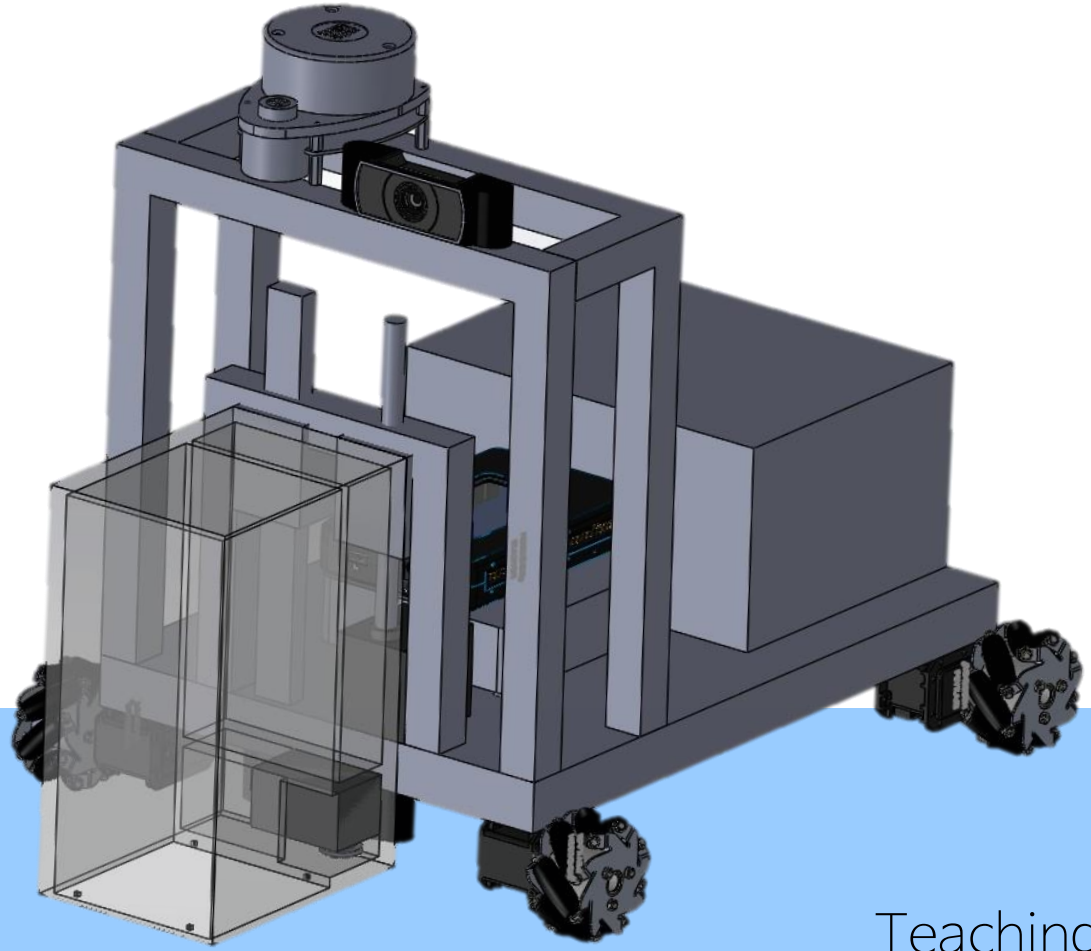
1st Presentation, MAR 30th



ME400 CAPSTONE DESIGN

Advisor : Prof. Junho Oh

Teaching Assistance : Kangkyu Lee, Jaesung Oh (in HuboLab)

20140344 Yejun Yang　20140870 Bomi Lee　20140931 Simeneh S.Gulelat
20150027 Jiwon Kang　20150589 Jaeseong Lee　20150629 Haewoo Lee
20160259 Jeongsoo Park

TABLE OF CONTENTS

PROBLEM

AIM

To pick the three blue balls using vision recognition and turn back to the starting point and dump the balls into the basket

PROBLEM DEFINITION

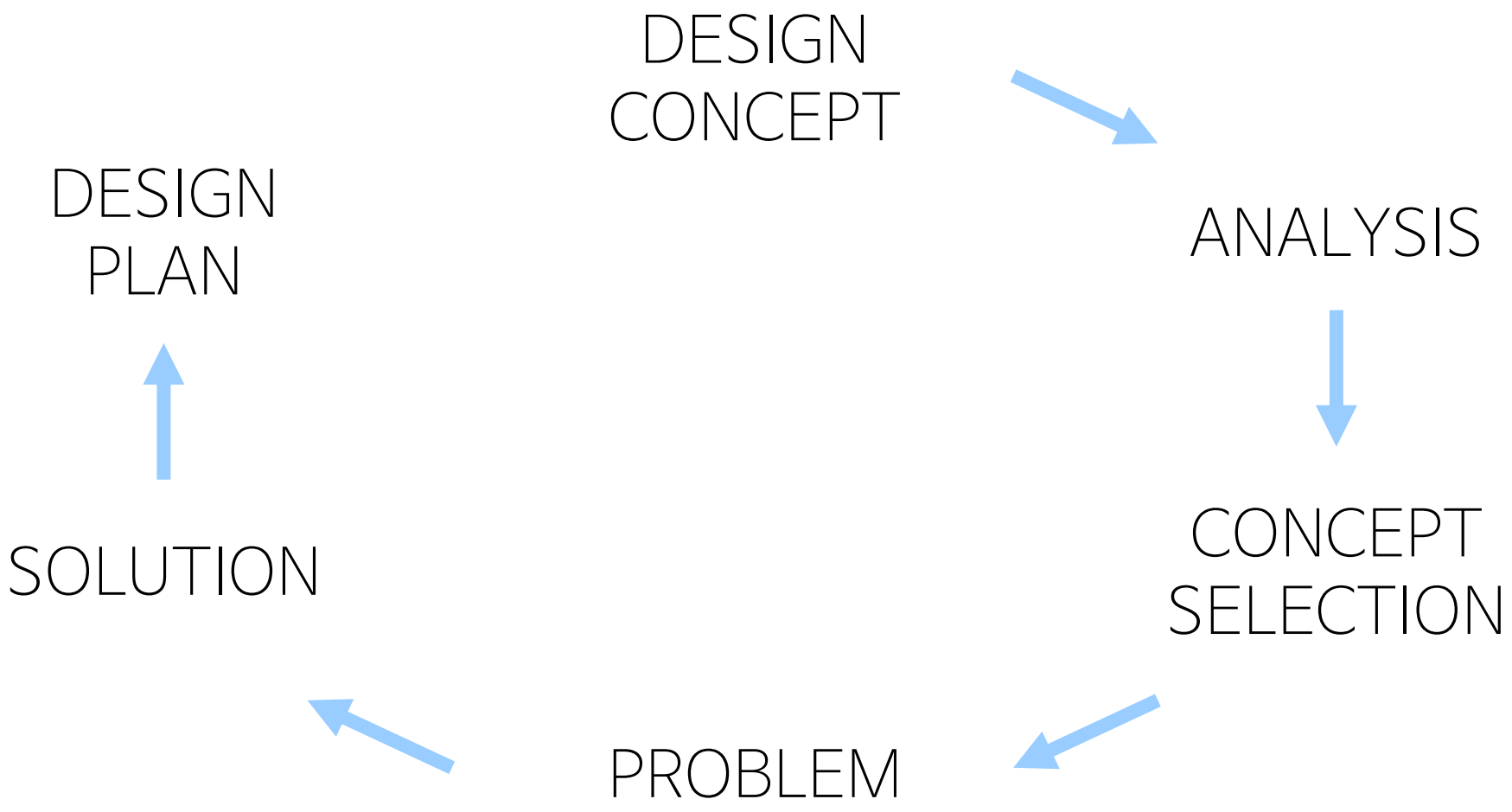
1. Detect the ball and distinguish the color
2. Set the optimum route
3. Move the bot with desired route
4. Pick up the ball and store the ball*3
5. Return to the basket
6. Drop the balls

PROBLEM DEFINITION

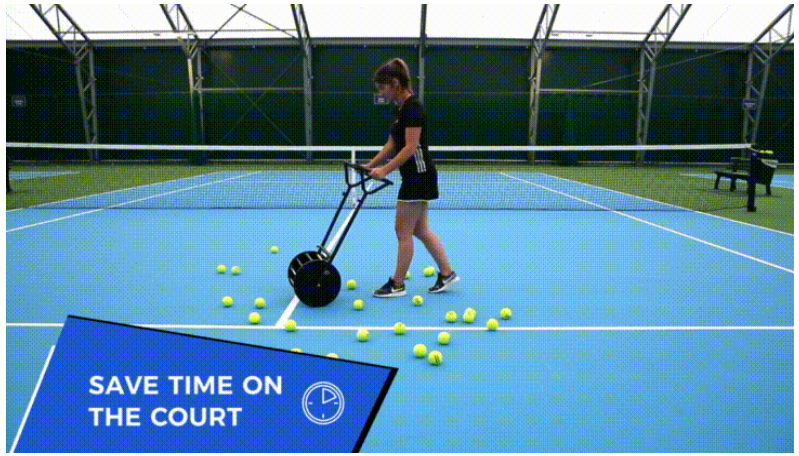
1. Detect the ball and distinguish the color
2. Set the optimum route
3. Move the bot with desired route
4. Pick up the ball and store the ball*3
5. Return to the basket
6. Drop the balls

SYSTEM

SYSTEM DEFINITION



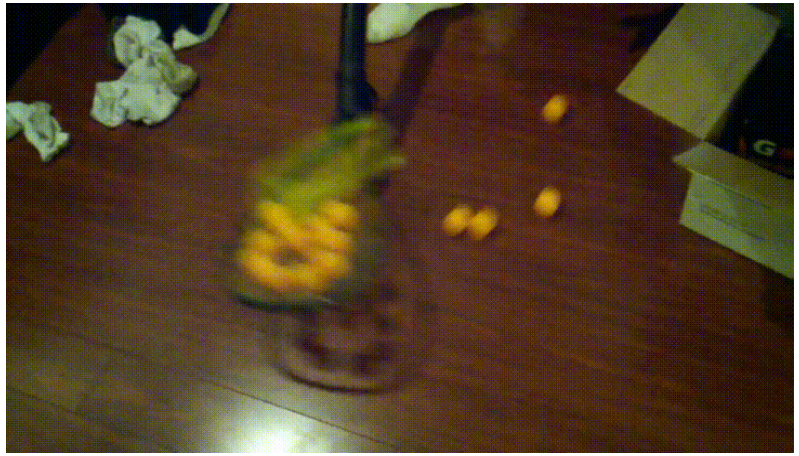
CONCEPT GENERATION



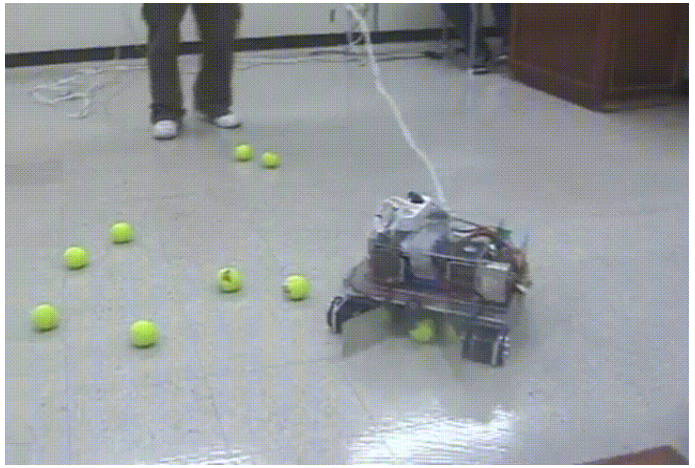
Cage

Robot arm

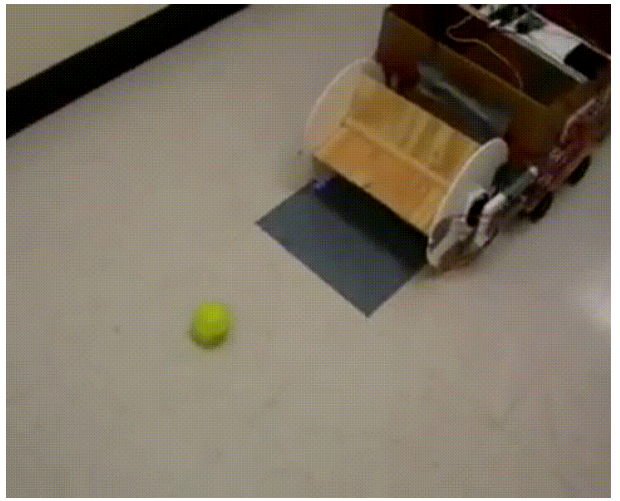
Suction



Valve



Swipping



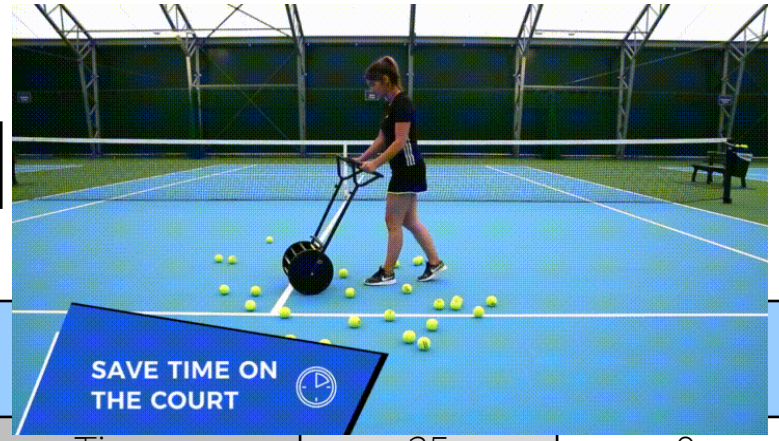
Roller

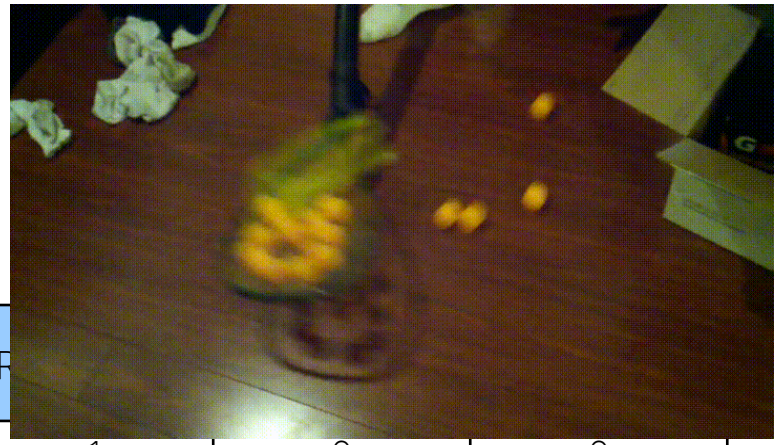
ANALYSIS

	Weight	Datum (Roller)	Cage	Valve	Robot arm	Swipping	Suction
Time	25	0	0	−1	−1	0	0
Weight (Volume)	20	0	0	1	−1	0	−1
Cost	8	0	0	0	−1	0	−1
Complexity	6	0	0	−1	−1	0	−1
Uncertainty	6	0	1	1	−1	0	0
Energy efficiency	15	0	1	1	−1	0	−1
Durability	5	0	−1	−1	−1	0	0
Accuracy	15	0	0	1	1	0	−1
Total	100	0	16	20	−70	0	−64

PUGH'S DECISION MATRIX METHOD

AN



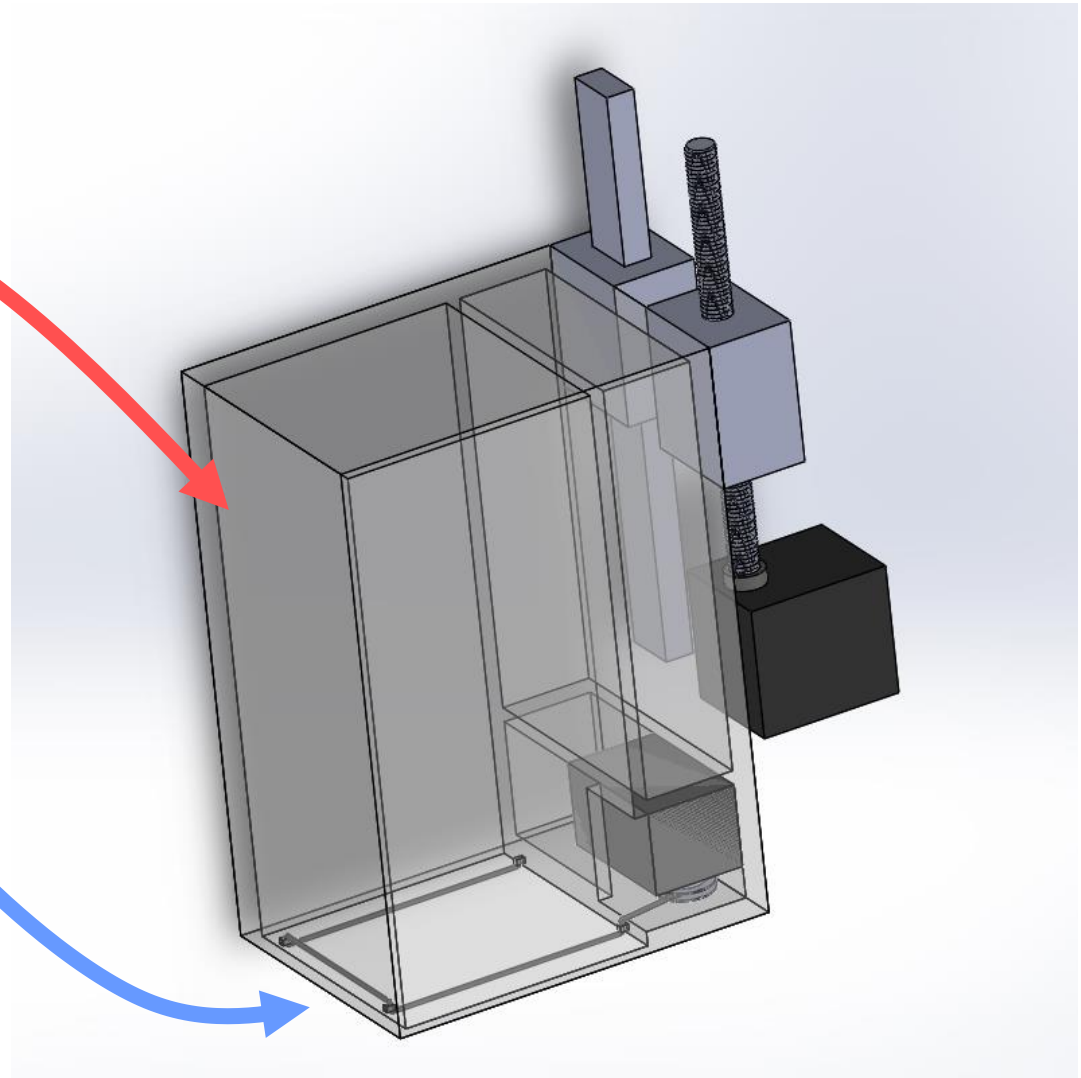


			Cage	Valve	R		
Time	25	0	0	−1	−1	0	0
Weight (Volume)	20	0	0	1	−1	0	−1
Cost	8	0	0	0	−1	0	−1
Complexity	6	0	0	−1	−1	0	−1
Uncertainty	6	0	1	1	−1	0	0
Energy efficiency	15	0	1	1	−1	0	−1
Durability	5	0	−1	−1	−1	0	0
Accuracy	15	0	0	1	1	0	−1
Total	100	0	16	20	−70	0	−64

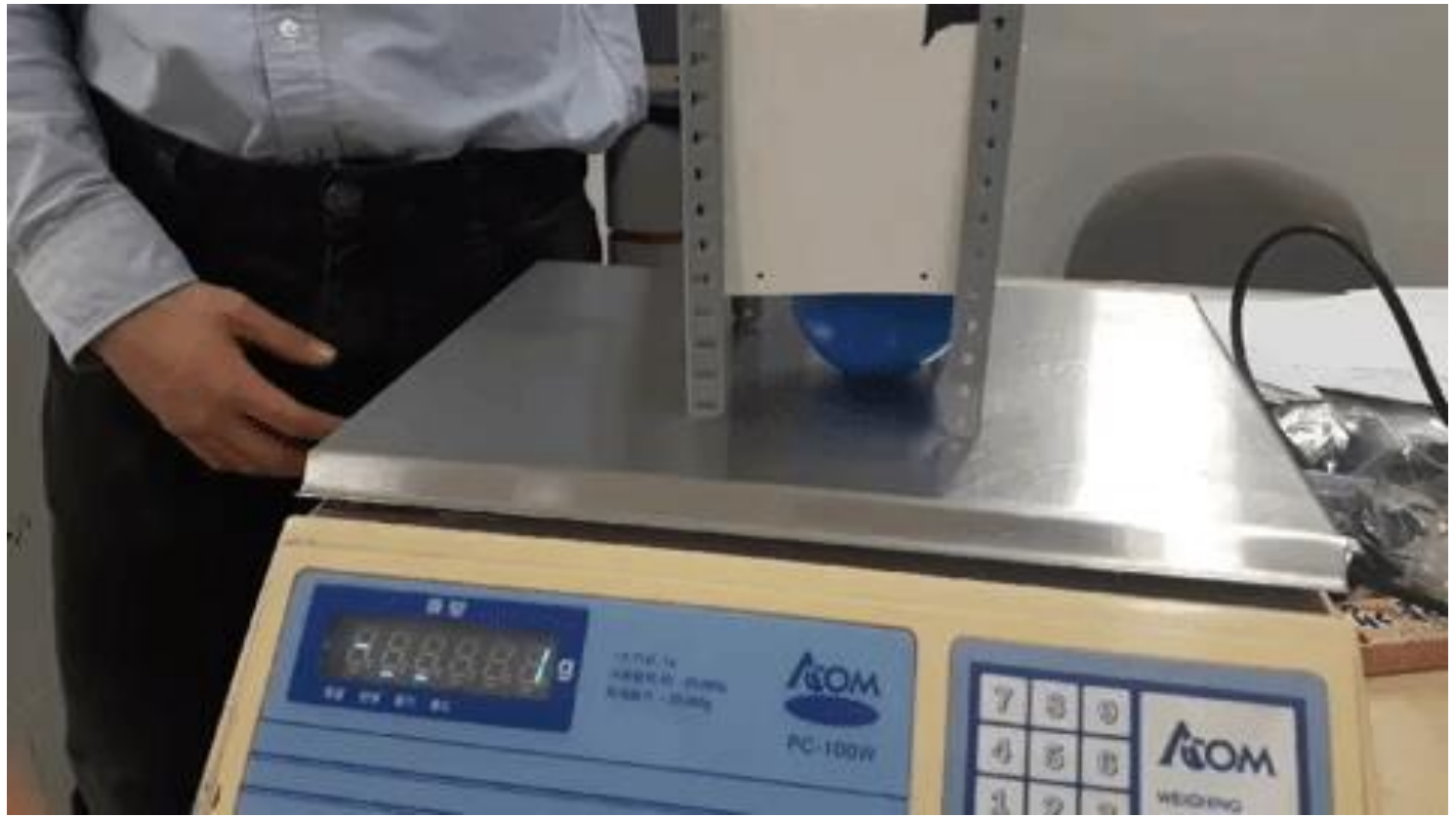
PUGH'S DECISION MATRIX METHOD

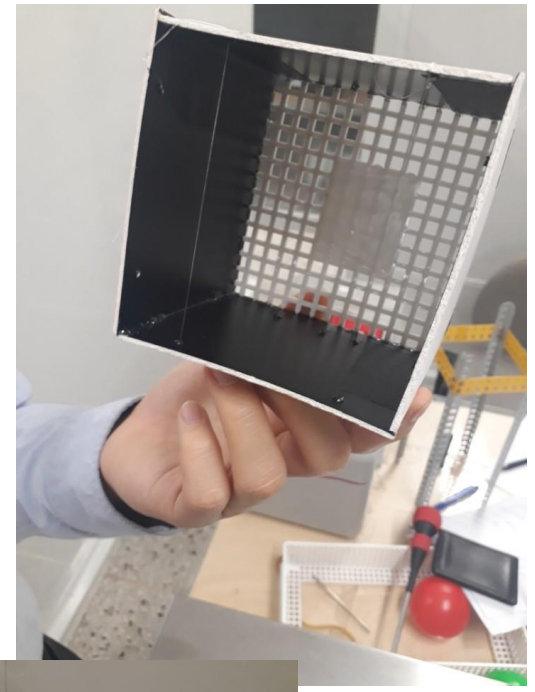
CONCEPT SELECTION

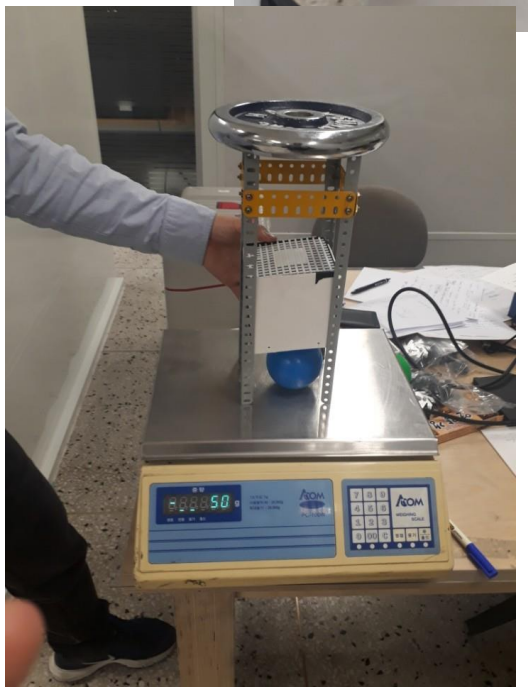
CAGE + VALVE



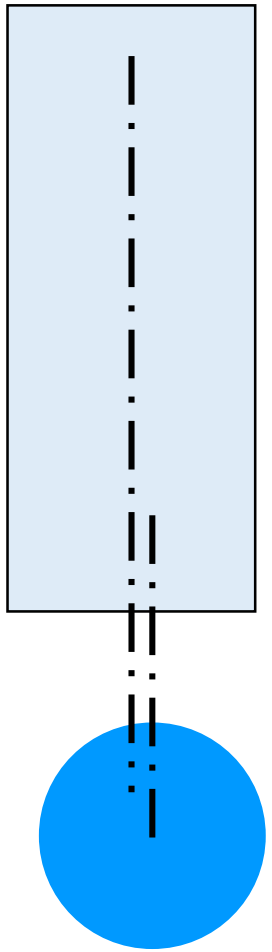
EXPERIMENTAL ANALYSIS



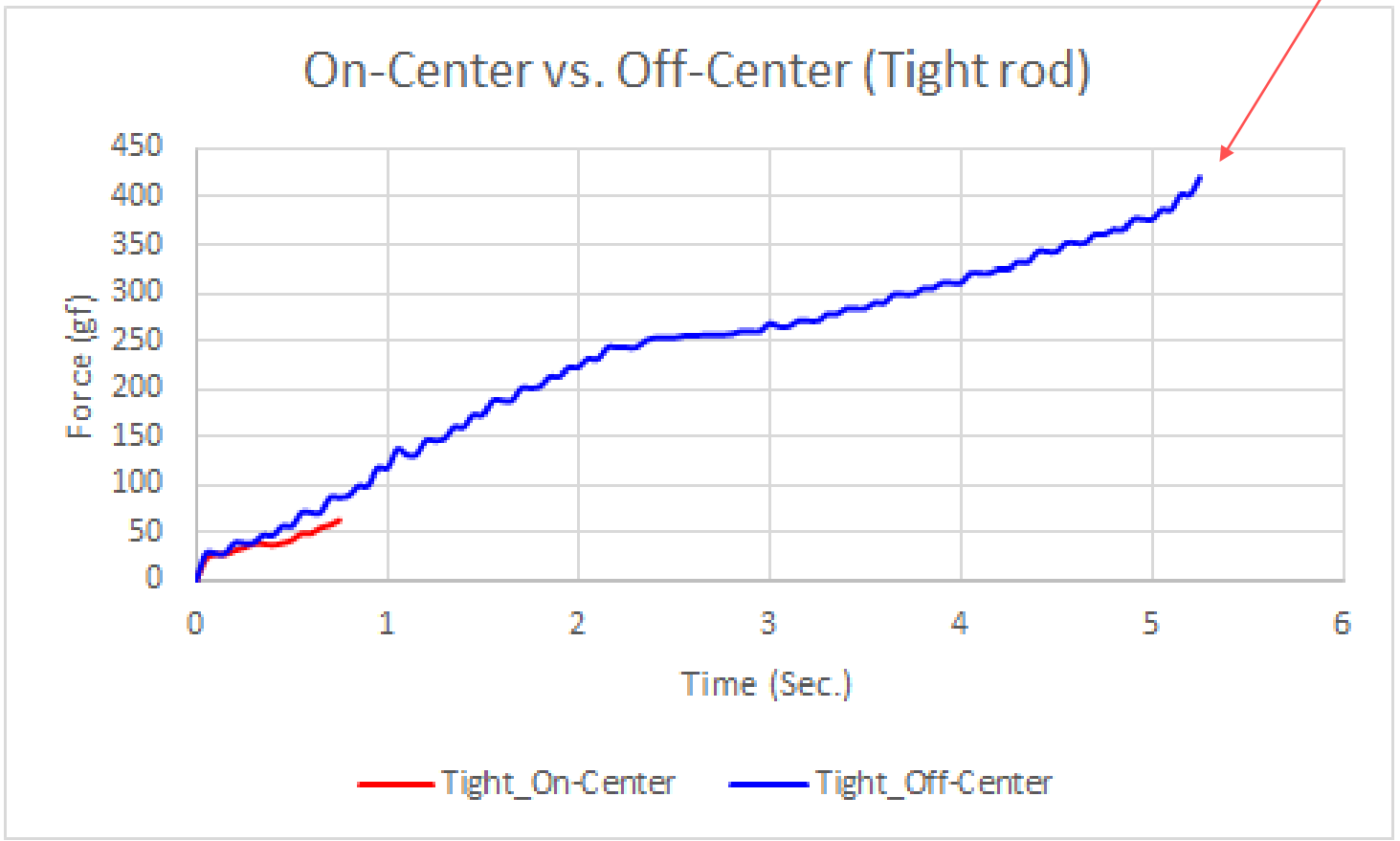




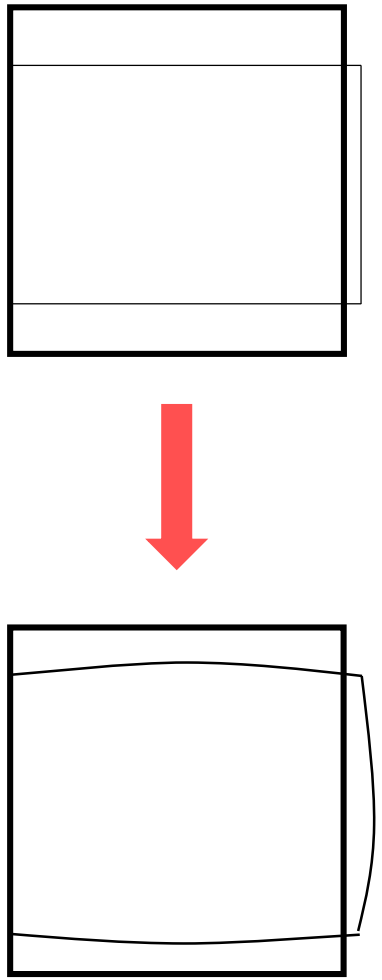
PROBLEM

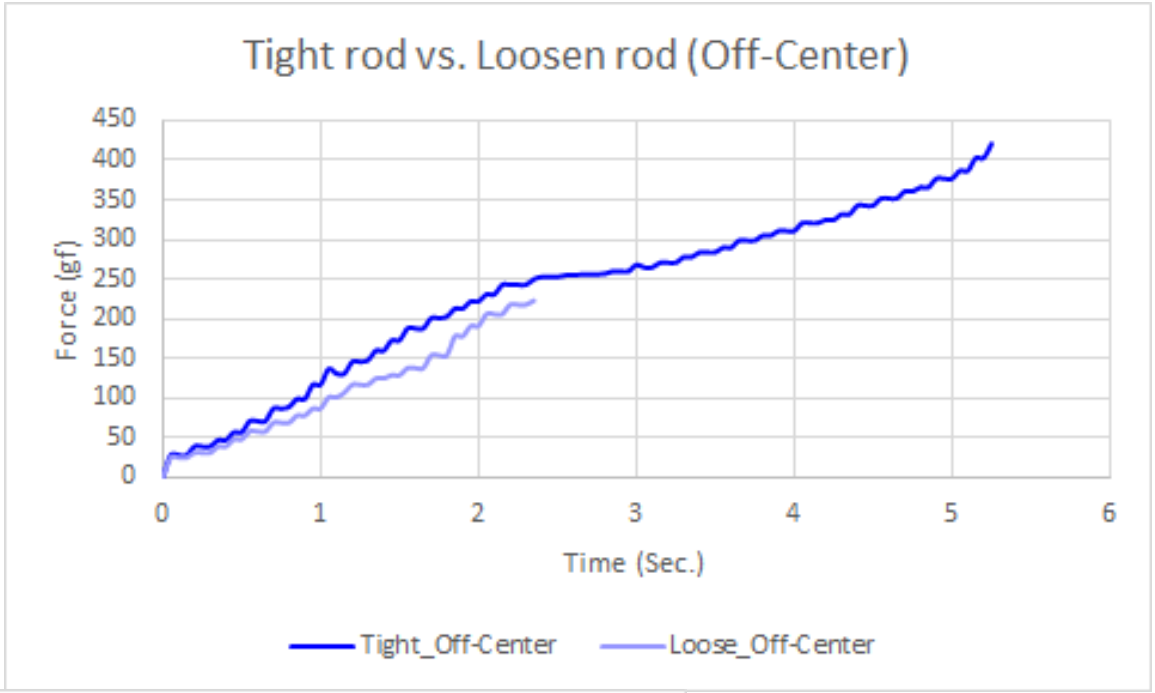


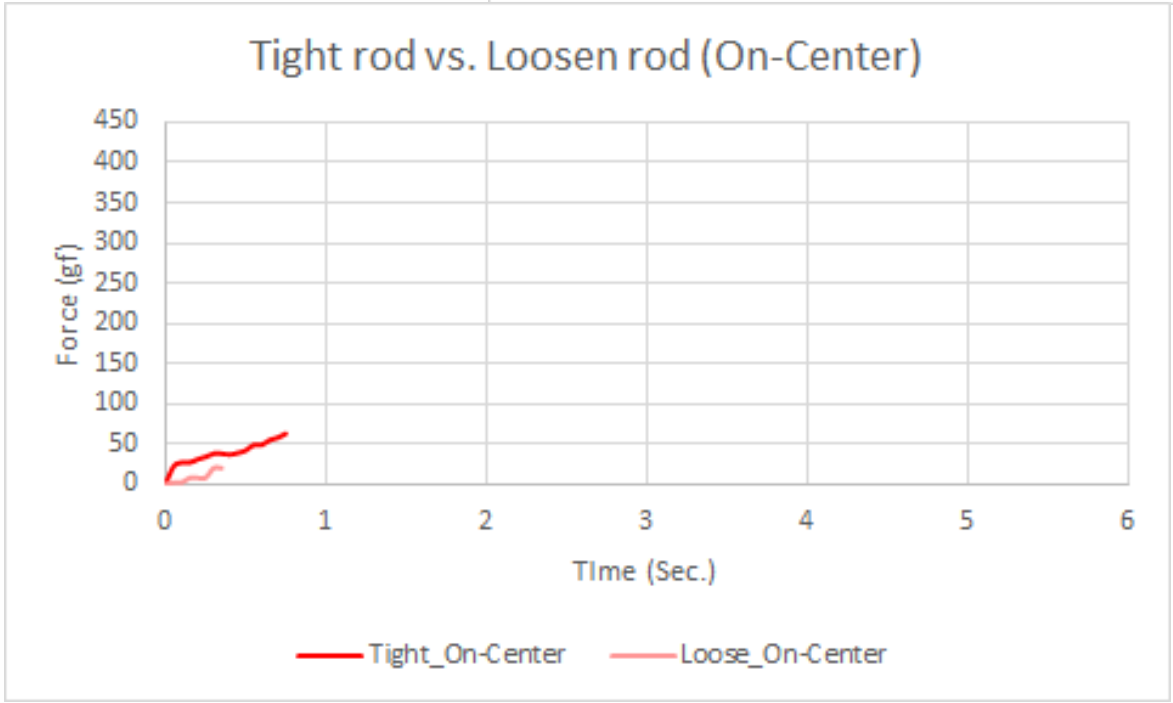
If the ball is off the center, it requires lots of time and force to pick up : (



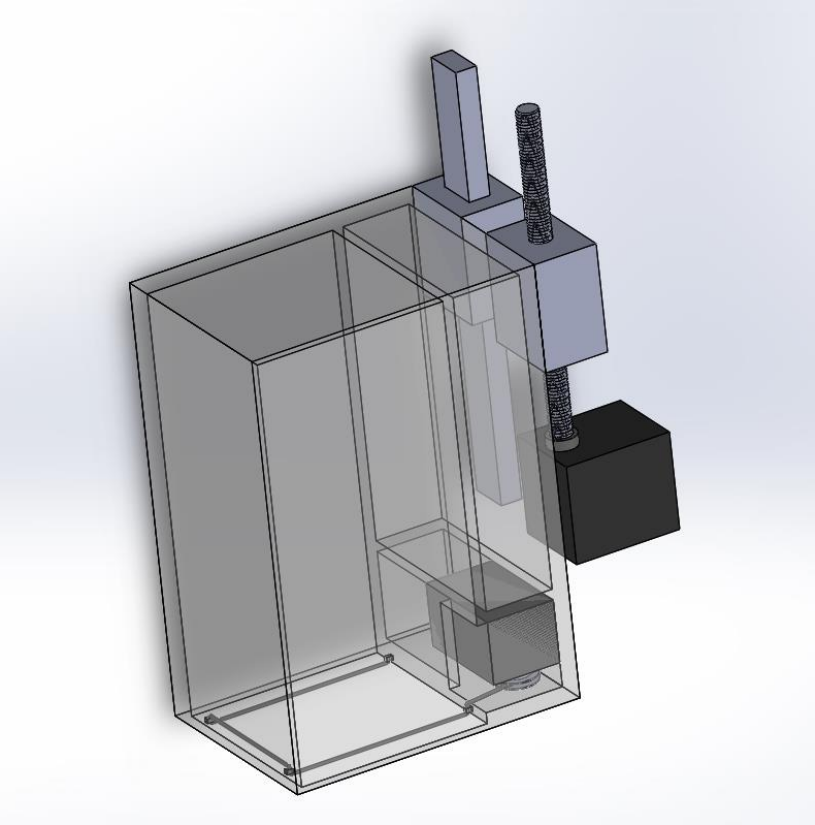
SOLUTION

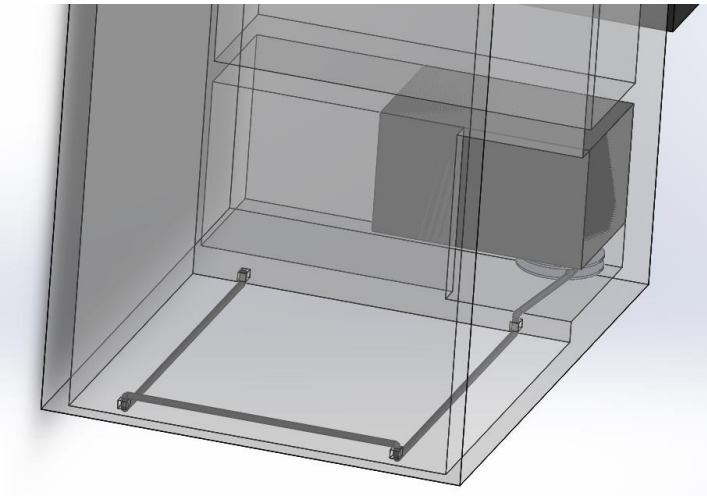



Tight rod vs. Loosen rod (Off-Center)
Force (gf)
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
Time (Sec.)
Tight_Off-Center
Loose_Off-Center

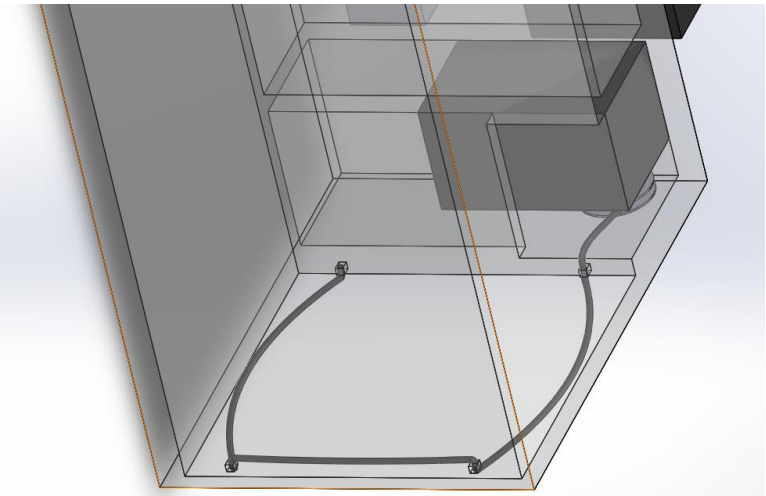

Tight rod vs. Loosen rod (On-Center)
Force (gf)
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
TIme (Sec.)
Tight_On-Center
Loose_On-Center

DESIGN PLAN





Tighten

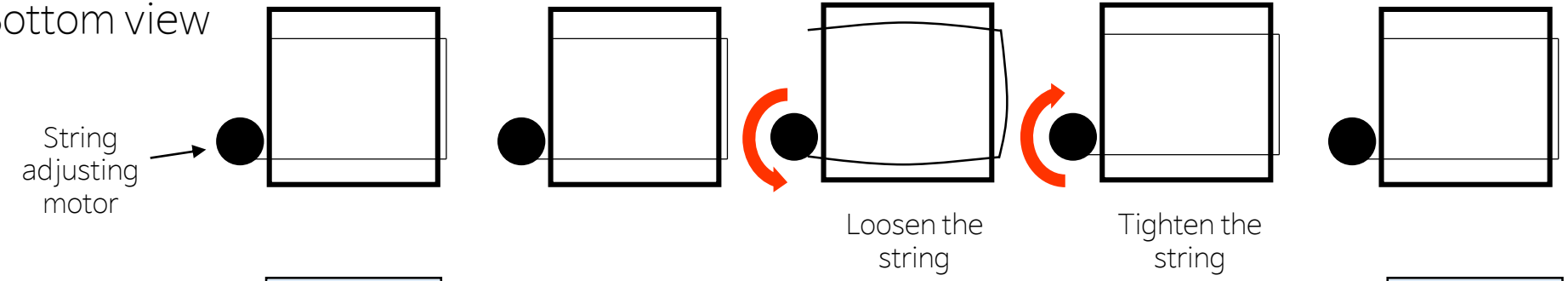


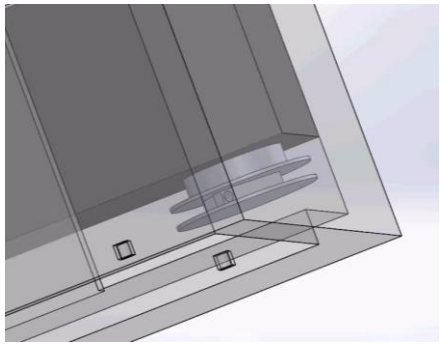
Loosen

SYSTEM PICK-UP MECHANISM

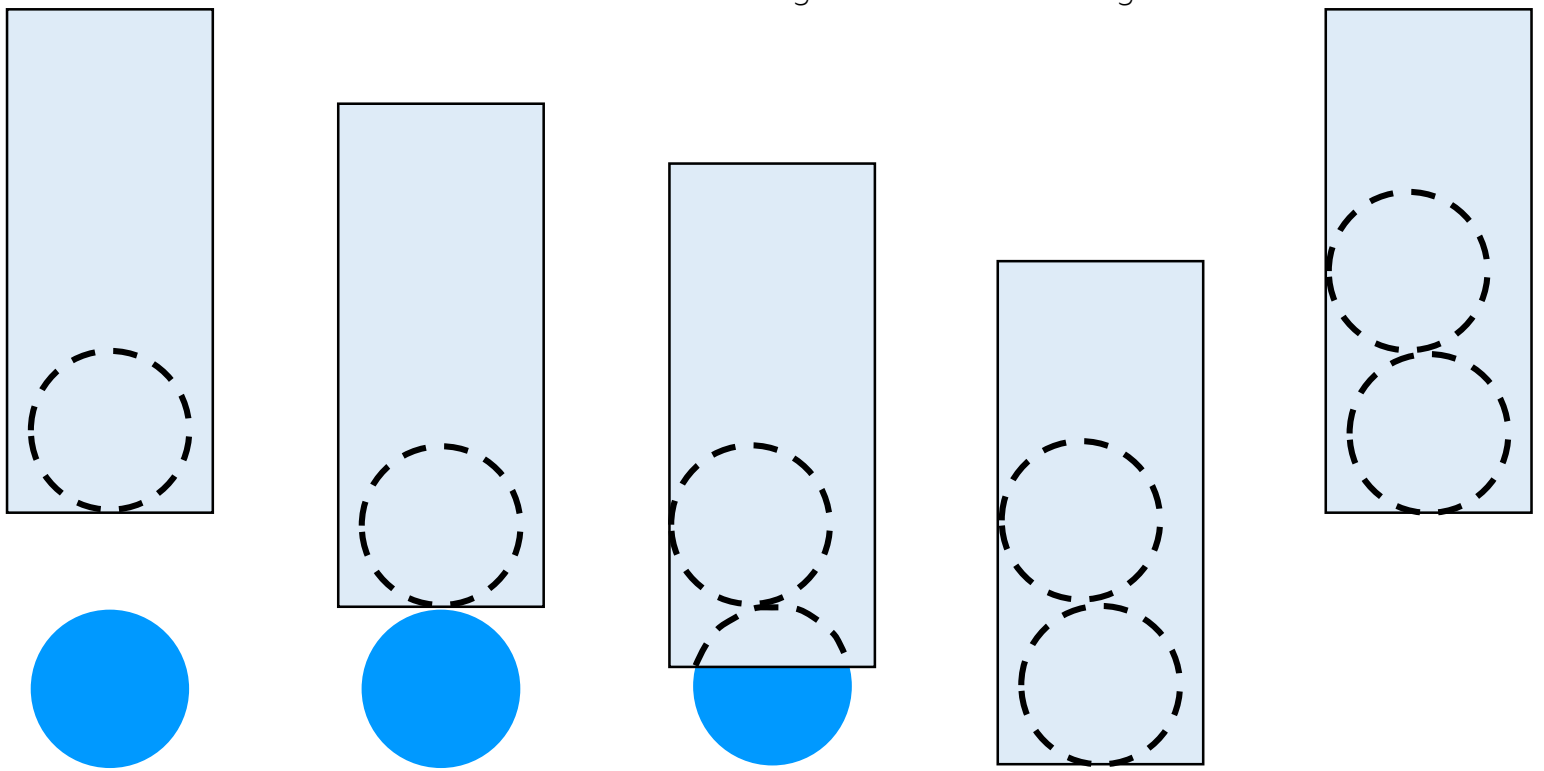
PICK-UP MECHANISM

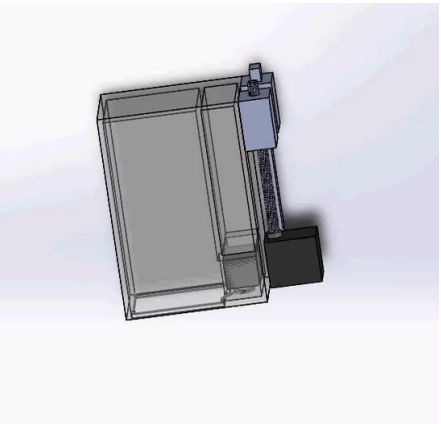
Bottom view





Side view

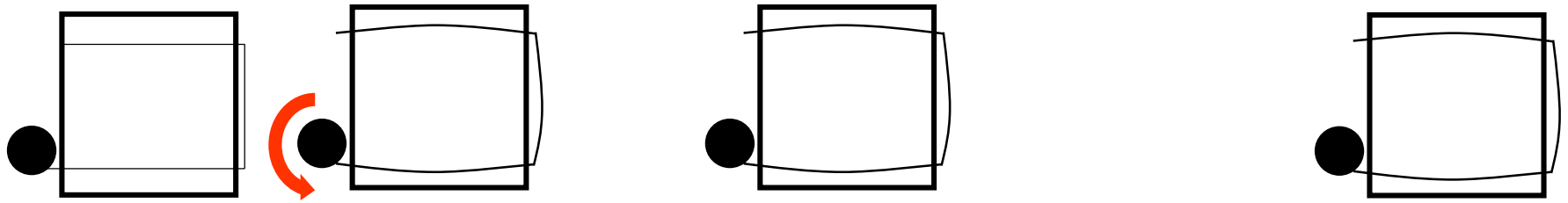




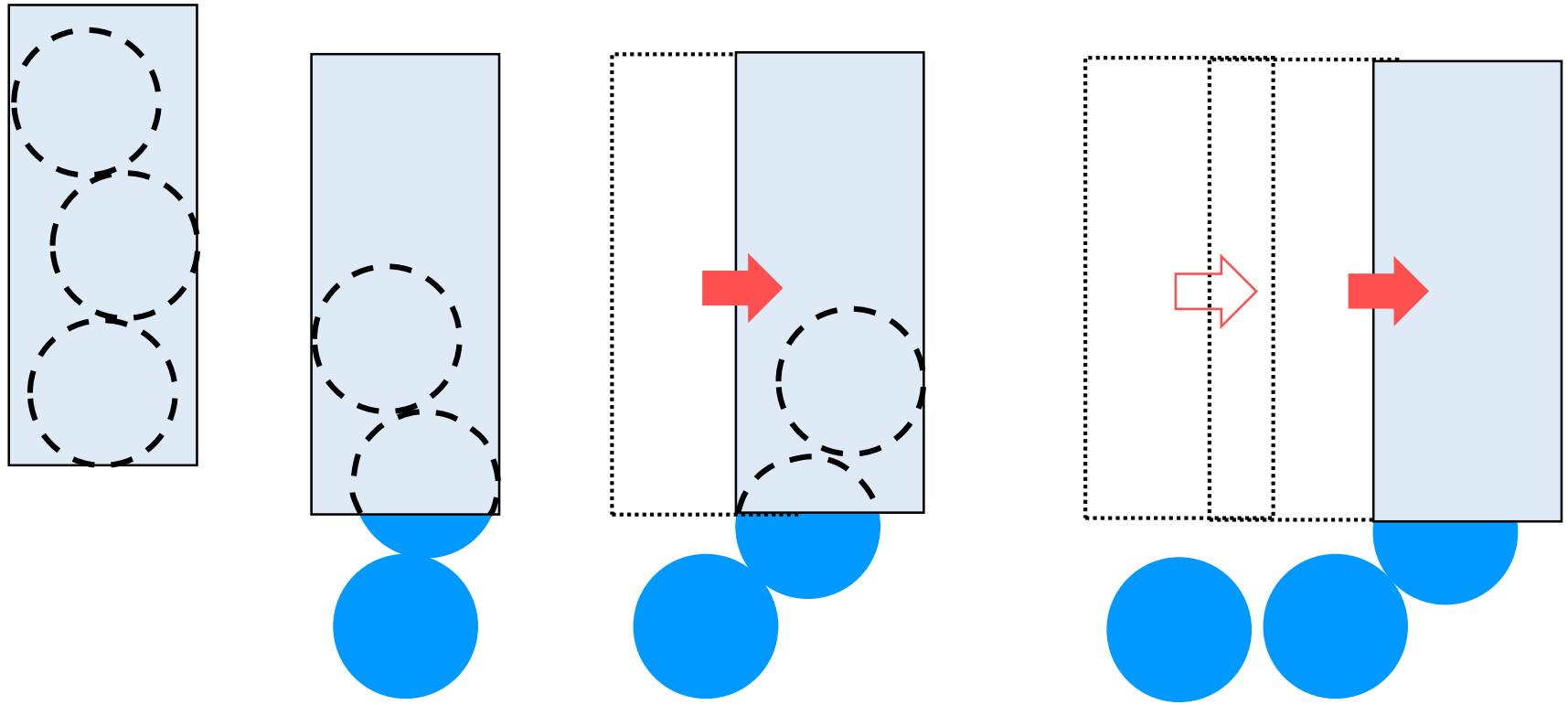
SYSTEM DUMPING MECHANISM

DUMPING MECHANISM

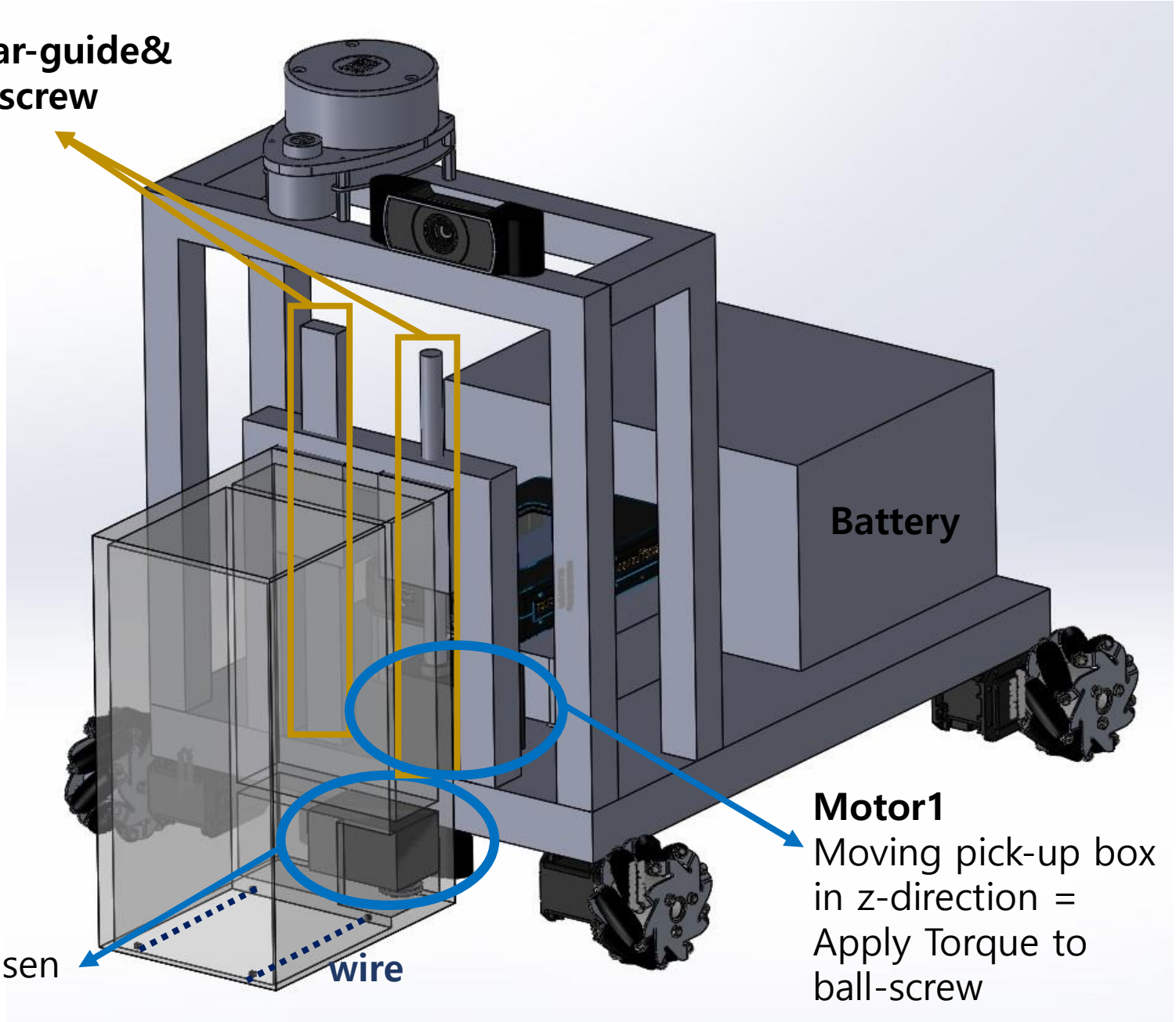
Bottom view



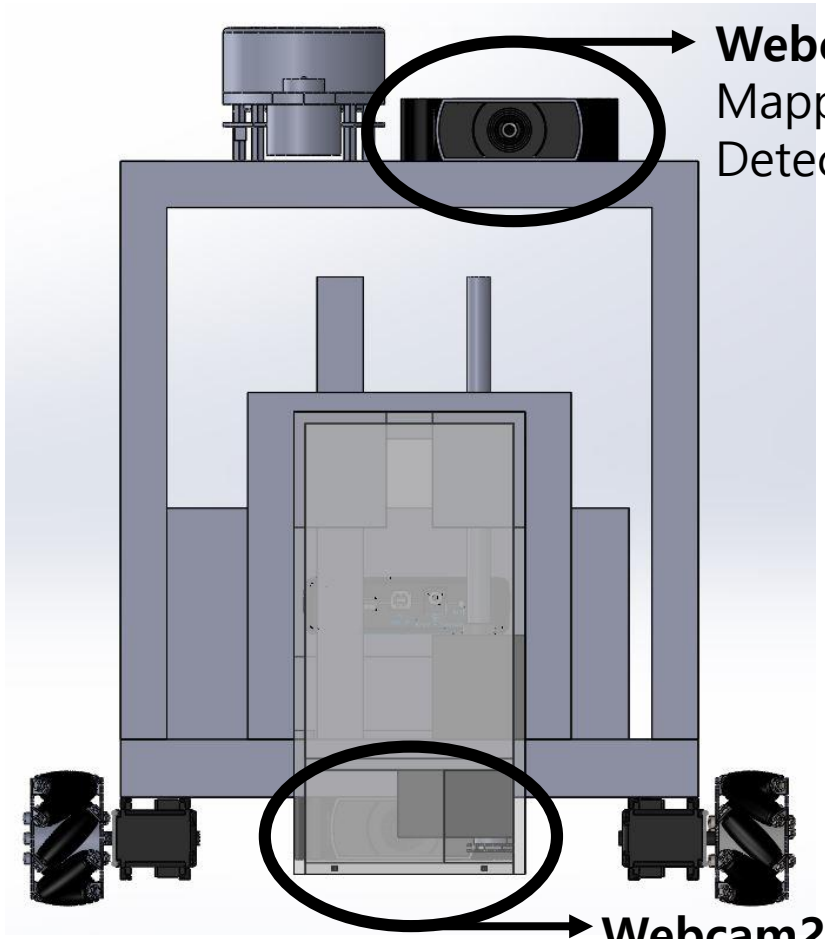
Side view



DESIGN OVERVIEW



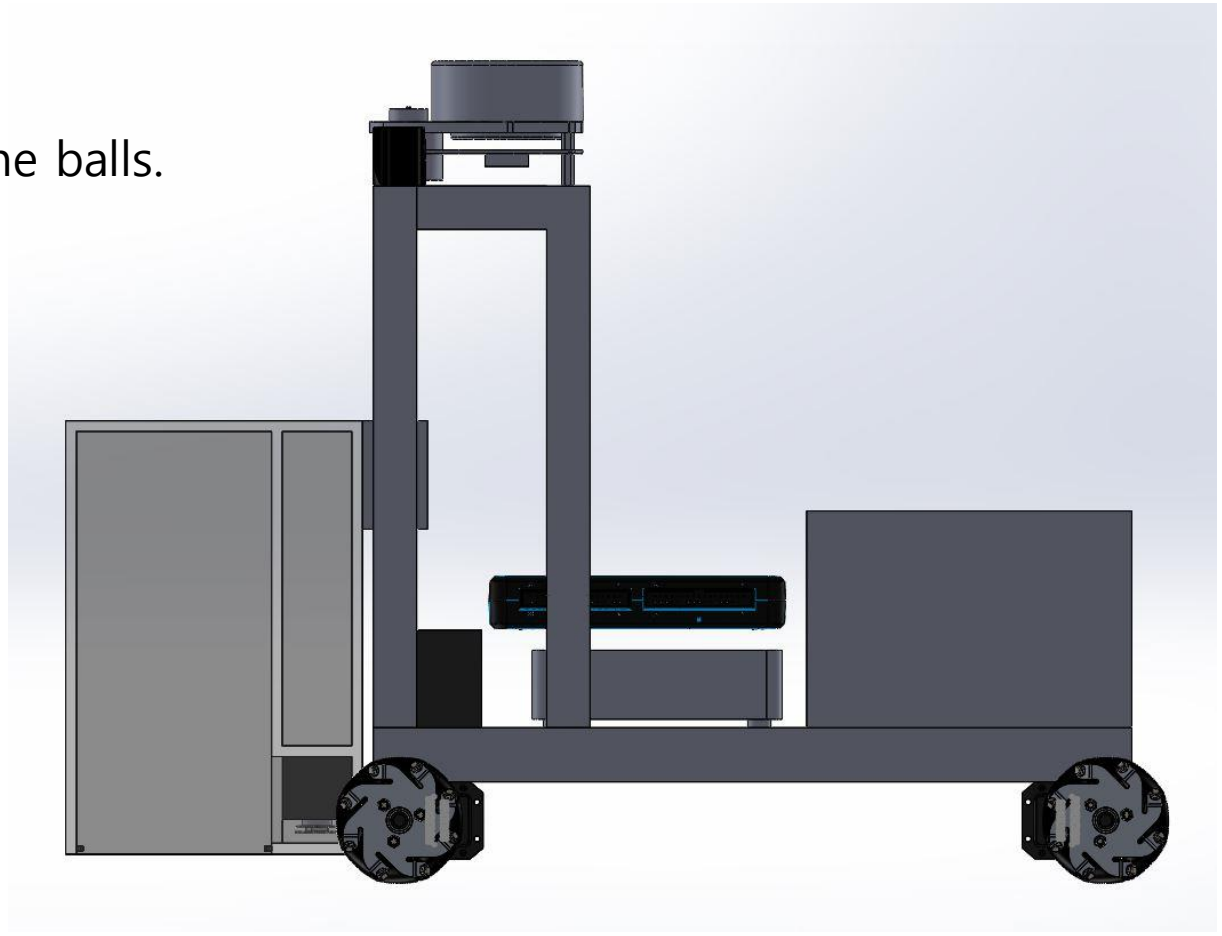
DESIGN OVERVIEW



Webcam1
Mapping &
Detecting the balls.

Webcam2
Detecting the precise location
of near blue ball

Front view

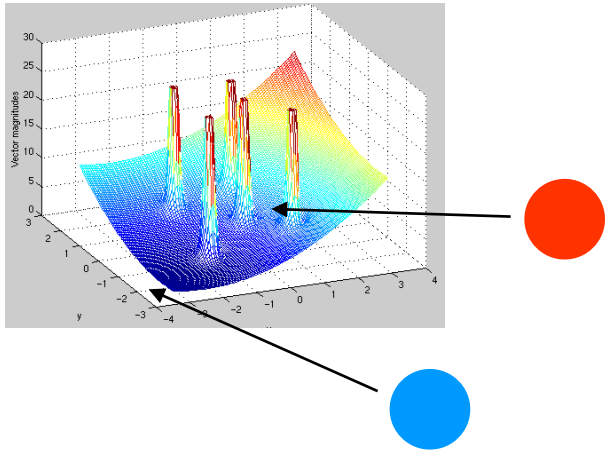


Side view

START

State: i = 0

Mapping starts and continue until the system stops



Set the target (nearest blue ball)

The most effective route is set

Follow the route

Distance between the ball and bot 〈 certain distance

Webcam 2 ON

Locate the bot right under the picking-up box

PICKING OPERATION

**By calculating the ratio of the pixel that has blue color

Is ball picked up?

NO

YES

State: i +=1

Is i == 3?

YES

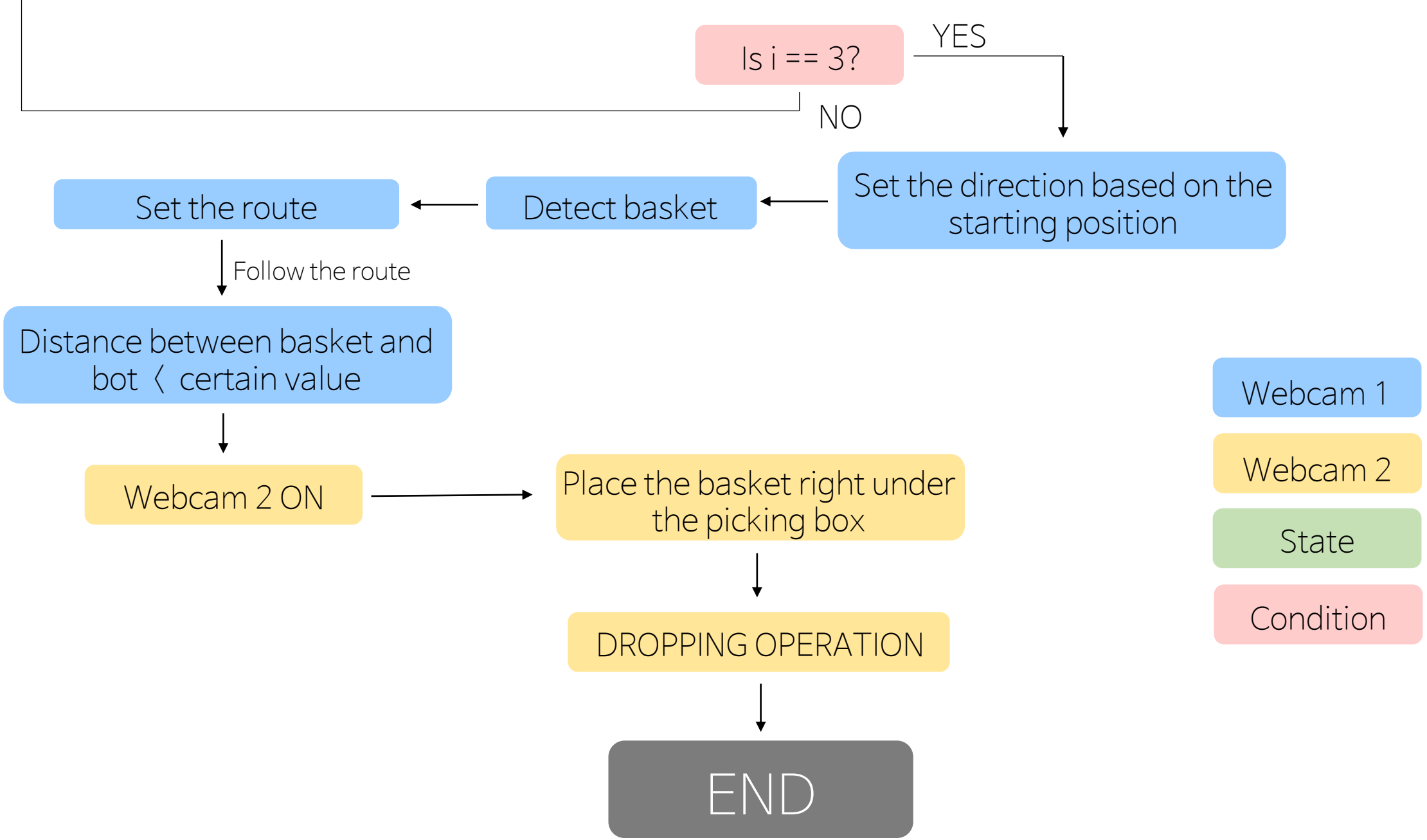
NO

Webcam 1

Webcam 2

State

Condition


Is i == 3?
YES
NO
Set the direction based on the starting position
Detect basket
Set the route
Follow the route
Distance between basket and bot 〈 certain value
Webcam 2 ON
Place the basket right under the picking box
DROPPING OPERATION
END
Webcam 1
Webcam 2
State
Condition

SYSTEM VISION RECOGNITION

COLOR DETECTION

RGB

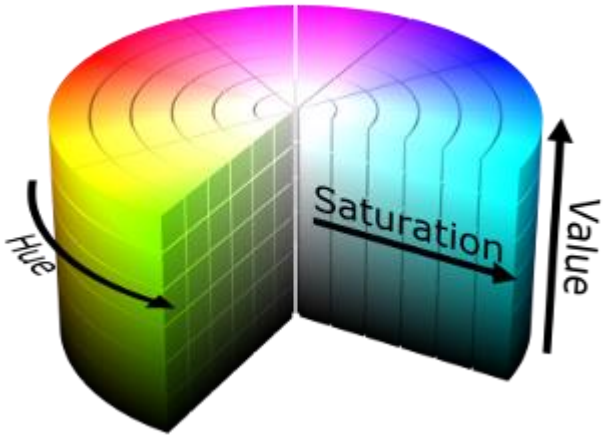
To focus on

the color isolation

HUE VALUE

HSV

SATURATION



COORDINATION SETTING

Catch the contour of the ball → Get the coordinate of the contour → Compare to get distance and the angle

Canny Edge-Detection Algorithm

Self-made code for alternative of the Hough Transform

**Problem:
Hough transform is not stable and requires fine tuning for several parameters

ALTERNATIVE LOCALISATION METHOD

Solution

Use least squares method to minimize:

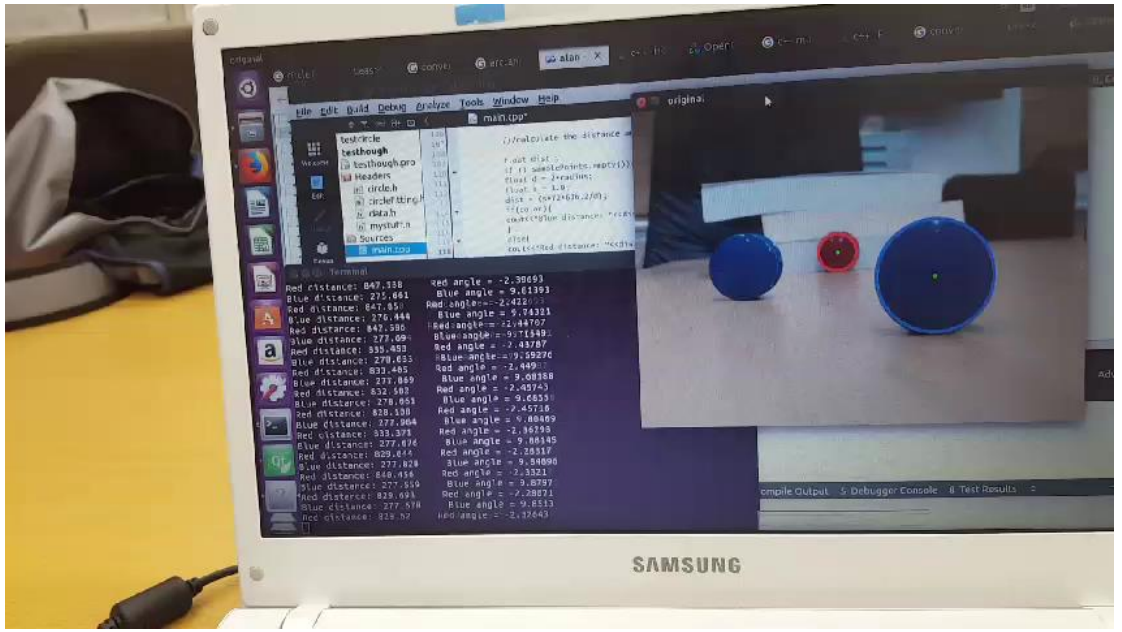
$$u = \sum_{i=1}^{N} [(x_i - A)^2 + (y_i - B)^2 - R^2]^2 = \min$$

subjected to constraints $\frac{\partial u}{\partial A} = \frac{\partial u}{\partial B} = \frac{\partial u}{\partial R} = 0.$

assuming $C = R^2 - A^2 - B^2$

We solve

$$\begin{pmatrix} 2\Sigma x_i & 2\Sigma y_i & N \\ 2\Sigma x_i^2 & 2\Sigma x_i y_i & \Sigma x_i \\ 2\Sigma x_i y_i & 2\Sigma y_i^2 & \Sigma y_i \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} \Sigma(x_i^2 + y_i^2) \\ \Sigma(x_i^3 + x_i y_i^2) \\ \Sigma(x_i^2 y_i + y_i^3) \end{pmatrix}$$

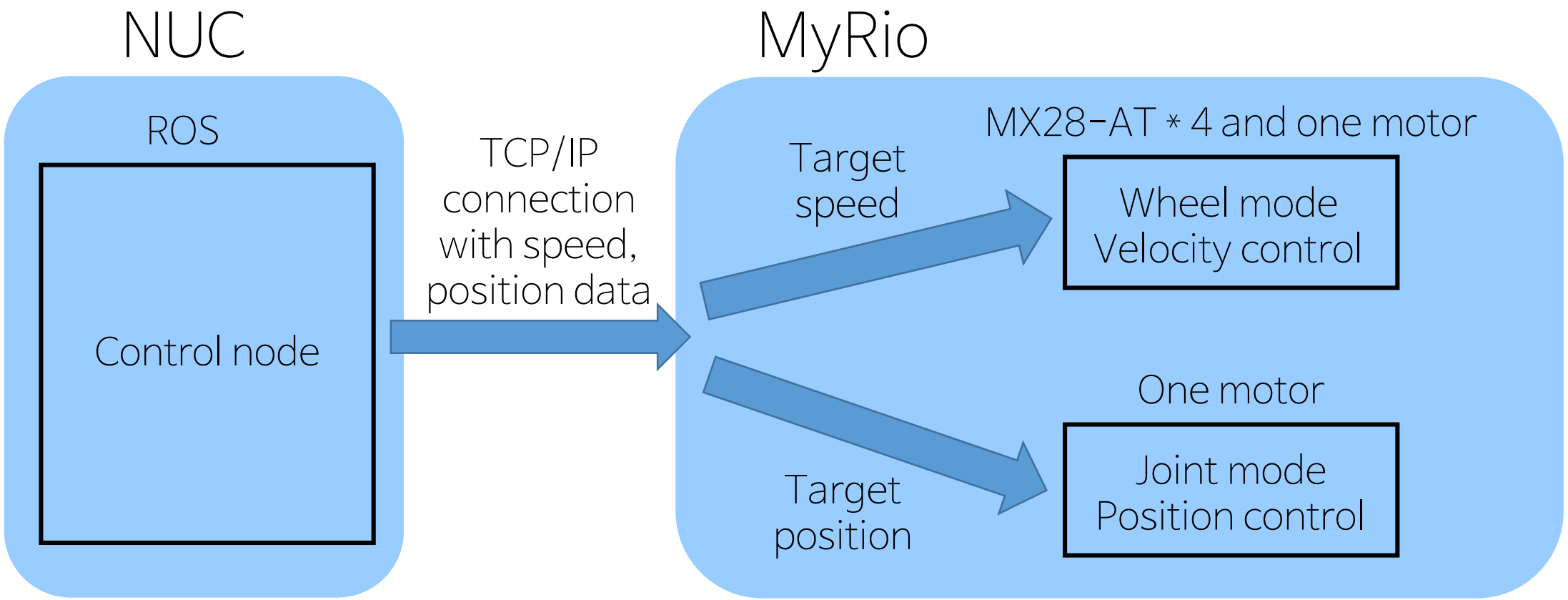


➡ Center (A, B) and radius R obtained from N points!

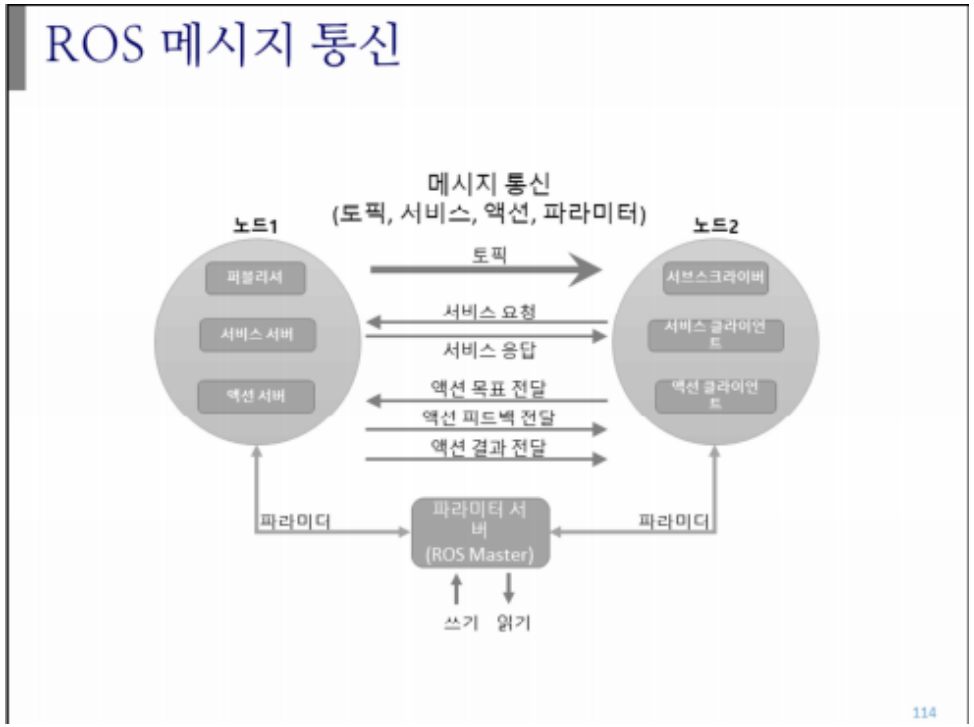
Ref. Kåsa, I., IEEE Transactions on instrumentation and measurement, 1976

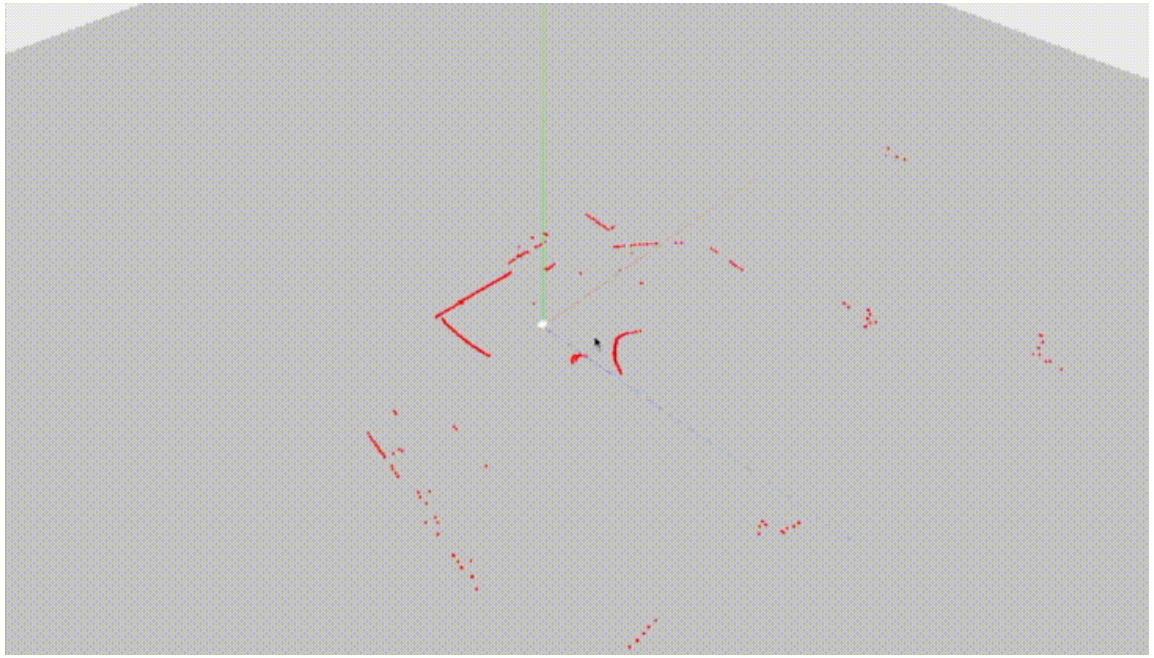
SYSTEM SOFTWARE

LABVIEW


NUC
ROS
Control node
TCP/IP
connection
with speed,
position data
MyRio
MX28-AT * 4 and one motor
Target
speed
Wheel mode
Velocity control
One motor
Target
position
Joint mode
Position control

ROS

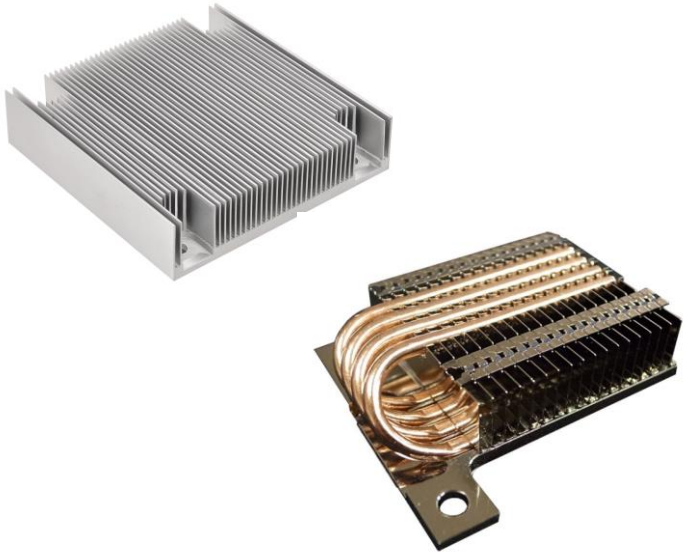

ROS 메시지 통신
메시지 통신
(토픽, 서비스, 액션, 파라미터)
노드1
노드2
퍼블리셔
서비스 서버
액션 서버
서브스크라이버
서비스 클라이언트
액션 클라이언트
토픽
서비스 요청
서비스 응답
액션 목표 전달
액션 피드백 전달
액션 결과 전달
파라미터
파라미터
파라미터 서버
(ROS Master)
쓰기
읽기
114



SYSTEM ELSE

HEAT TRANSFER

Passive Cooling



Active Cooling (Fan)

Oil Immersion Cooling

Pros	Most affordable Easy to maintain	Heat sink + Heat Pipe + Fan → Proper price & performance	High thermal conductivity (k_{air} = 0.026W/mK, k_{oil} = 0.018W/mK)
Cons	Performance may be low	Bulky	Hard to maintain (Leakage,)

VIBRATION REDUCTION

1) Vibration reduction for cameras
  -gimbal : device to minimize movements of cameras

2) Vibration reduction for motors
  -ball bearings
  -buffer

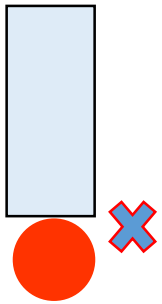
CONCLUSION

DISCUSSION

1. We take lots of time to pick and bring the balls.

Why?

Picking system, moving system cannot operate simultaneously.



2. Ball might stuck under the picking box.

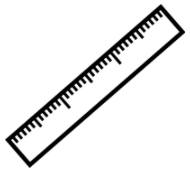
Why?

We don't have any mechanism that remove red ball that might stuck under the box

3. We need two cameras.

Why?

One for picking system, one for mapping.



4. There are many uncertainties.

Why?

We have to set optimum values with lots of experiments and calculations.

FUTURE PLAN

OpenCV

- Getting the distance of all the balls at the same time
- Finding the way to distinguish the ball of the same color when they are overlapped
- Finding the way to deal with the reflection on the ball

ROS

- Integrating the subsystem that we are constructing
- Locating the coordinate using transforming based on the data from RPliadar and webcam

Labview

- Testing the speed and the direction of the wheel by connecting with motors controlled by Labview
- Connecting controller with Labview

Solidworks

- Making pick-up part and the main body
- Deciding the materials and the optimum gap between wires
- Based on the bot made, analyze the vibration and heat flow

Thank you for listening

APPENDIX

APPENDIX – BUDGET

- Dynamixel – string loosening part
- Acrylic panel – car body, pickup part
- Aluminum profile – car structure
- Ball screw and linear guide – vertical translating the picking up part
- String – fishing line
- Web cam – for delicate control
- Micro5pin – USB