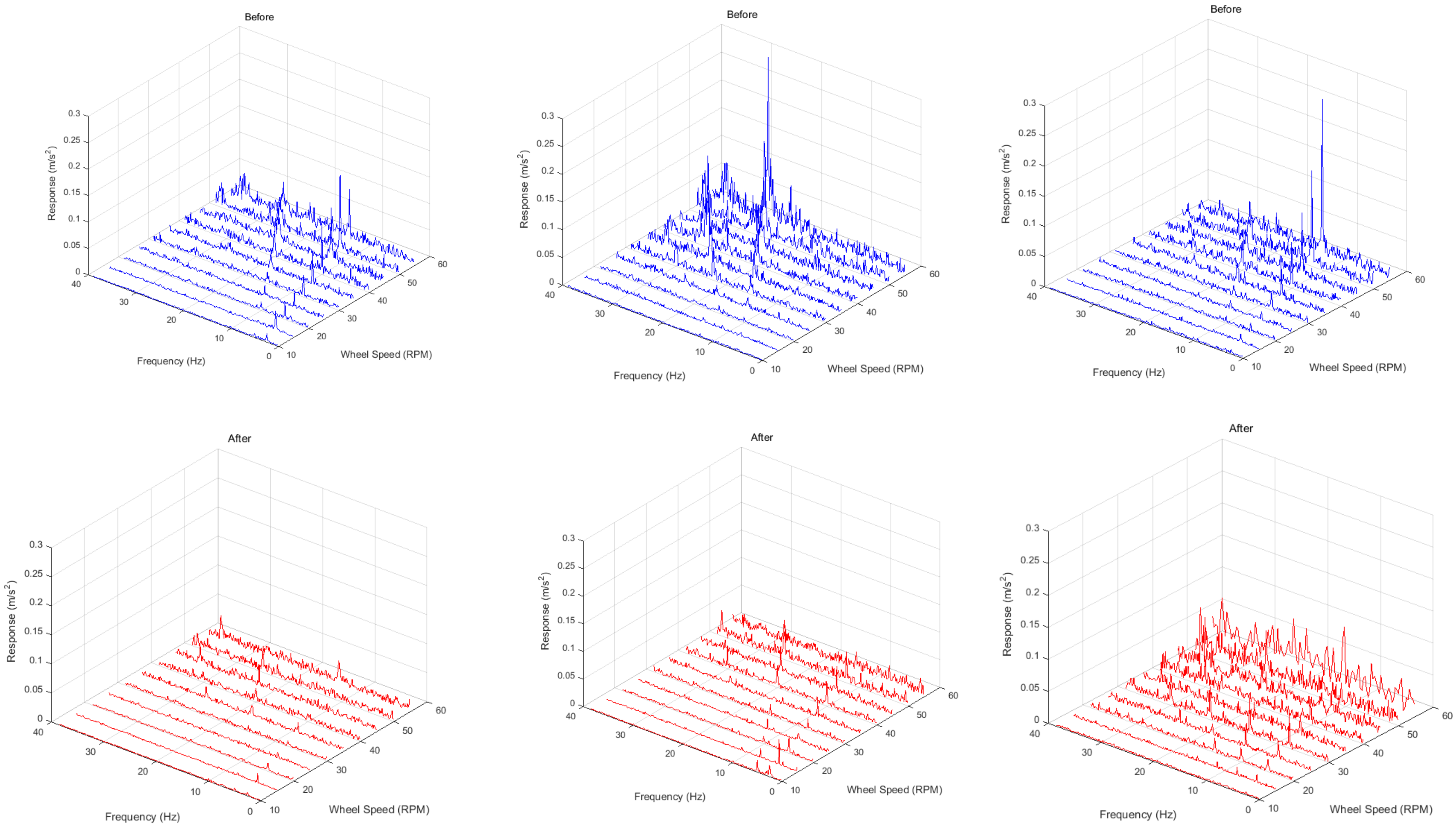
Accurate Control system

Adaptable to various environments

Thank you for listening

QnA

APPENDIX


Before
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)
Before
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)
Before
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)
After
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)
After
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)
After
Response (m/s^2)
Frequency (Hz)
Wheel Speed (RPM)