걷지 말고 기어

"Speed. What else?"

Capstone Design Final

Advisor: Prof, YongHwa Park
TA: Sooyong Kim
Team Member : Sangwon Yoon, Duckyoung Kim, Minkyung Kim, Won Choi, Yechan Lee, Sungwoog Hong, Cheol Sagong

INDEX


Hardware
Design

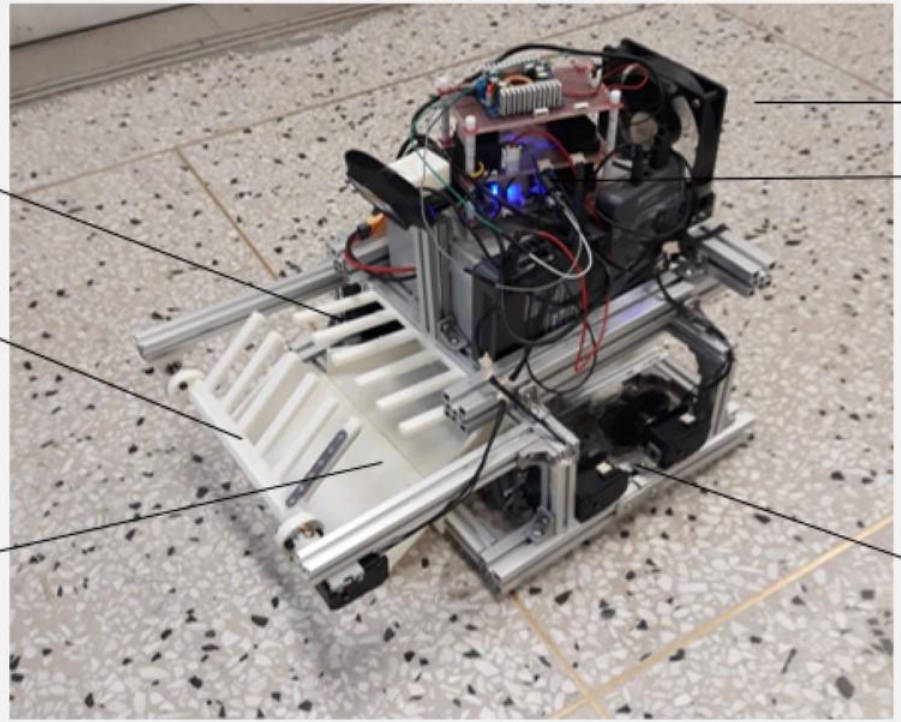
Overview

1. PICK UP MODULE

RAKE SHAPED ROOF

RAKE SHAPED ROLLER

STORAGE
& BACK DOOR



2) HEAT TRANSFER

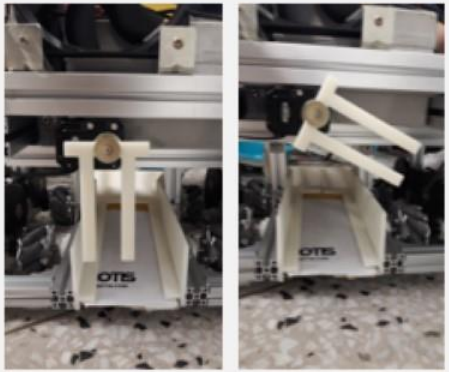
FAN

ELECTRICAL SYSTEM

3) GEAR-WHEEL SYSTEM & VIBRATION REDUCED STRUCTURE

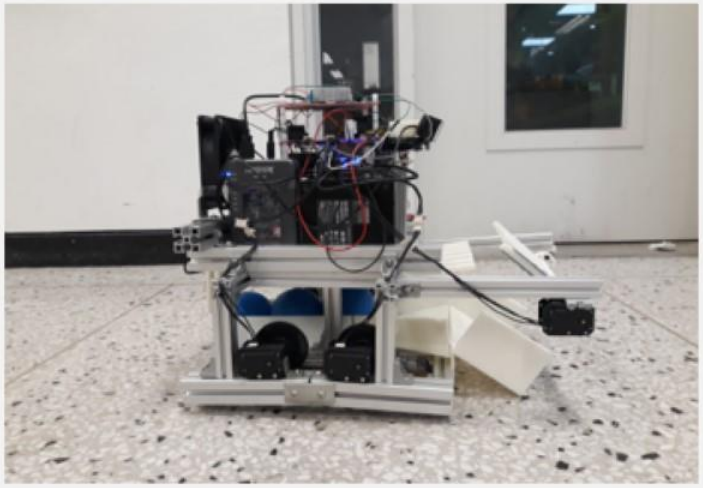
01) PICK UP & DROP MODULE

(BEHIND VIEW)

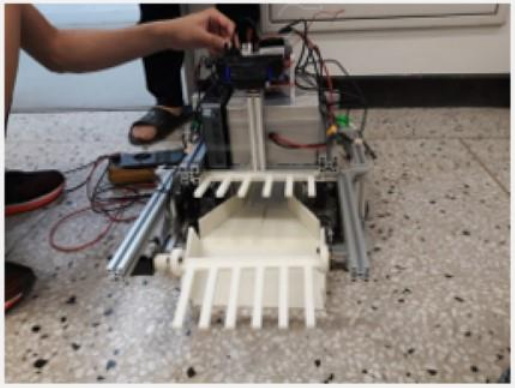


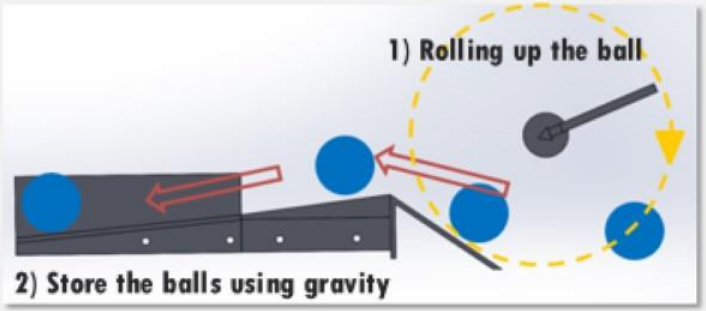
Use Motor to open & close the door

(SIDE VIEW)



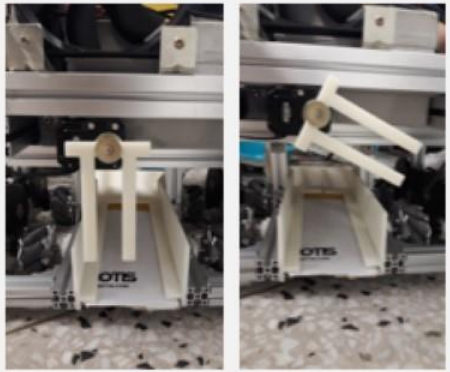
(FRONT VIEW)



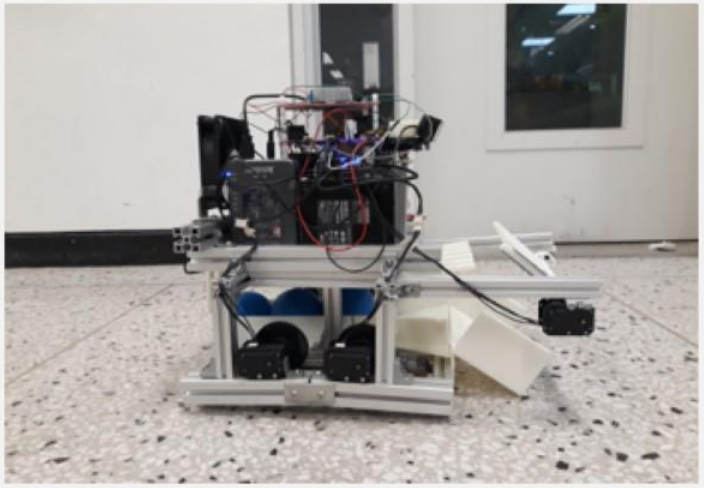


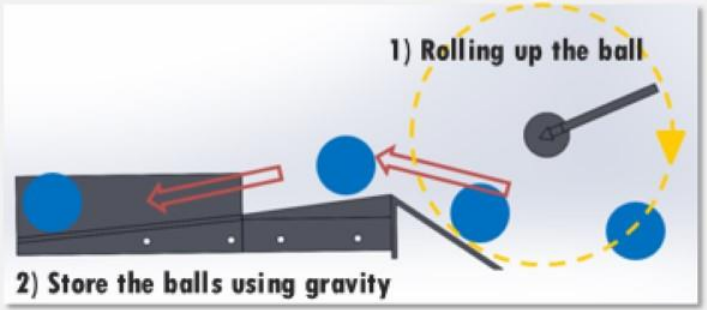
01) PICK UP & DROP MODULE

(BEHIND VIEW)

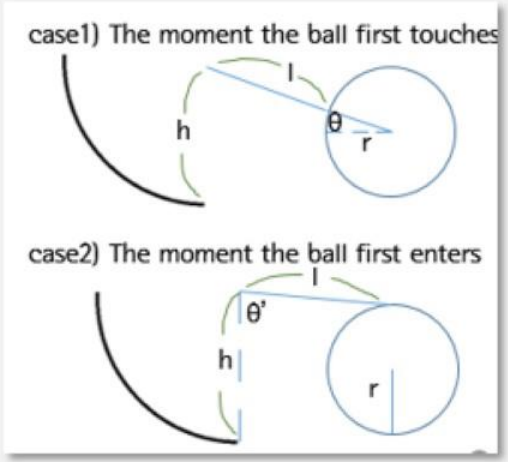


(SIDE VIEW)





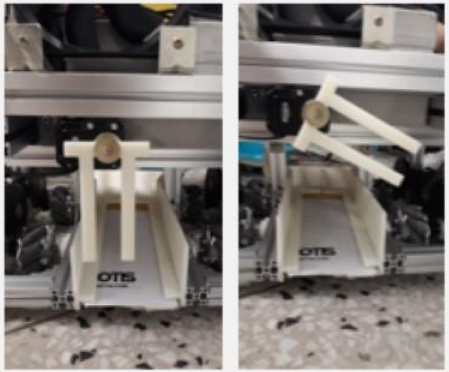
Optimal dimension of picking up the ball (cf.2nd presentation)



Minimize the ball escaping
∴ h≒12cm, l≒9cm

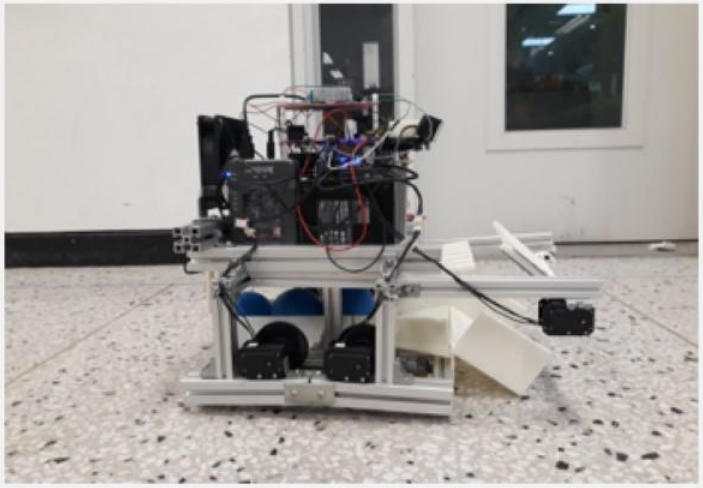
01) PICK UP & DROP MODULE

(BEHIND VIEW)

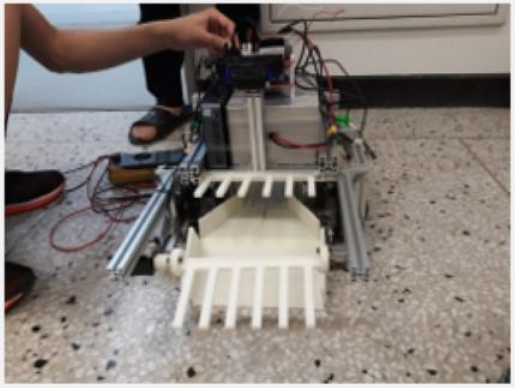


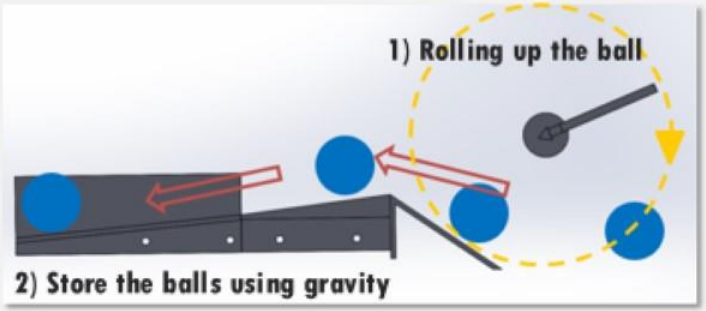
Use Motor to open & close the door

(SIDE VIEW)



(FRONT VIEW)

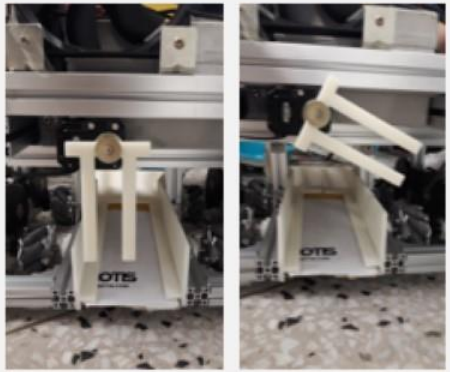




Hardware

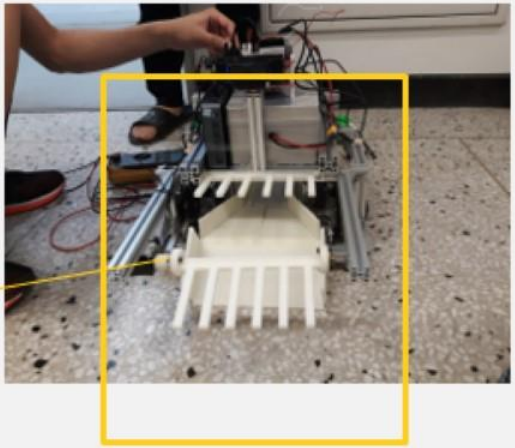
01) PICK UP & DROP MODULE

(BEHIND VIEW)



Use Motor to open & close the door

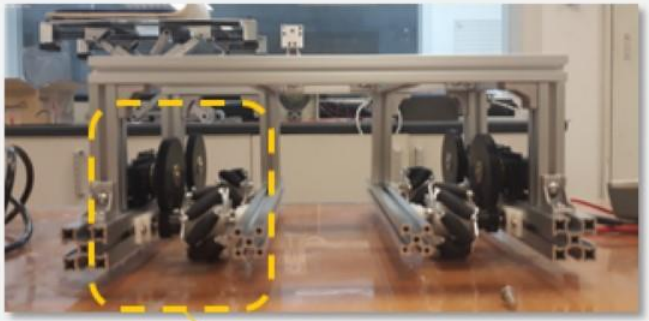
(FRONT VIEW)

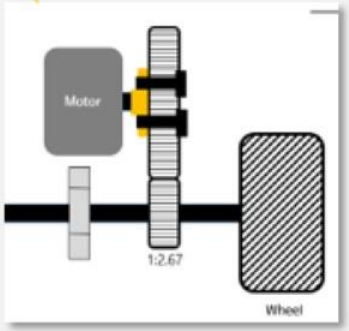


Rake shaped roof preventing **Ball Escaping**

1. Lighter
2. Effectively block the ball

02) GEAR SYSTEM



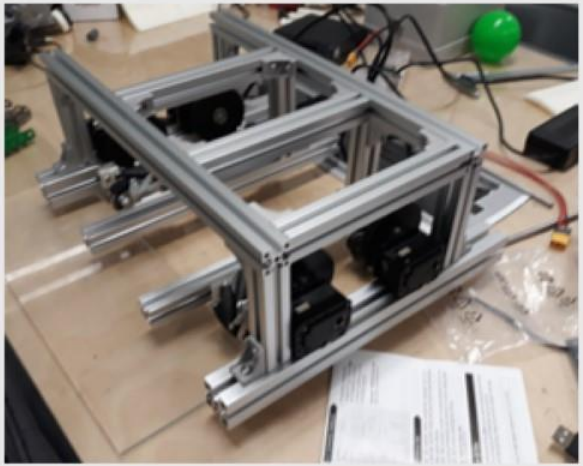


X2.67 faster!

Effect of Gear-Wheel System (c.f. 2nd Presentation)

03) FRAME ISSUE

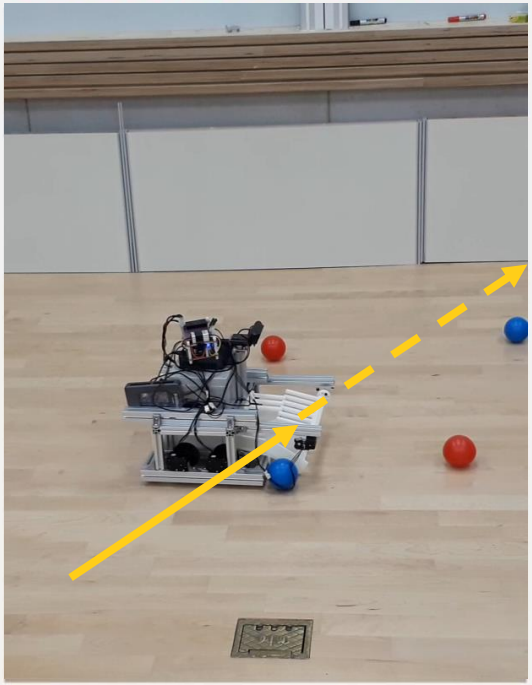
Primitive Design



Very Rigid Body Frame

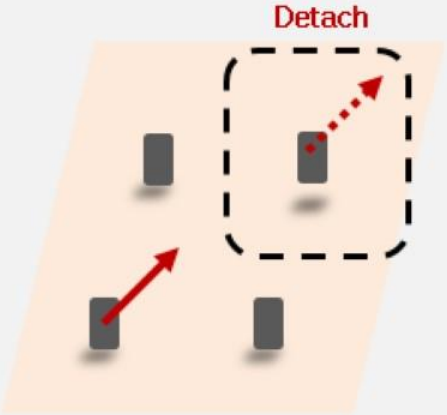
Assumption: The filed will be flat

However, in real situation



Why the diagonal movement Is stopped?

The field is not flat,
Not all the wheels touches the floor.



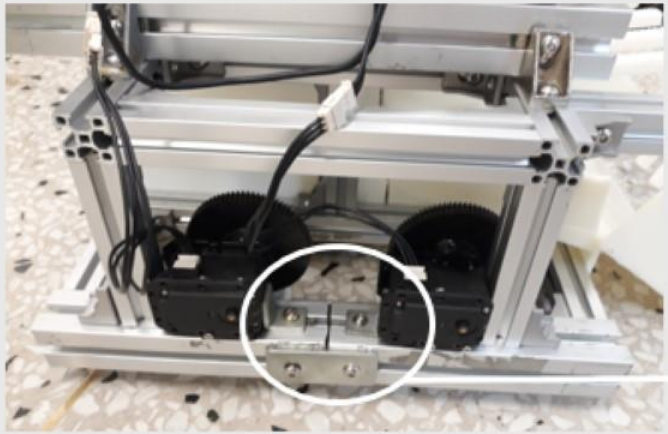
Mecanum wheel system

03) FRAME ISSUE

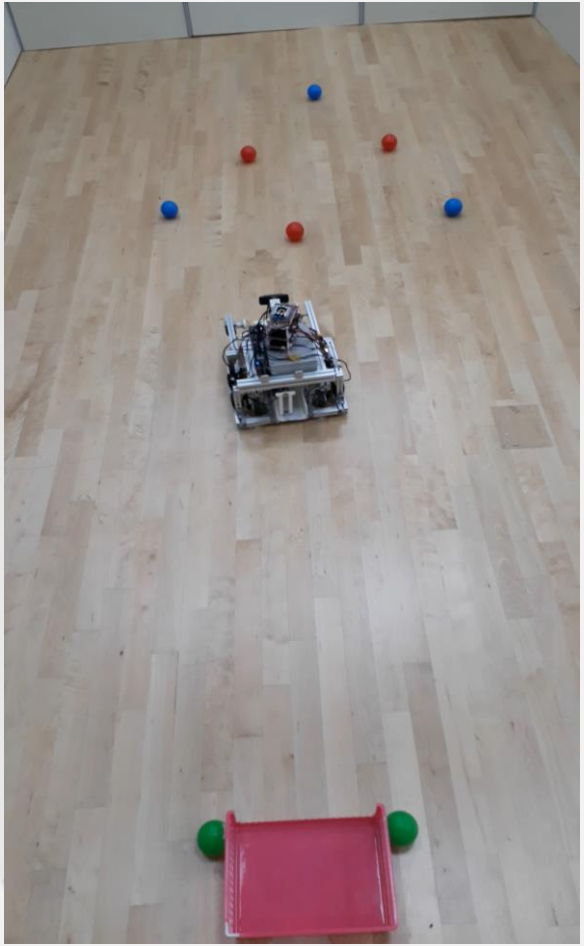
***Improved* Design**

Lack of Time
Lack of Cost
Preserve Stability

→ TRIZ : Segmentation

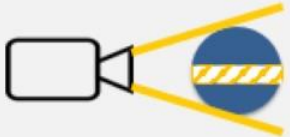


Segmentation
: Add Degree of Freedom

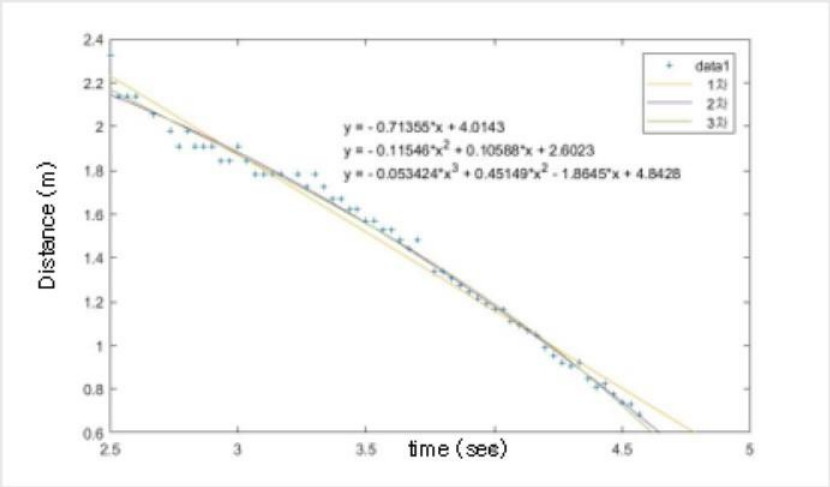


04) VIBRATION ANALYSIS

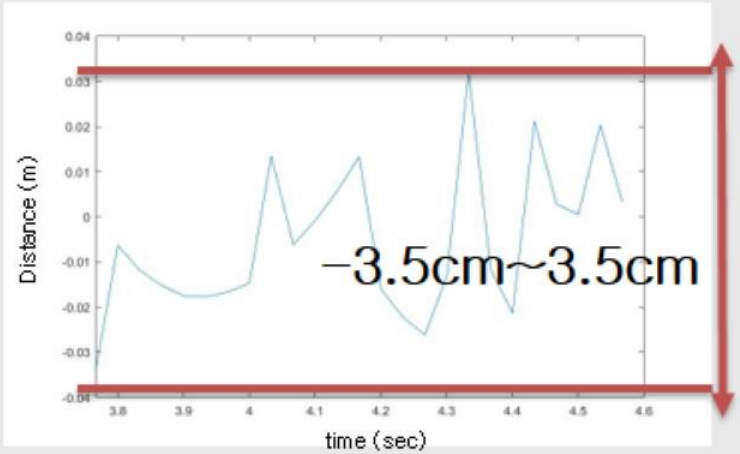
Ball Depth Detection



Raw Distance Data (AC+DC)



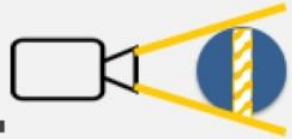
Vibration (AC) Distance Data



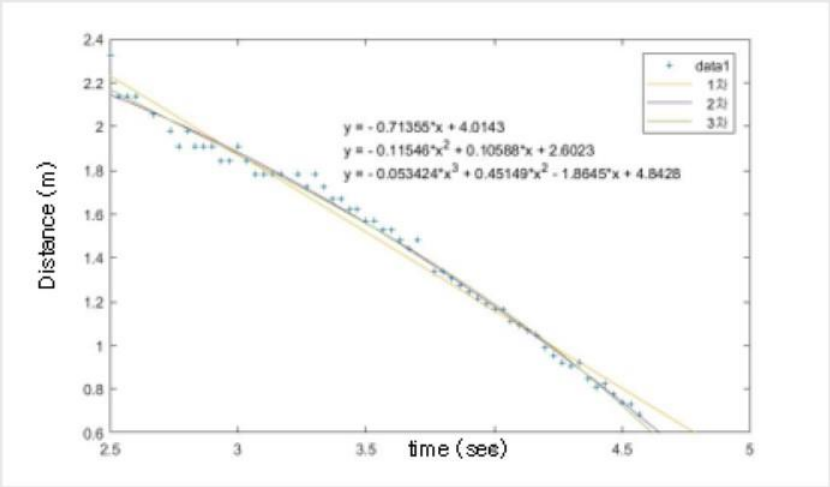
Eliminate 2nd order polynomial & Pixel errors

04) VIBRATION ANALYSIS

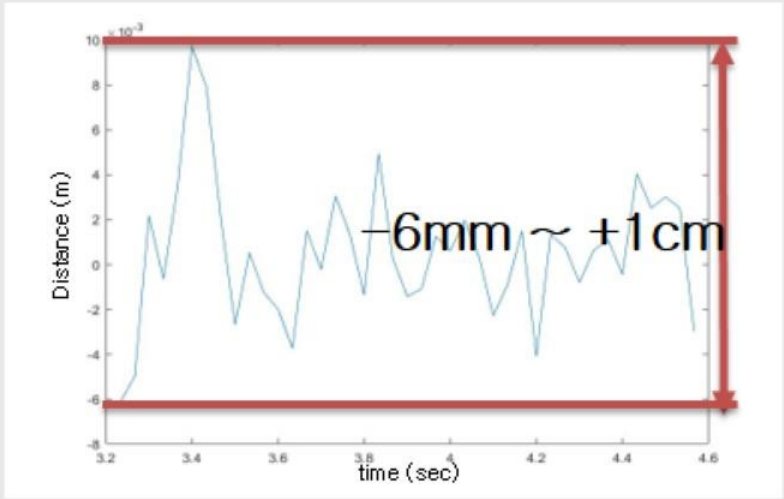
Horizontal position Detection



Raw Distance Data (AC+DC)



Vibration (AC) Distance Data

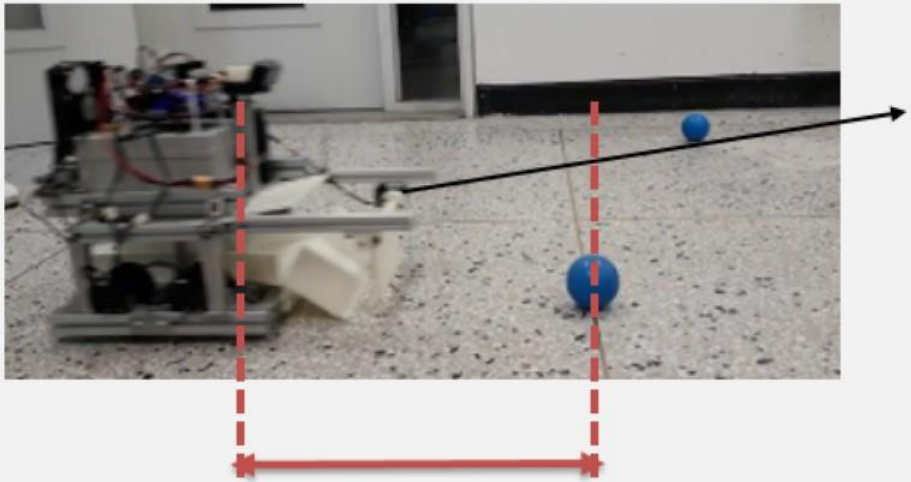


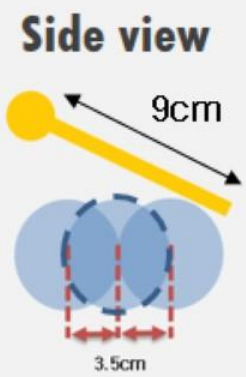
Eliminate 2nd order polynomial & Pixel errors

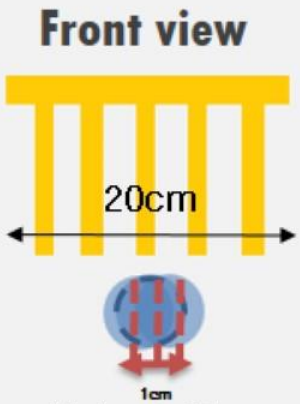
04) VIBRATION ANALYSIS

Acceptable Range of Picking up

Ball Pick up Algorithm :
The roller starts to rotate when the blue ball is 60cm away

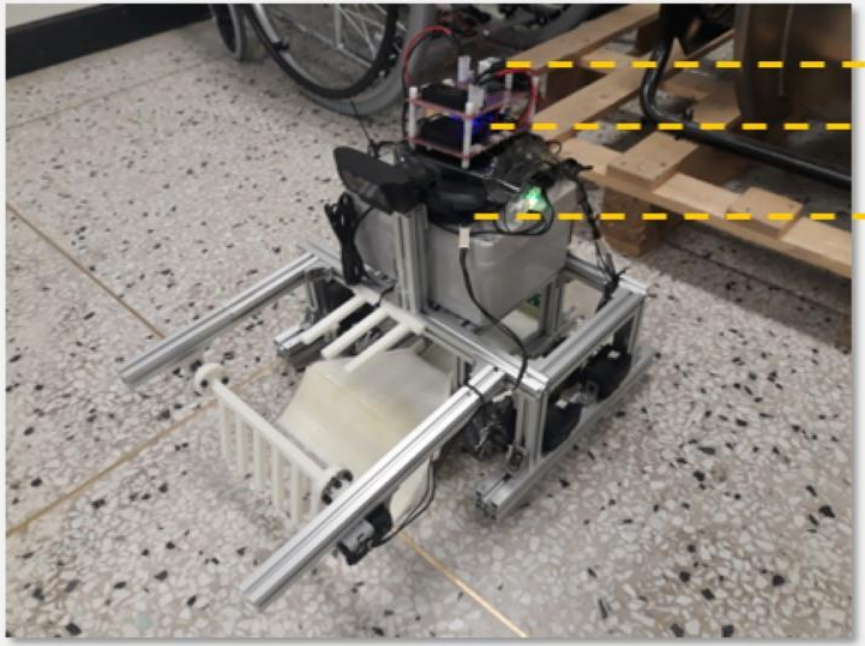






Detection error from vibration is in affordable range !

05) HEAT TRANSFER



Before Heat Transfer Design

Roller Converter : 48℃

Wheel Motor Converter: 67 ℃

Heat Transfer System is required

NUC: 45~50 ℃

Analyze required spec of fin & fan!

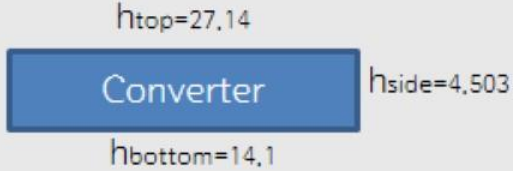
05) HEAT TRANSFER

Assumption: Q=3.5W (converter efficiency 93%)

Analytical Solution

(i) No fin&fan, Natural Convection

Ti=25 ℃



ΔT=38.67 ℃

∴Tf=63.67 ℃

(ii) Fin & Forced Convection

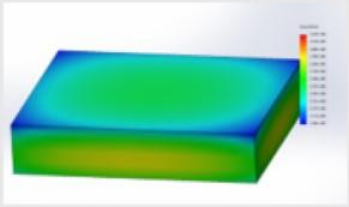
ΔT=4.63 ℃

∴Tf=29.63 ℃

Solidworks Simulation

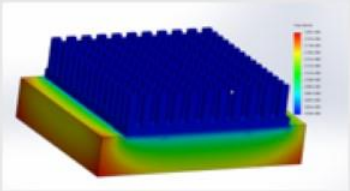
Condition Set
1) Steady state
2) Convergence Tolerance: 0.0001

(i) No fin&fan, Natural Convection



Result: Tmax 65℃

(ii) Fin & Forced Convection

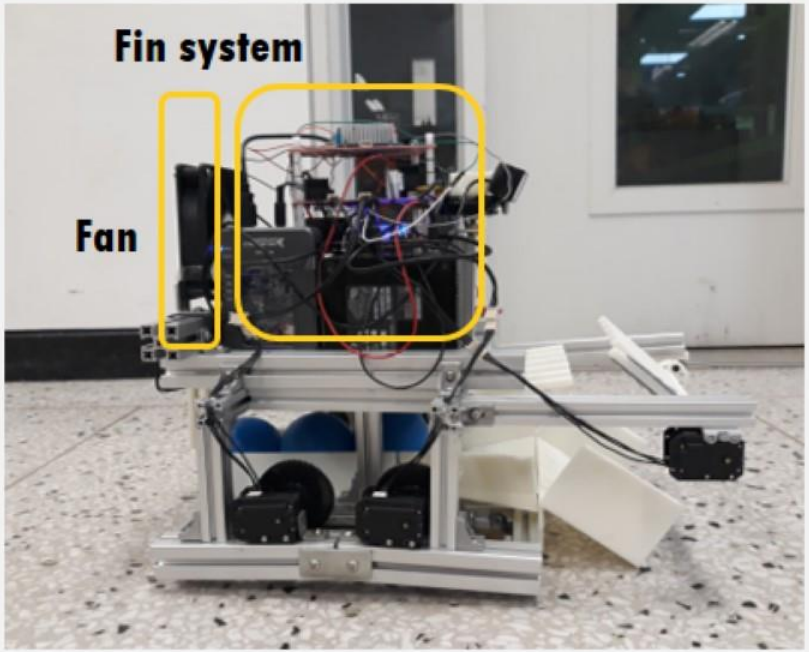


Result: Tmax 43℃
Tfin_surface 30 ℃

Two results are same! Suggested Fin&Fan is appropriate!

05) HEAT TRANSFER

Heat Transfer system



Real Temperature obtained from thermal camera

NUC

(FRONT VIEW)

(SIDE VIEW)

(BACK VIEW)


Software

Software

Software Integration

Ball_detect_node

- Detect the ball and get the position of the ball
- Publish the position data of Red, Blue and Green balls

Control_node

-Subscribe the position data

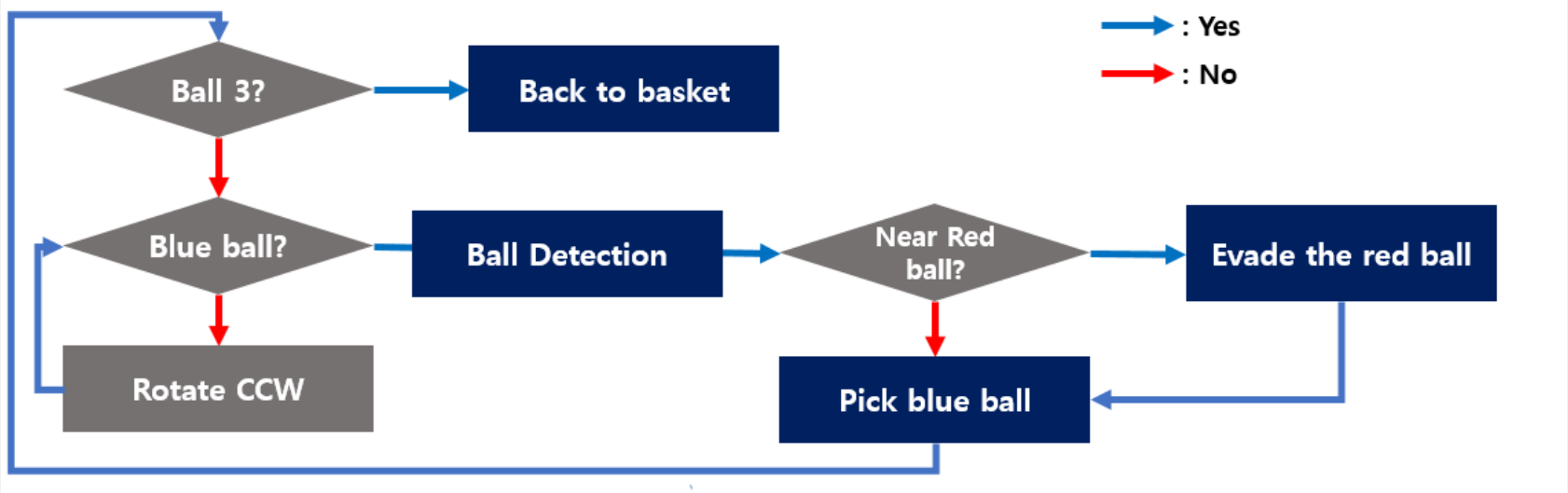
-Decide the proper action of each situation.

-Publish the motor control signal

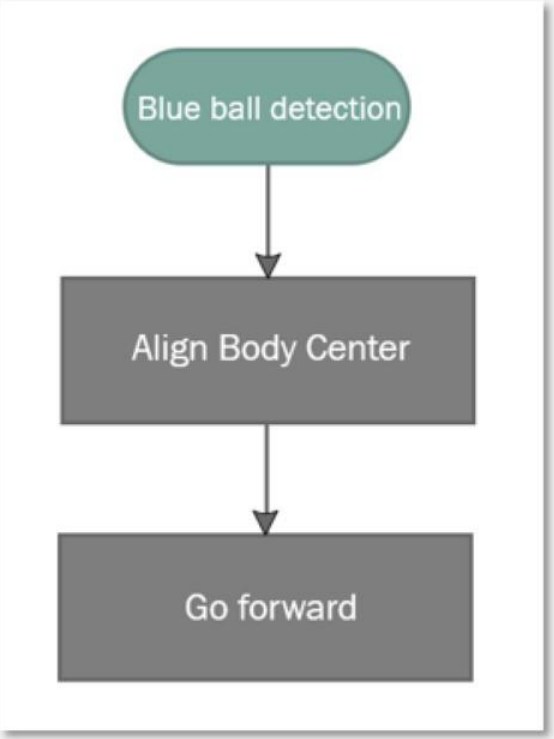
Labview

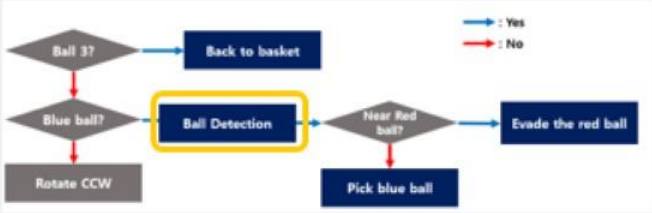
-Subscribe the motor control signal
-Decide the motor speed ...

Overall Path Generation Algorithm

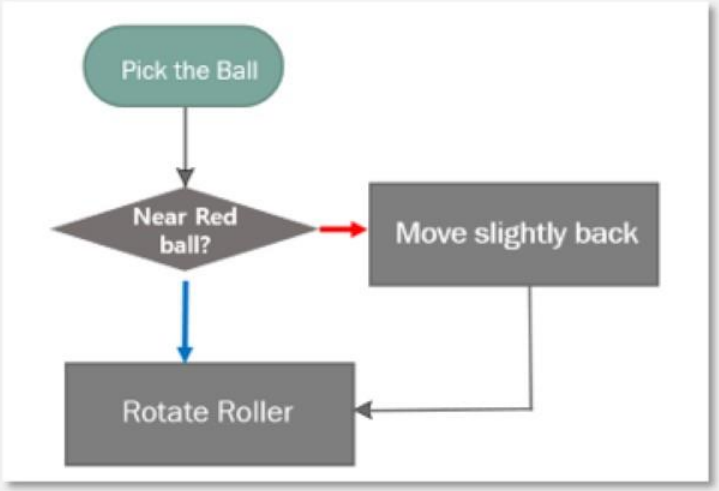


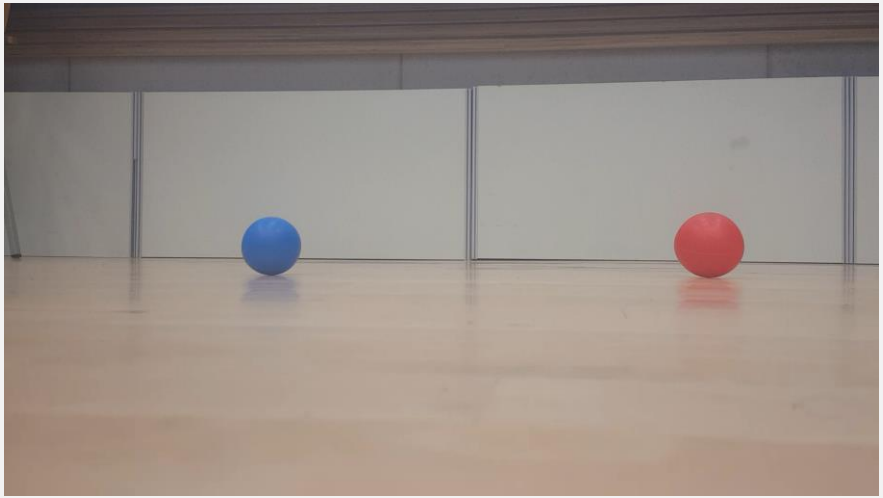
Ball Detection



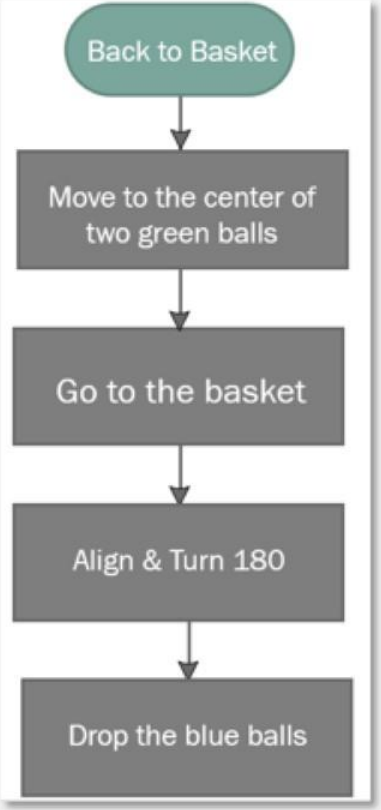


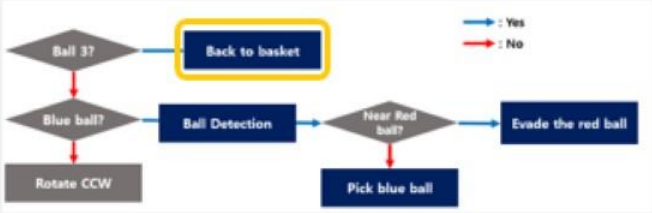
Pick the ball

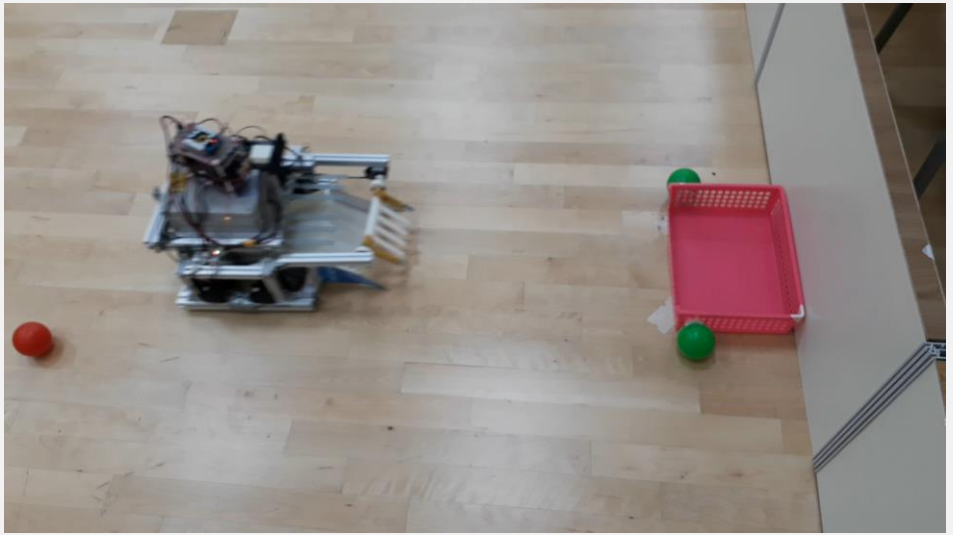




Back to the basket







Check
the final system
on the DEMO!!

Conclusion: Creative solutions

Creativity

Light & Simple structure

Reduce roller weight

Rake shape: reduce **85%** of weight

Frame Segmentation

Fast Speed

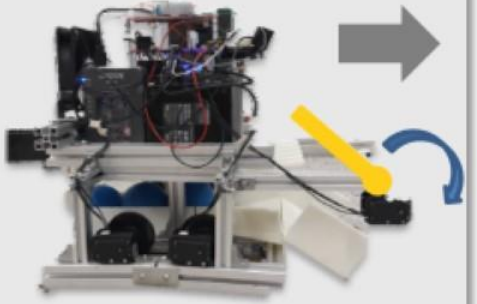
Gear system!

X2.67 faster

Efficient Algorithm

Picking while moving!

Feedback control!

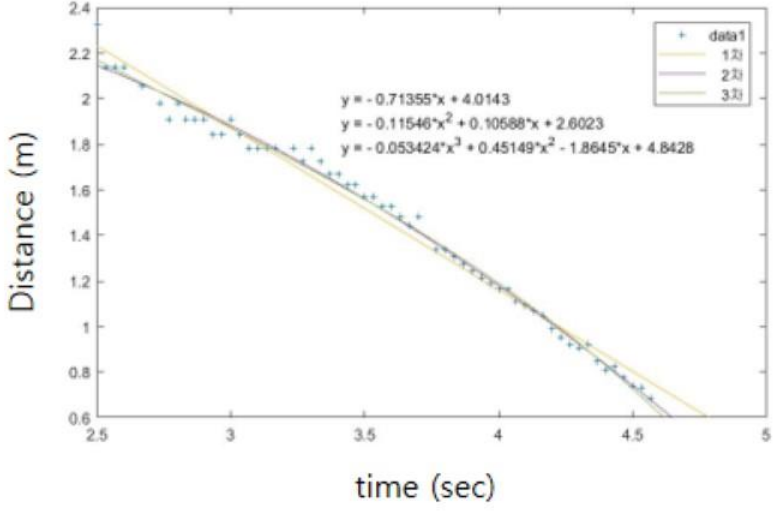


Q&A

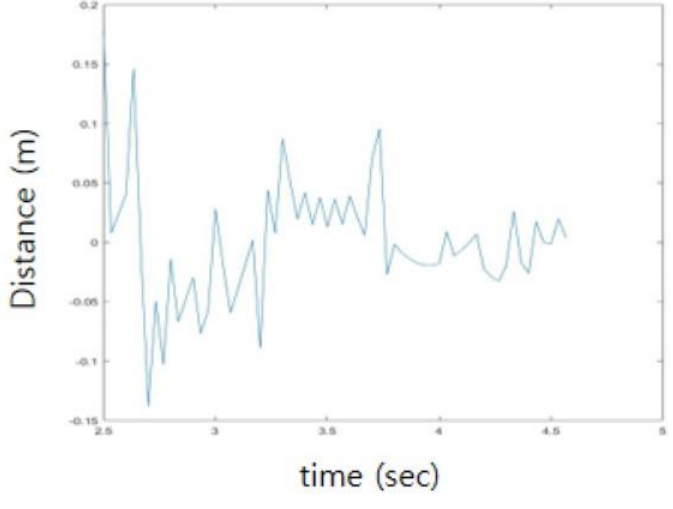
Appendix

Vibration analysis

Raw Distance

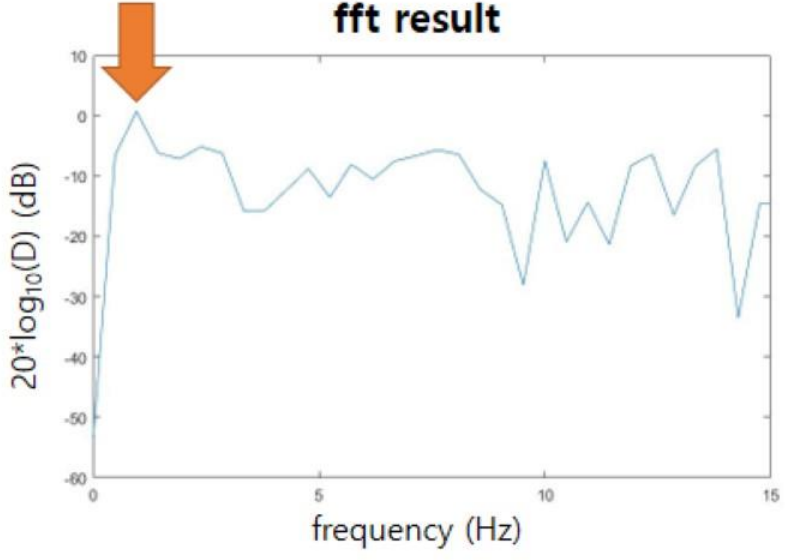


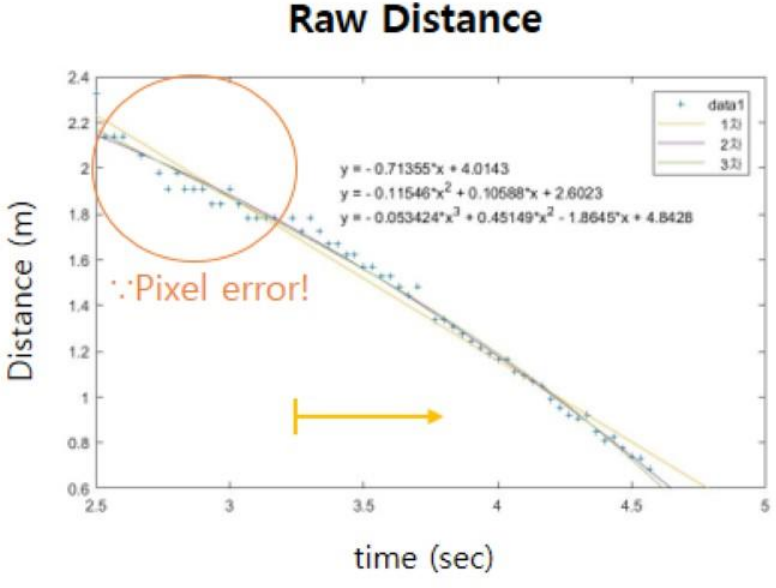
Distance – 2nd order polynomial



Vibration analysis- fft result

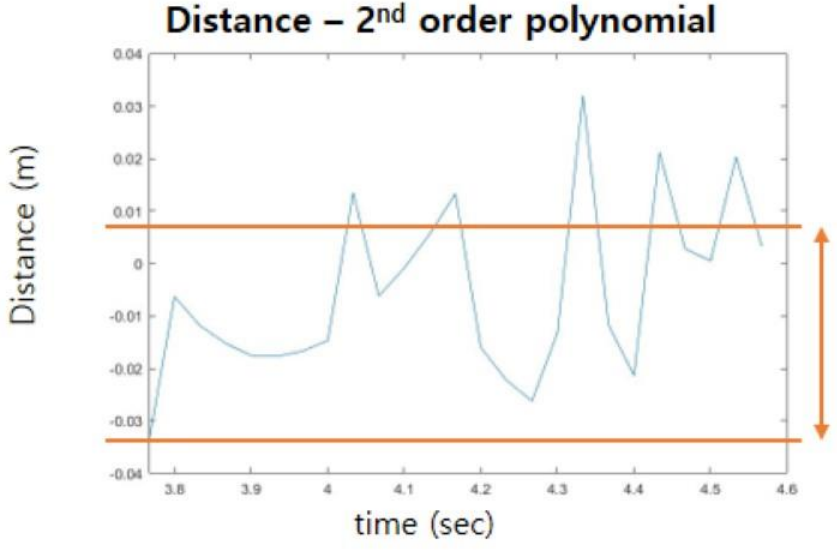
Dominant vibration on 0.95Hz

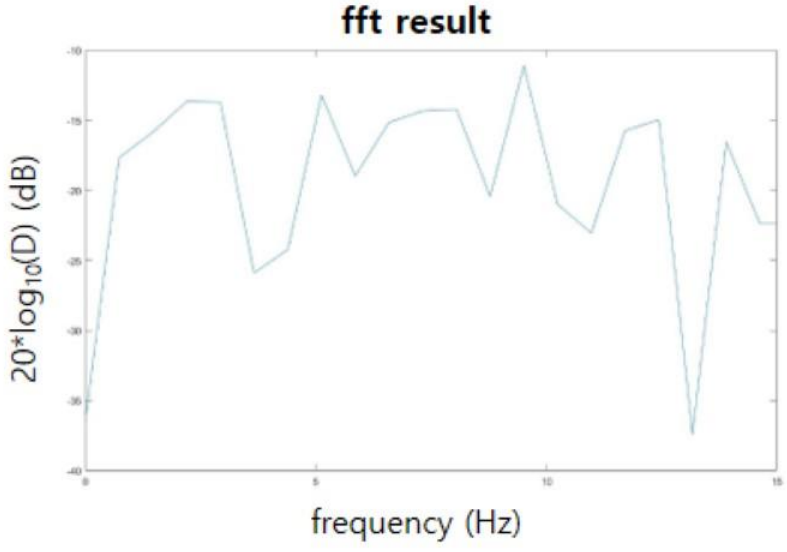




near distance was chosen for analysis!

Vibration analysis- fft result (direct motion)

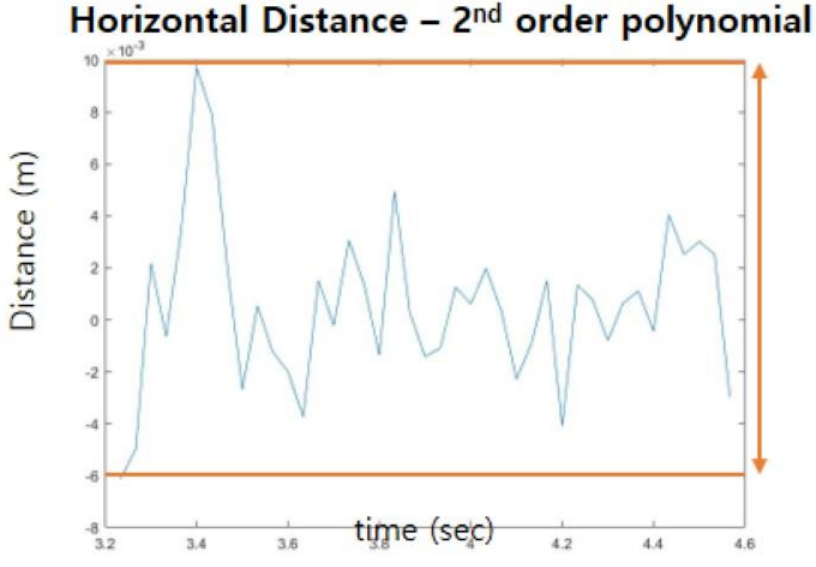


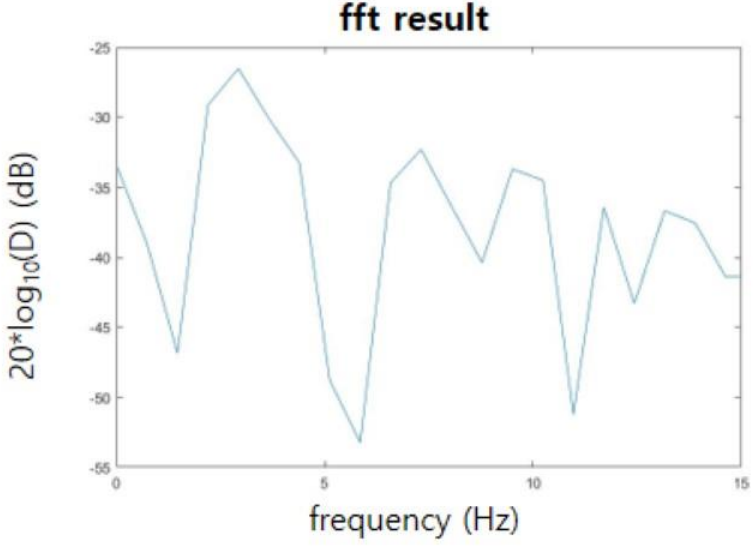


Distance error is affordable!

No meaningful vibration included!

Vibration analysis- fft result (direct motion)

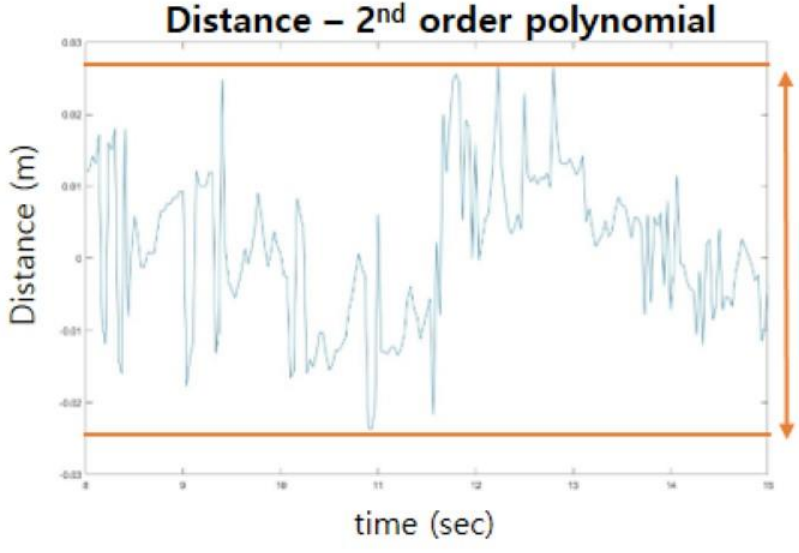


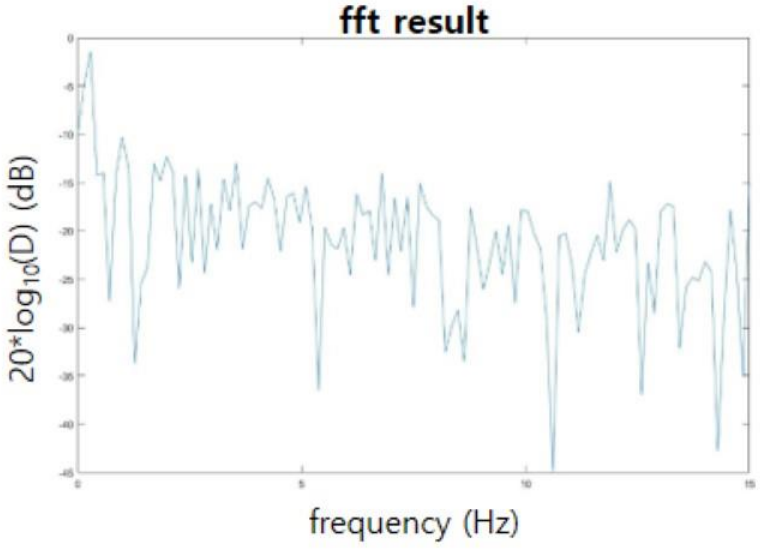


Distance error is affordable!

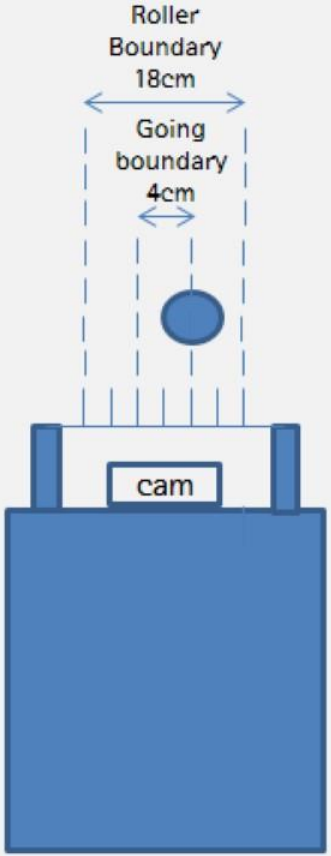
No meaningful vibration included!

Vibration analysis- fft result (diagonal motion)





Distance error is affordable!



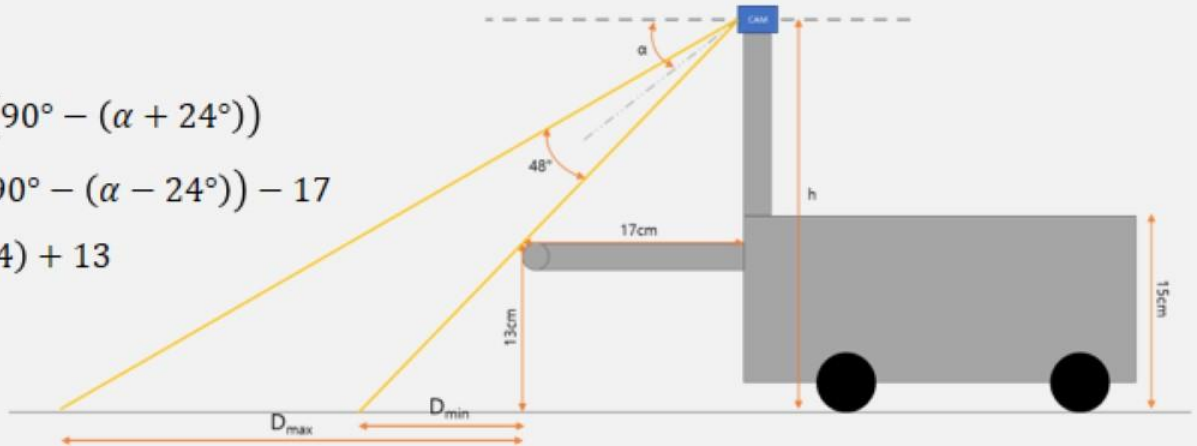
∴0.7cm vibration amplitude is acceptable
within the roller boundary!

Cam Position

$$D_{min} = 13 \times \tan\left(90° - (\alpha + 24°)\right)$$

$$D_{max} = h \times \tan\left(90° - (\alpha - 24°)\right) - 17$$

$$h = 17\tan(\alpha + 24) + 13$$



$h\uparrow \Rightarrow D_{min}, D_{max}\downarrow$

$D_{max} \leq \infty \Rightarrow \alpha=24°, D_{min}=11.7cm \ , h=31.9cm$


Thank You