KAIST ME & NAVER Labs

Capstone Design 2018

Team 必勝

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Advisor:
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Detachable system with light and fast collector

02. Specific Issues
Heat, vision, vibration, motor control, ROS, and cable reel

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Lessons learned & great team

2-Body System: Station and SCV

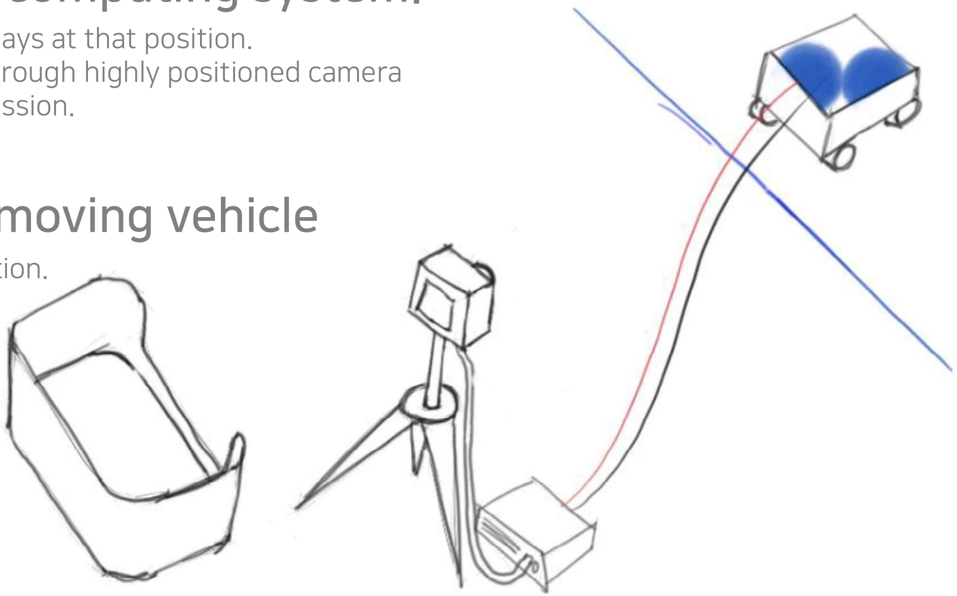
Our vehicle is composed of **2 independent bodies** connected by a wire for powering: **Station and SCV.**

Station is a central computing system.

When it arrives target place, it stays at that position.
It sees SCV and surroundings through highly positioned camera and controls SCV to complete mission.

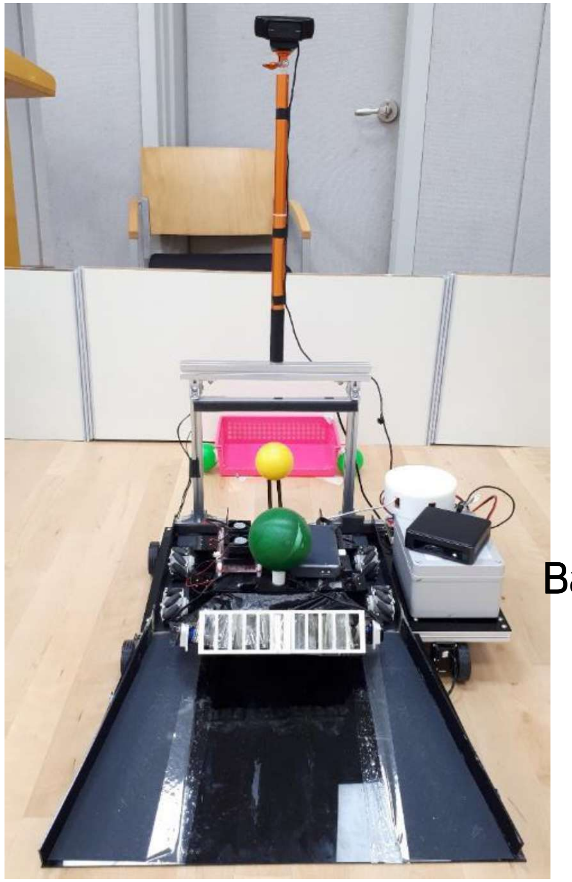
SCV is a light, fast moving vehicle

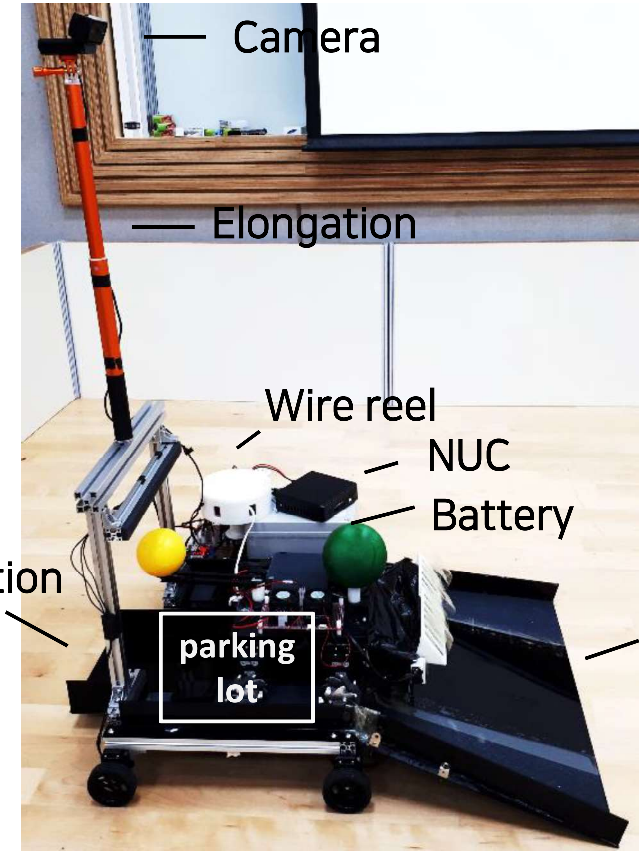
that dribbles the balls to the station.



01.
System Description

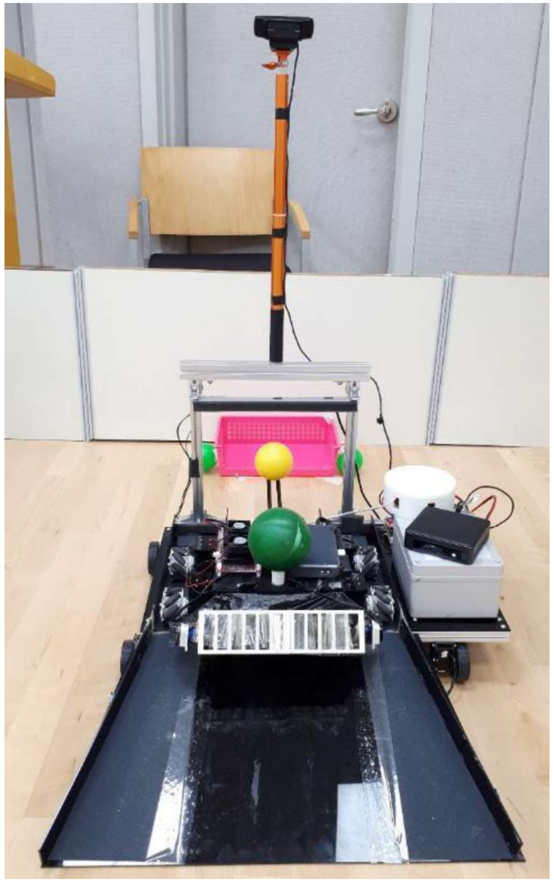
Station and SCV(simply collecting Vehicle)_Station

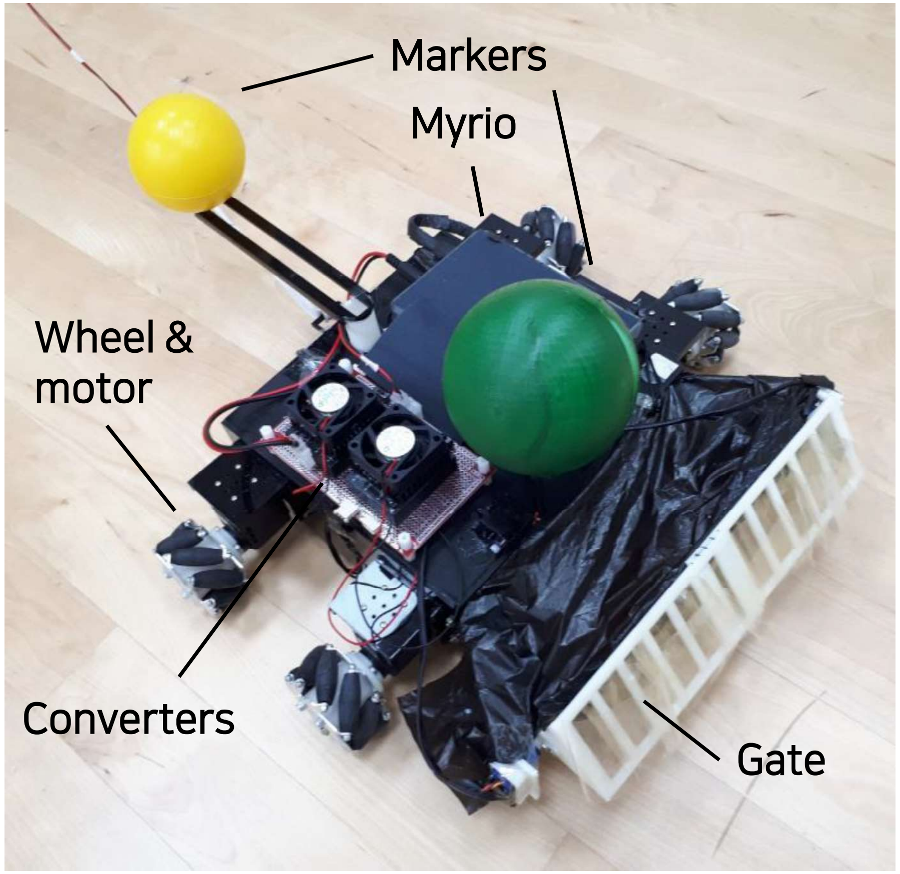




01.
System
Description

Station and SCV(simply collecting Vehicle)_SCV





01.
System Description

02. Specific Issues

Heat_improving h(convection coefficient)

Measuring steady state temperature and analyze cooling efficiency improvement

Vision_recognizing the (real) world

Marker calibration, distortion correction

Vibration_is suspension needed?

Control motor and Communicate with ROS to get input

Motor Control_rotation speed control

Nonlinear control

ROS_integration of all systems

Data analysis, calculation, ordering, and station motor control

Cable Reel_connecting two rotating line

Spiral spring, slip ring, and 3d printing

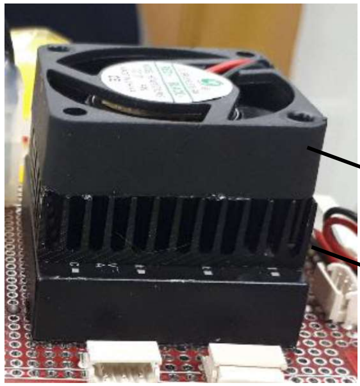
Heat

Improving h(convection coefficient)

Major Heat source: Converter

Without cooling system

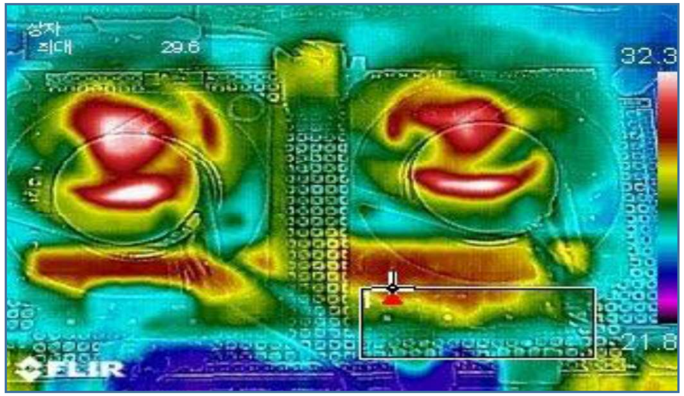
Max. temp. = 48.3°C



fan

fin

After fin & fan attached



Max. temp. = 29.6°C

Heat

Improving h(convection coefficient)

Heat analysis: change in h

$$T_b = 48.3℃$$

$$\overline{Nu_L} = 0.54 Ra_L^{0.25} = 3.706$$

$$= \frac{\bar{h}L}{k}$$

$$\therefore \bar{h} = 9.99\, W/m^2K,\ q = 0.448\, W$$

X10 improvement

$$Re = 63018.87$$

$$\overline{Nu} = 0.664 Re^{0.5} \mathrm{Pr}^{0.33} = 148.5$$

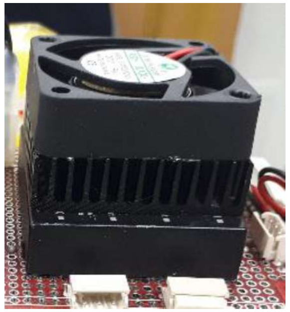
$$= \frac{\bar{h}L}{k}$$

$$\bar{h} = 97.6\, W/m^2K$$

$$\eta(fin\ efficiency) = 0.9537$$

$$\therefore\ T_b = 25.83℃,\ T_{actual} = 27.1℃$$

u = 14.4m/s

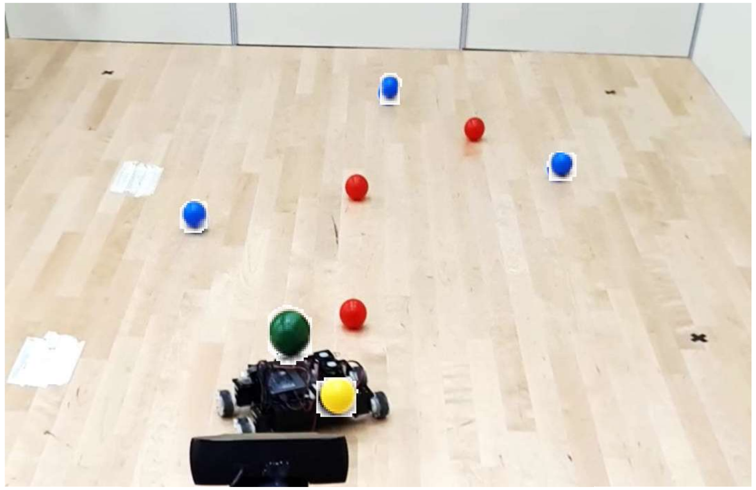


Vision

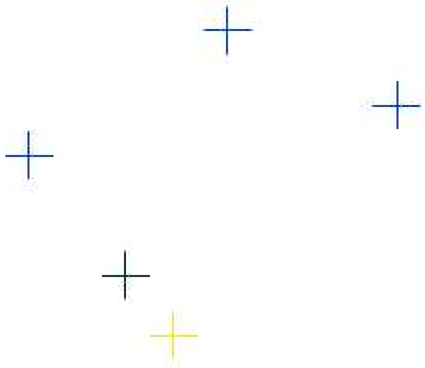
Recognizing the (real) world

How do we see the world?

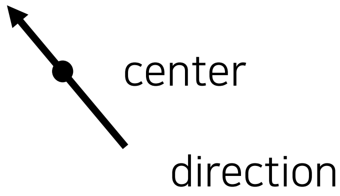
Image from camera



Detecting balls (except red)



Convert into position data

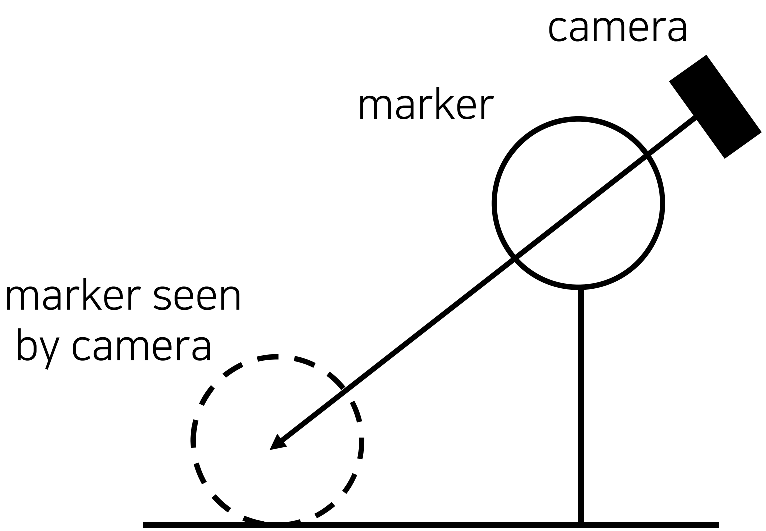


Vision

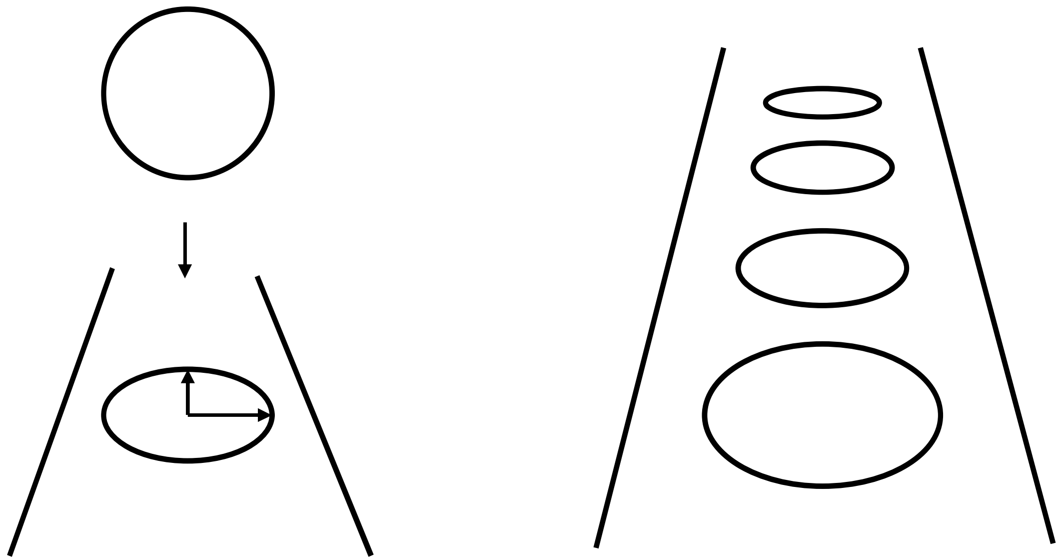
Recognizing the (real) world

Distortion factors

Distortion by height of marker



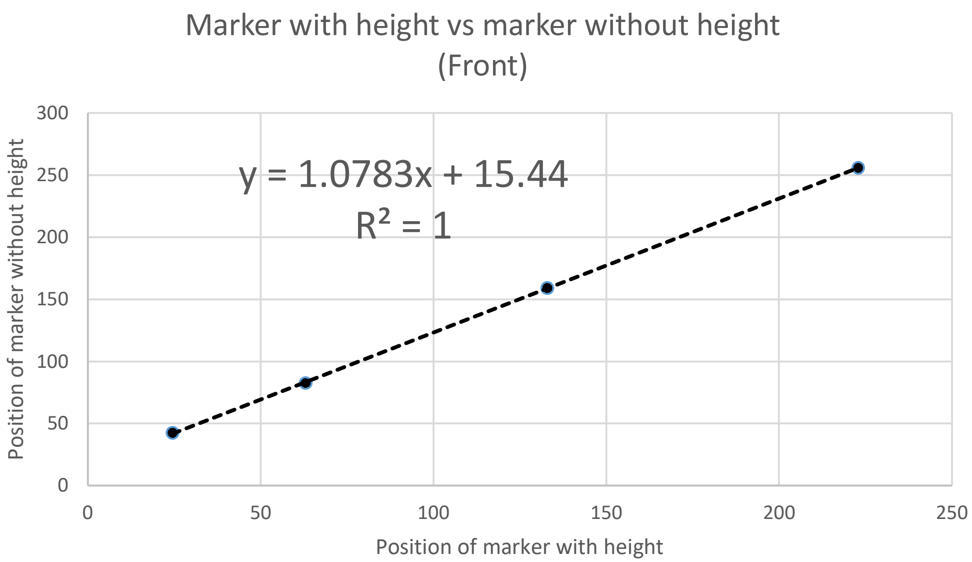
Distortion in angle and distance

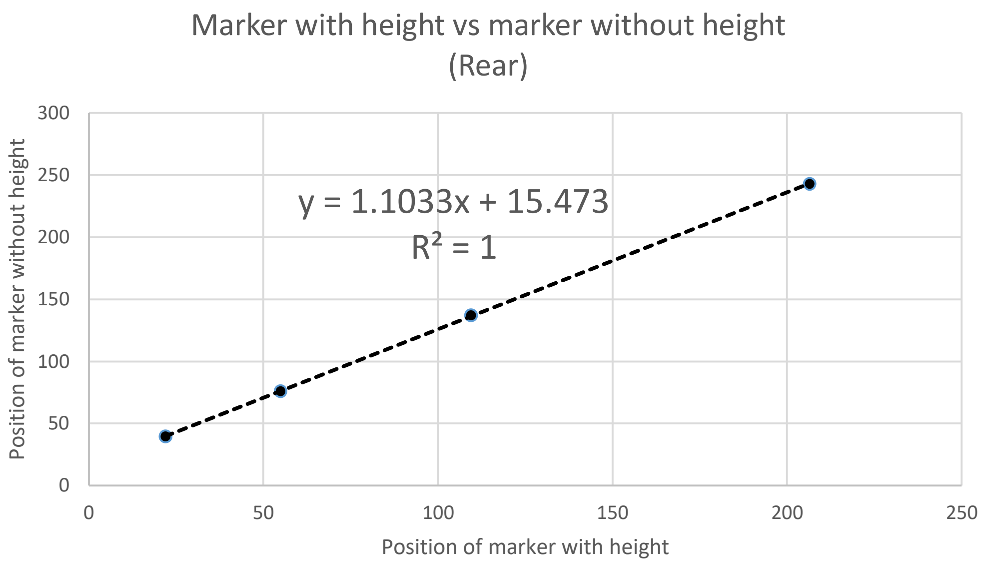


Vision

Recognizing the (real) world

Calibrating distortion by height of marker





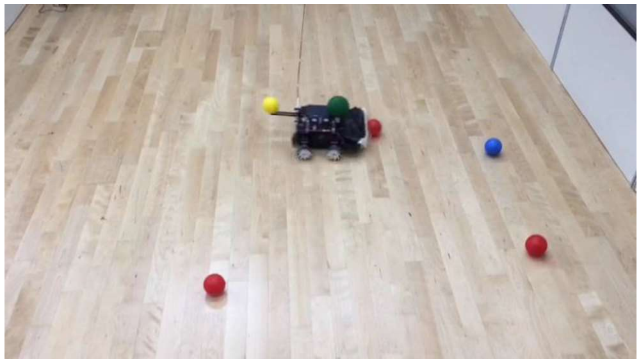
Vision

Recognizing the (real) world

Calibrating distortion in angle and distance

$$\text{Unit vector} = 1\ \overrightarrow{\text{SCV}}$$

: vector between two markers(after calibration)
: contains information about distortion in angle and distance

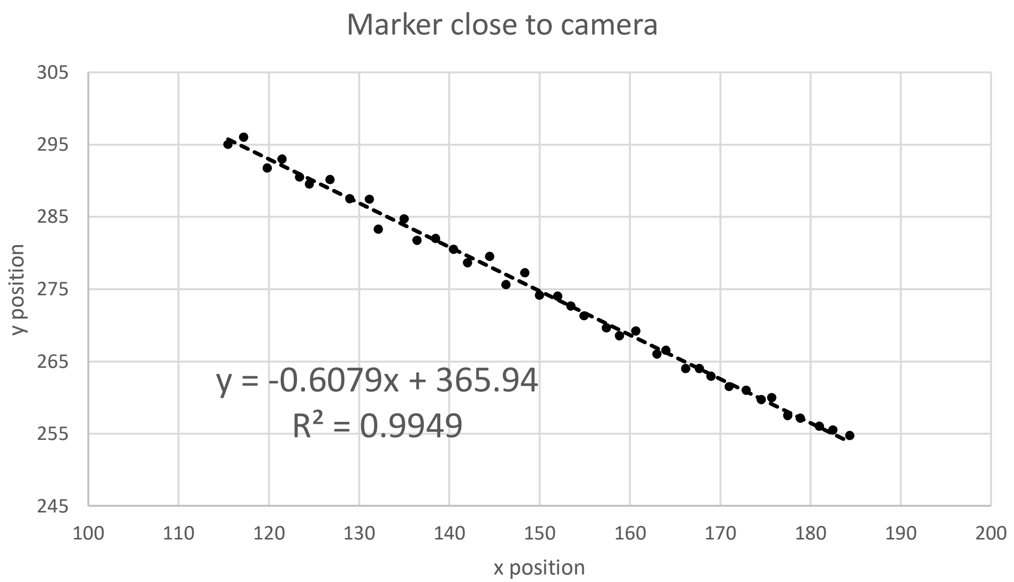


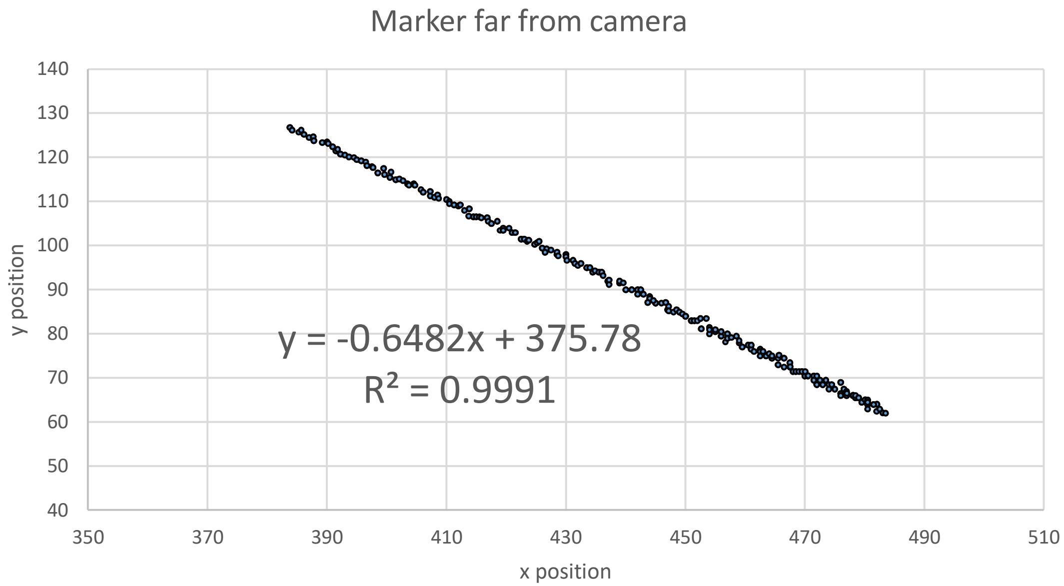
Distance needed to initiate 'eating' = 1.5 SCV

Vibration

Is vibration reduction system needed?

Tracking yellow ball during straight movement



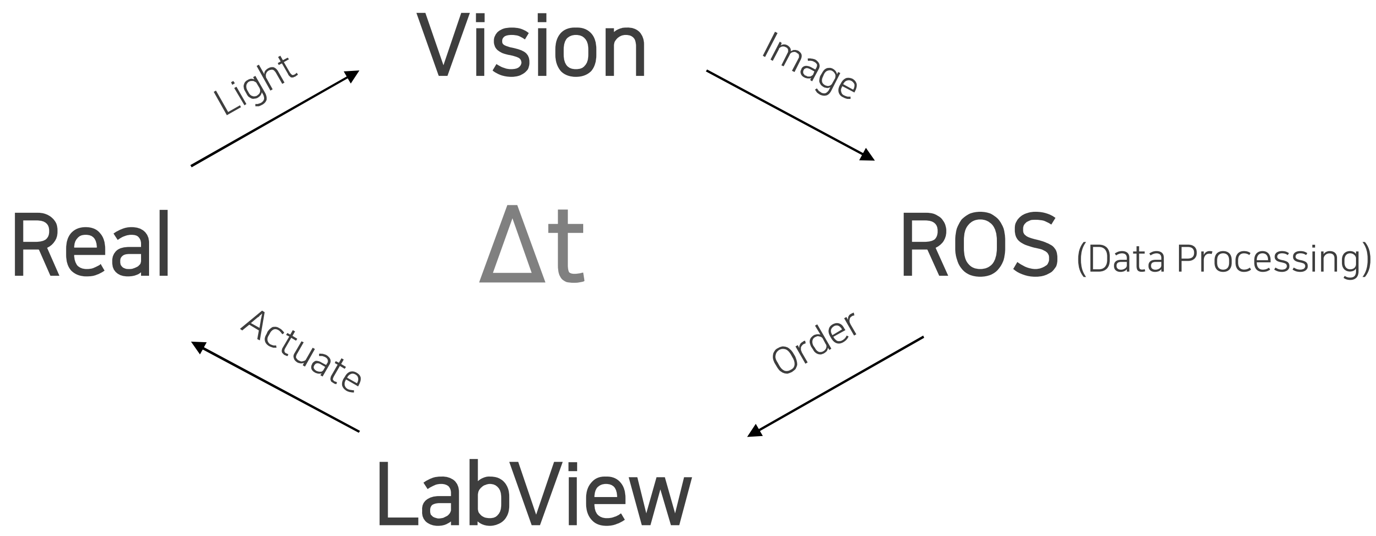


Conclusion: vibration of markers is not significant!

Motor Control

Nonlinear control

Time delay caused by communication and computational speed



Time delay = Δt Error = Δt * v(translational), Δt * ω(angular)

Motor Control

Nonlinear control

Gradual speed change as vehicle reaches target angle or position

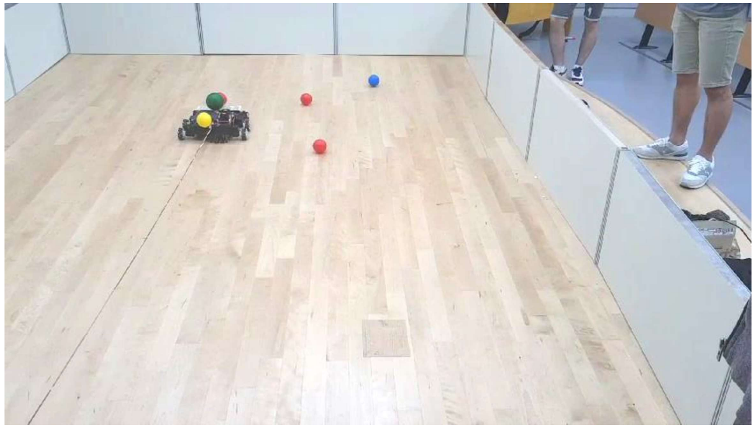
$$\omega = 0.125 + 3 * \left\{\frac{\min(30, \Delta\theta)}{30}\right\}^2$$

Decay speed

$$v = 0.05 + 0.2 * \left\{\frac{\min(80, \Delta x)}{80}\right\}^2$$

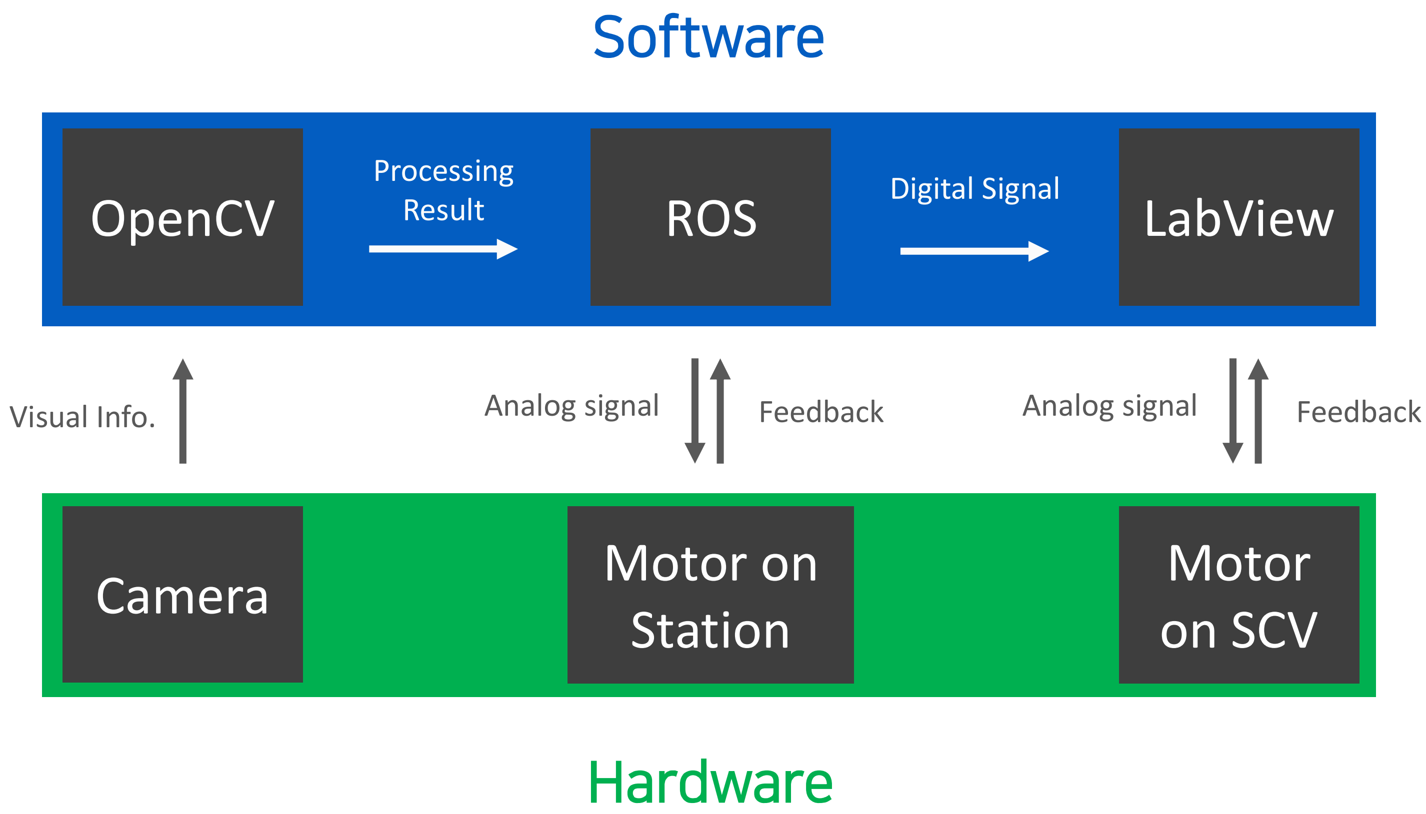
Minimum value

Control range



ROS

System integration



ROS' job

Get vision data

Control station

Mapping balls

Path planning

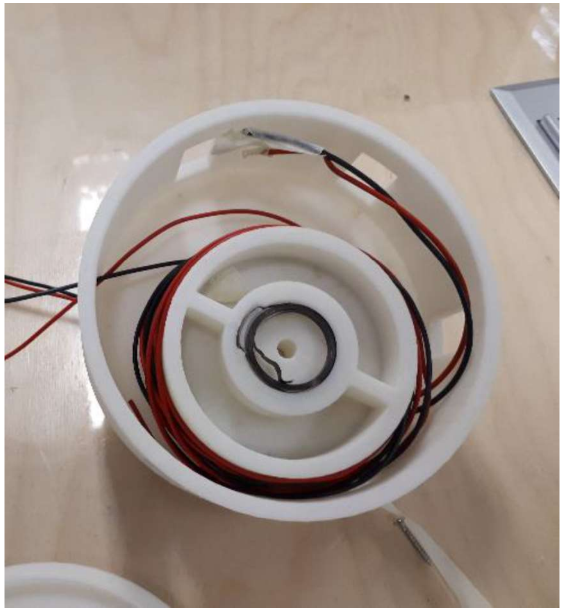
Execute algorithm

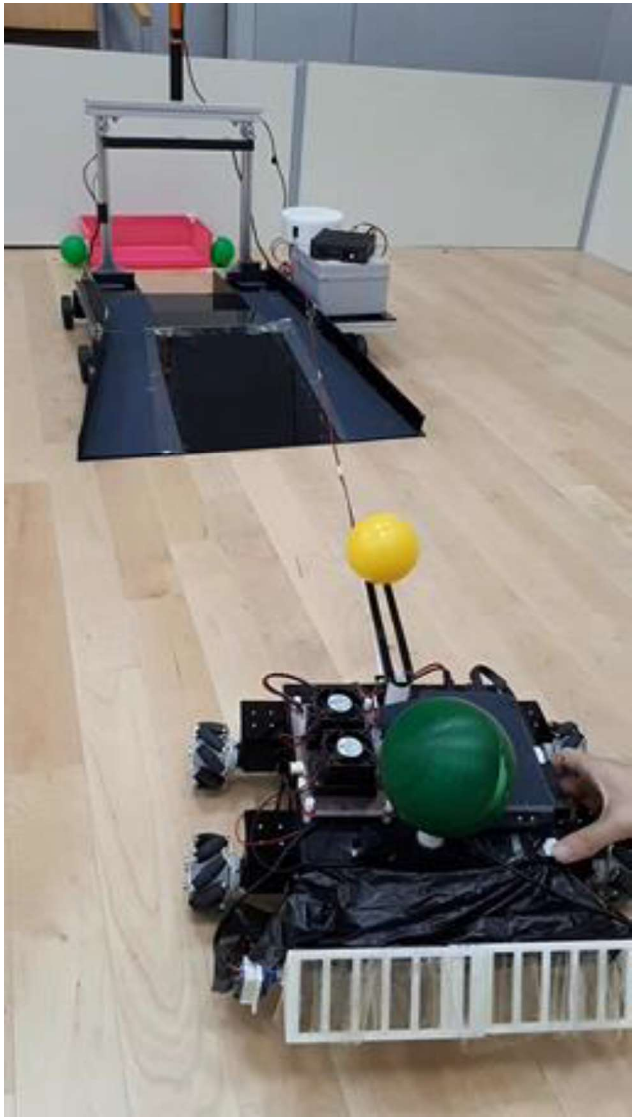
Order to LabView

Cable Reel

Connecting two rotating line

Slip ring + spiral spring + 3D printing
= rotating cable reel





03.
Key
Features

"Clever system"

Big Picture

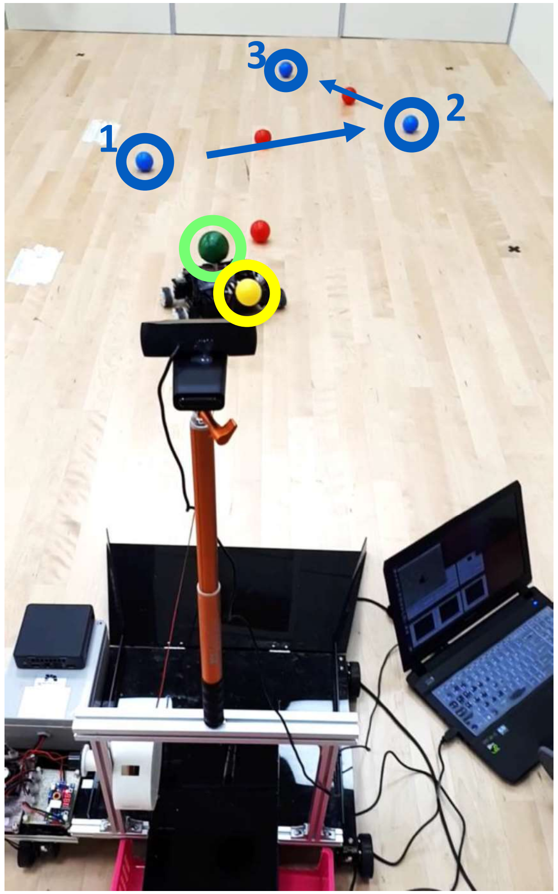
we **see entire map** from high position

Sorting & Planning

sort balls from closest and **plan path, re-checking**

Glue Red Ball

tape sticks red ball on the body



View from camera

03.
Key
Features

"fast and accurate"

Lighter, faster!

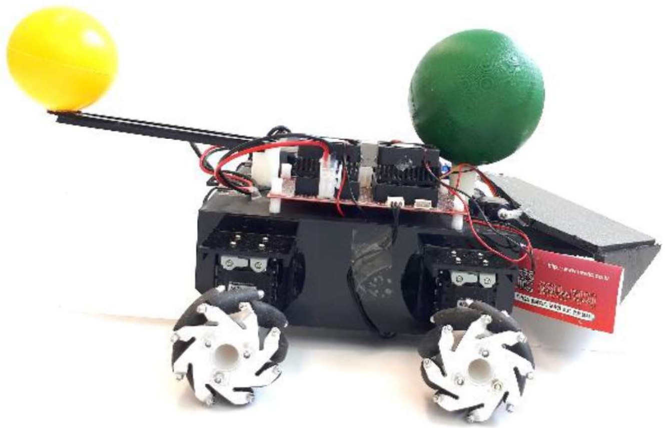
SCV(**1.5kg**) < battery(**1.6kg**)

Markers

using markers to detect position and orientation of SCV

No Picking Method

dribble the balls to the basket



04. Demo Video

Trial records (yesterday)

trials	1	2	3	4	5	6	7	8	9	10	average
Time(s)	52	fail	56	59	57	48	56	56	42	56	53.6

Special Thanks to

Professor **Philseung Lee** | TA **Sooyoung Kim** | Technician **Sangeun Yeo**

Great Team

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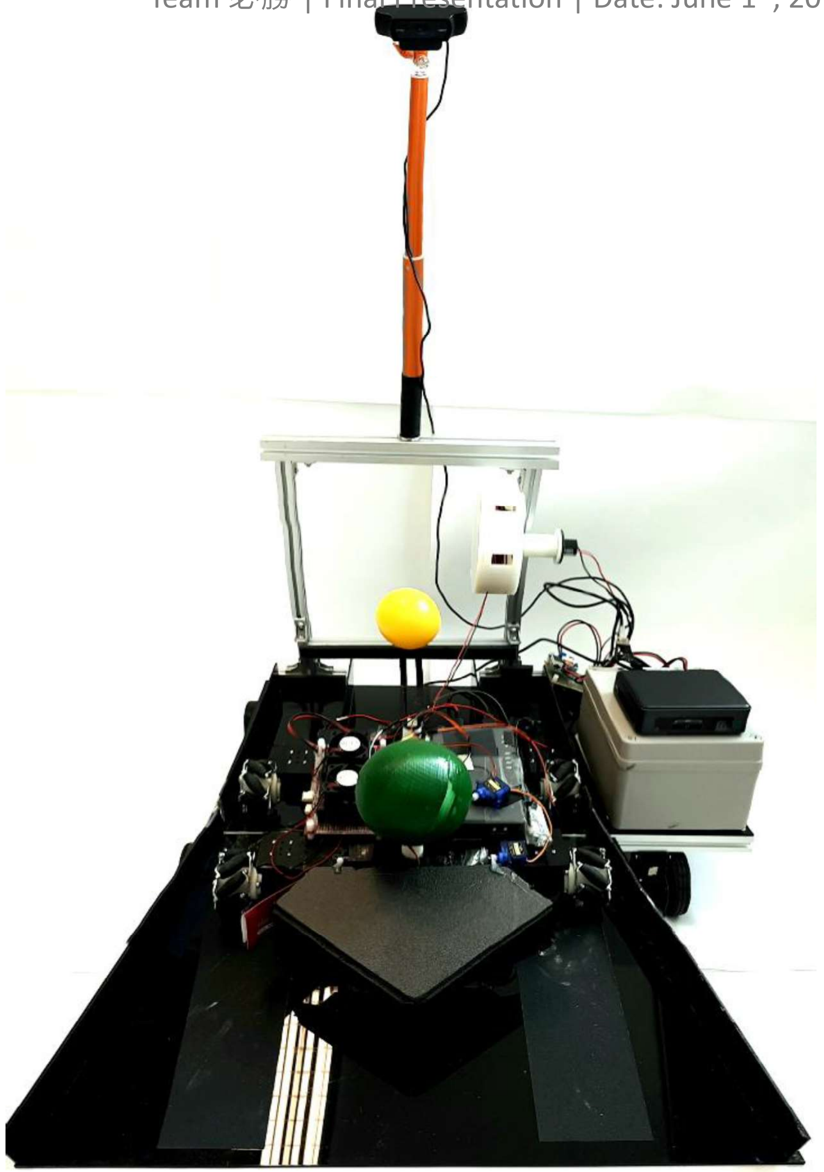
Dongha Nam | Kyeongwon Park | Jeongseok Oh

05. Final Comment



Thank you!

Q&A