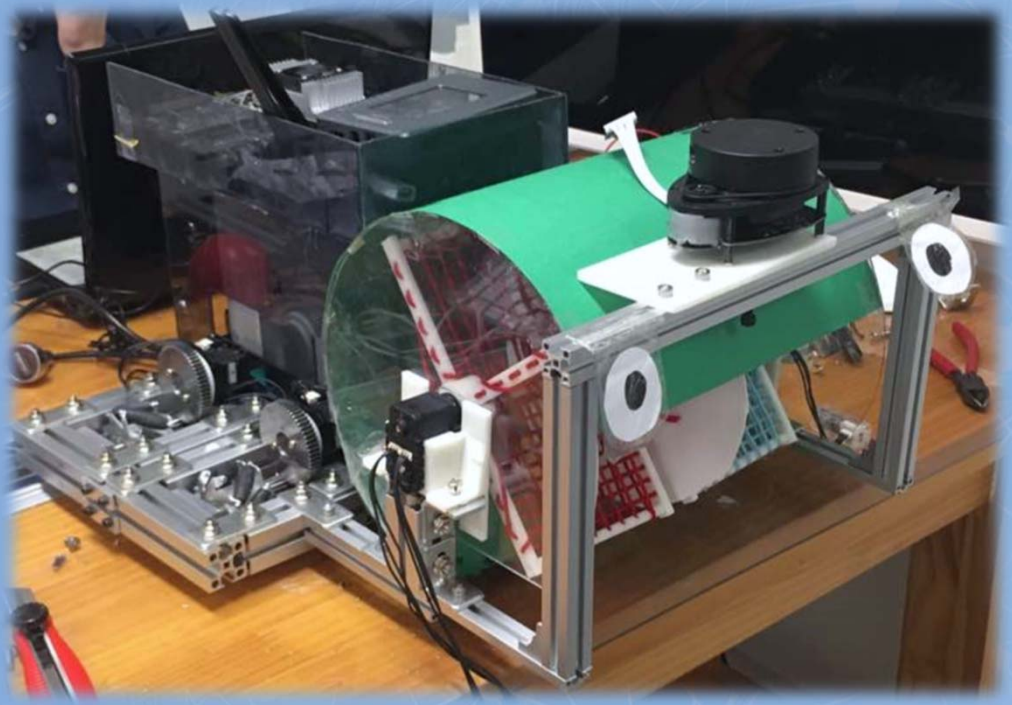


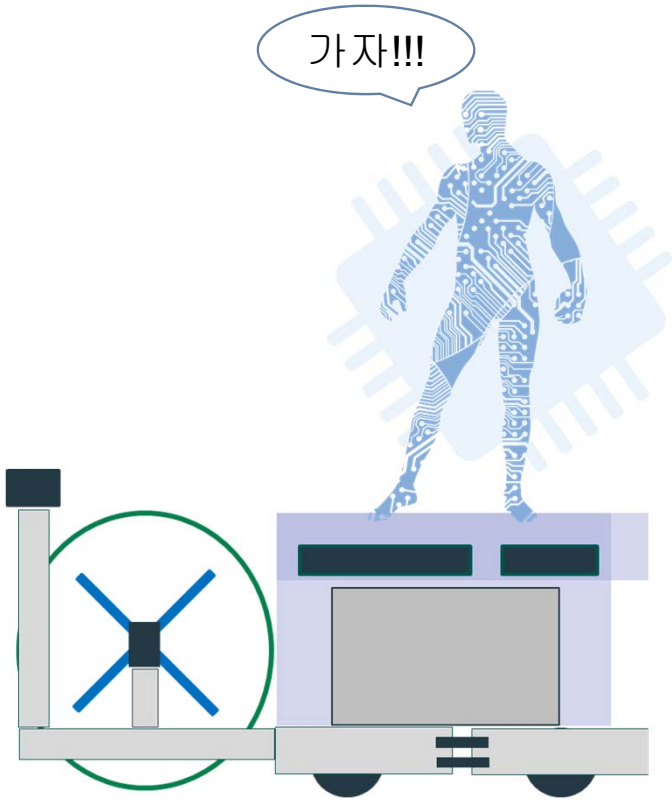
Team TTB
Design Review #3

김원빈, 김현준, 박태룡,

현규진, 김민직, *Abi, and Fahim*

Professor: **한순흥** / *TA:* **김우람**

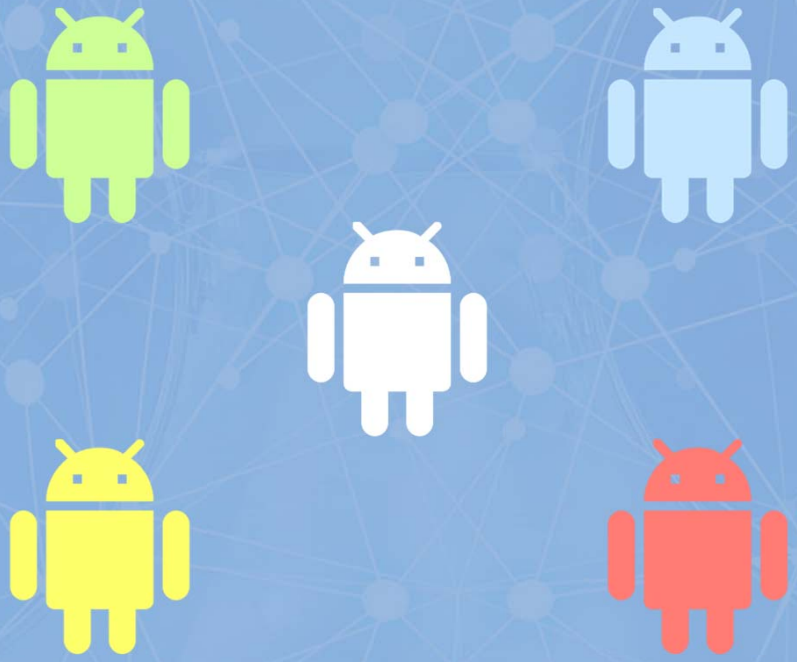
Contents



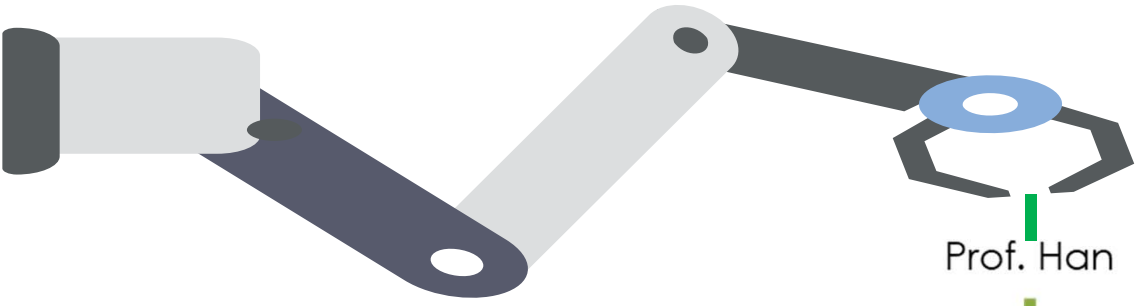
01

Intro

Team members, and tasks.



Team



Prof. Han

TA: 김우람

SolidWorks & LabVIEW | **Machine Learning** | **SLAM** | **ROS**

Fahim Masum

김원빈

김민직

김현준

현규진

Abi Rahman Syamil

박태룡

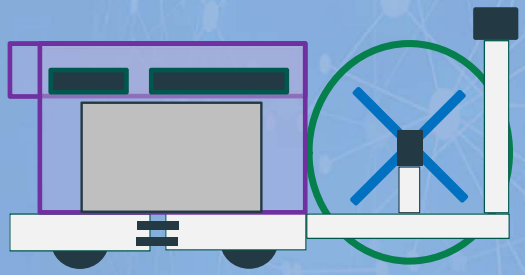
Organization Map

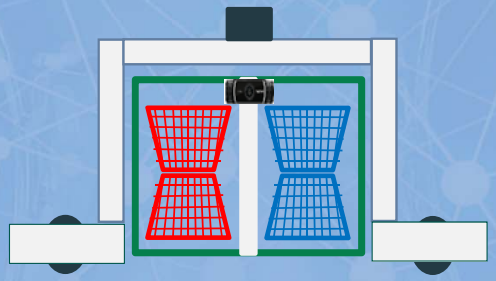
SolidWorks & LabVIEW	Fahim Masum	Collector Improvement
	김원빈	Motor & Gear
Machine Learning	김현준	Code for Classification
	김민직	Code Improvement
SLAM	현규진	Path Planning
ROS	Abi Syamil	System Integration
	박태룡	Code Improvement

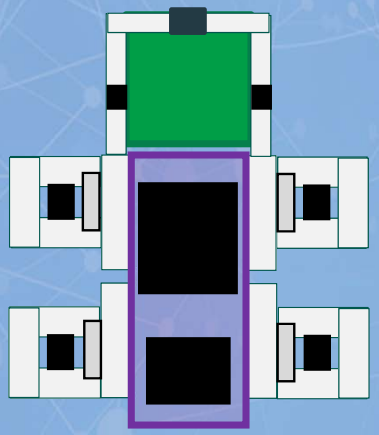
02

Hardware

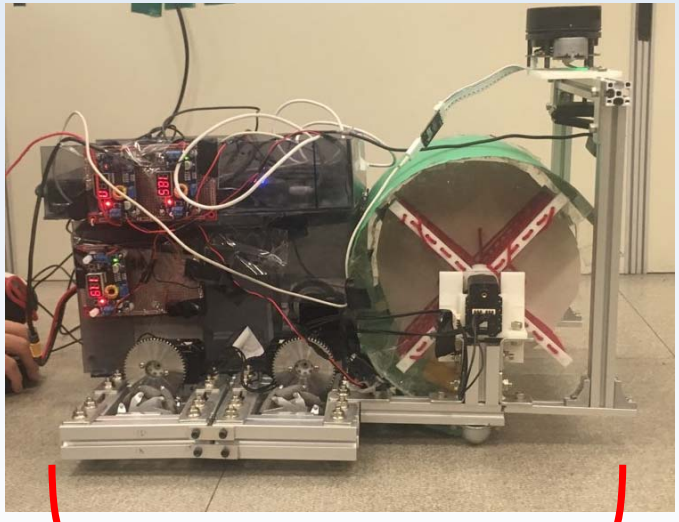
Strengths, configuration, reasoning, and analysis.



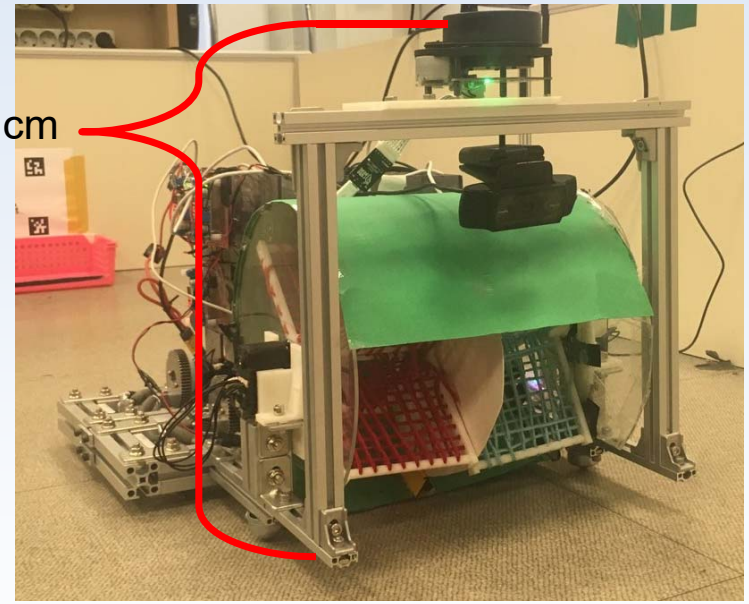




Configuration



52 cm



32 cm

46 cm

Weight = 11.6 kg

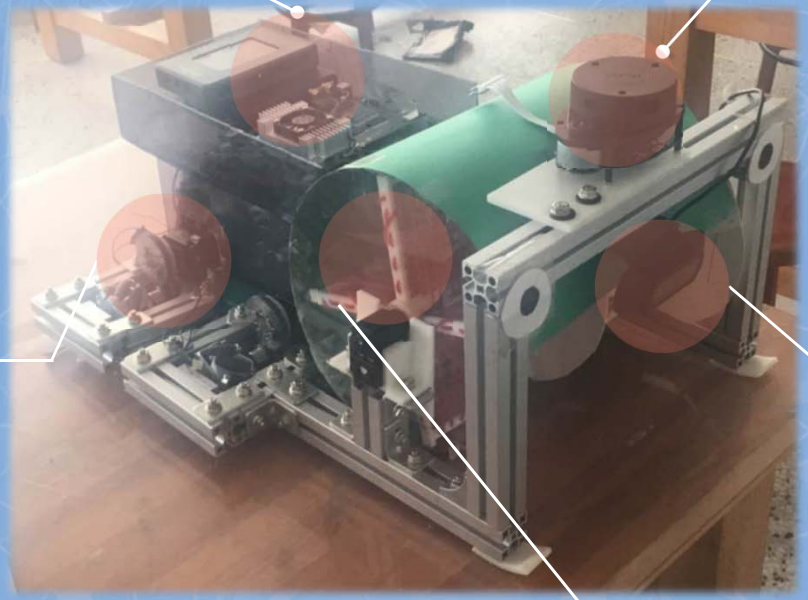
Configuration

Processors

The MyRIO, NUC, and Jetson are on the second floor of the container.

Gear system

Implemented gears in mobile platform to meet the requirements of Capstone Design II.



Collector System

Dual red-blue collector, storage, and disposal system.

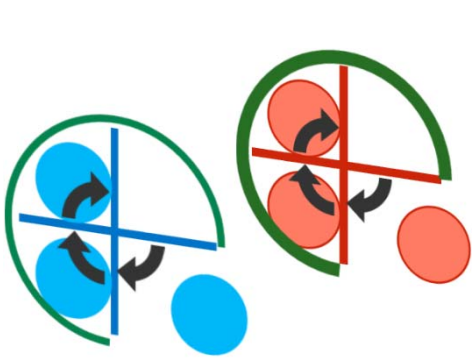
LIDAR

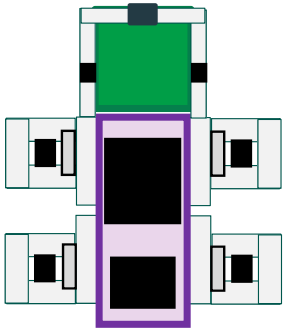
Our primary navigation sensor, the LIDAR, is at the highest point and centre.

Camera

Our vision sensor, the webcam, is located just below the LIDAR, with an obstructed POV from a high vantage point.

Strengths





Twin integrated Collector, Storage, Disposal

Modularized platform

Strengths

Design Feature	Goal	Hypothesis	Result
New collector	Multi-purpose Collector, Storage, Disposal system	Make wide enough to collect, but narrow enough for easy maze navigation	25cm wide CSD, with binder clip for support
Modularization	Fixes ground contact problem of wheel, and makes assembly and repair easier	Large single body has uneven weight distribution	Modularized body with convenient gear attachment

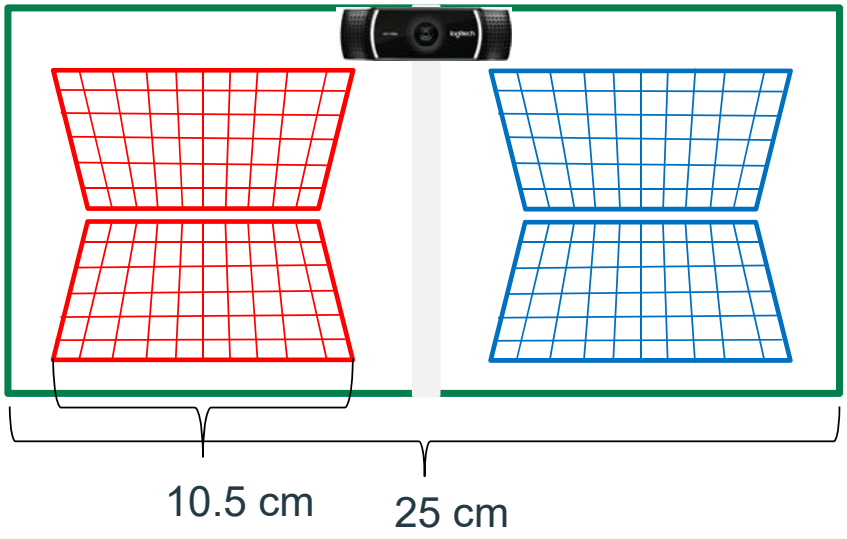
Strength [1] Collector

Goal

Contradiction:

- *Greater width of collector ensures easier collection of ball*
- *Too wide a collector would make vehicle width too large*

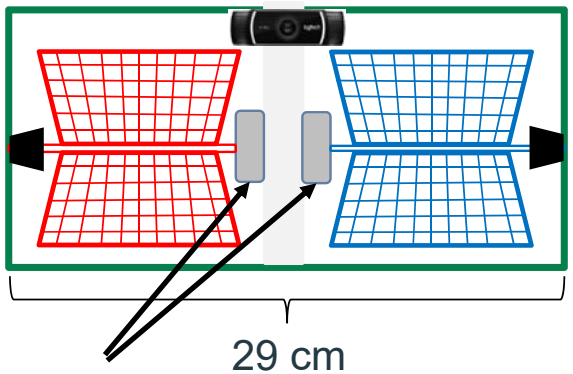
Choose width sufficient for ball collecting, and for easy maze navigation



Strength [1] Collector

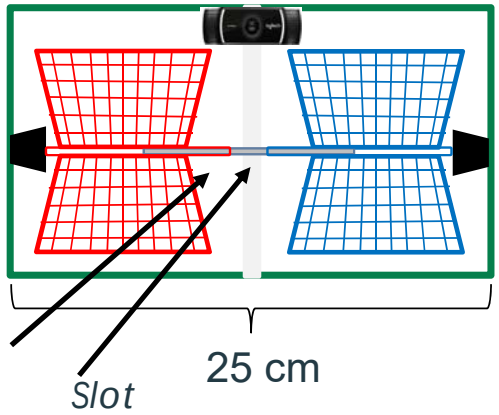
Hypothesis

Before



Independent connector

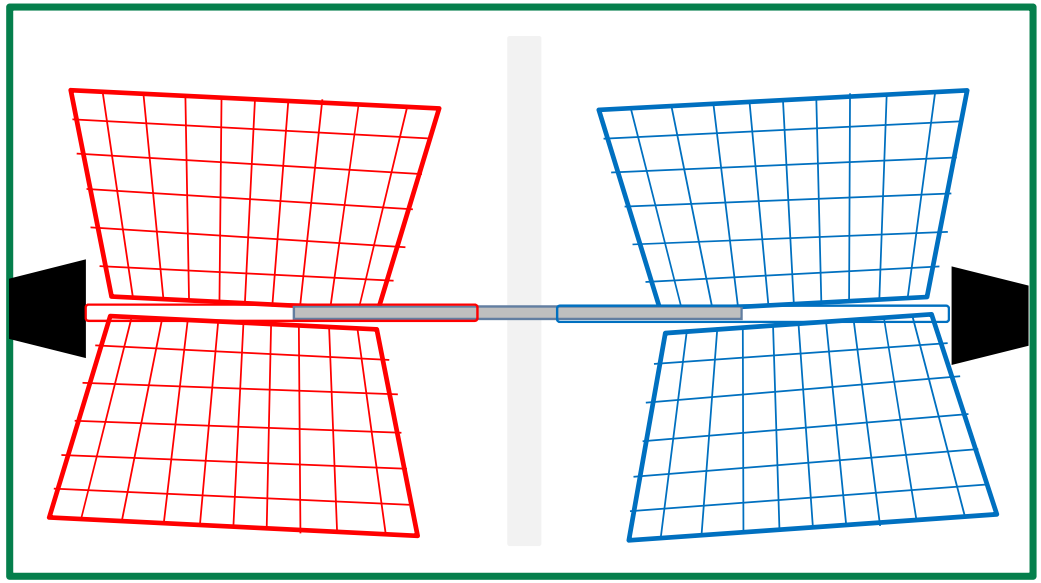
After



Able to make 4cm narrower!

Strength [1] Collector

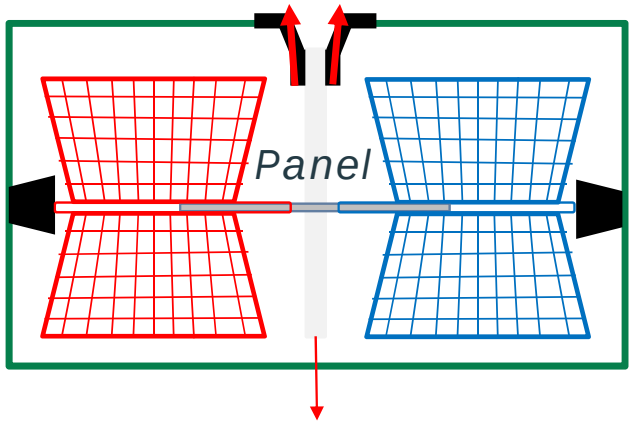
Problem



Strength [1] Collector

Analysis

Option 1: Tape to top

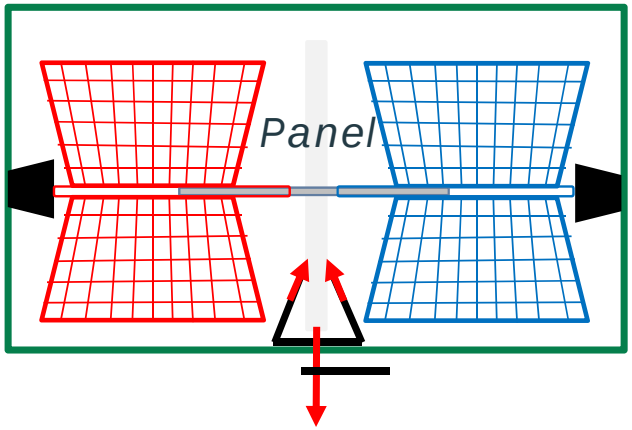


$$\text{Peel strength} = \frac{Peel\ Force}{Width}(1-\cos\theta) + \frac{Peel\ Force^2}{2.Width^2.Thickness.E}$$

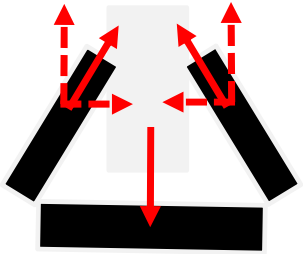
For strong adhesive tape:
Strength = 0.4 N/mm, Width = 18 mm, Thickness = 0.2 mm,
Young's Modulus of Construction Paper, E = 1.5/1.8 MPA
Chosen peel angle = 90°
∴ Peel Force = 7.38 N

Weight of separator + connecting rod + sweepers = 932 g
∴ Downwards forces = 9.13 N
Since downwards forces > Peel Force → Tape delaminates

Option 2: Grip at bottom



Base support exerts forces with both horizontal and vertical components.



Vertical component supports weight; Horizontal keeps separating panel straight.
Easy to place and functions well!

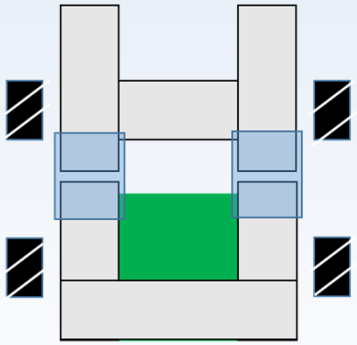
Strength [1] Collector

Implementation

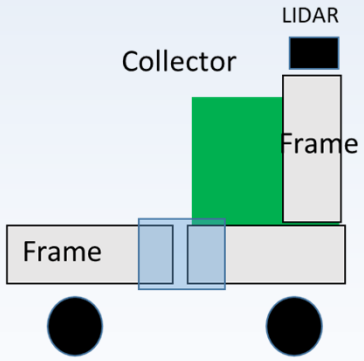
Strength^2 Modularization

Goal & Hypothesis

Proposed modification – Separate a single body into two bodies to solve contact problem.



Top View



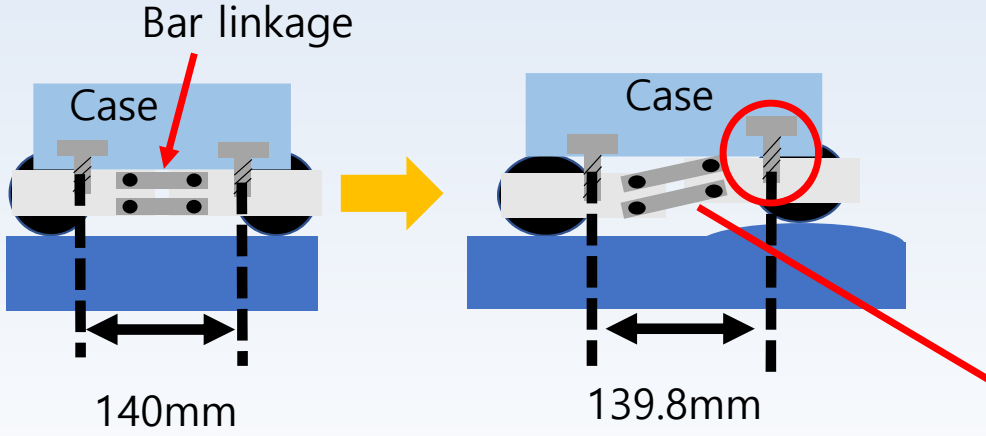
Side View

- *Cut the long frame into two.*
- *Connect separate frames while allowing free movement.*
- *Add gear.*

Strength²Modularization

Analysis

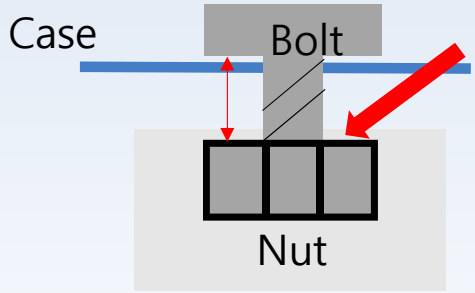
<Side view of the system>



Assumption: The maximum floor roughness is 3mm.

Side view

It should be same as the roughness.

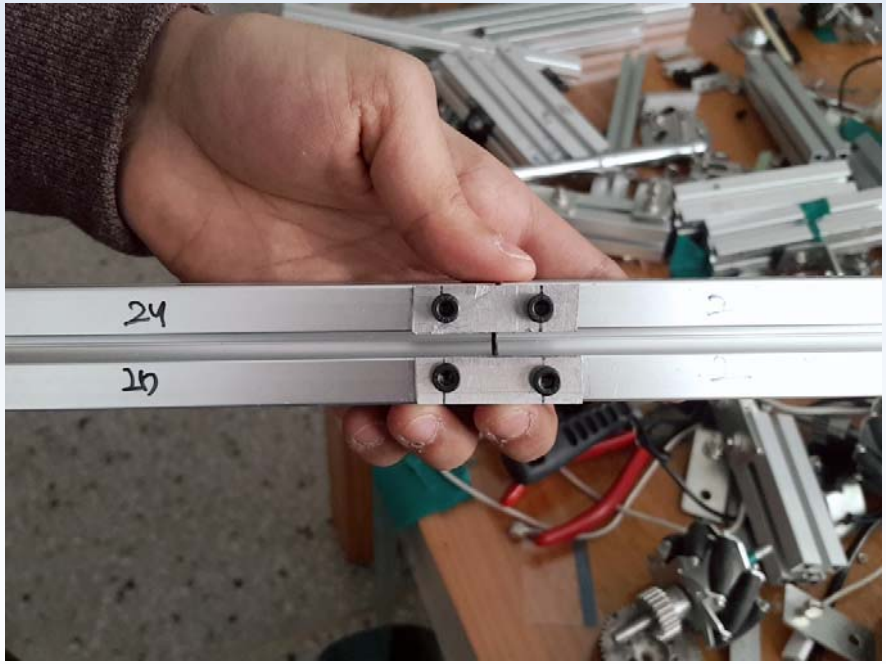


Chemical bonding between a nut and a bolt

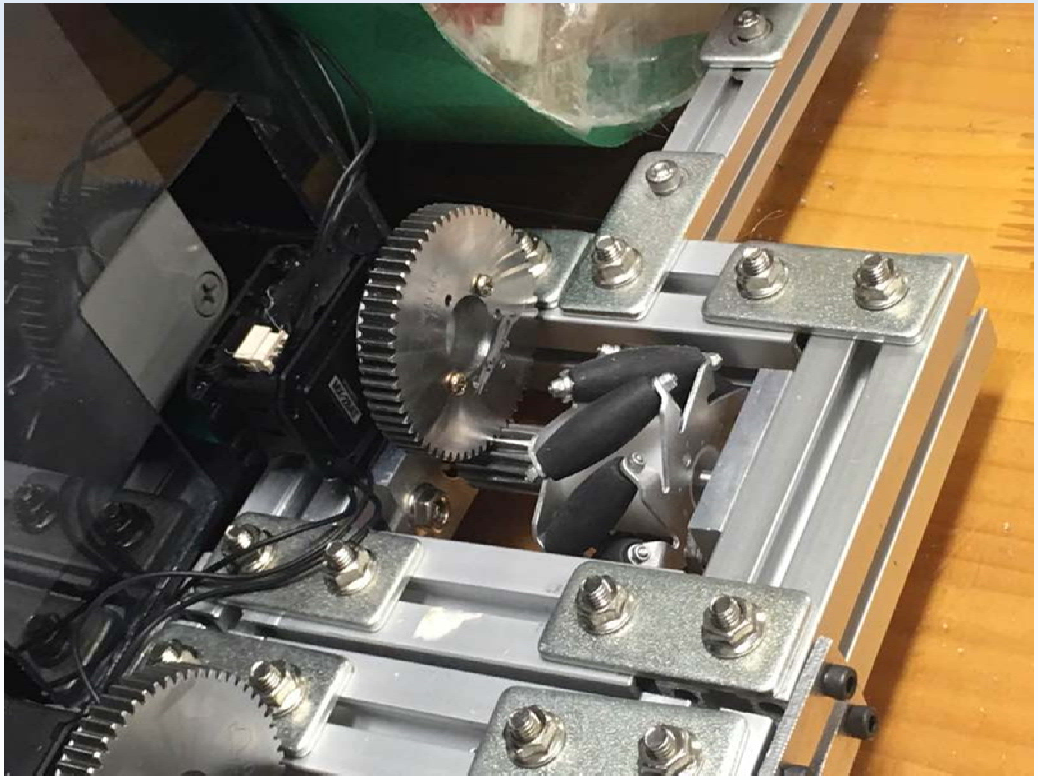
Top view

Strength ²Modularization

Bar linkage

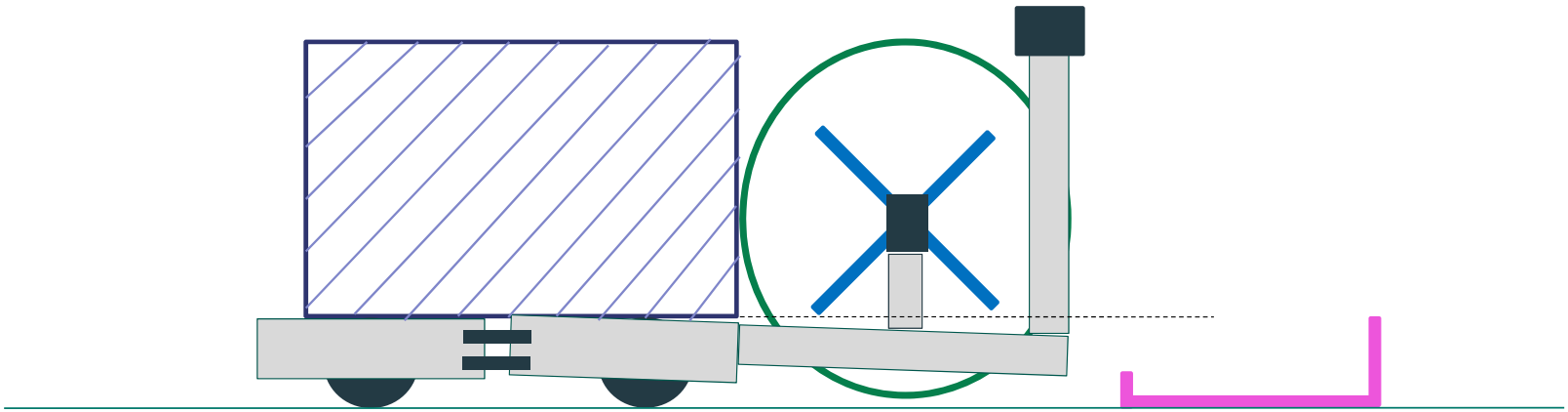


Gear system



Gear ratio of 58:15

Most challenging problem



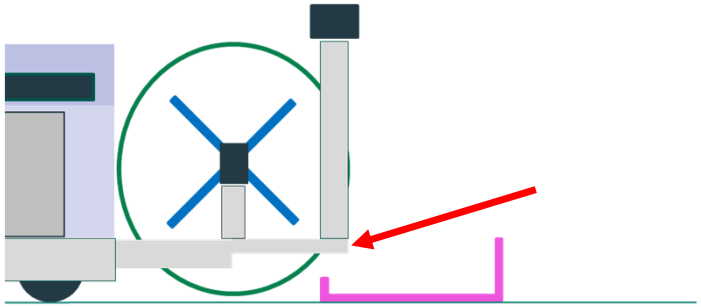
Problems:

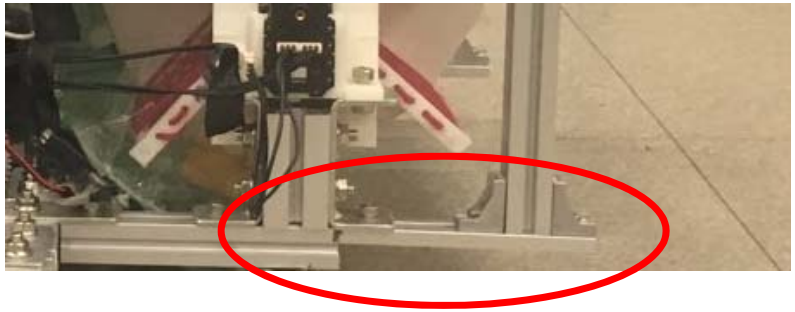
- *Drooping of front section*
- *Load on front motor is too high → causes failure!*

Collector bending

Proposed solution

Cut the profile in half to ensure collector goes into basket:



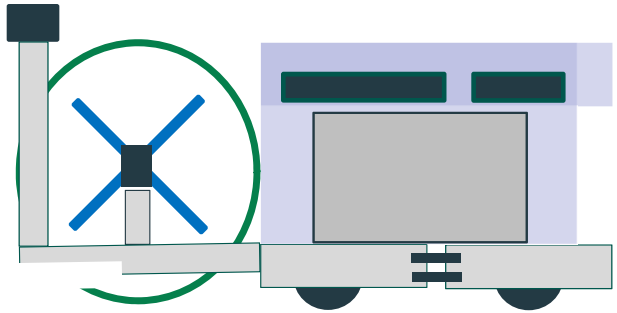


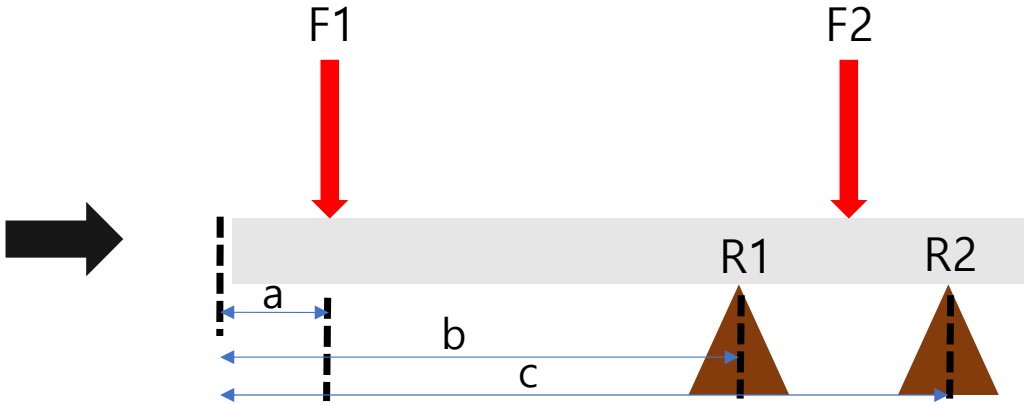
Still problem of drooping persists, and load on front wheels remains large!

Load Reduction

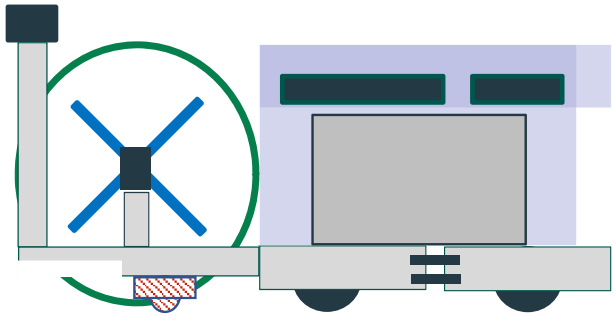
Analysis

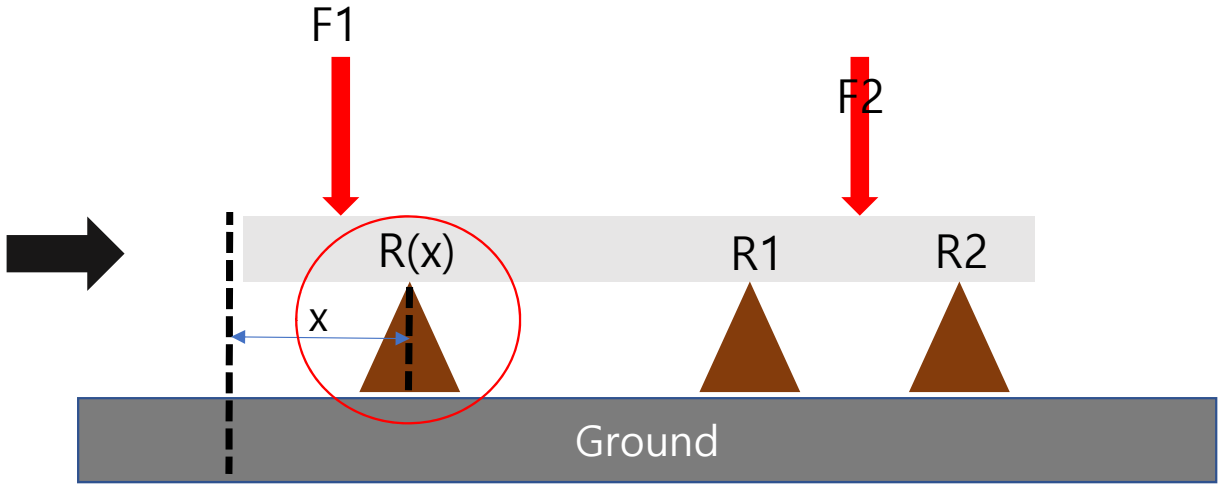
Without the sphere roller bearing





With the sphere roller bearing

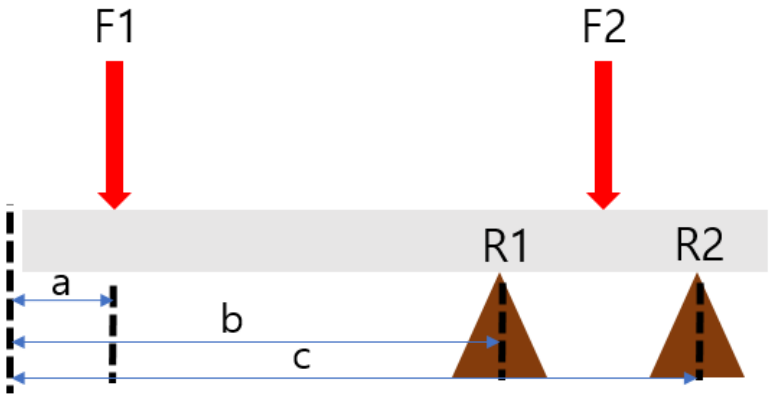




Load Reduction

Analysis

Optimization of the location of the sphere roller bearing



<Force balance>

$$R1 + R2 = F1 + F2$$

<Moment balance>

$$0 = F1(b - a) + R2(c - b) - F2\left(\frac{c - b}{2}\right)$$

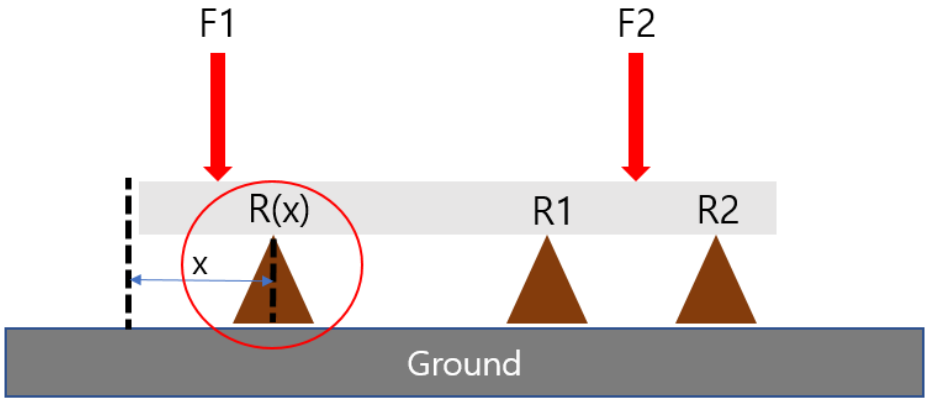
<Result>

R1 = 123N
R2 = 16N
R2/R1 = 0.13 Unbalanced loads on each wheel

Load Reduction

Analysis

Optimization of the location of the sphere roller bearing



<Force balance>

$$R1 + R2 + R(x) = F1 + F2$$

<Moment balance>

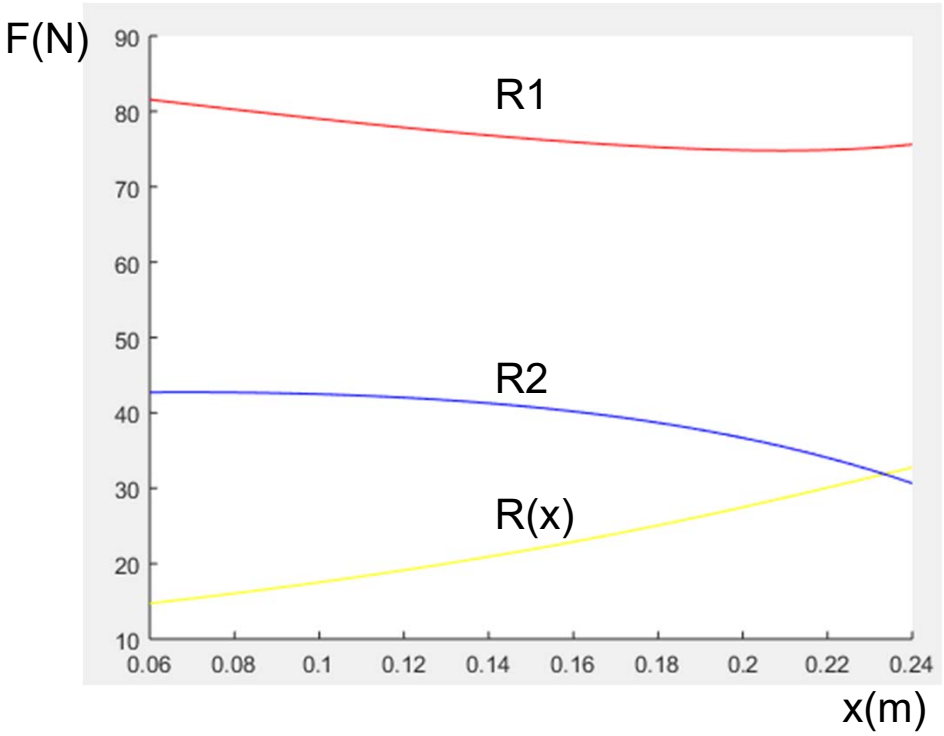
$$0 = F1(b-a) - R(x) \times (0.30 - x) + R2(c-b) - F2\left(\frac{c-b}{2}\right)$$

Due to the Indeterminate case,

$$0 = y(x) = \int_0^L \frac{M}{EI} \cdot \frac{\partial M}{\partial R(x)} dz \qquad Castigliano's\ theorem$$

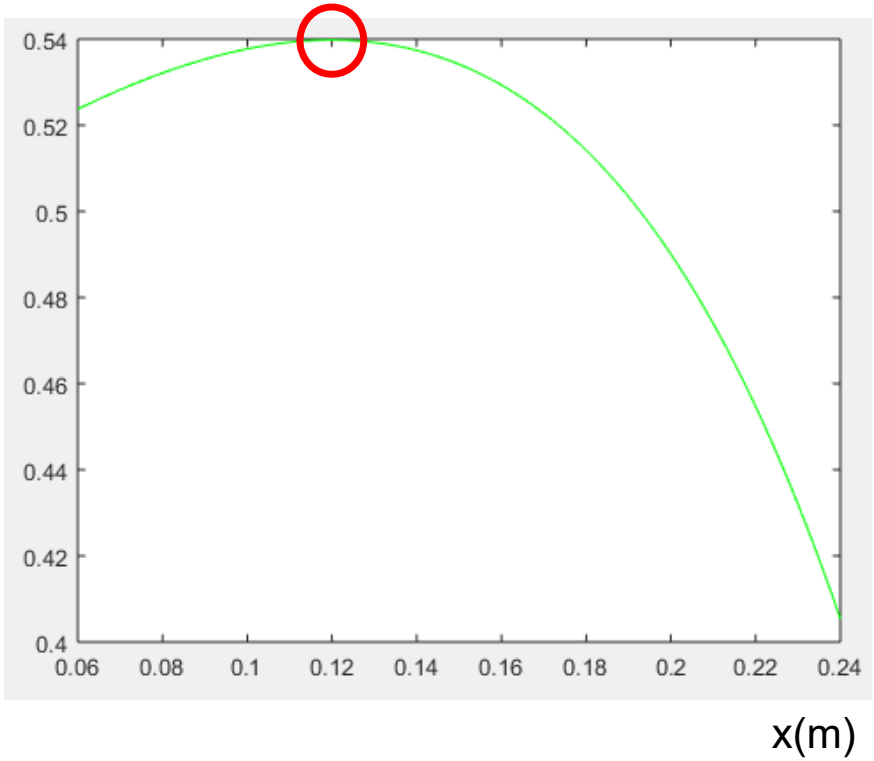
Load Reduction

Analysis



<Loads on the wheels with respect to x>

Max @ x=0.12



<Ratio R2 to R1 with respect to x>

Load Reduction

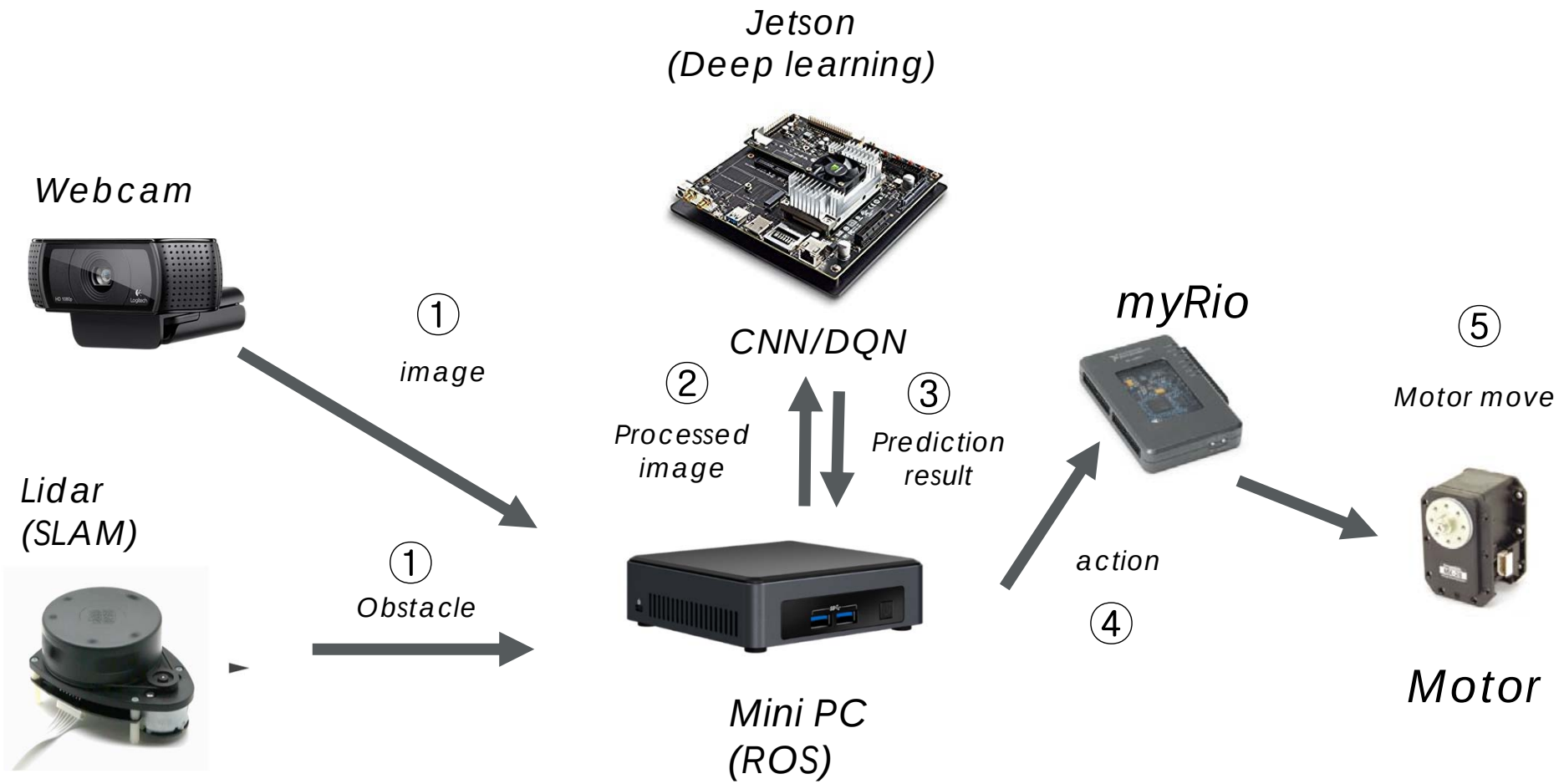
Result & Implementation

03

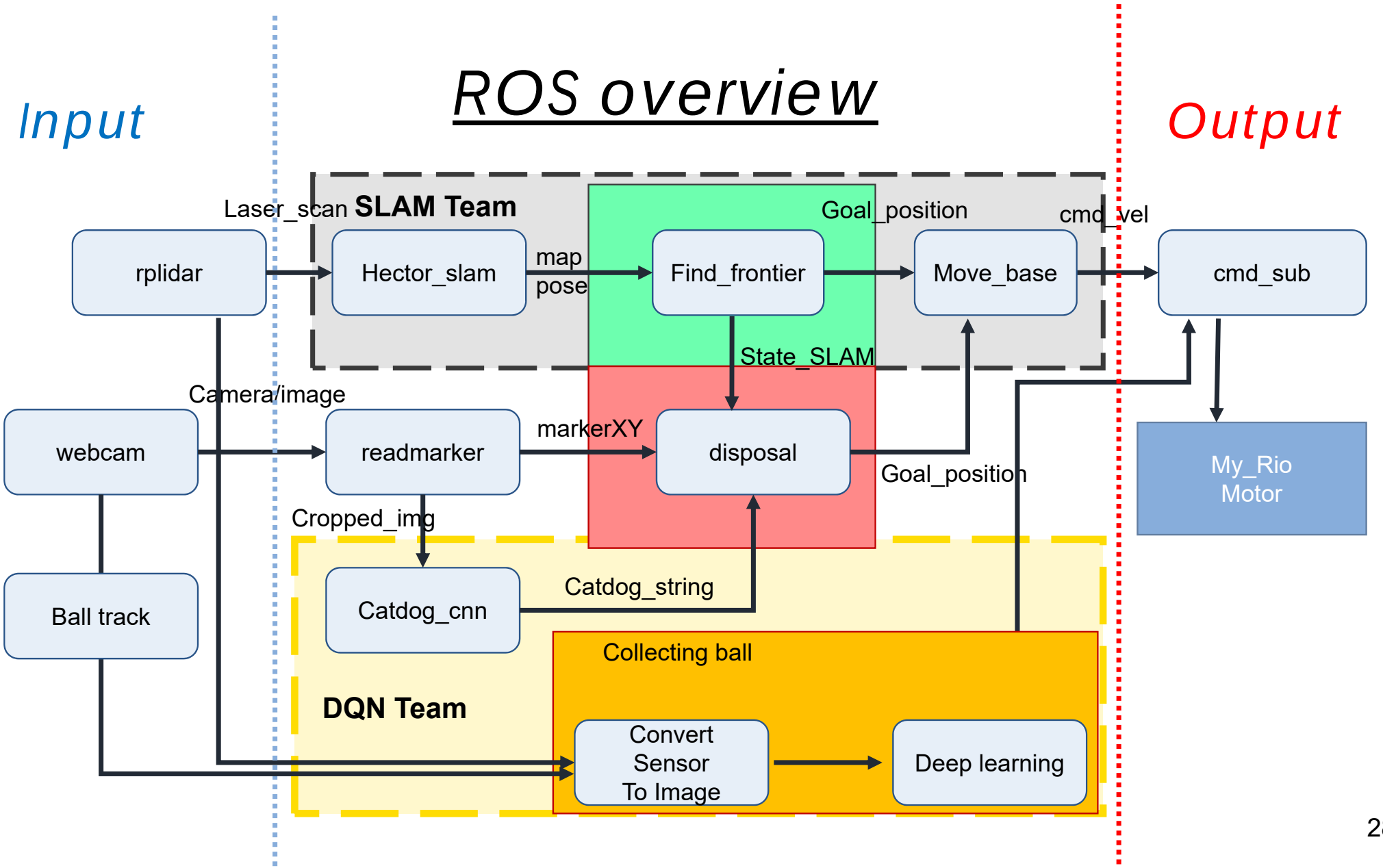
Software

SLAM, CNN, and DQN.

System overview

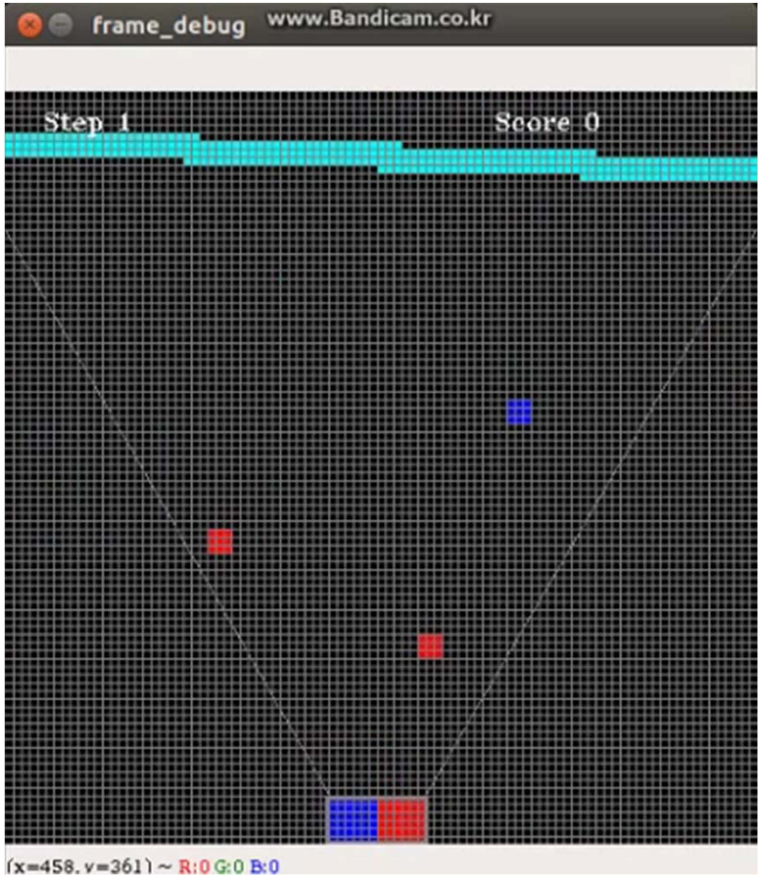


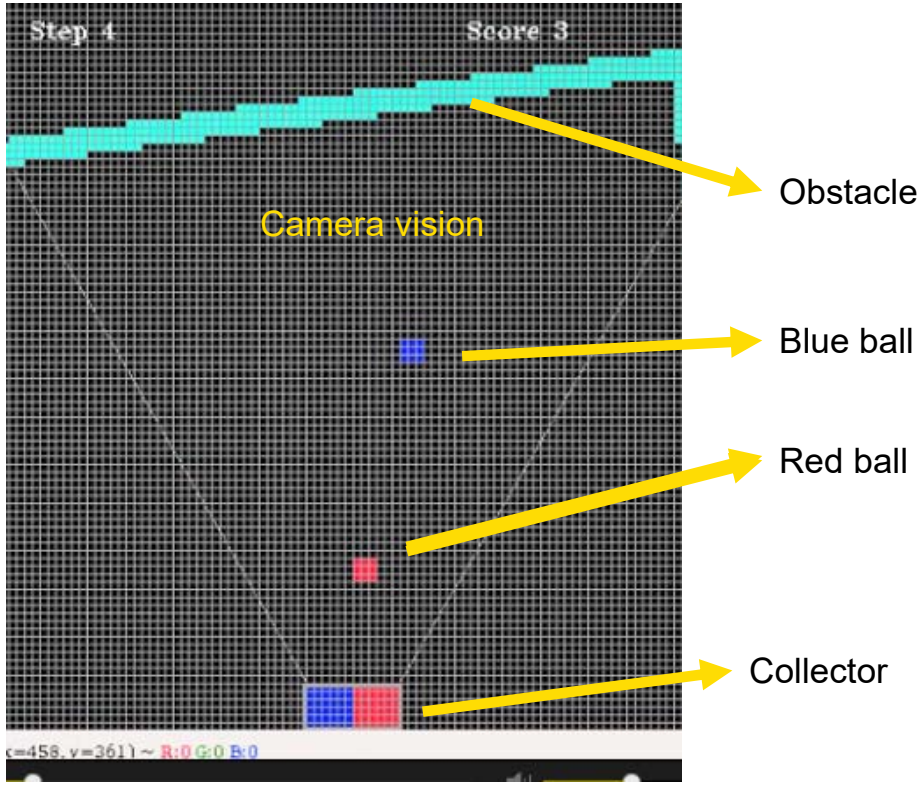
ROS overview



Video

Simulator Learning





Video

DQN performance

Difference between previous semester

Capstone I	Capstone II
Should program actions for every possible case	*DQN can handle every possible case*
We decide the robot's action	*Can't predict DQN solution (Black box model)*
Less data processing (camera → ROS → motor)	*More data processing (camera & lidar → ROS → JETSON → ROS → motor)*
Testing is straightforward	*Debugging takes more time (at least 12 hours for model training)*
Similar action is used (ex: balls are missing → rotate)	


Thank You
Any questions?

Appendix A

Restriction : $x \geq a$

<Moment along the beam>

$(x \leq z \leq b)$

$$M = -F1 \times (z - a) + R(x) \times (z - x)$$

$(b \leq z \leq \frac{b+c}{2})$

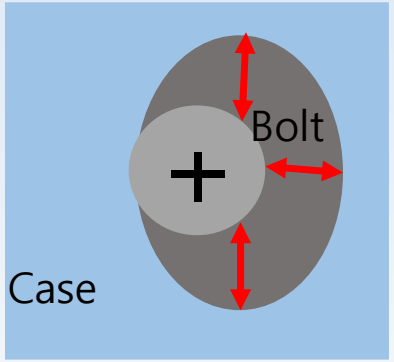
$$M = -F1 \times (z - a) + R(x) \times (z - x) + R1 \times (z - b)$$

$(\frac{b+c}{2} \leq z \leq c)$

$$M = -F1 \times (z - a) + R(x) \times (z - x) + R1 \times (z - b) - F2 \times (z - \frac{b+c}{2})$$

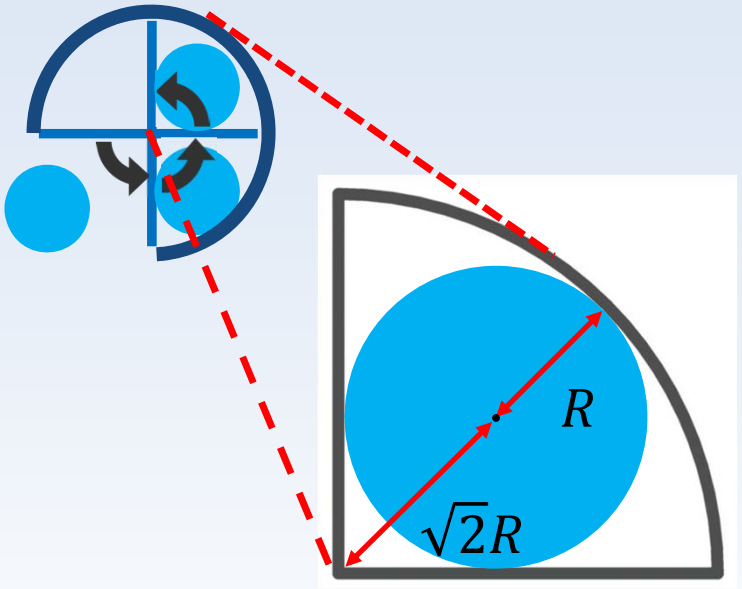
Appendix B

0.1mm



Due to decreasing the distance between bolts, we give clearance about 0.1mm depending on the location.

Appendix B



$R_{collector}$

$(1+\sqrt{2})R \leq R_{collector}$

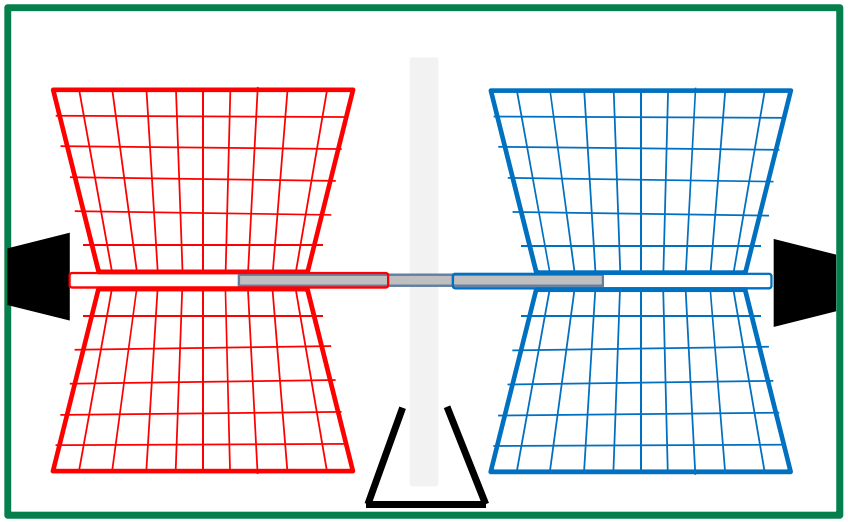
$R \approx 4(cm)$

$10(cm) \leq R_{collector}$

Strength [1] Collector

Result

Grip at bottom



Why not both?

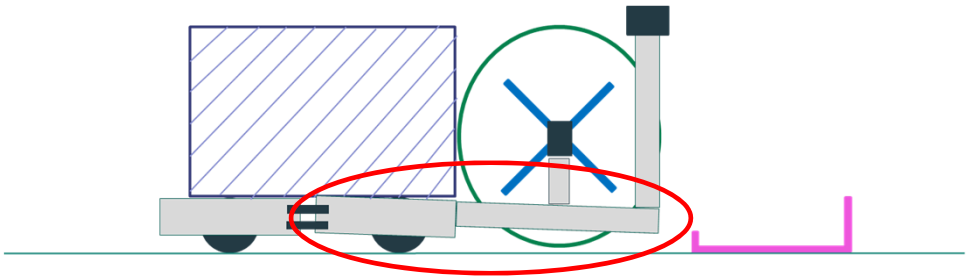
- *Attaching tape without hole is difficult, but with hole, tear may propagate during ball collection due to added weight of balls.*
- *Superfluous.*

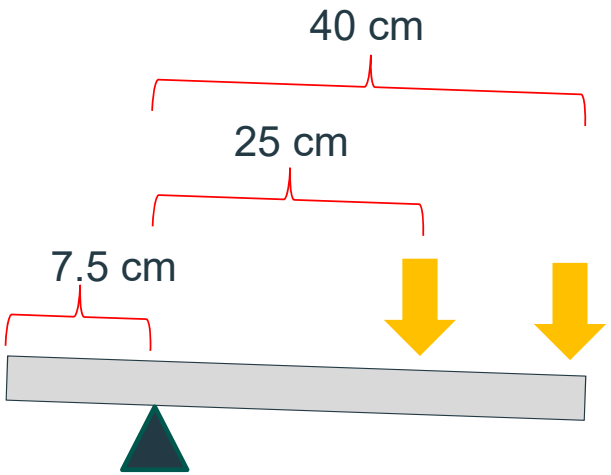
Most challenging problem

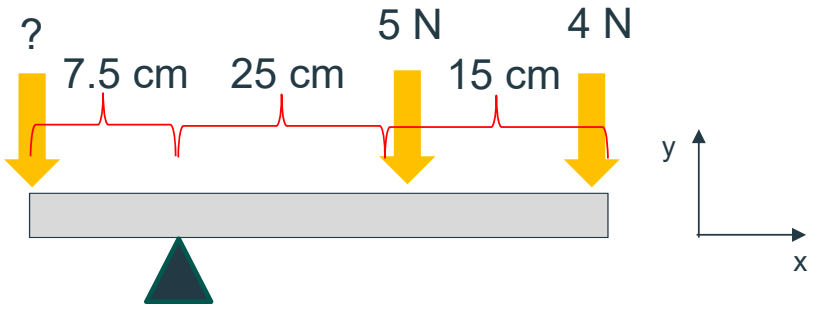
Hypothesis: Contradictions

Solutions	Improving feature	Worsening feature	TRIZ action
Add weight in back	Improved stability	Heavier platform	Taking out, Skipping, Parameter changes, Inert atmosphere → Taking out!
Add support in front	Raises height	Increases friction	Dynamics, Add another dimension → Dynamics!

Analysis





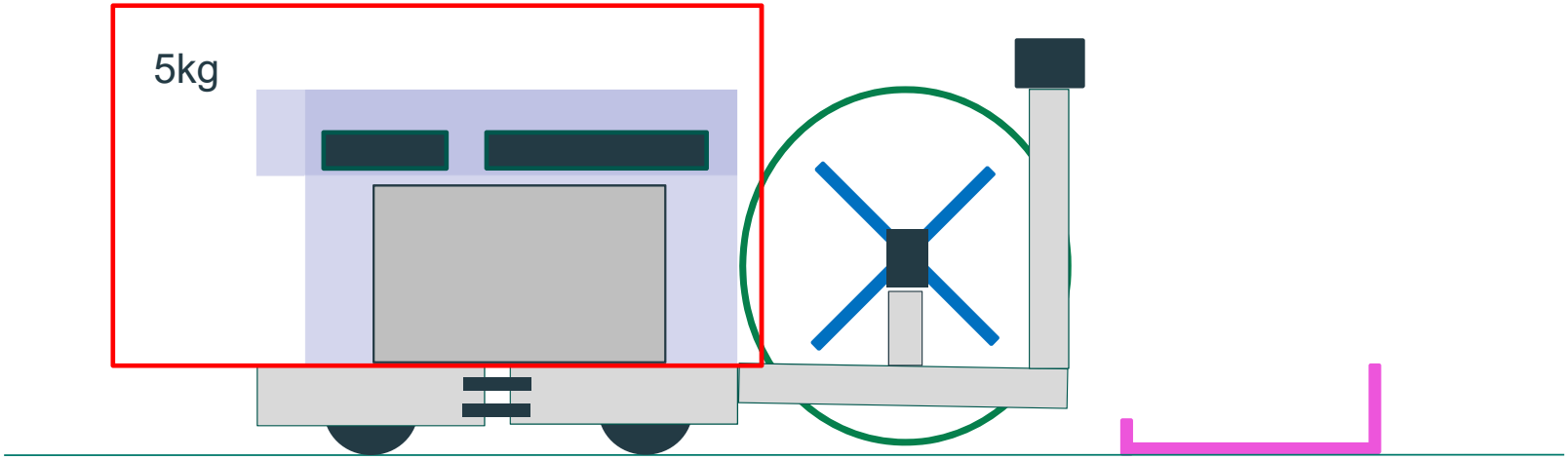


Weight of LIDAR & camera profile: ~400g
Acts at x = 40cm
Weight of collector: ~500g
Acts at x = 25cm
∴ Total clockwise moments= 4 x 40 + 5 x 25 = 285N

ΣM = 0
$\Sigma M_{CW} = \Sigma M_{CCW}$
285N= 7.5 x ?
∴ Force required for balancing = 38 N ≈ 3.8 kg

Bending of Module

Result



Back part is straight, but front part still bends and does not clear basket height!