UYCL 360

January 4th, 2024

Group 3

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Agenda

01. **UNRE 360 Pain points analysis**

Story board.
Problem analysis

02. **UYCL 360 concept display and workflow**

Solutions and product hypothesis
Basic process workflow by phase

03. **UYCL 360 model design and color selection**

Effective Engineering method
3D modeling

04. **UYCL 360 control engineering and design**

Handle design and optimized
Automated mobility

05. **UYCL 360 user interface design**

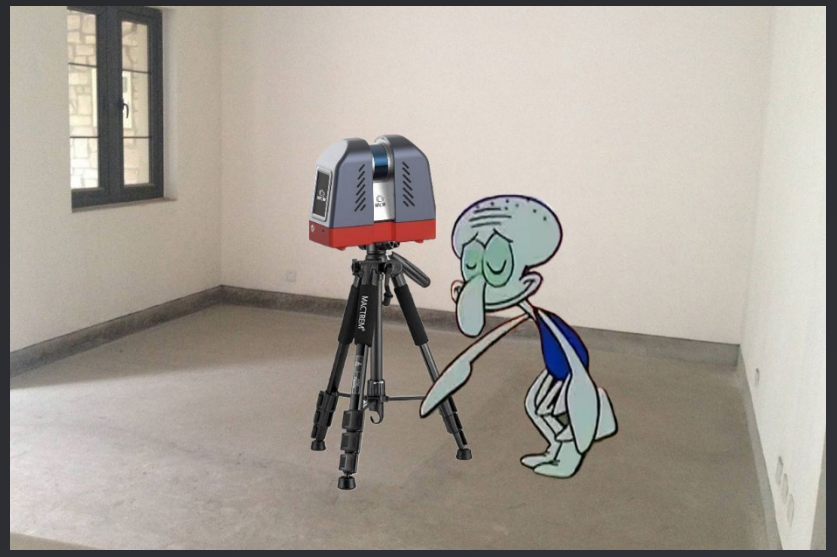
App design method
App using demonstration

06. **UYCL 360 operation display and core advantages**

Story board
KSP display

Problem definition: Story Board






Problem definition: Story Board






Problem Analysis

SCANNER WEIGHT

Solution:

- Lightweight
  - Weight lesser than the industry scanner
  - Human factors improvement

Problem Analysis (Con’t)

→ WASTE OF TIME

Solution:

- Utilise automation
  - Improve efficiency

Problem Analysis (Con't)

REQUIRES EXPERIENTIAL KNOWLEDGE

Solution:

- Having multiple UYCL 360 to collect data concurrently
  - Workers can easily control the device via an APP

Disadvantage (Con’t)

- High labor requirements
  - Mental Power
  - Training cost
  - Demands physical strength

Solution:

- Implement the usage of UYCL 360
  - Ease workload of workers

Product Hypothesis

Based on UNRE UCL 360, using a multi-machine collaborative working method to liberate workers, improve efficiency and propose a mobile platform with smart measurement solution for actual measurements in industry.

What does UYCL 360 look like?

What does UYCL 360 look like?

3D modeling

Color selection

Determination of modeling scheme

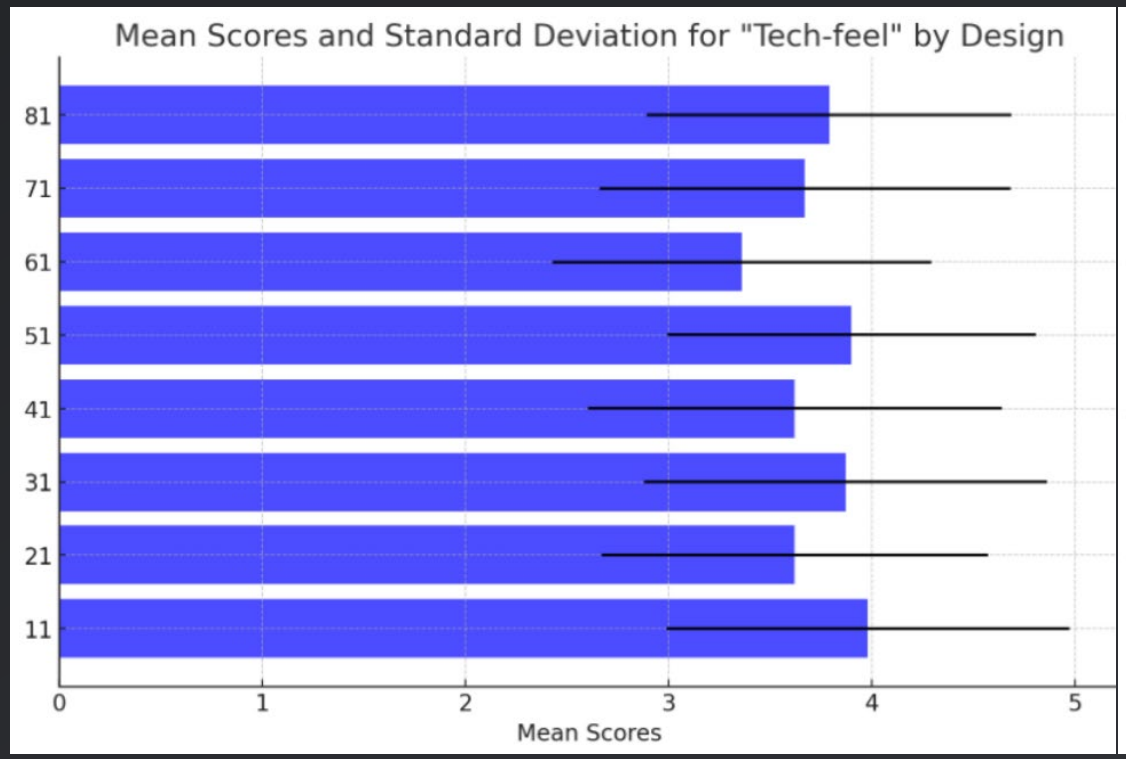
- Structure
  - Mobile platform
    - Kansei engineering survey
    - Shell design and modeling
    - Establishment of engineering characteristics
  - Spatial digitizer
  - Connecting structure
- Colour

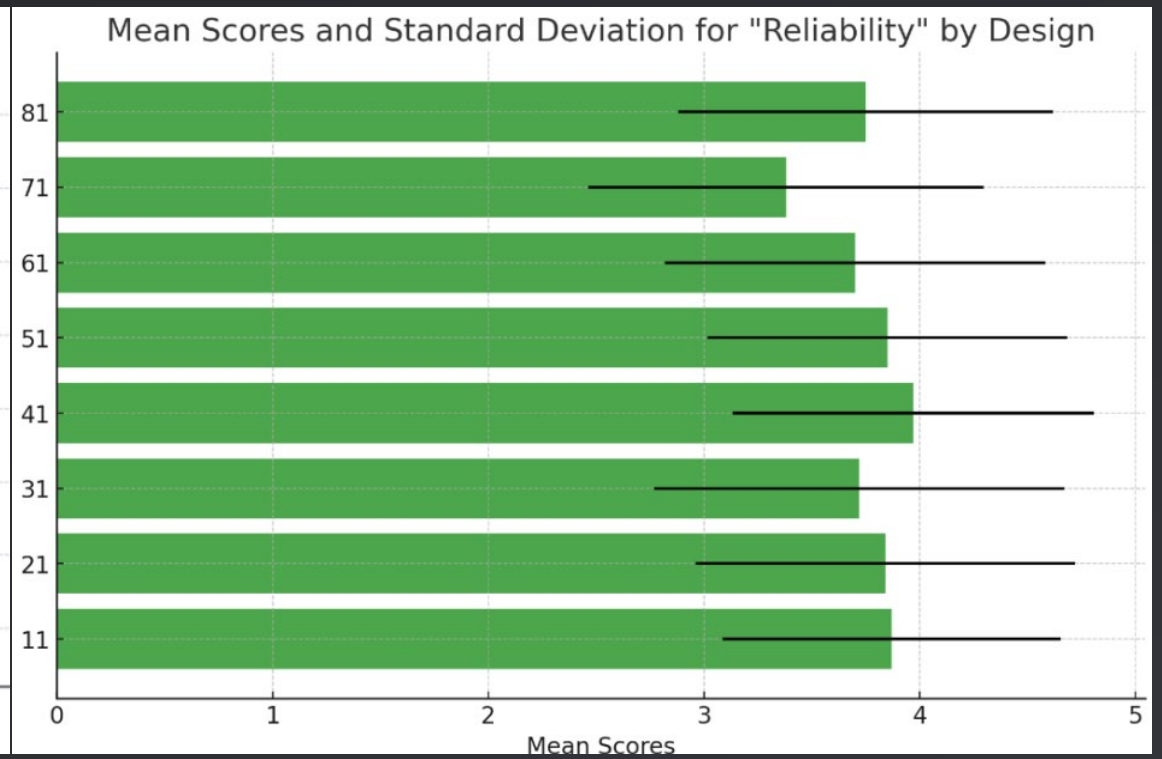
Kansei engineering survey

Use midjouney generation modeling schemes for evaluation and selection.

Kansei engineering survey

Use midjouney generation modeling schemes for evaluation and selection.





Kansei engineering survey

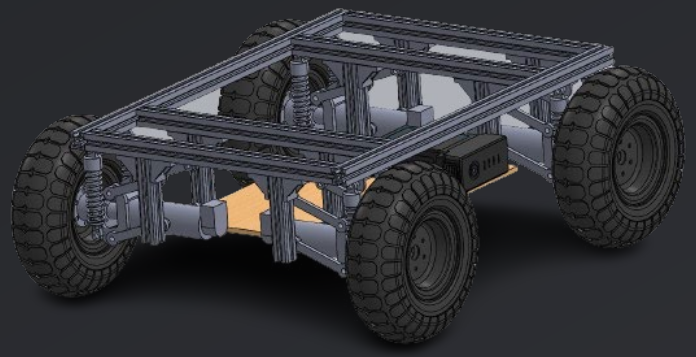
Use midjouney generation modeling schemes for evaluation and selection.

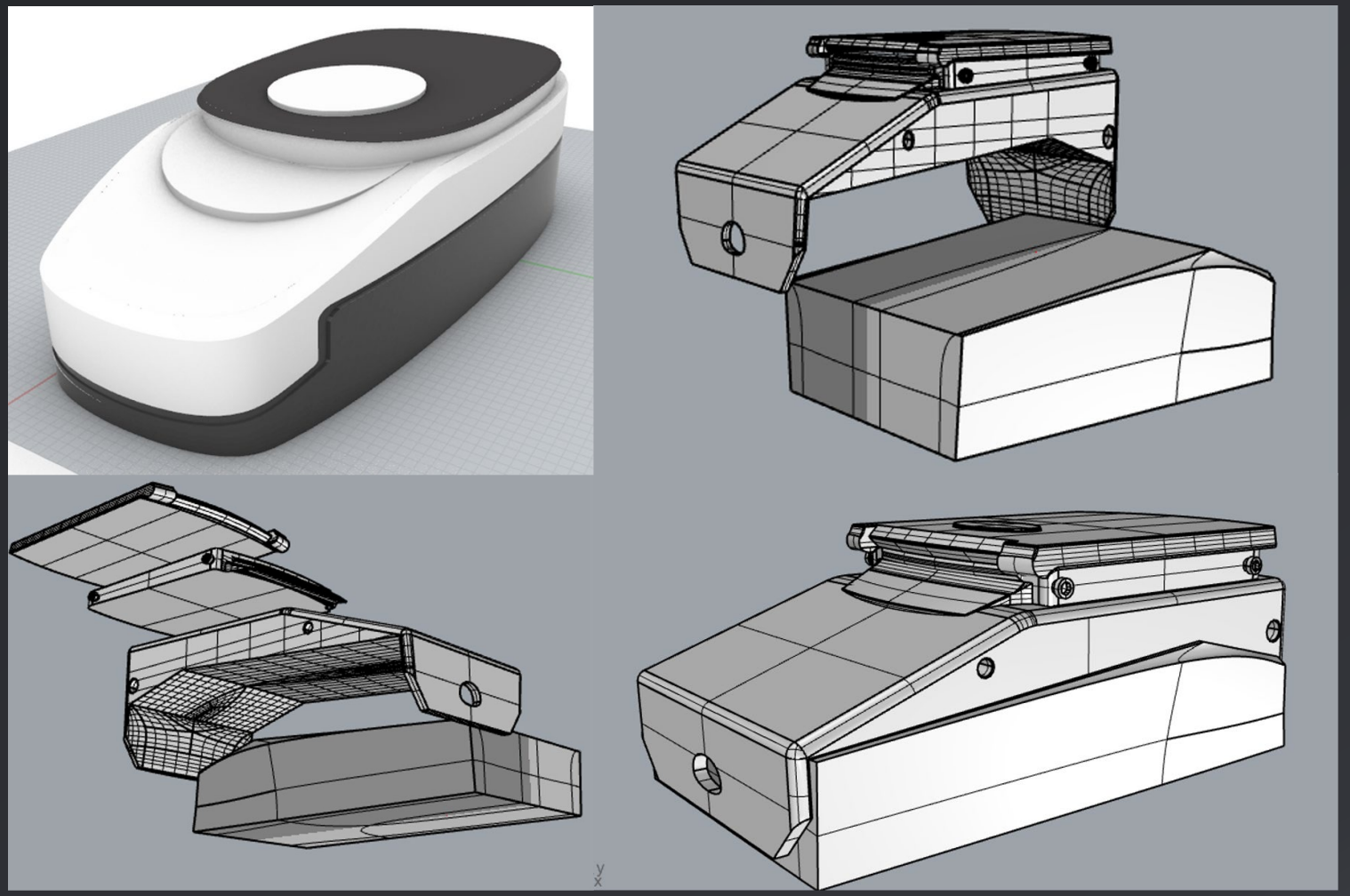
Kansei engineering survey

The final choice

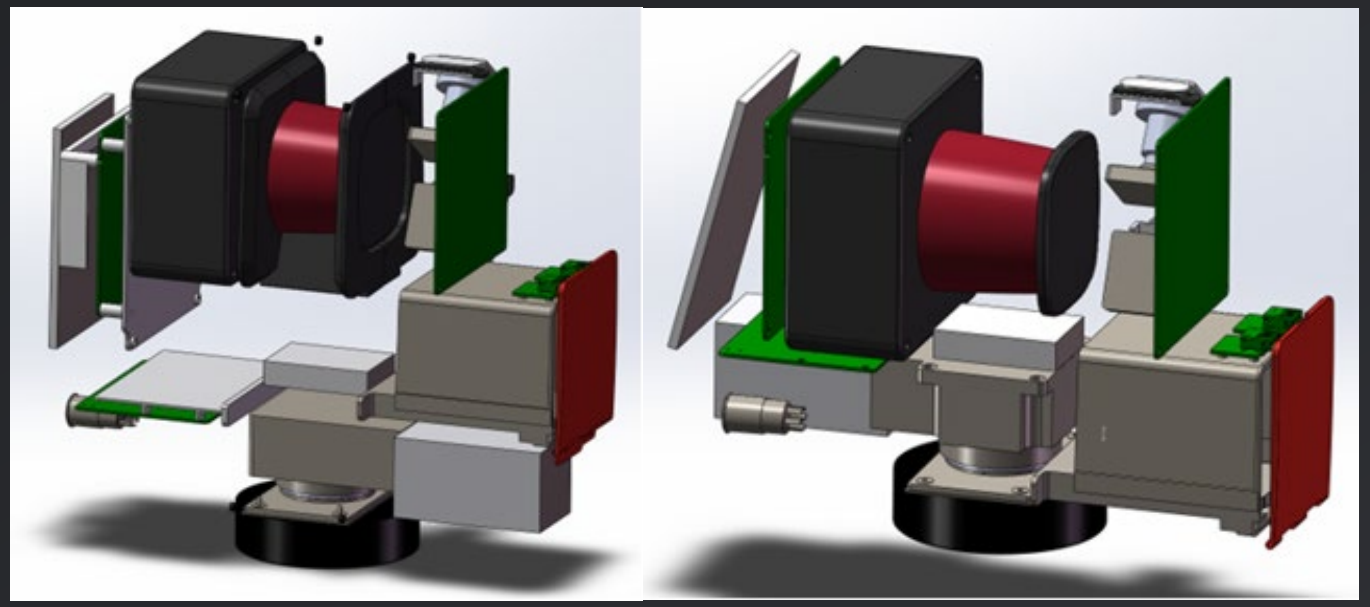
Modeling of vehicle shape

Dimension → Parting & Surface





Scanner

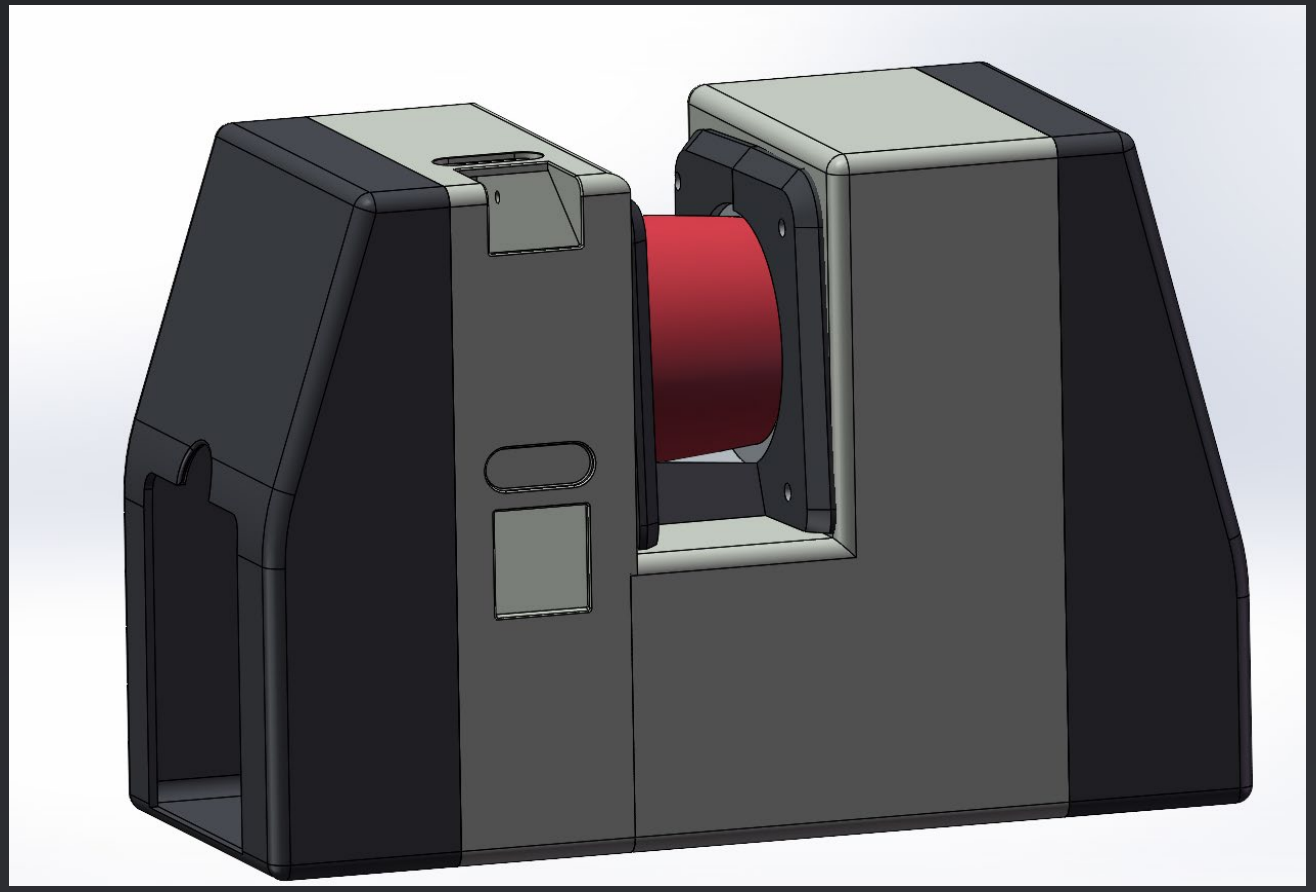


Internal components of the scanner before and after optimization

(left: before; Right: After)

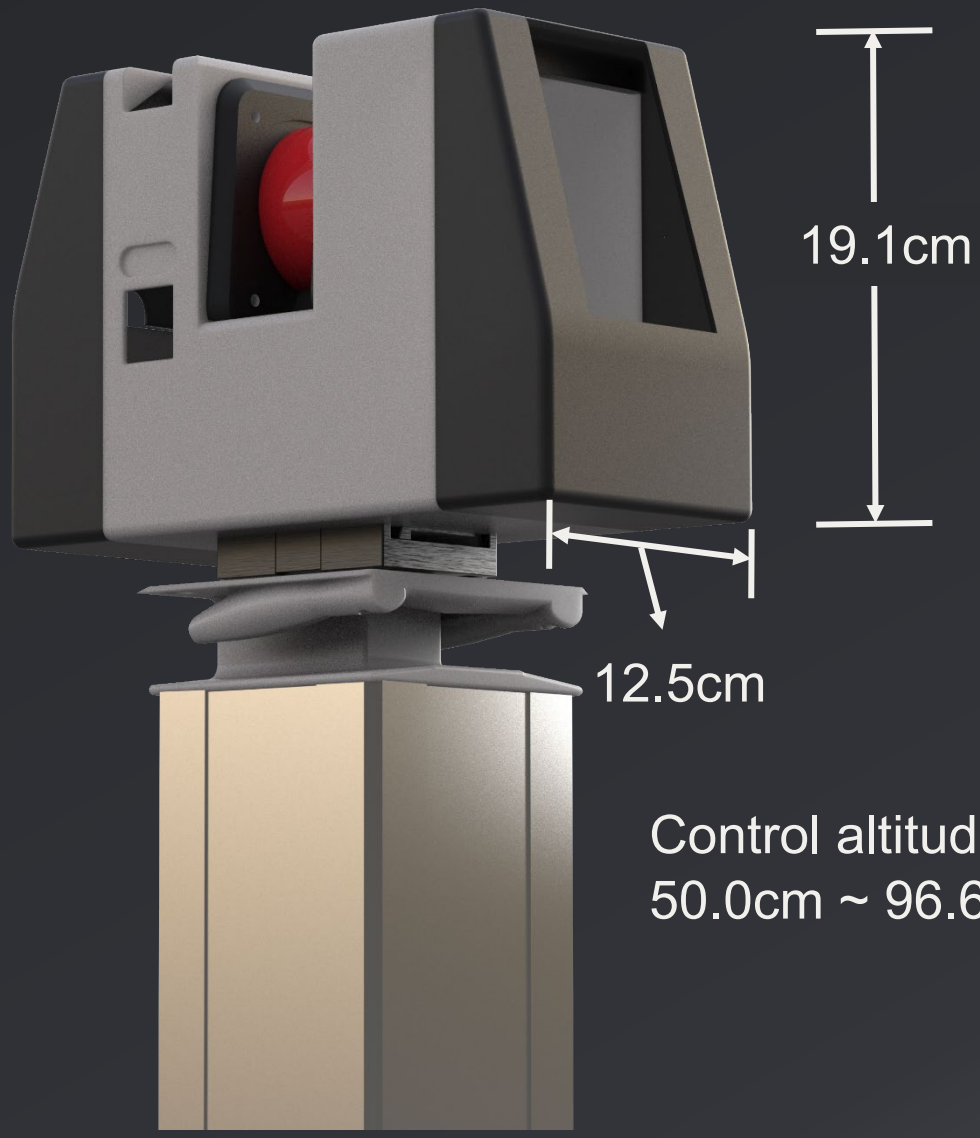
- Tilt screen
- Light weight
- Change from vertical to horizontal

Scanner



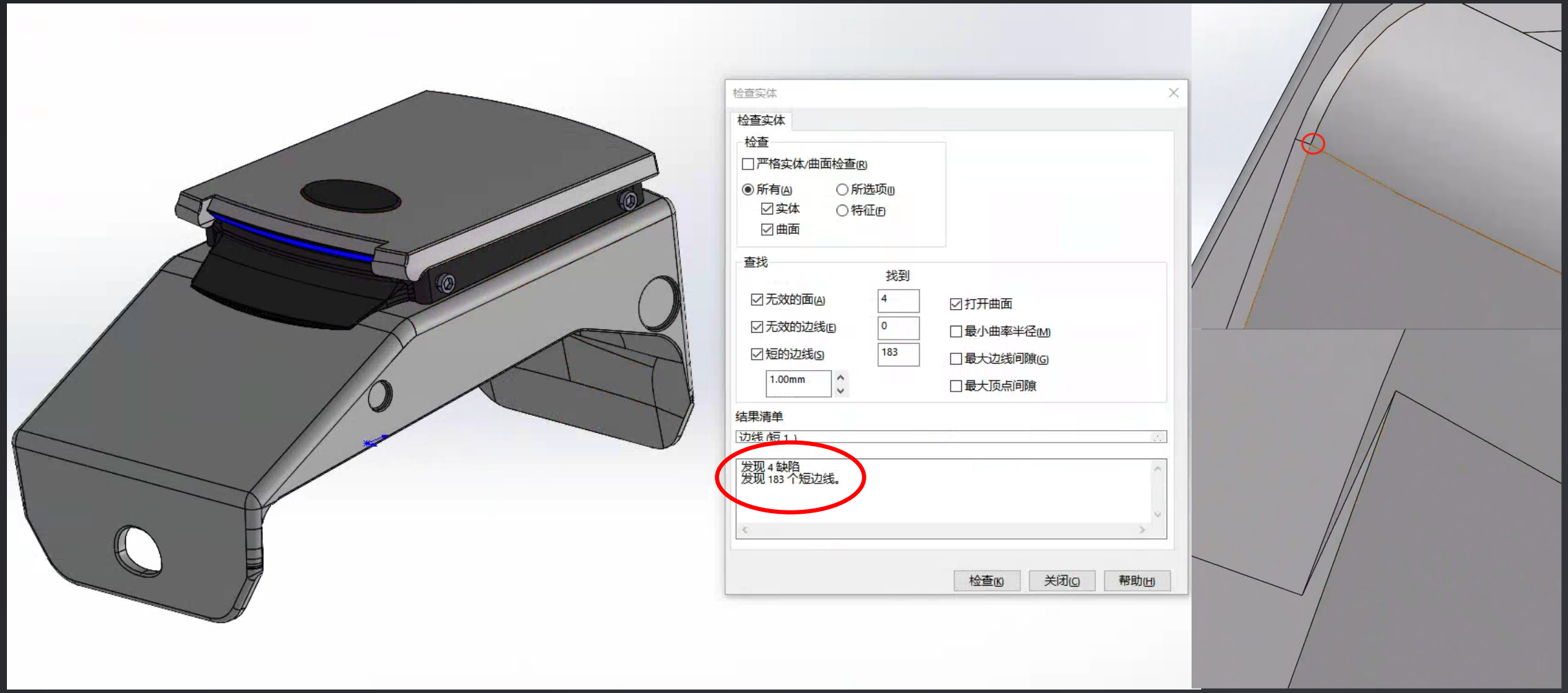
Dimensions with lifting mechanism

- Reliability in actual use
  - Hard to dump
  - Transportation
  - Meet scanning requirements



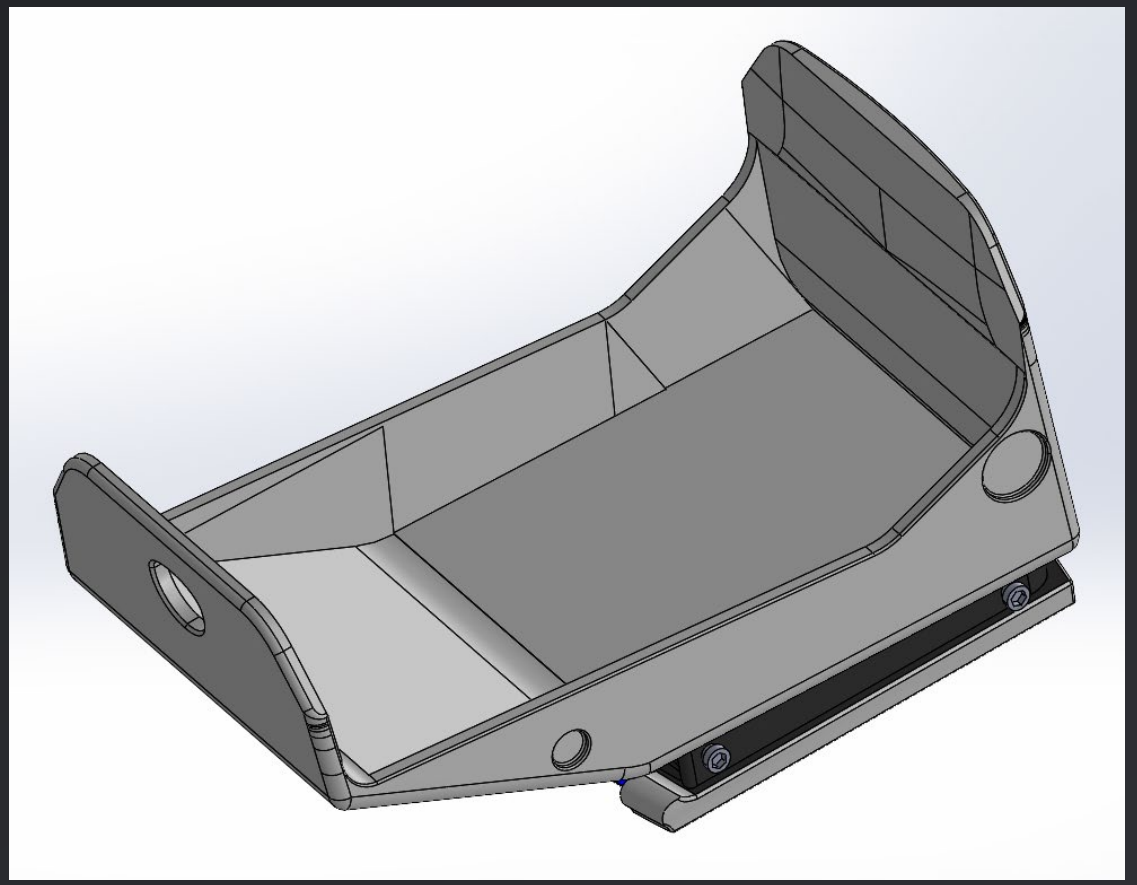
Control altitude：
50.0cm ~ 96.6cm

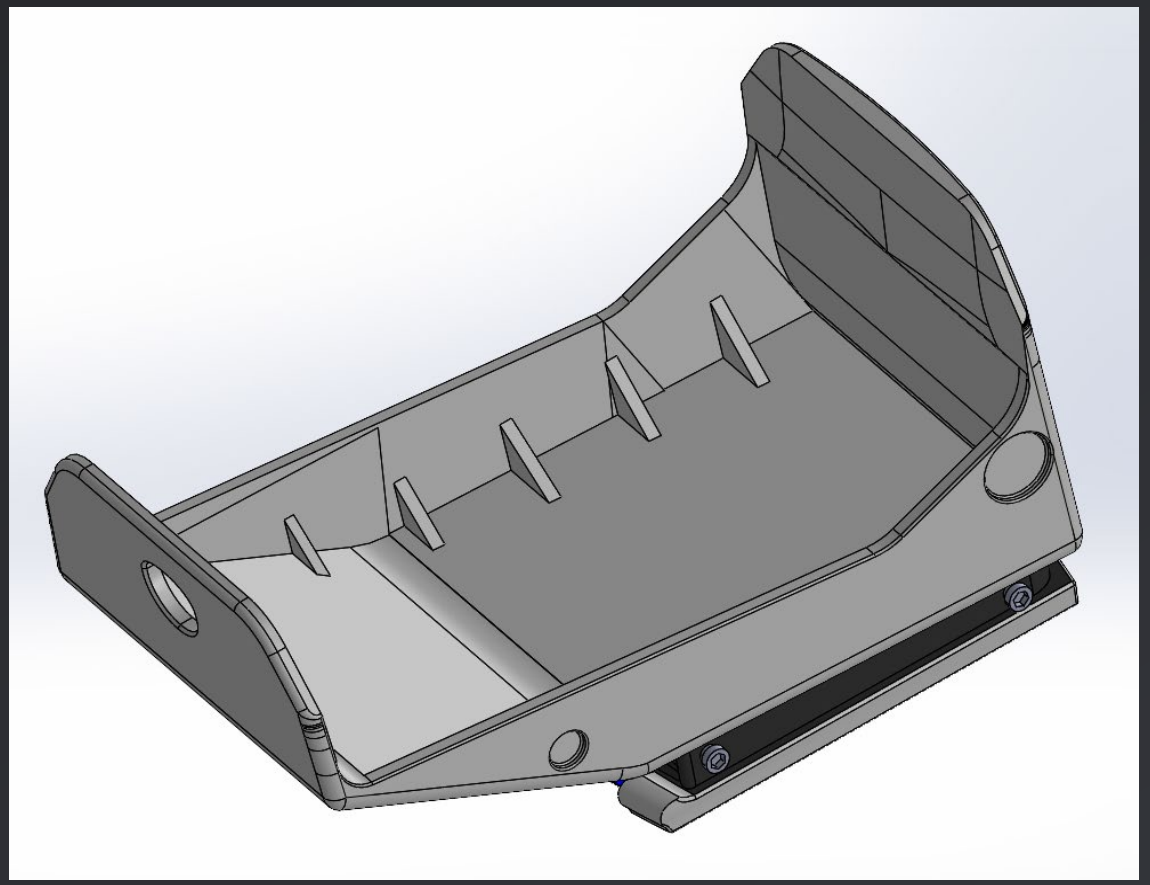
Establishment of vehicle engineering characteristics



Existing problems

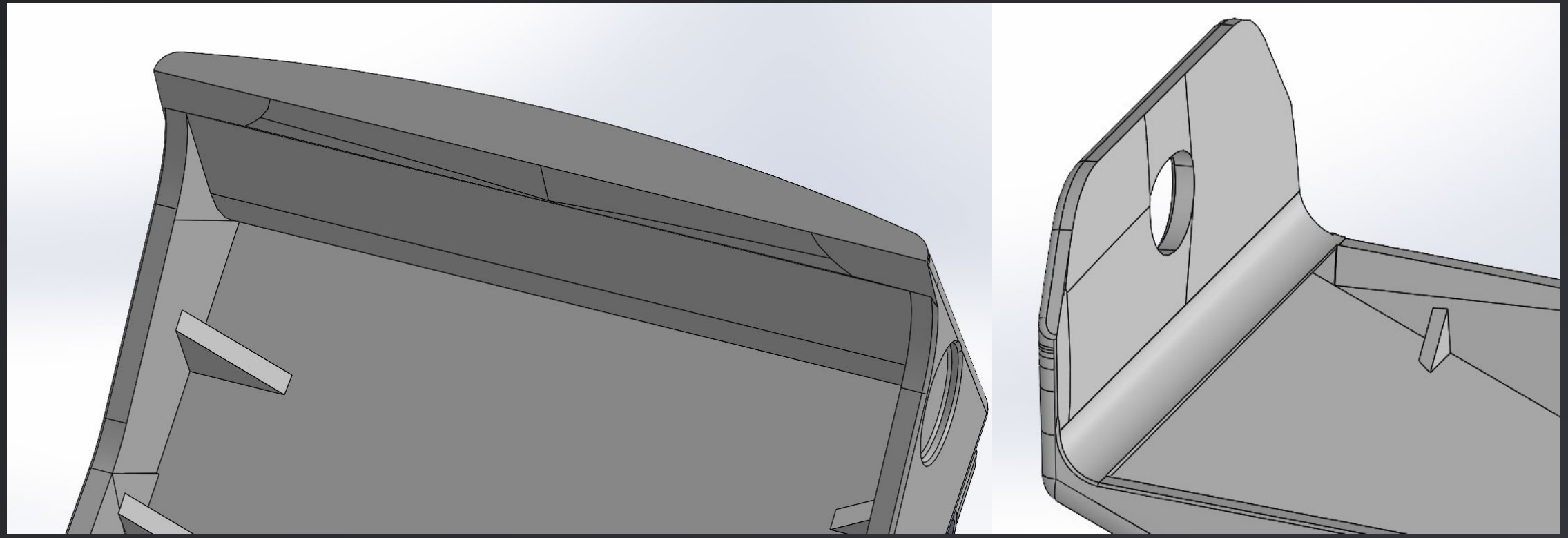
Establishment of vehicle engineering characteristics





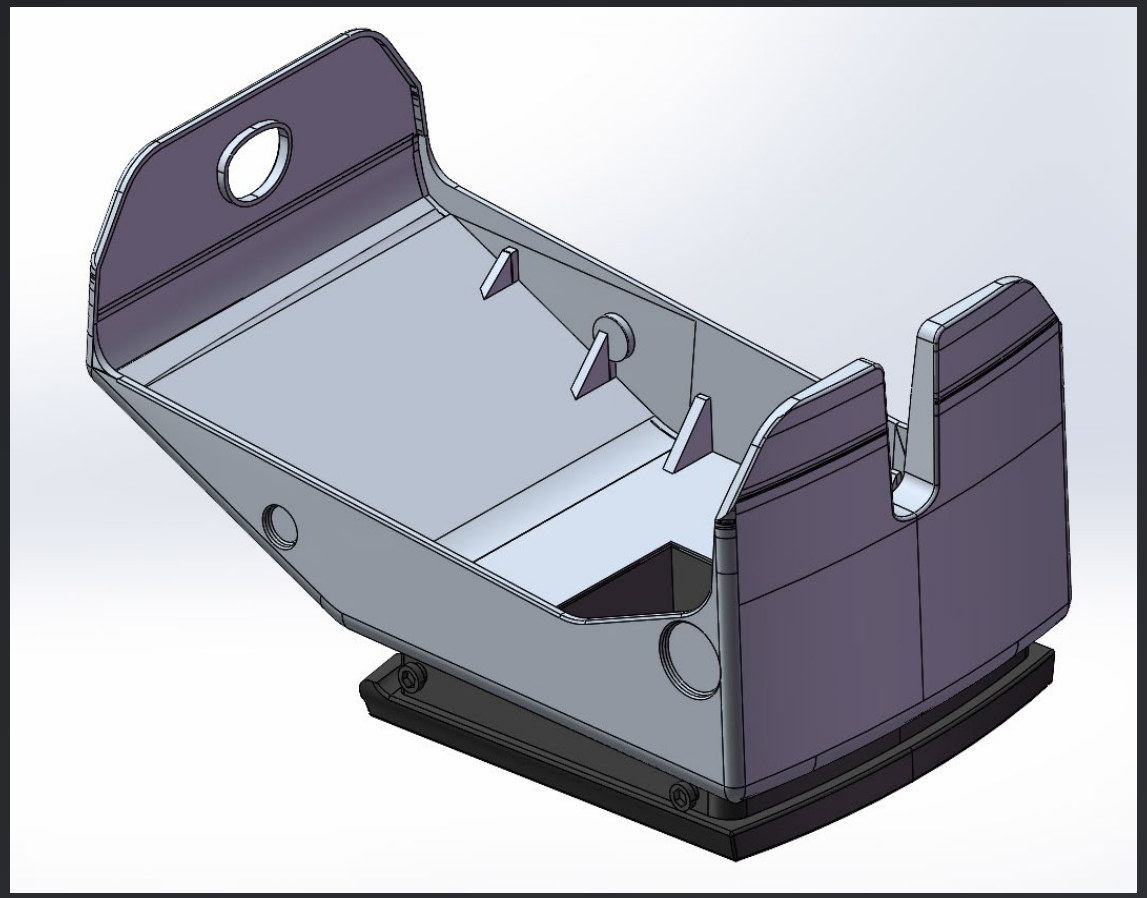
The first version

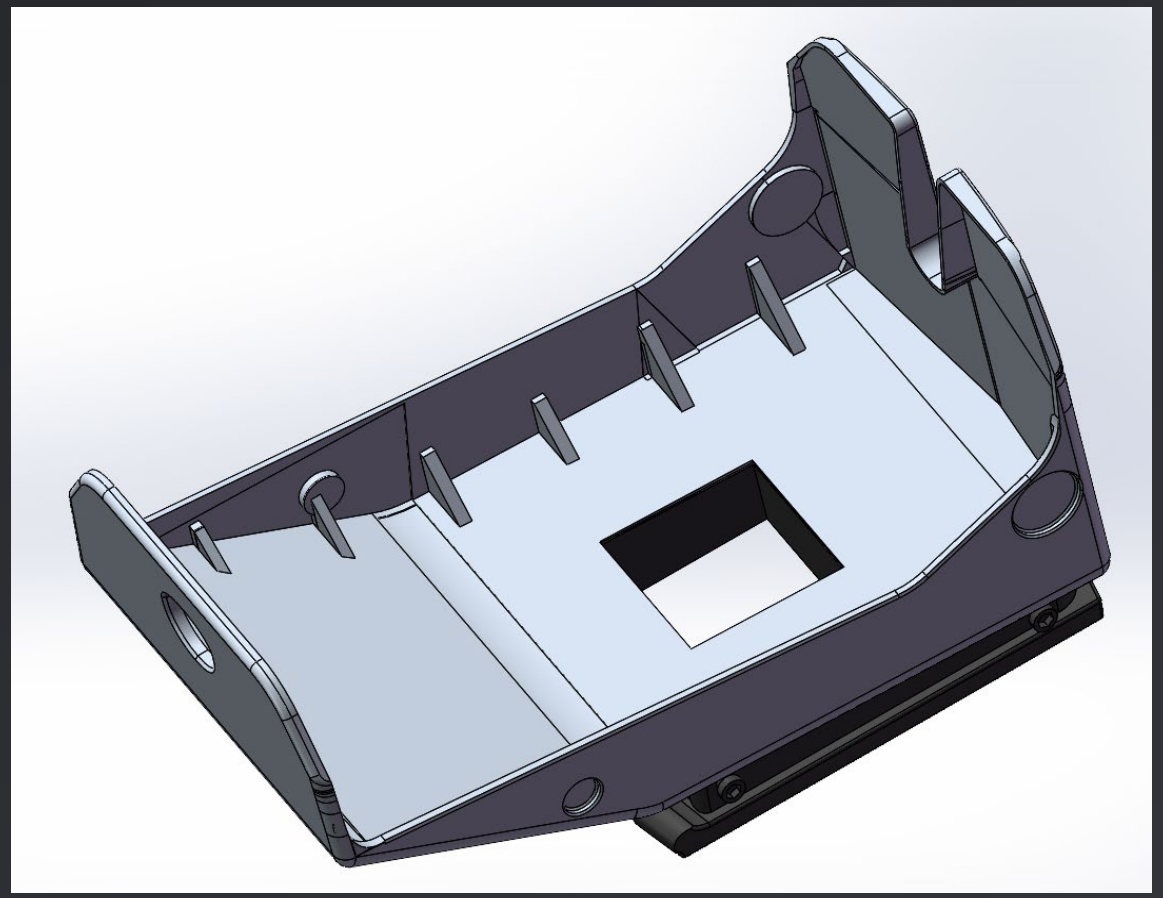
Establishment of vehicle engineering characteristics



Existing problems： Overthickness

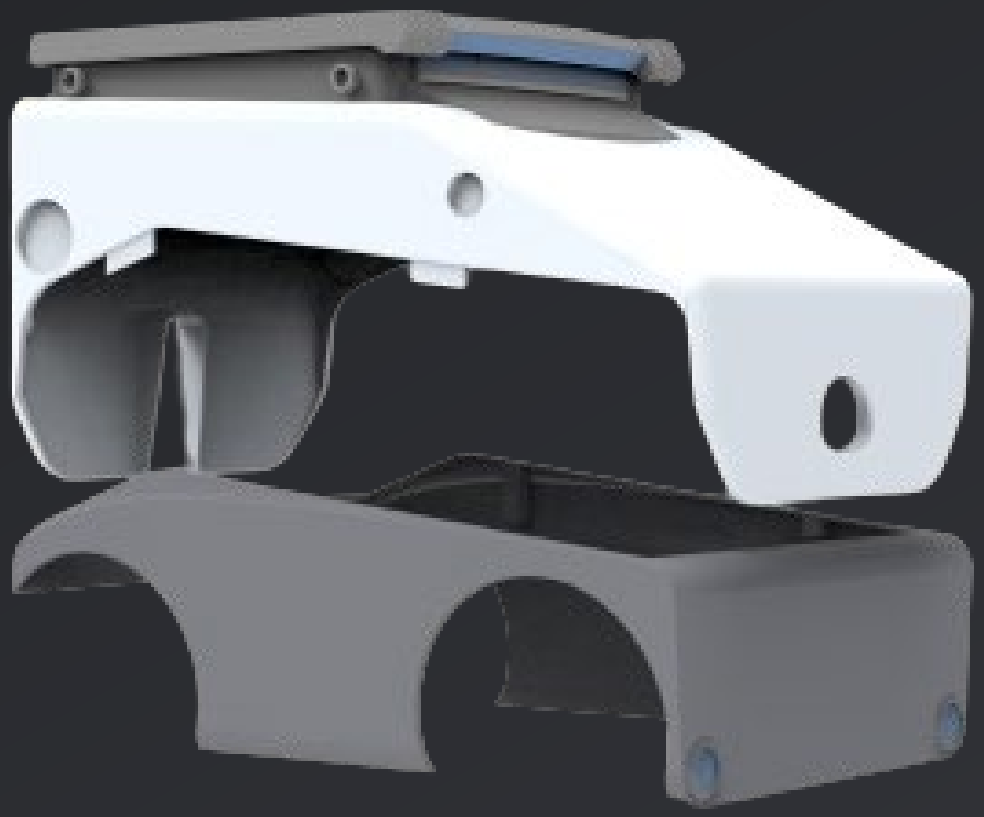
Establishment of vehicle engineering characteristics





The final version

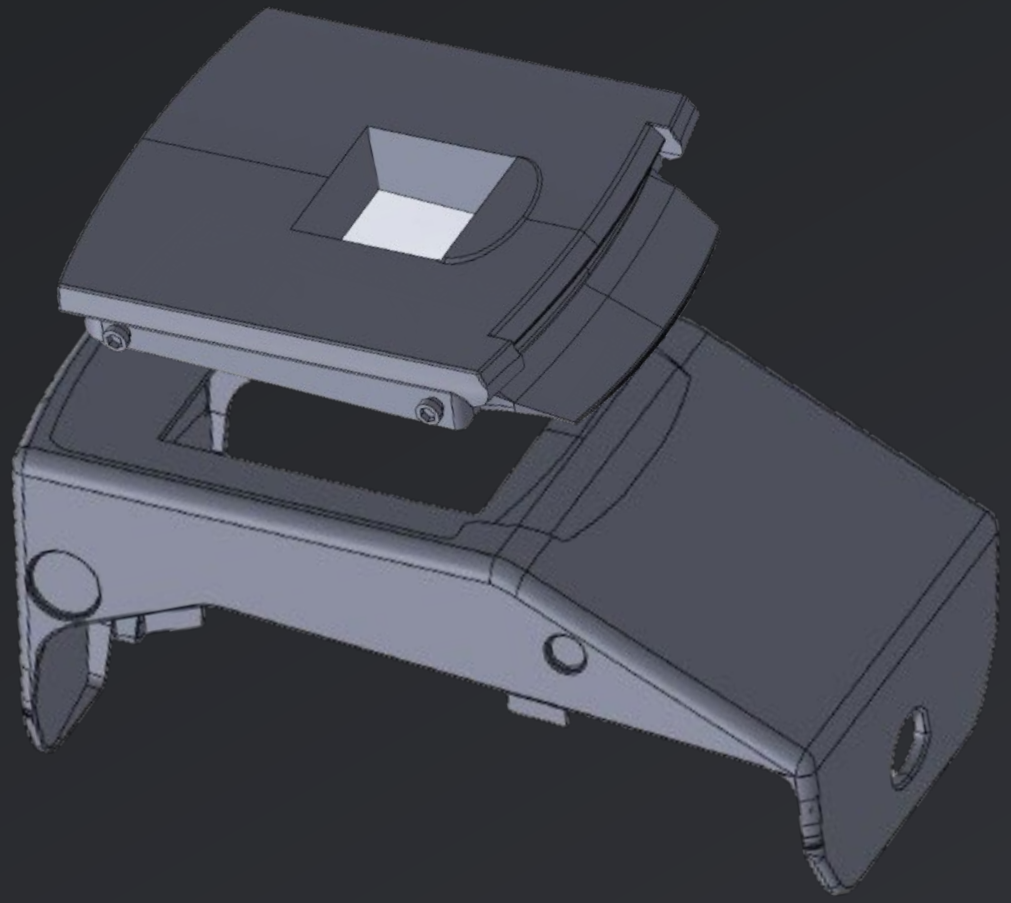
Connecting structure

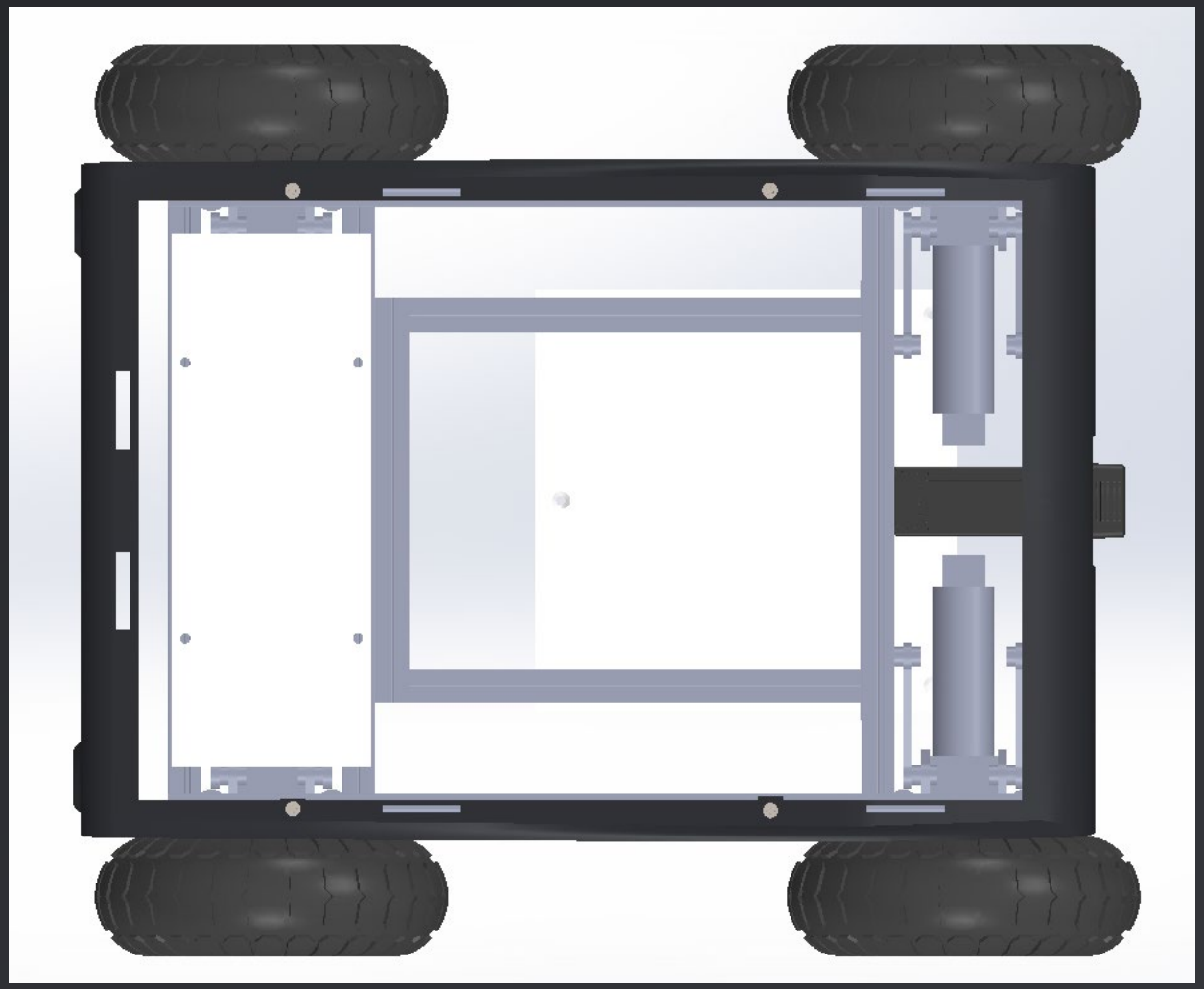


the connection between double shell

Connecting structure

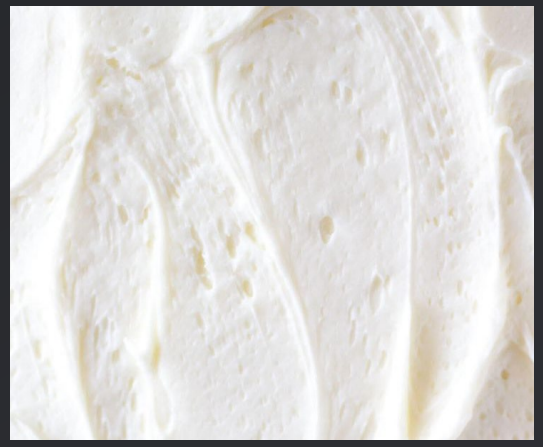
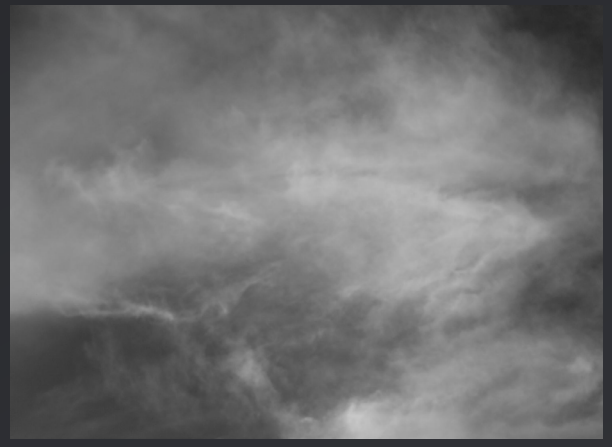
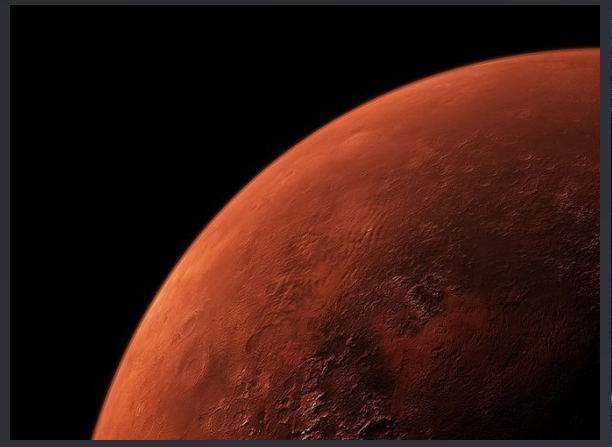
- Bolted connection
- adhesive connection





Color Selection

- Use Kansei engineering to decide the color scheme
- Base color：White + Gray
- Ornamental color
  - Mars red → Technology
  - Royal blue
  - Navy grey → Reliable


Final Model

Comparison of the reference scheme with the final product

(The car size: 53.0cm × 59.7cm × 41.3cm)

Reduce the burden of manual labor

HOW TO Reduce the burden of manual labor

HOW TO Reduce the burden of manual labor

Automated Mobility

Flexible Placement

Parallel Operation

BASIC PROCESS WORKFLOW BY PHASE

PHASE 1

Take UYCL 360 to the working place

More Intuitive Control
Multi-machine Movement

PHASE 2

UYCL 360 scans the rooms on this floor automatically

More Automatic Scanning
More Precise Positioning

PHASE 3

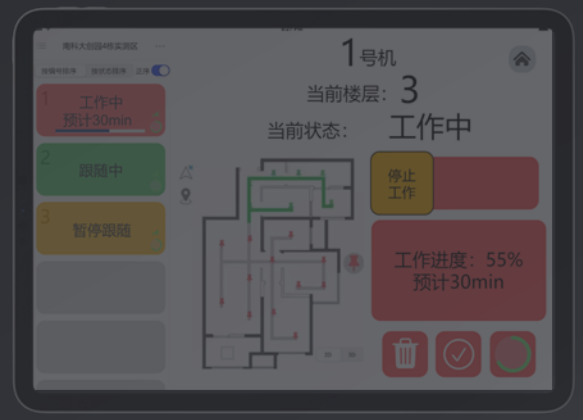
Achieve Multi-UYCL 360 cooperation

Multi-machine Scheduling
Multi-thread Management

PHASE 4

Check the point cloud and take machines back

More intuitive Visualization
Controllable Error Repair



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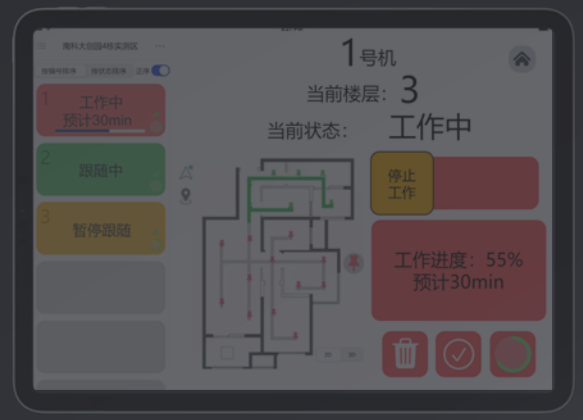

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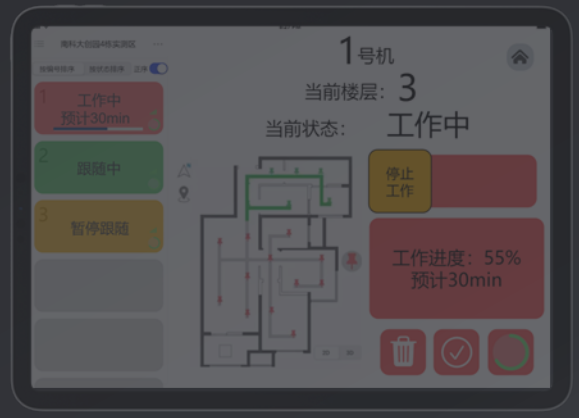

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Automated Mobility – Follow-up Solution

- Construction sites feature Complex Terrains
- Challenging to Control Multiple Robots simultaneously

UWB (Ultra-Wideband) technology TOA algorithm: Frequency ≈ 14Hz, Accuracy ≈ 0.2m

Each UYCL 360 is positioned in relation to the follower by two base stations,
and also ascertain its relative position to other UYCL 360.

Adopting the most intuitive control methods to free technical workers from the
Hands-on, Visual, and Cognitive demands of traditional remote controllers.

Flexible Control – Adjusting Handle

Steps or Terrain

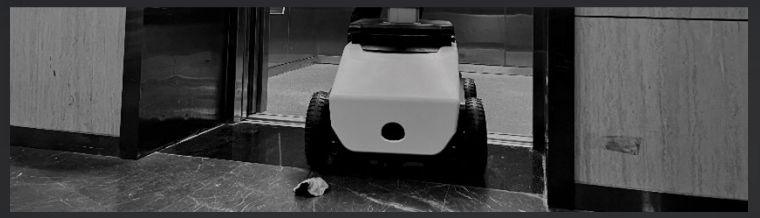
Initialize the Location

Into the Elevator

Flexible Control – Adjusting Handle

Steps or Terrain

Initialize the Location



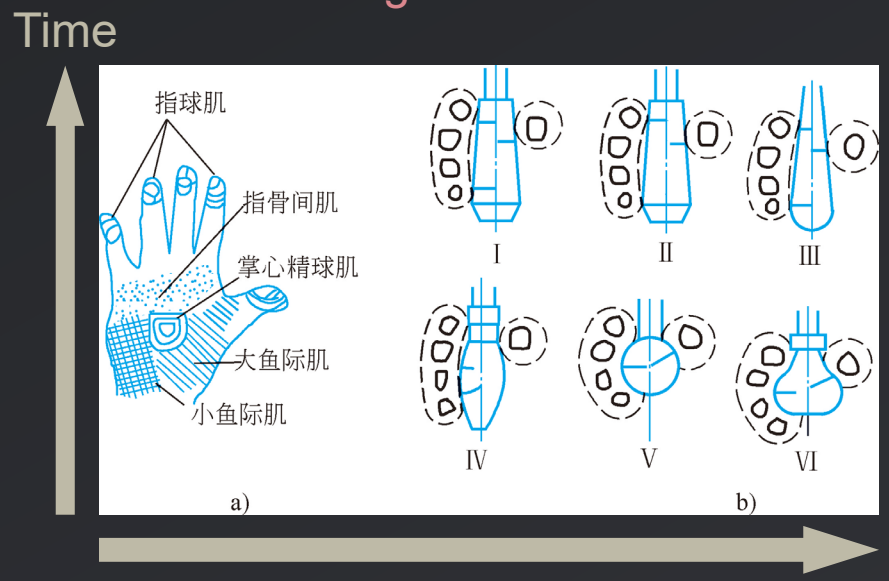
Into the Elevator

Flexible Control – Adjusting Handle

More Comfortable

Lift · Drag · Hold

- The handle diameter is 46mm, allow maximum grip strength.
- Small curvature to help distribute the forces.
- A slight inclination brings the heel of the palm into contact and keep the center of gravity on the line of force.
- The handle can be raised to a position of 93.6cm, which is in line with the height of force exerted for adult men to carry.



- For handles that are “lifting" on both sides, use medium burst + medium time.
- For the front "pull" handle, use small bursts + long time.

Flexible Control – Adjusting Handle

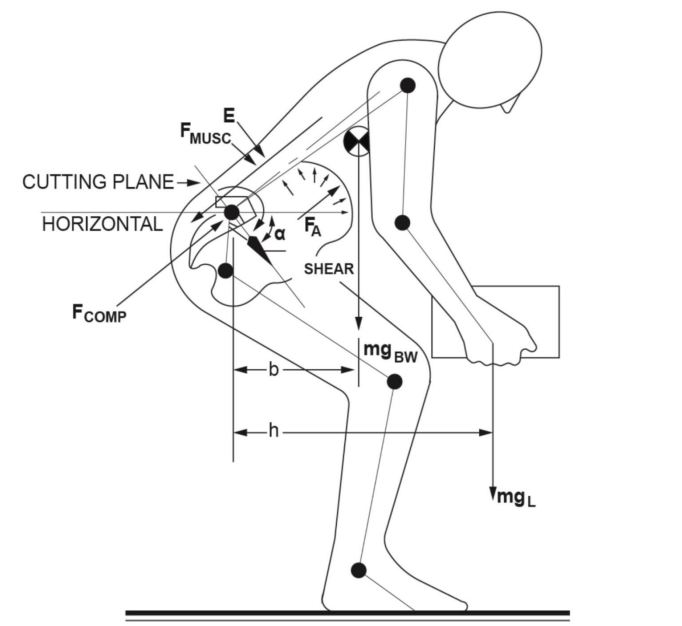
More Safe

Biomechanical Models

Low-back biomechanics of lifting

Ensure that the most vulnerable link of the musculoskeletal system is safe

Calculate the stress on the body structures at the low back (especially at the L5/S1 lumbosacral disc).



$$M = W_{load} \times h + W_{torso} \times b$$

$$\sum forcesatthe\mathrm{L5/S1}disc) = 0$$

$$\Rightarrow$$

$$F_{comp} = W_{load} \times \cos\alpha + W_{torso} \times \cos\alpha + F_{back-muscle}$$

Flexible Control – Adjusting Handle

More Safe

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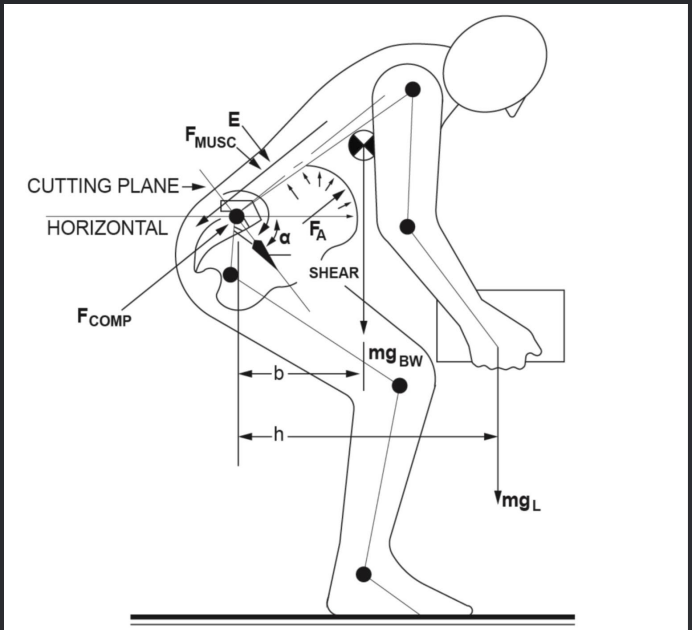


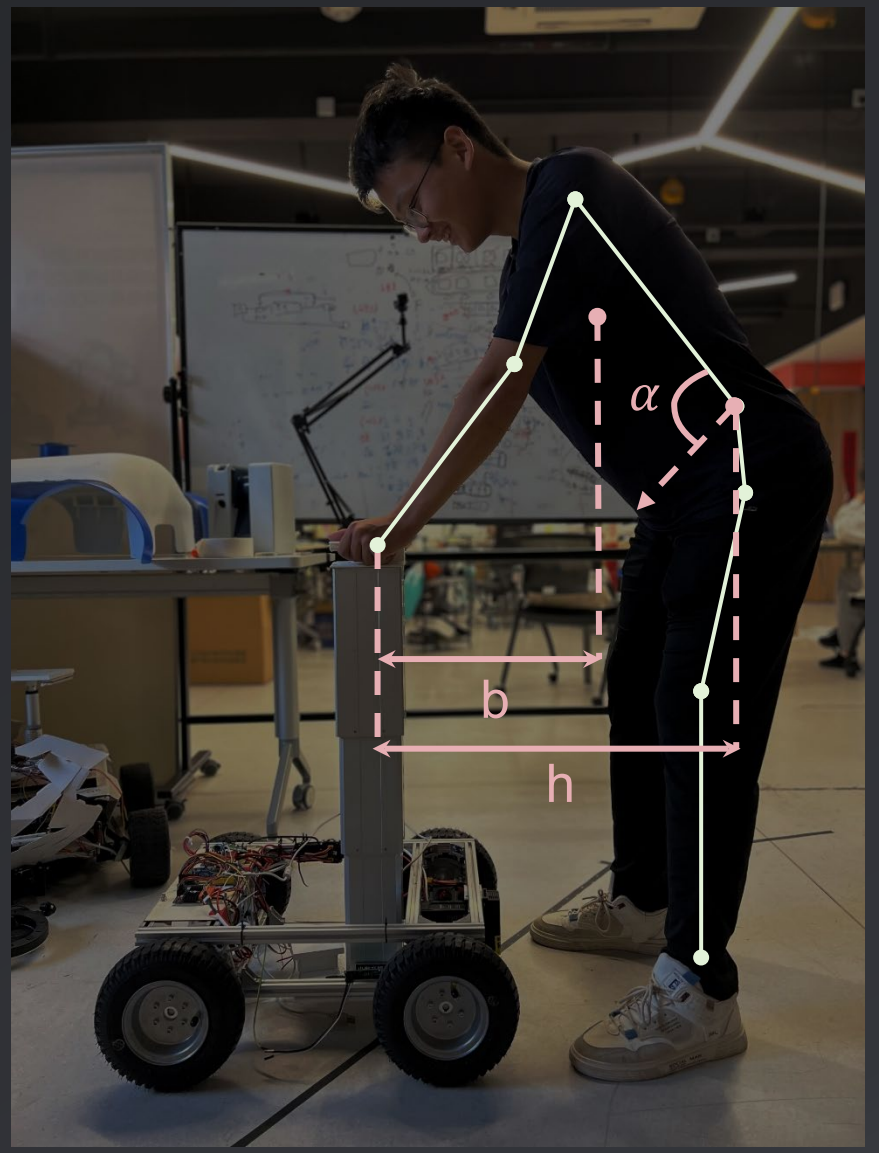
Ensure that the most vulnerable link of the musculoskeletal system is safe

Calculate the stress on the body structures at the low back (especially at the L5/S1 lumbosacral disc).

Assuming h = 25cm, b = 35cm, α = 75°, W_{load} = 20kg, we can obtain:

$$F_{comp} = 200 * 7 + 350 * 5 + 200*\cos(50°) + 350*\cos(50°) = 3292.70\ \text{N}$$

$Which\ is\ Smaller\ than\ 3.4KN$, A criterion that is associated with increased risk of low-back injury.



Make UYCL 360 more reliable

HOW TO Make UYCL 360 more reliable

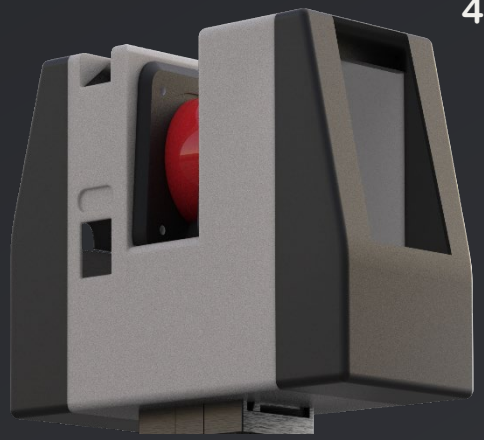
HOW TO Make UYCL 360 more reliable

Scanner structure

Shell connection

Handle optimization

Scanner structure simulation

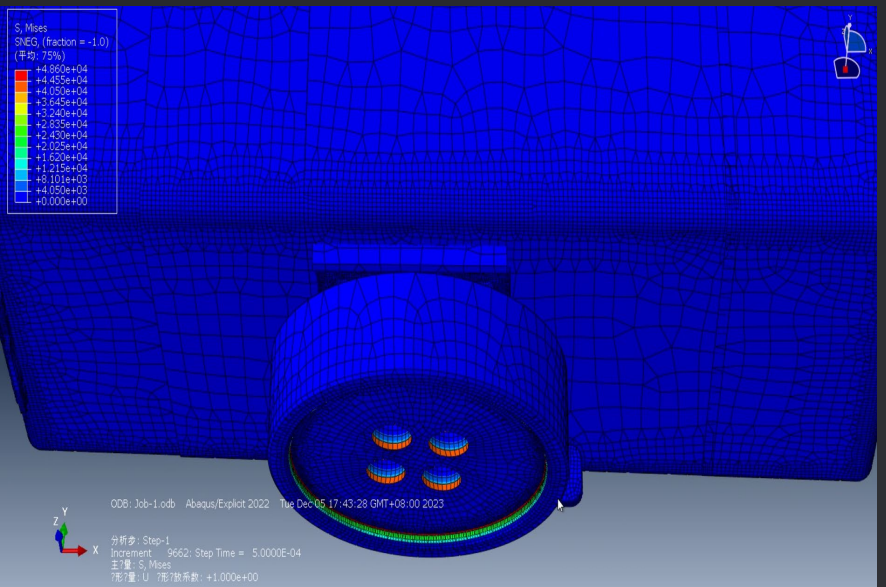


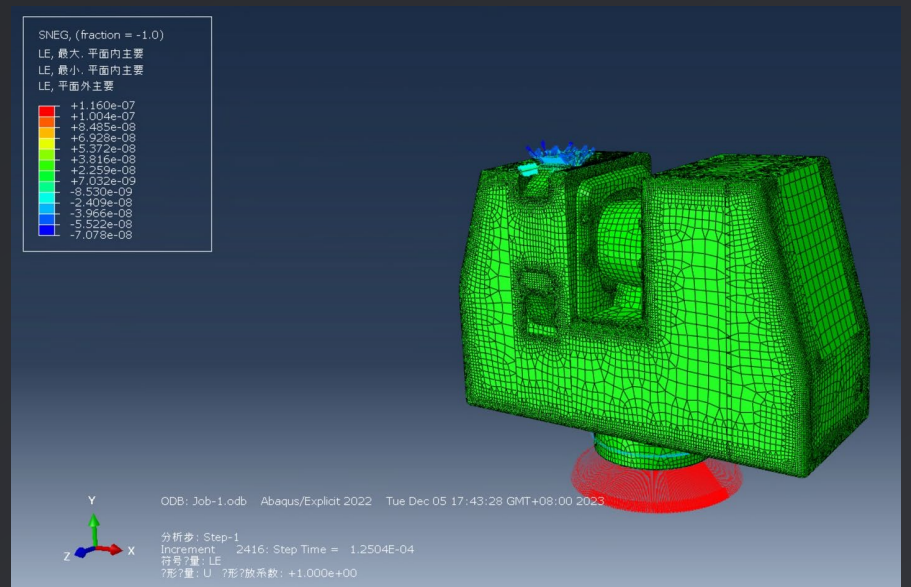
Static Analysis

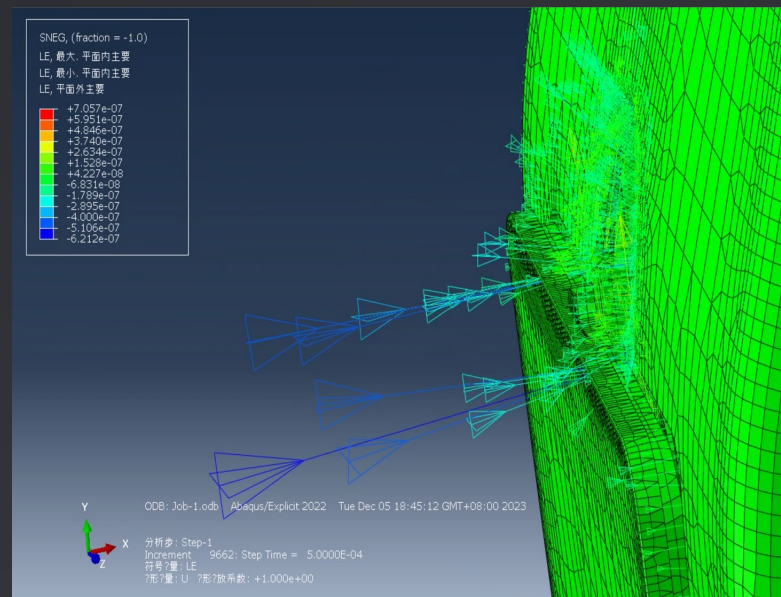
The scanner’s velocity and acceleration are 0.
The main stress point is in the threaded hole and the connecting part of the head

Kinetic Analysis

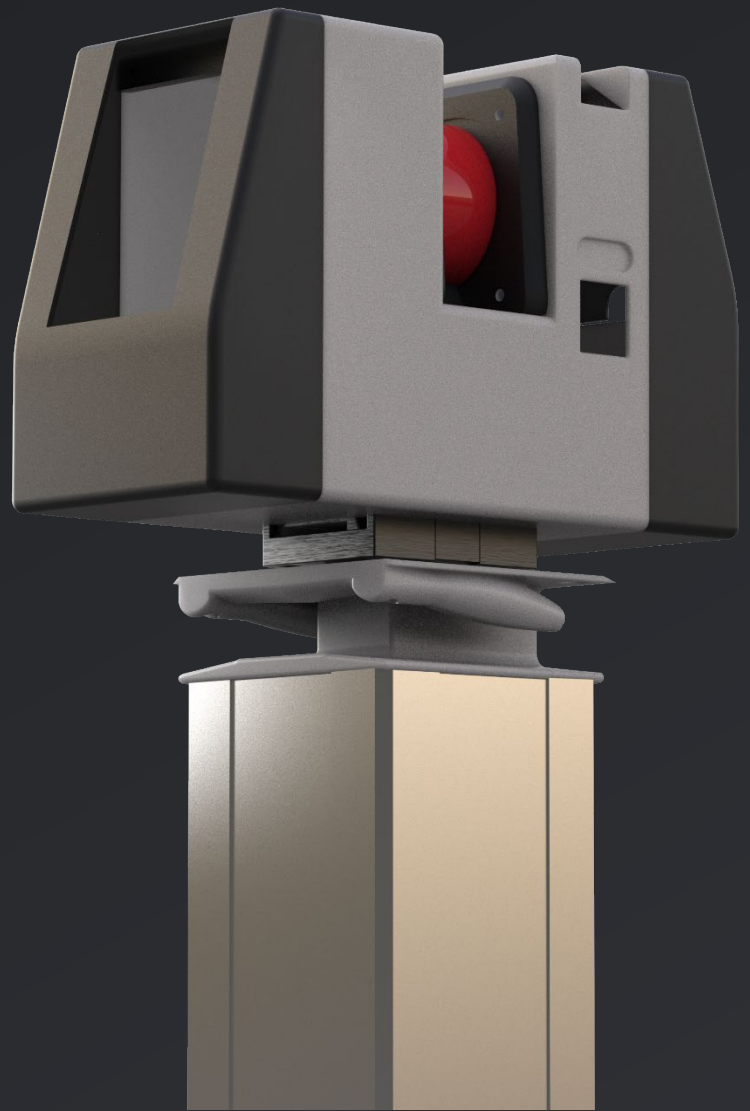
The velocity of scanner is 0
The acceleration is 1m/s
The main load point and the maximum strain part are near thread hole, and the force on the shell part is small
Therefore, the connection part need to be designed bearing force.







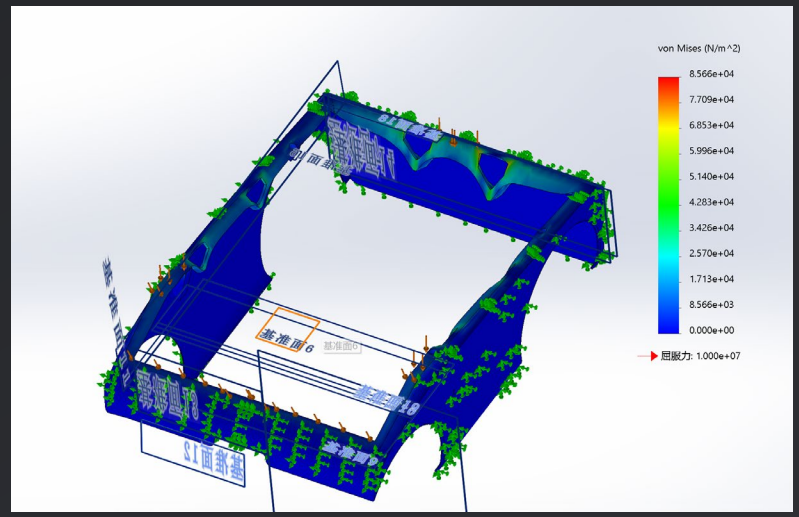
Scanner structure simulation



Connection optimized

- We use non-bearing structure, because the force is mainly generated in the acceleration stage,
- Select thicker screw.
- In order to fit tripod connection board, the width of connection part is fixed.

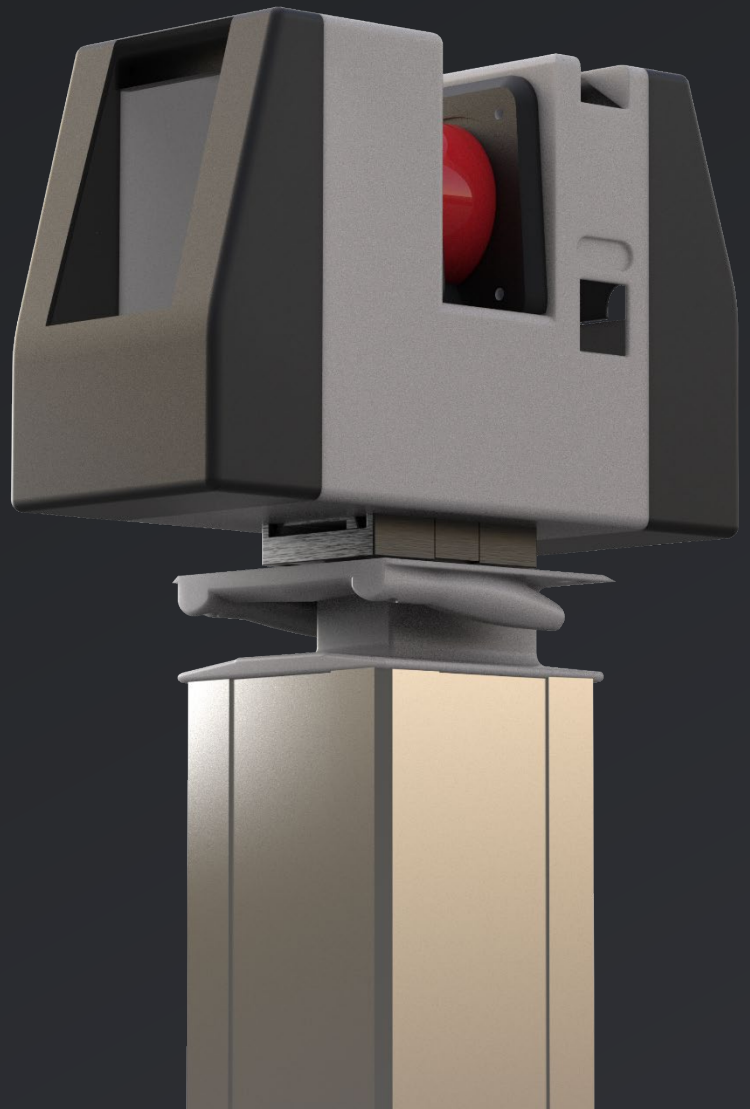
Shell connection simulation



Structure verification

- The lower shell’s velocity and acceleration are 0.
- Apply 5kg pressing force to the lower shell.
- The simulation results show that connecting with the buckle type, and the safety factor is much greater than 1.
- The strain of the lower shell is tiny.

Handle simulation



Dimension:

- 125*125*45mm

Load:

- Scanner ≈ 50N
- Handle ≈ 175N

Print Parameters:

- Thickness = 0.2mm
- Filling rate = 25%
- Printing speed = 60

Yield stress ≈ 27MPa

Polylite PLA Properties

MECHANICAL PROPERTIES

Property	Testing Method	Typical Value
Young's modulus (X-Y)	ISO 527, GB/T 1040	3426.9 ± 64.8 MPa
Young's modulus (Z)		3064.9 ± 83.4 MPa
Tensile strength (X-Y)	ISO 527, GB/T 1040	52.3 ± 0.3 MPa
Tensile strength (Z)		40.5 ± 0.5 MPa
Elongation at break (X-Y)	ISO 527, GB/T 1040	6.3 ± 0.6 %
Elongation at break (Z)		1.8 ± 0.1 MPa
Bending modulus (X-Y)	ISO 178, GB/T 9341	3230.9 ± 55.3 MPa
Bending modulus (Z)		N/A
Bending strength (X-Y)	ISO 178, GB/T 9341	86.9 ± 1.2 MPa
Bending strength (Z)		N/A
Charpy impact strength (X-Y)	ISO 179, GB/T 1043	3.3 ±0.2 kJ/m^2
Charpy impact strength (Z)		N/A

3D Printing Parameters

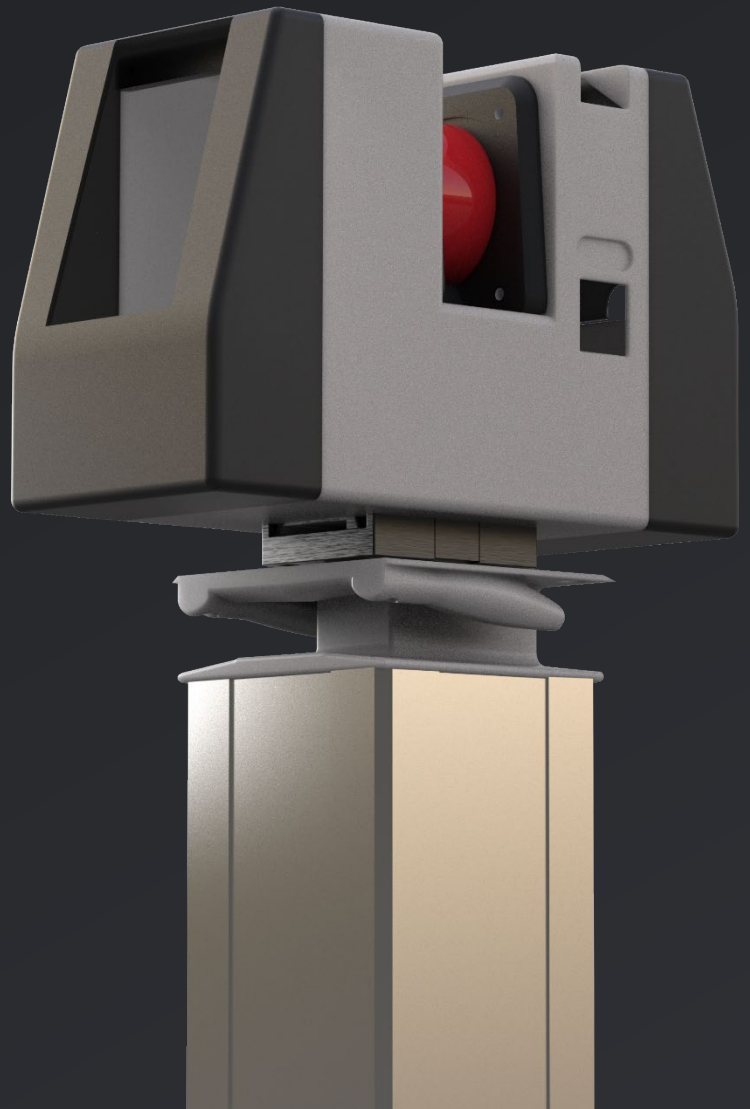
表 1　因素水平表

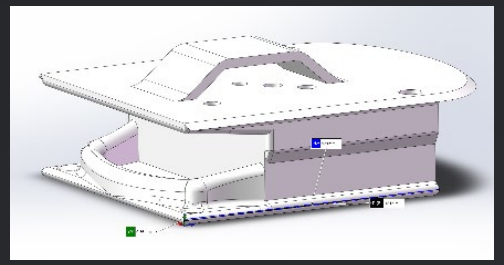
水平	因素				
	打印层厚 (A) / mm	填充密度 (B) / %	打印温度 (C) / ℃	填充速度 (D) / (mm · s^{-1})	外壳厚度 (E) / mm
1	0.1	10	210	40	0.4
2	0.15	20	220	50	0.8
3	0.2	30	230	60	1.2
4	0.25	40	240	70	1.6

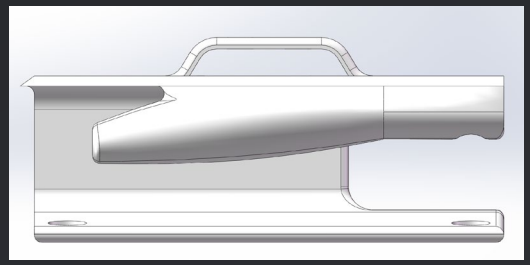
表 4　回归模型计算结果

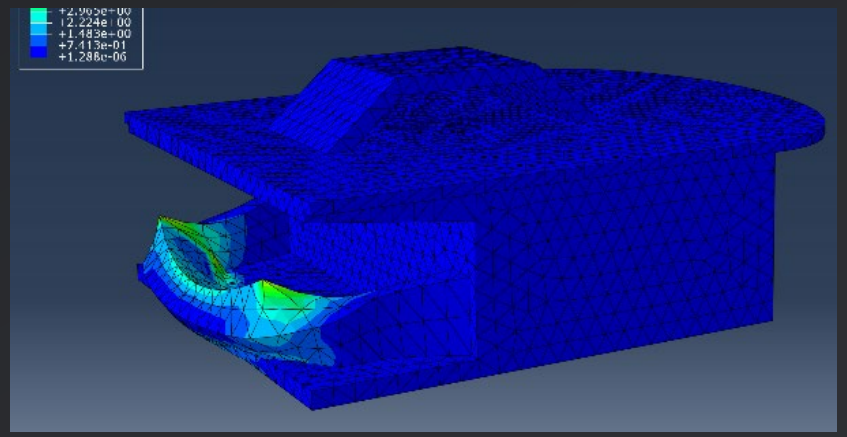
回归系数	回归系数估计值	回归系数置信区间	检验统计量
β_0	30.23	[20.37, 40.08]	R^2=0.95
β_1	−7.50	[−15.81, 0.82]	F=38.71
β_2	0.07	[0.03, 0.11]	P=0.00
β_3	−0.04	[−0.08, 0.01]	S^2=0.70
β_4	−0.03	[−0.07, 0.02]	
β_5	6.07	[5.03, 7.11]	

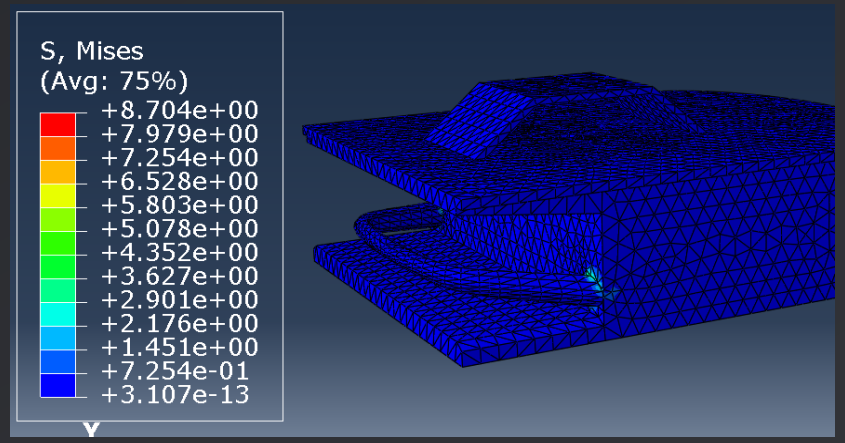
Handle simulation

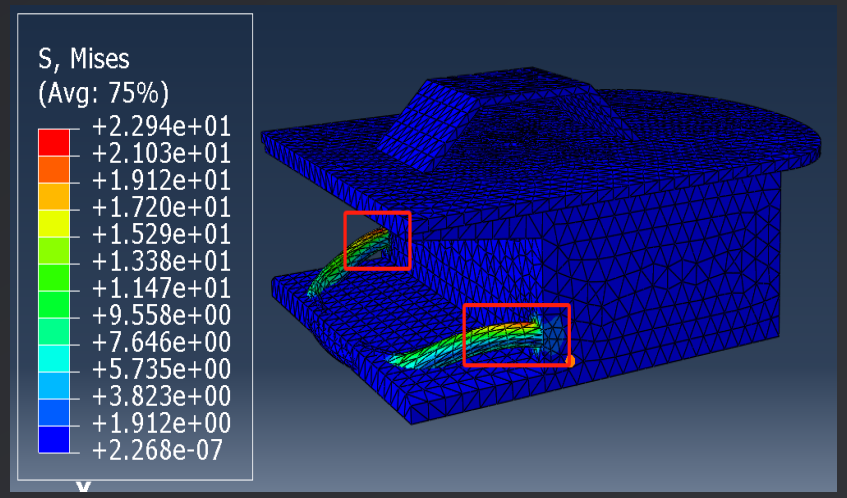


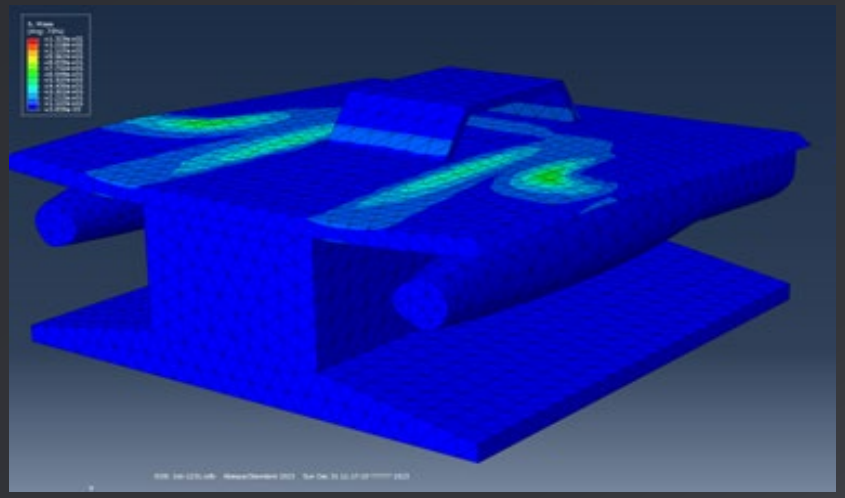




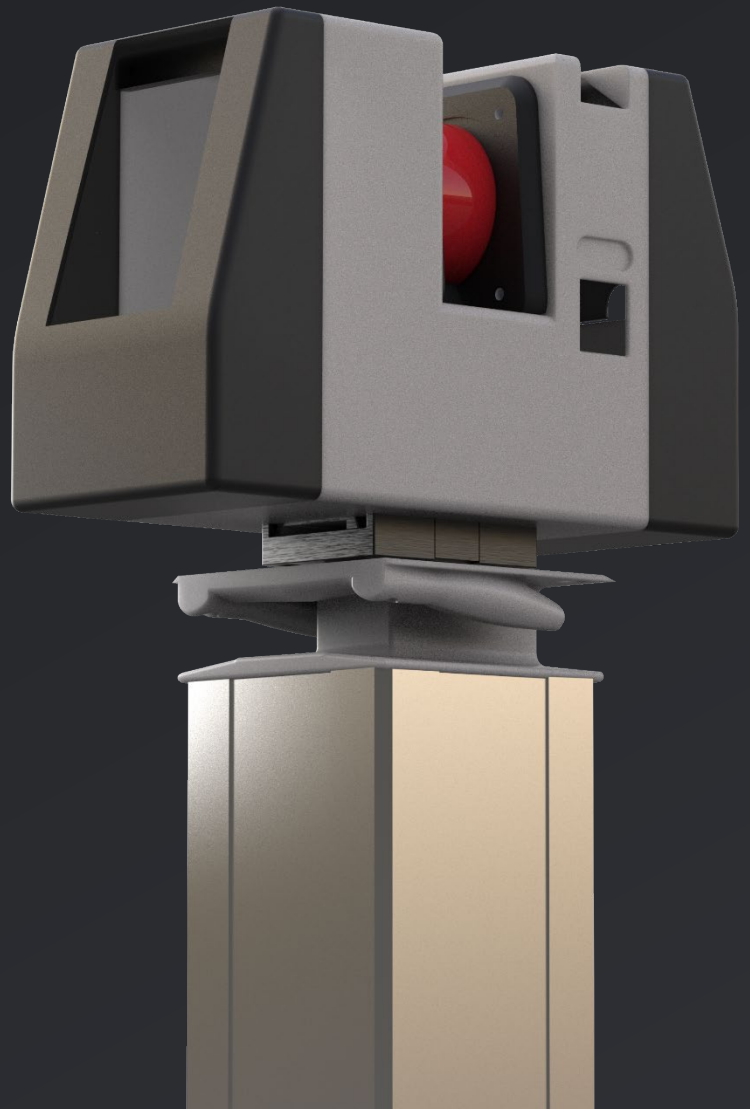


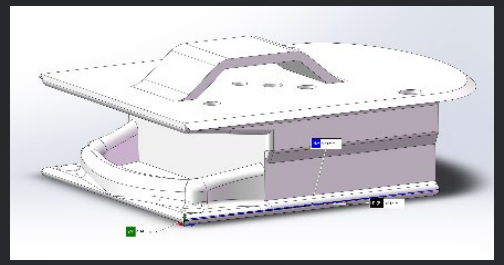


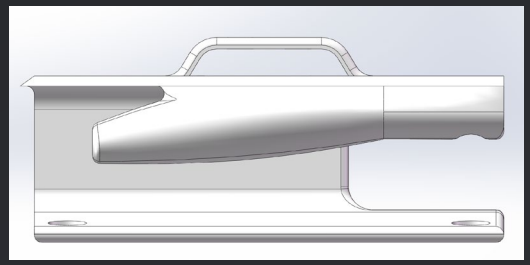


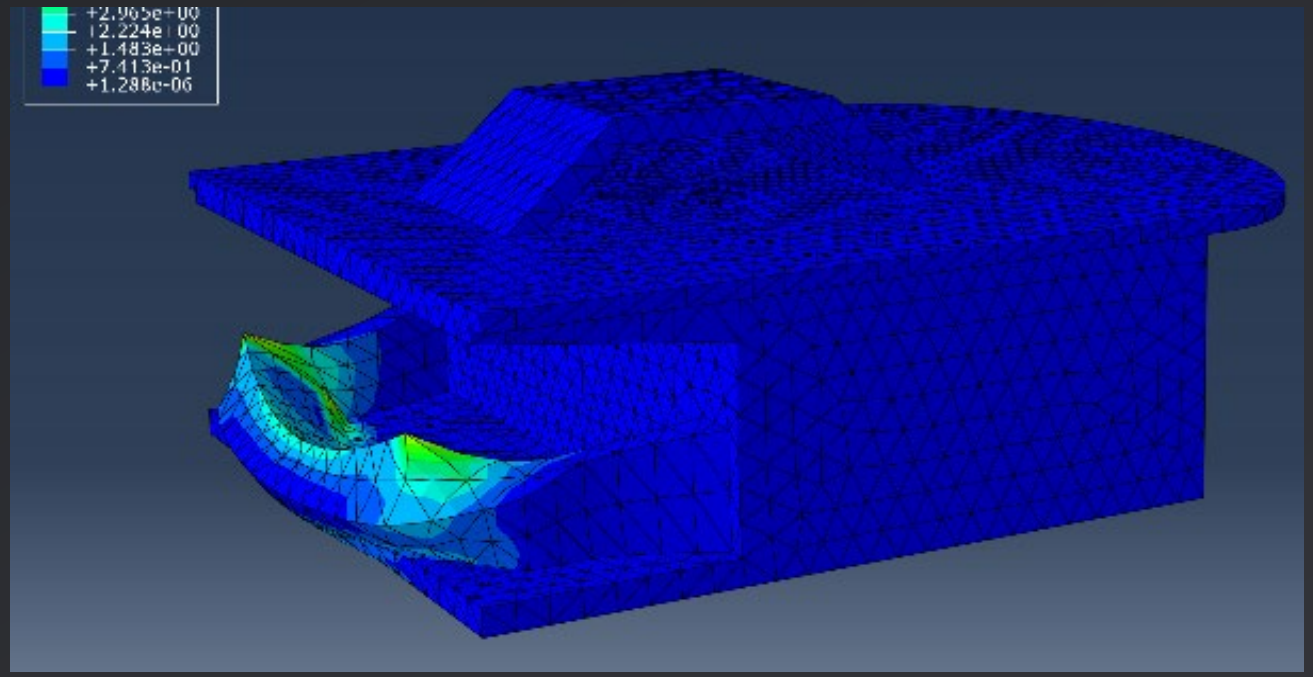


Handle simulation



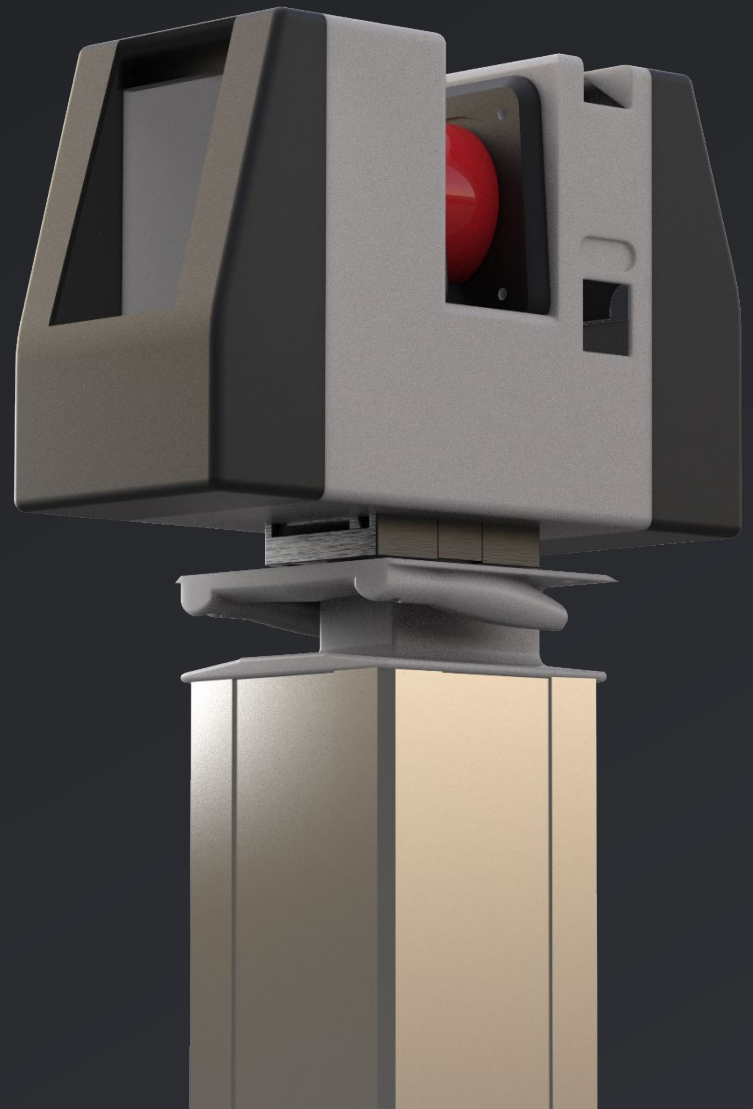


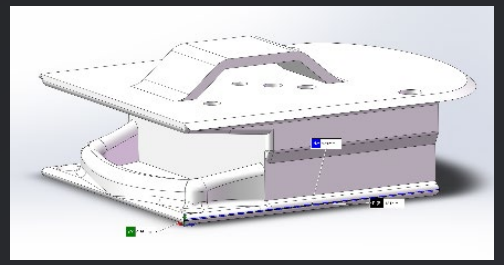


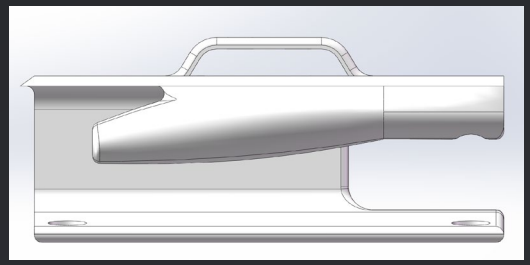


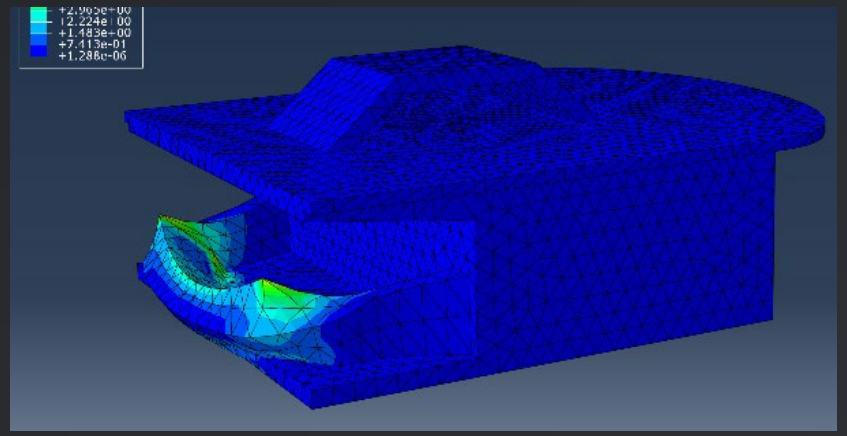
- The safety factor is about nine. So we change the handle structure to cantilever.

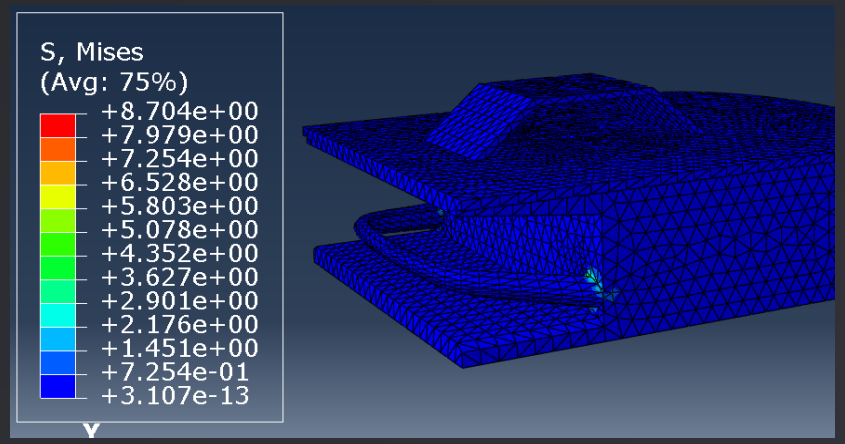
Handle simulation

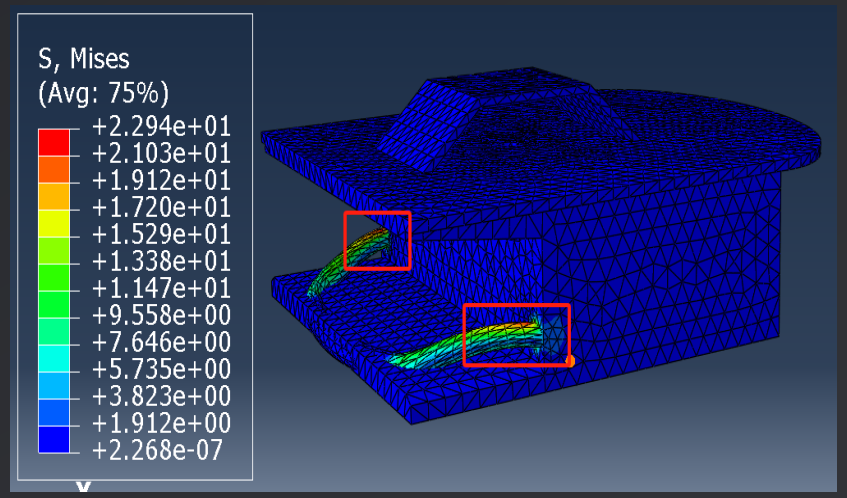


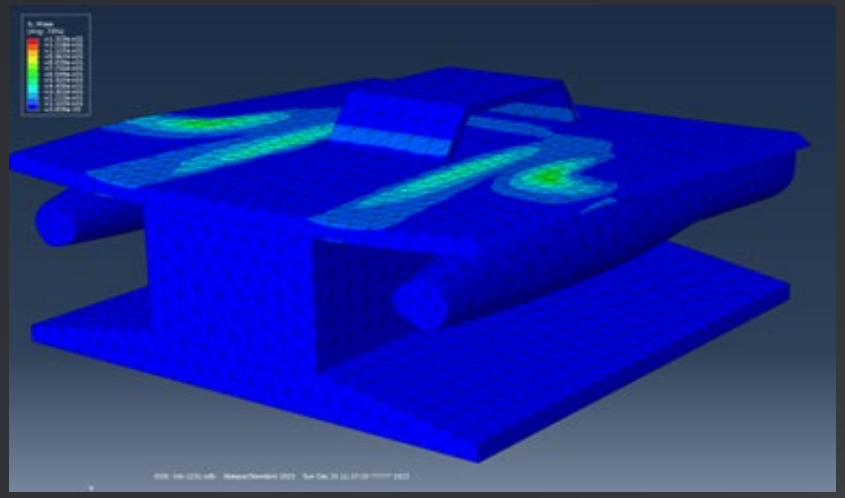




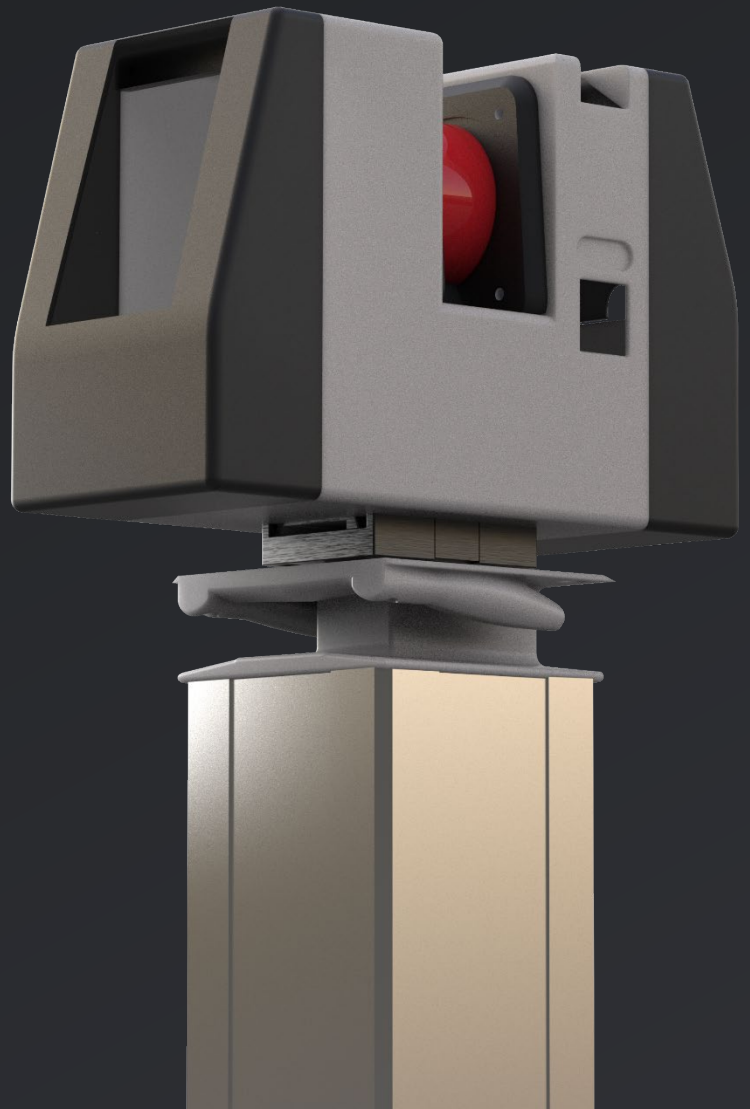


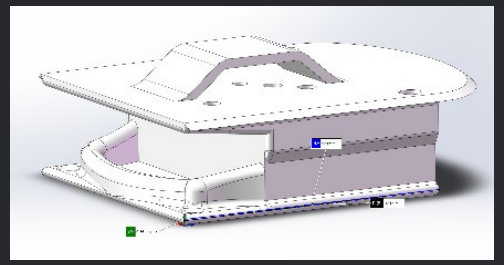


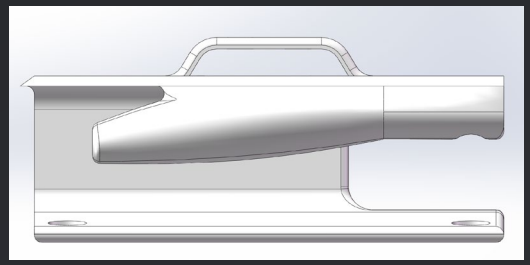


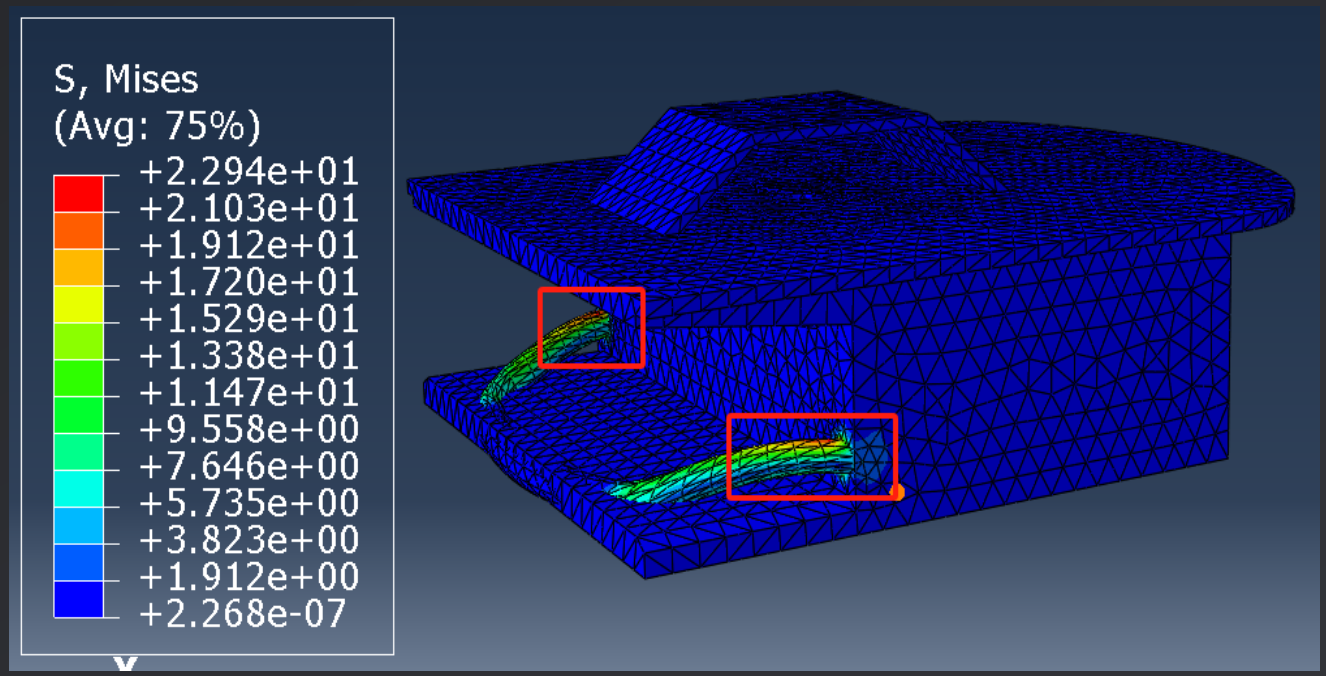


Handle simulation



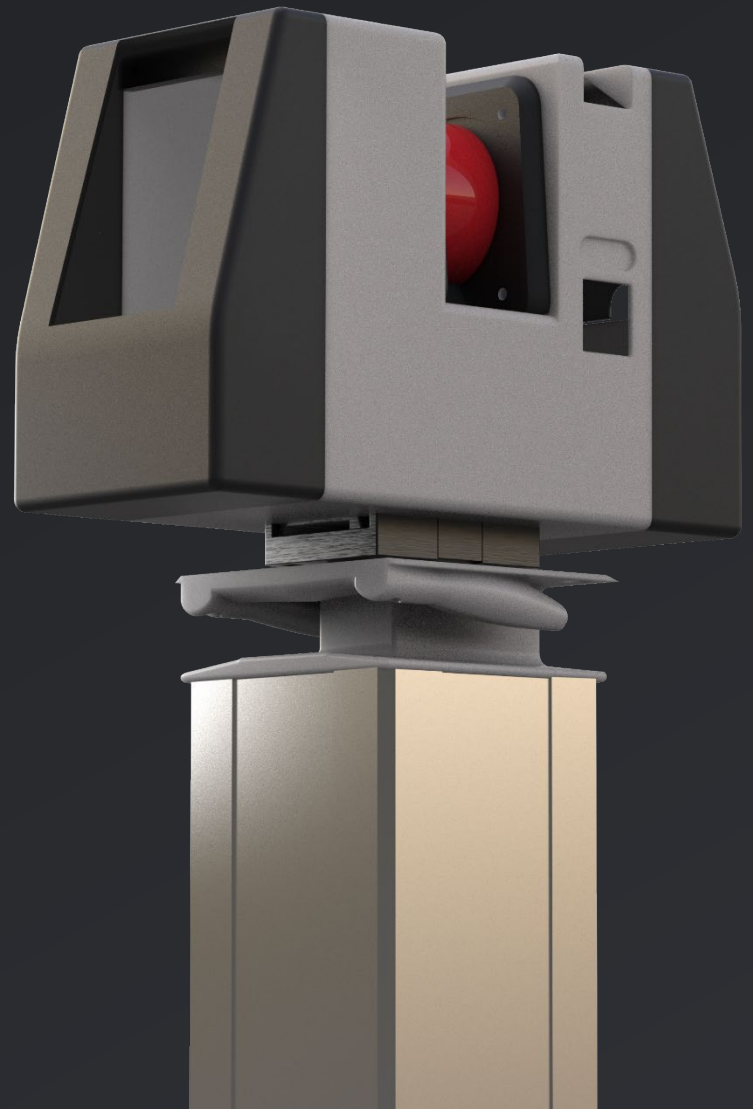


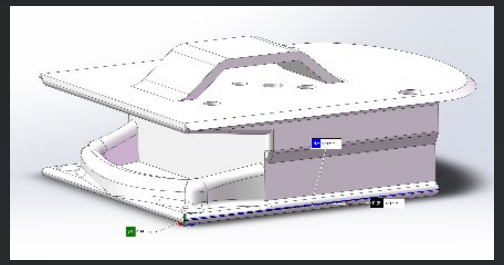


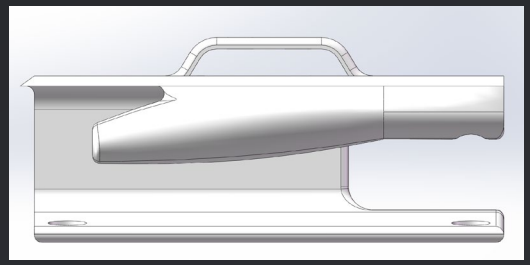


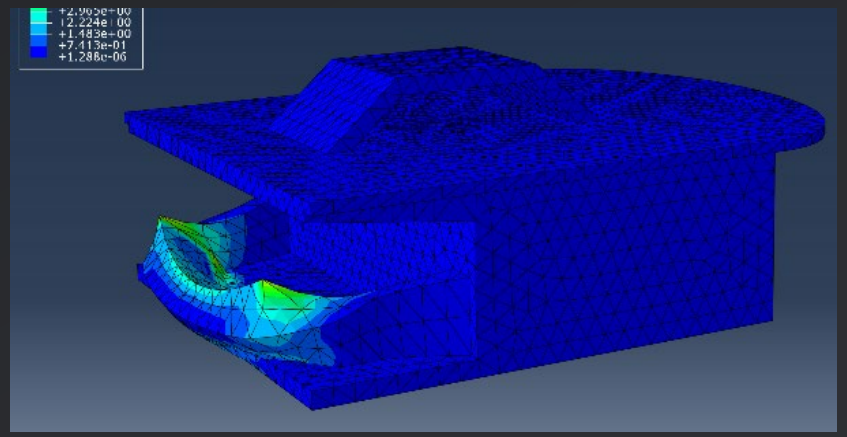
- When the cross-sectional area is uniform, the safety factor is less than 1.5, and the root of the cantilever deform a lot. So make the root thicker and the middle thinner.

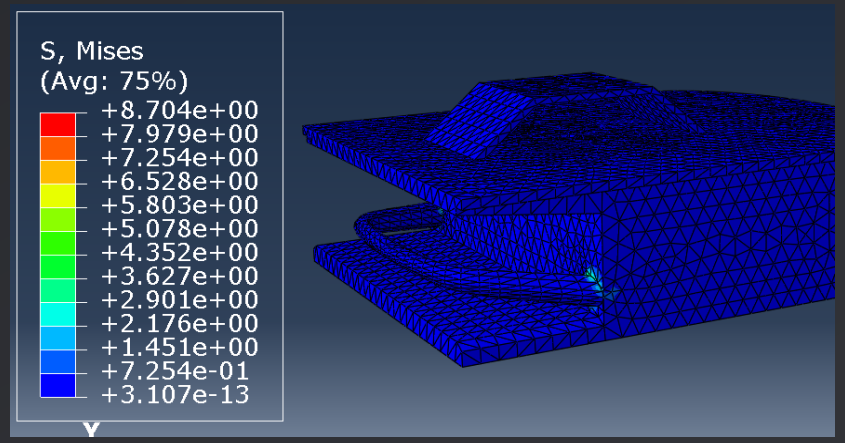
Handle simulation

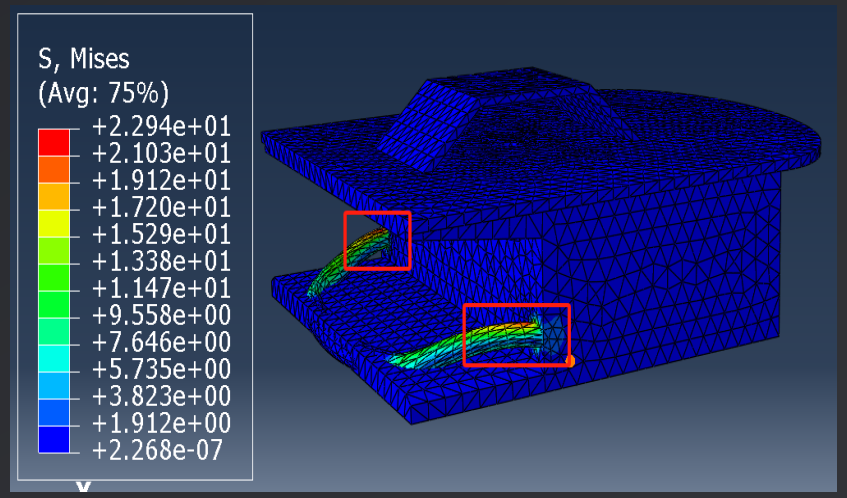


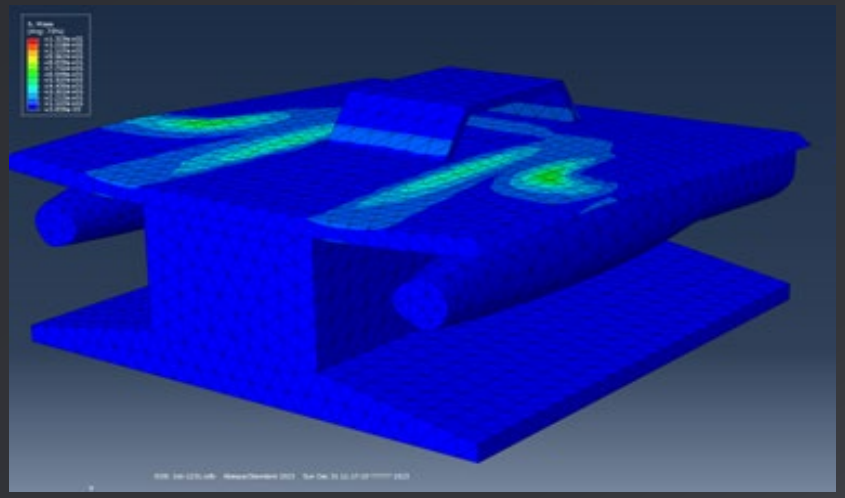




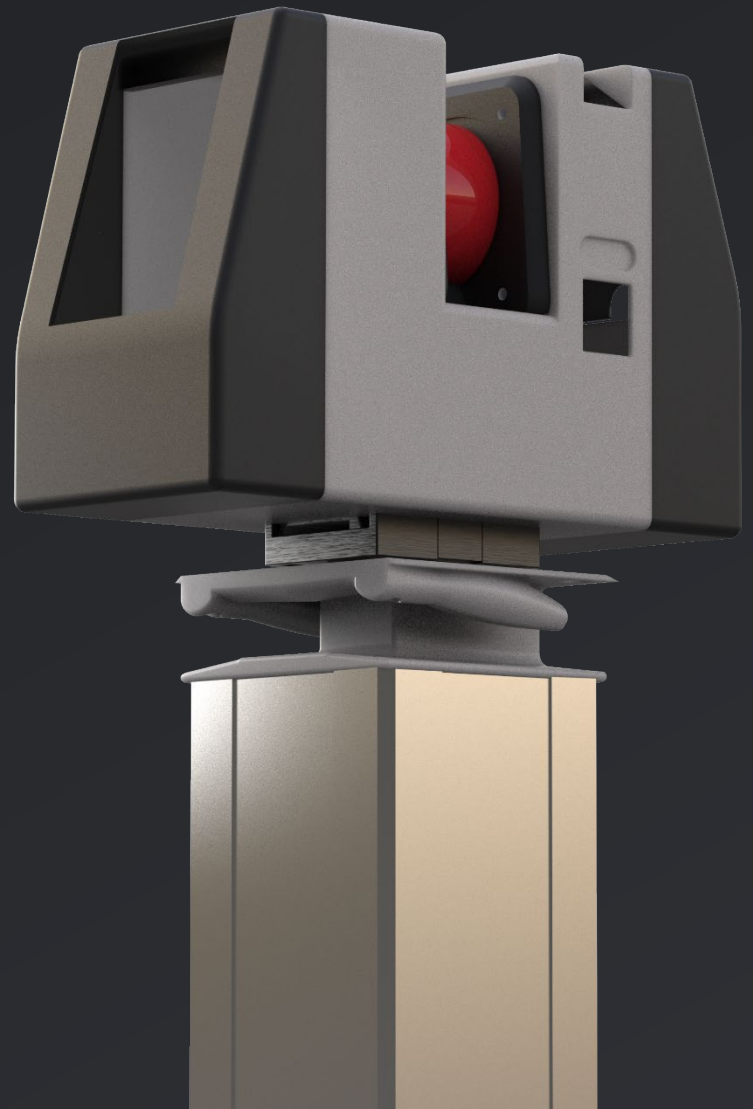


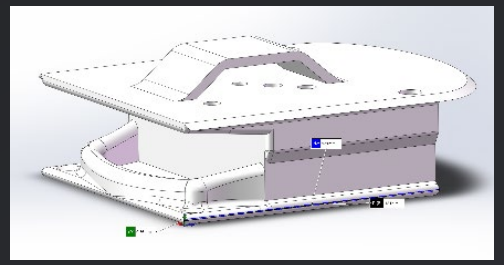


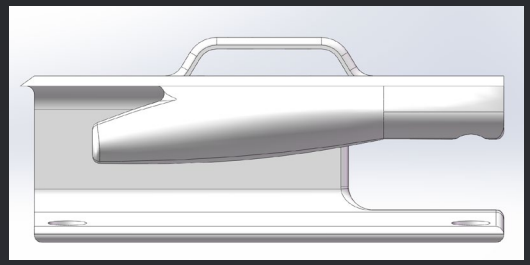


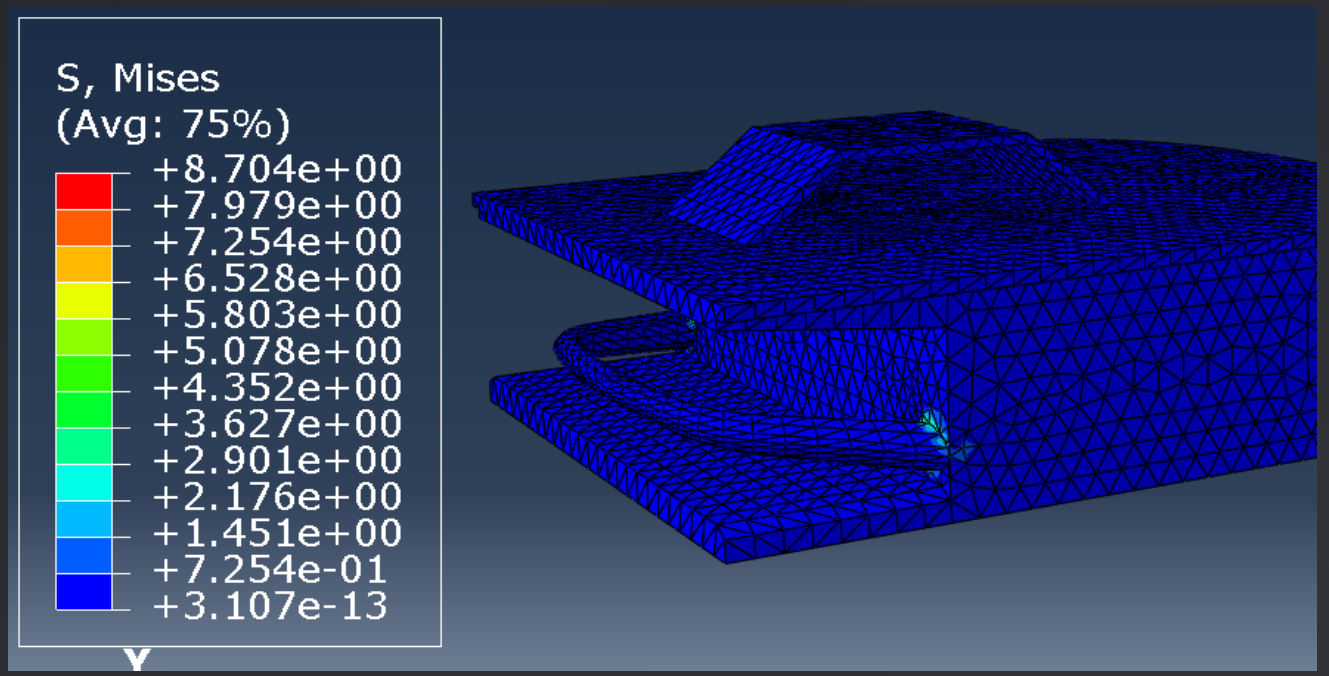


Handle simulation



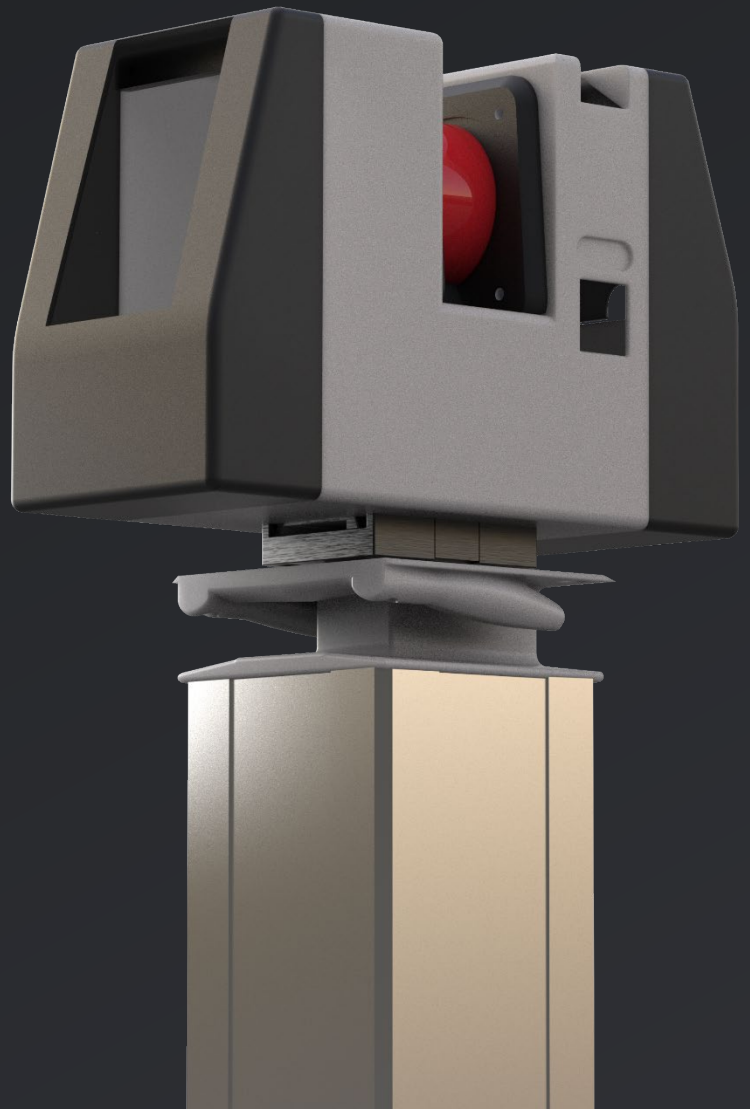


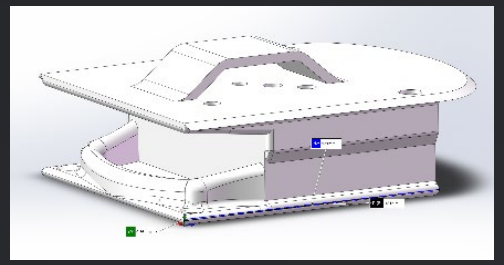


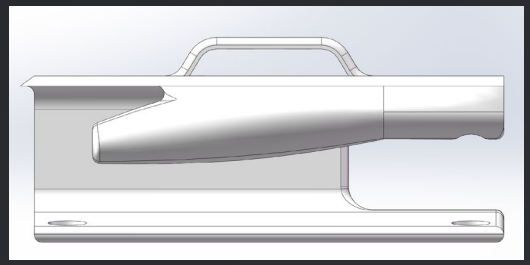


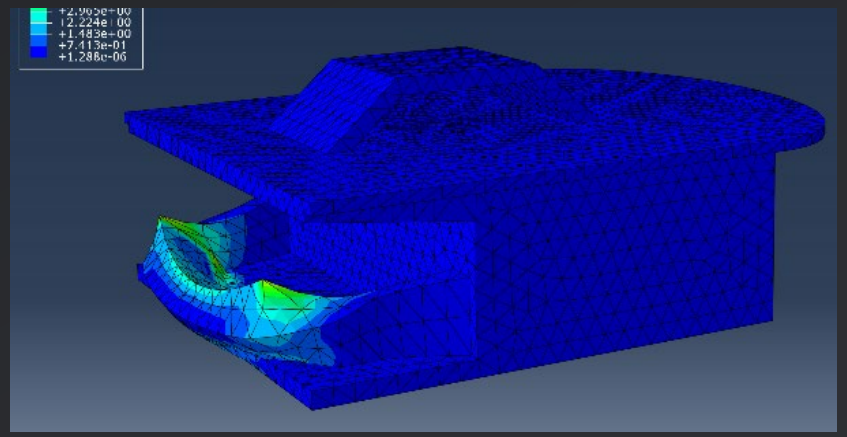
- We increased cross-sectional area in the root by 50% and decreased area in the middle by 20%. The safety factor is about 3.1, and The total material improvement is only 16%.

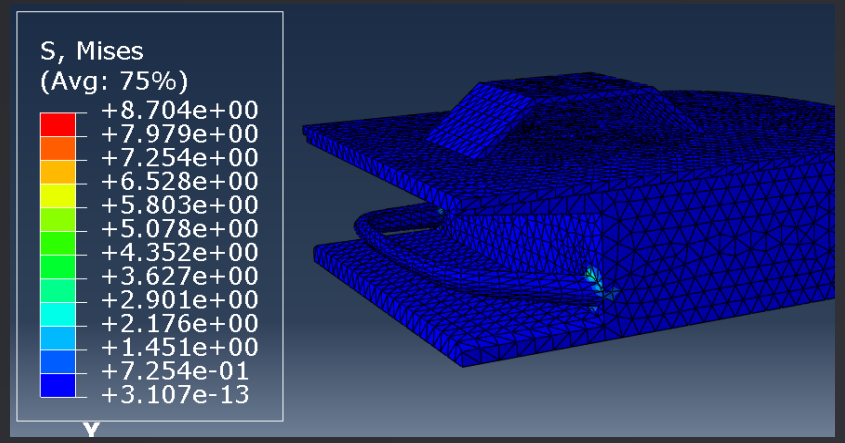
Handle simulation

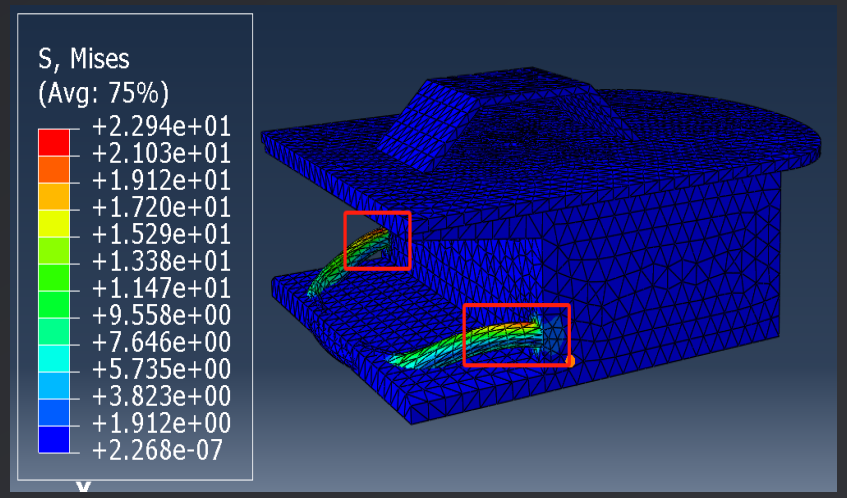


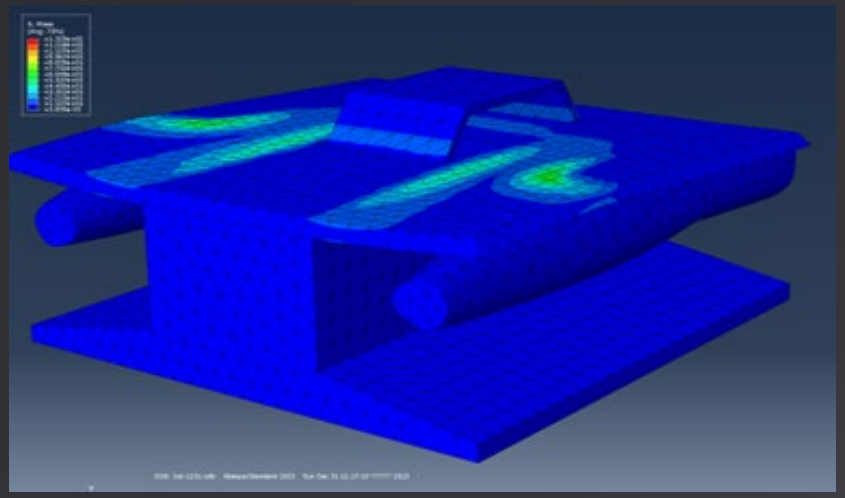




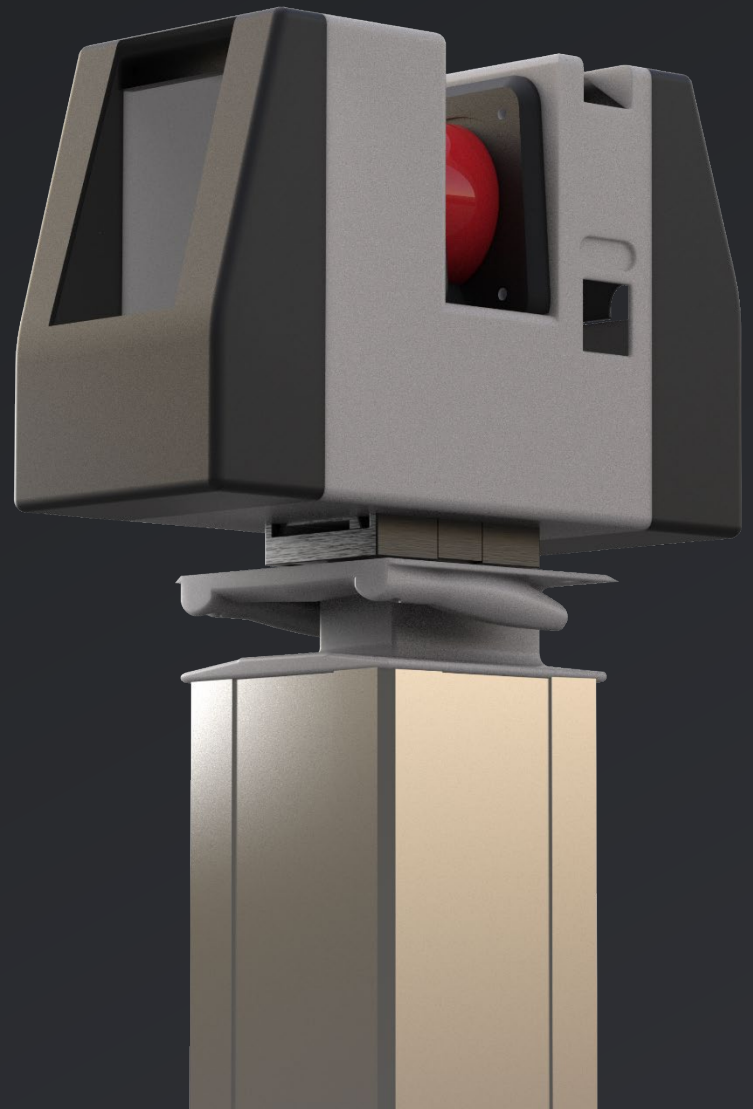


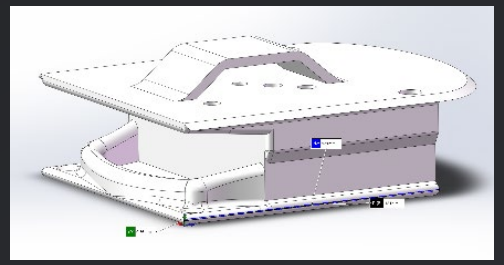


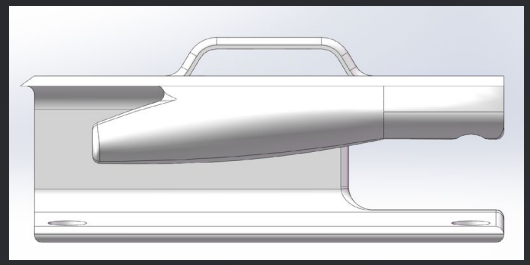


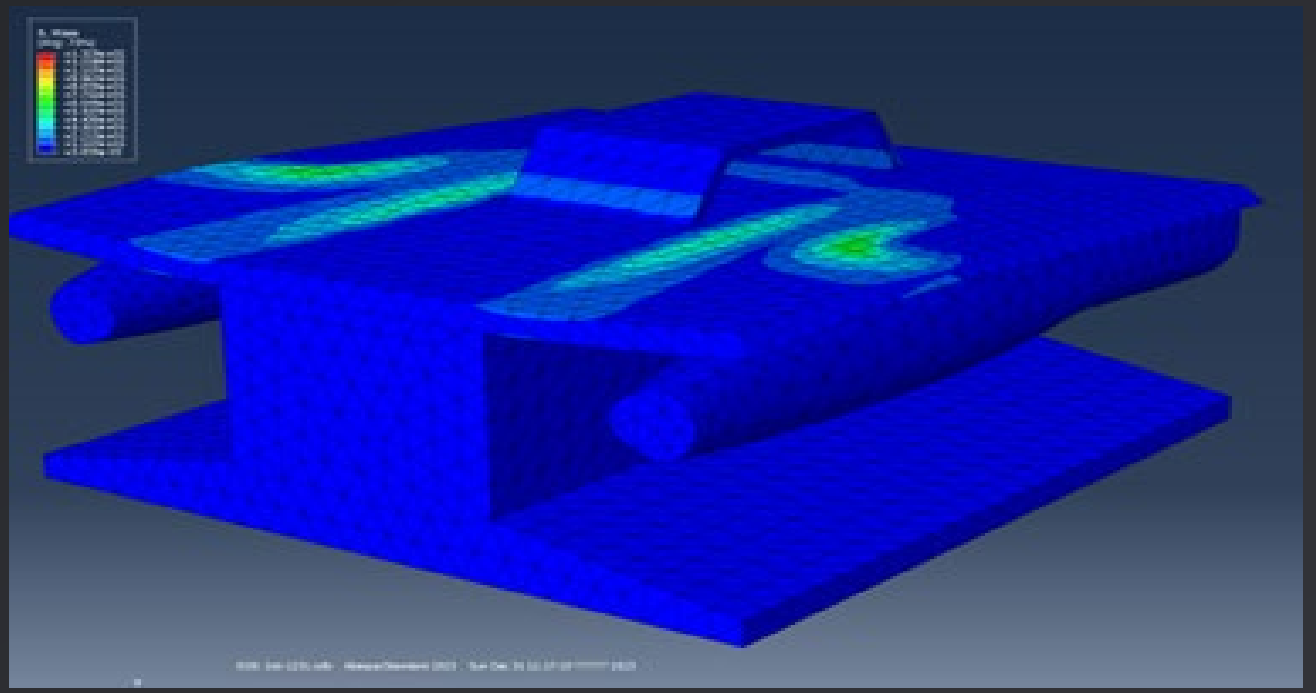


Handle simulation









- By combining ergonomics, it is considered that lifting car is more frequently used than pulling car. The handle diameter is 46mm, allow maximum grip strength.

Make UYCL 360 automatically

HOW TO Make UYCL 360 automatically

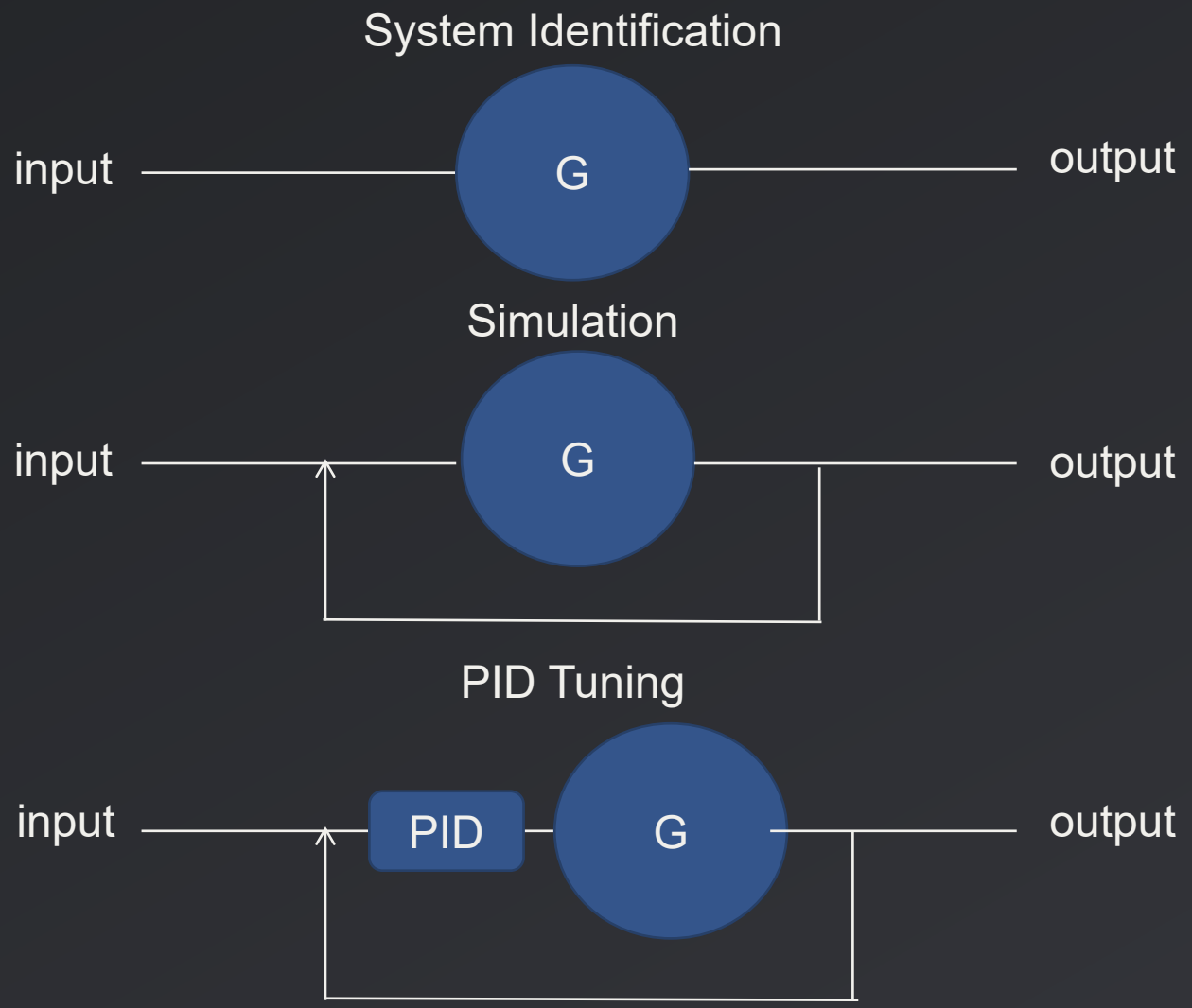
HOW TO Make UYCL 360 automatically

Velocity closed-loop PID

Gray value identification

Intelligent tracking

Fundamental Control Experiment Introduction

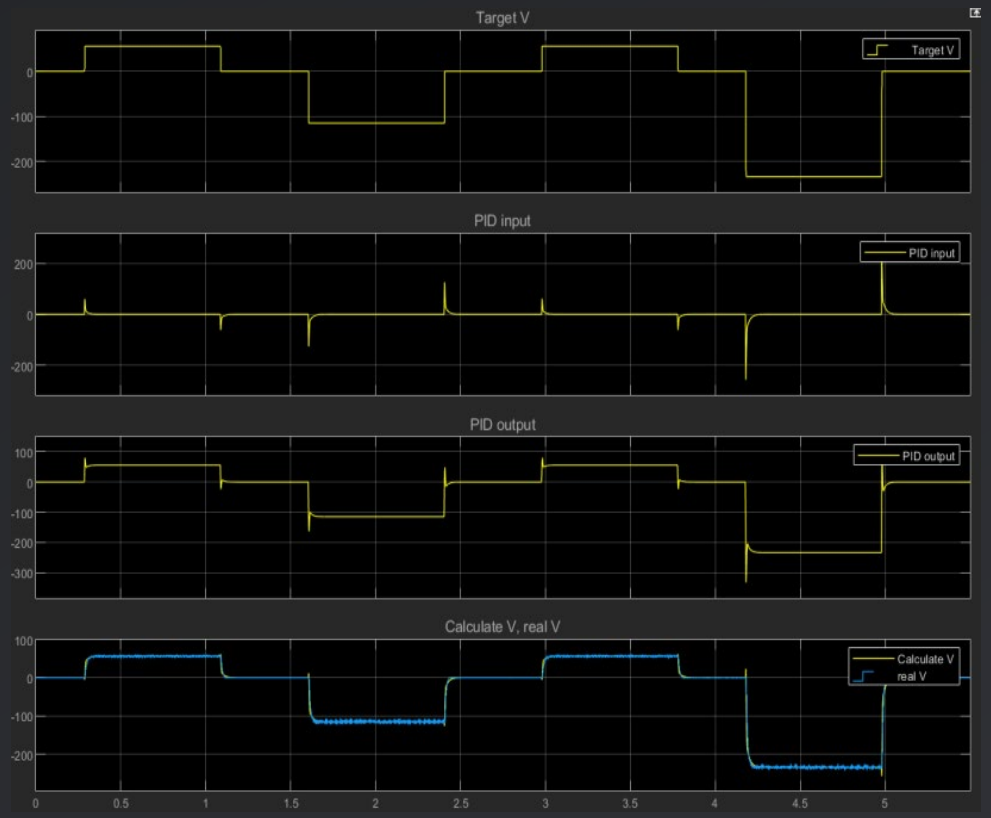


Speed closed loop experiment

Problem: Interfering signals between the ground and the tires

Objective: Ensure that the actual speed is close to the expected value

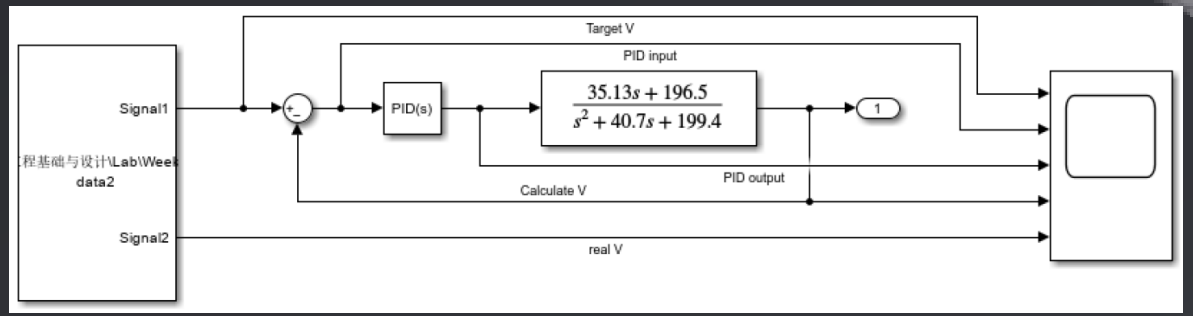
Transfer Function: $\frac{35.13s + 196.5}{s^2 + 40.7s + 199.4}$ Accuracy: 94.2%

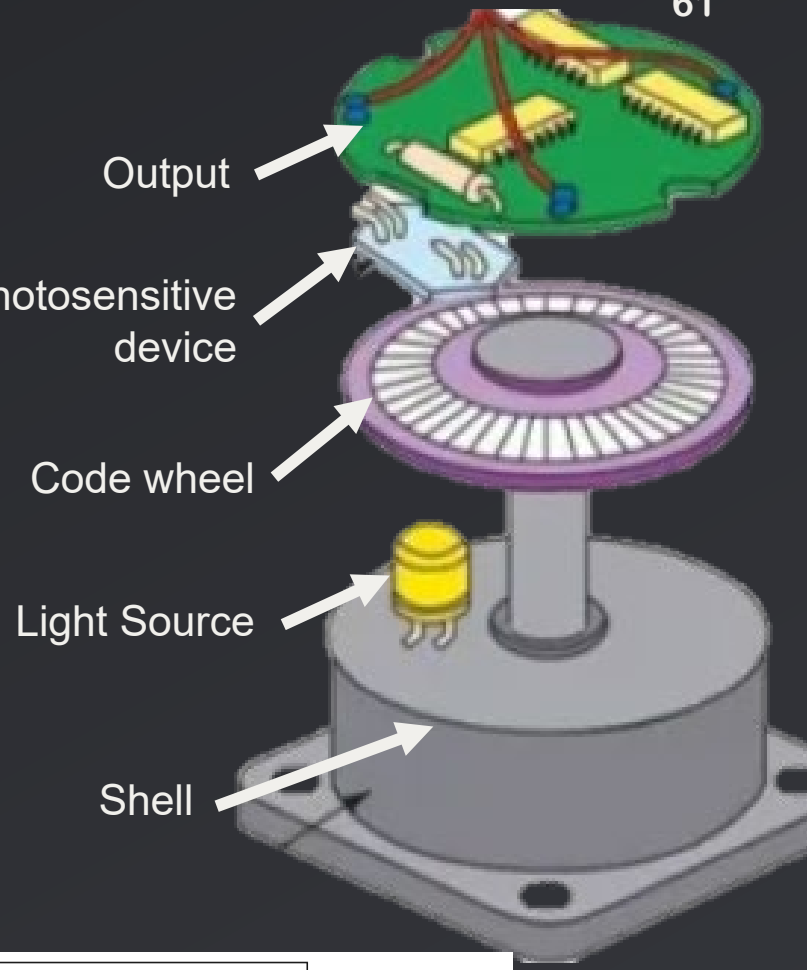


Sample Time: 0.002s

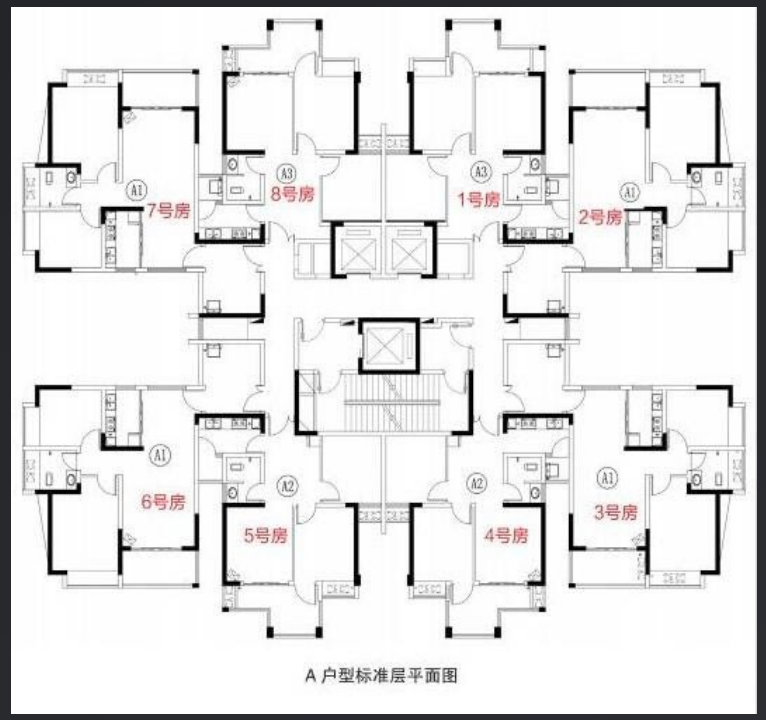
Speed: 10-30% of Max

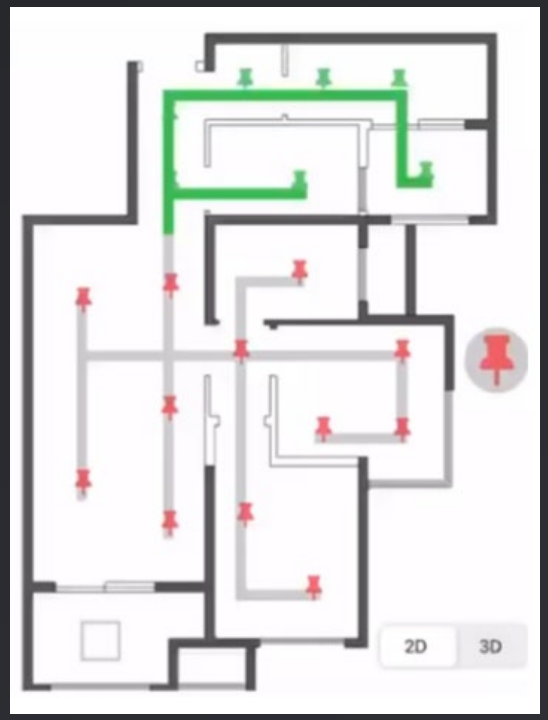
Conversion:PWM and speed



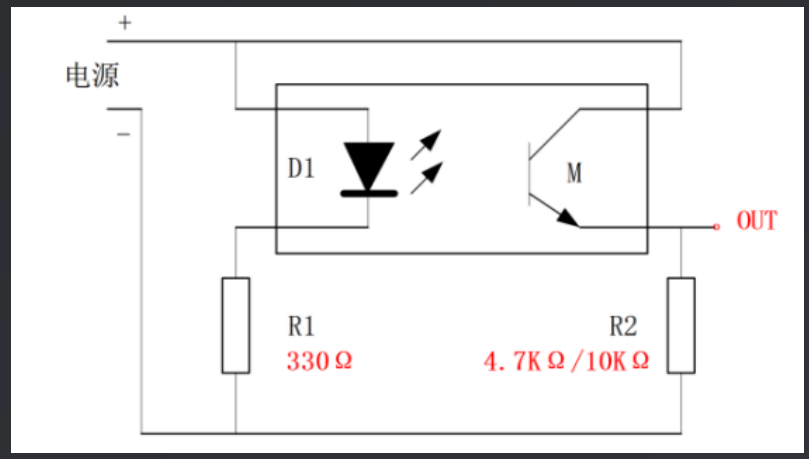


Patrol Experiment – Position closed-loop control





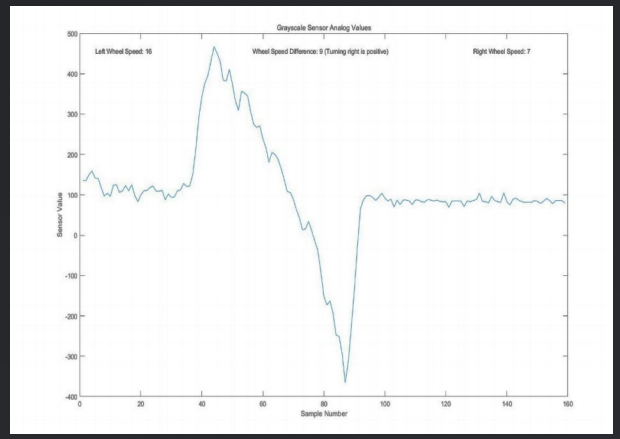
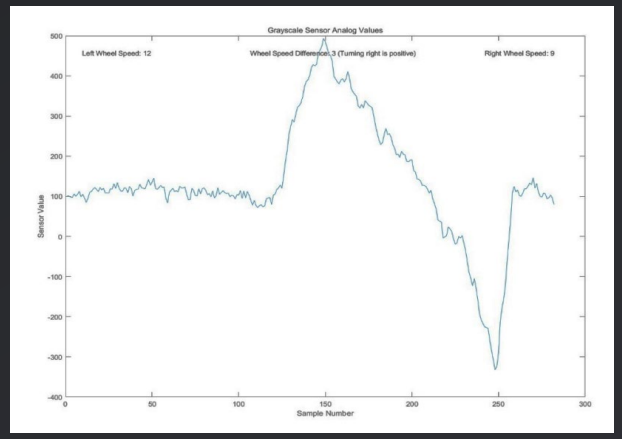
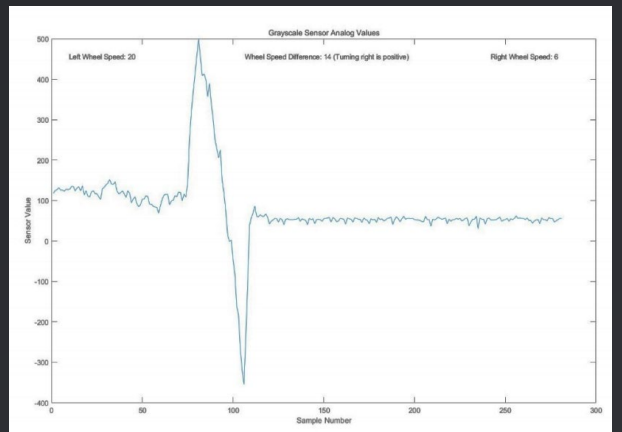
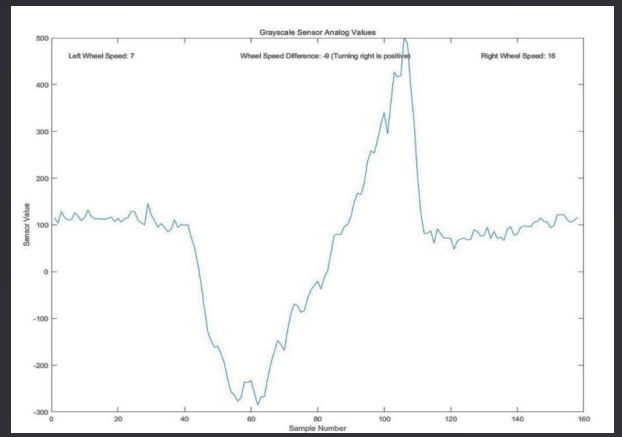
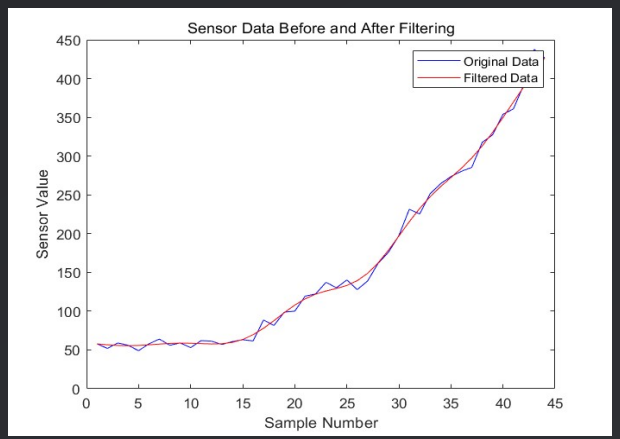
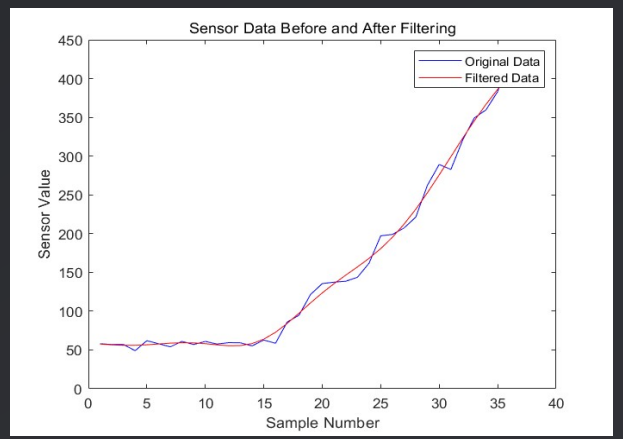
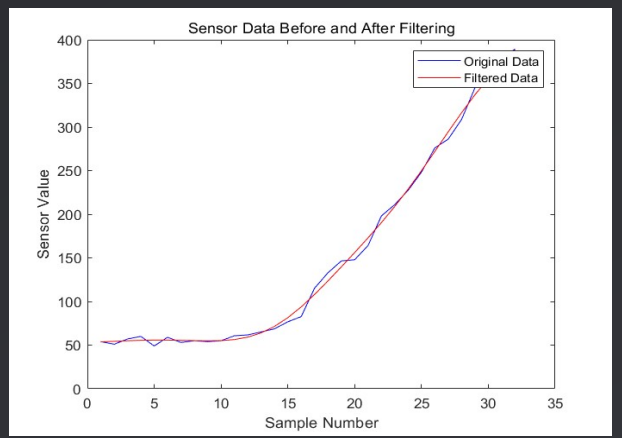
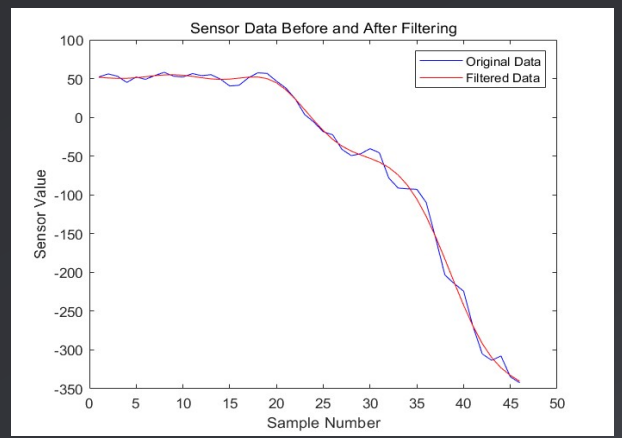
Imagine: get the optimal route from the floor plan and plan the move



Actual: Use grayscale sensors to monitor lines and simulate position closed-loop control

Patrol Experiment – System Identification

Perform zero-phase digital filtering (lower row) on the original data (upper row) and intercept the response part at the same time.

Left V = 24, Right V = 16 V Diff = +8	Left V = 22, Right V = 18 V Diff = +4	Left V = 13, Right V = 27 V Diff = +14	Left V = 16, Right V = 24 V Diff = -8
			
			

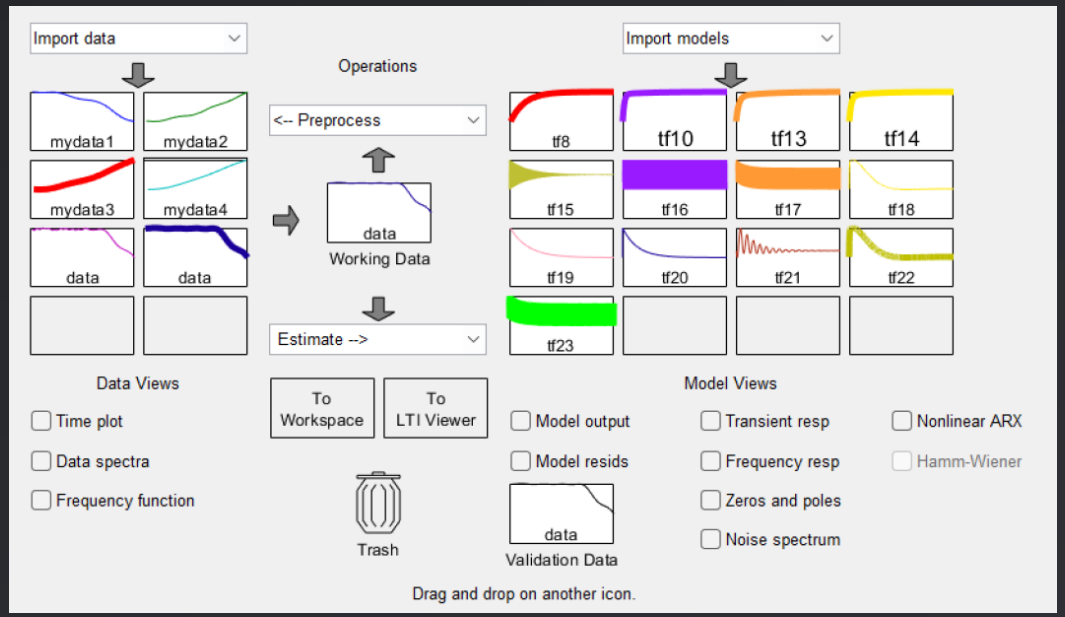
Patrol Experiment – System Identification

All input data are the average of five experiments.

Use MATLAB System Identification Toolbox on the data part of zero-phase digital filtering:

Parameters: Poles = 2, Zeros = 1.

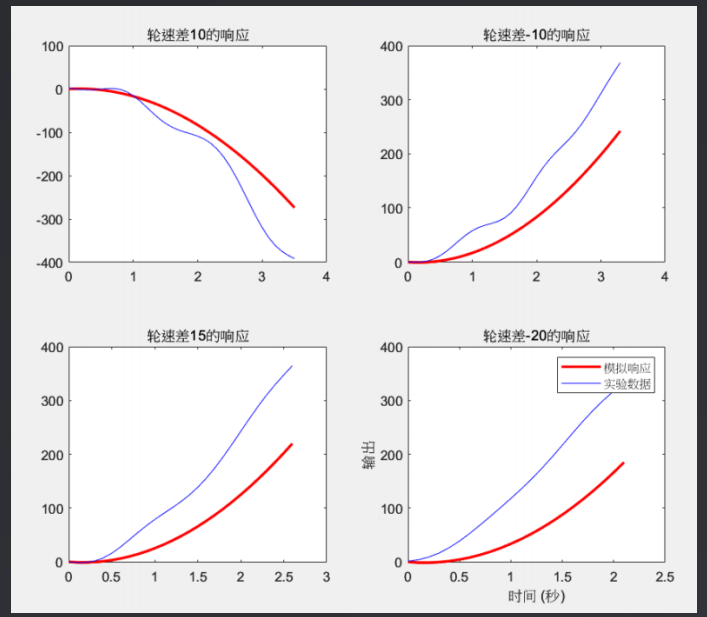
Then, select the model with a best accuracy.



Get the Transfer Function:

$$\frac{-0.816s + 4.991}{s^2 + 3.746e^{-7}s + 0.01324}$$

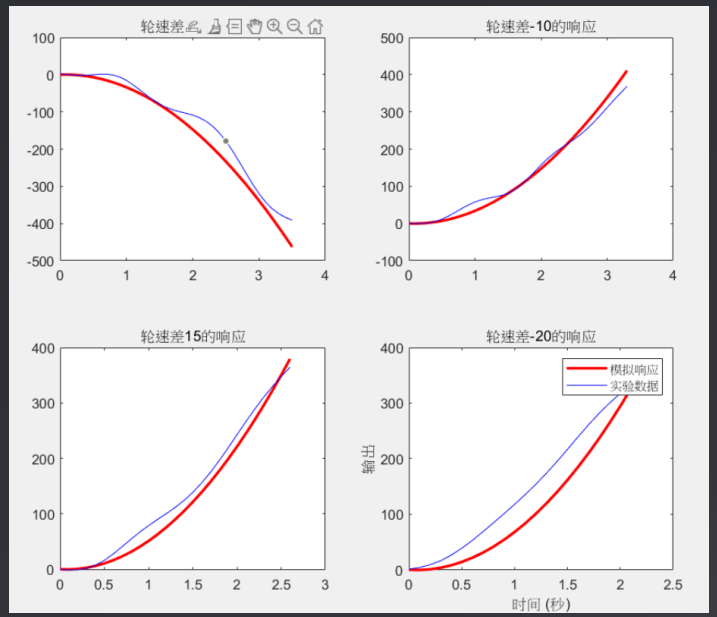
Accuracy = 83.97%



Adjust it manually:

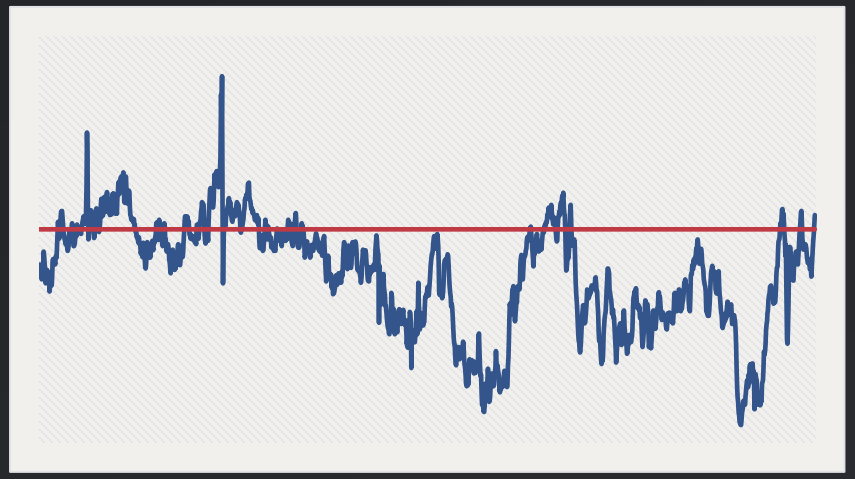
$$\frac{-0.6s + 8.0}{s^2 + 3.746e^{-7}s + 0.01324}$$

The fitting effect is as below



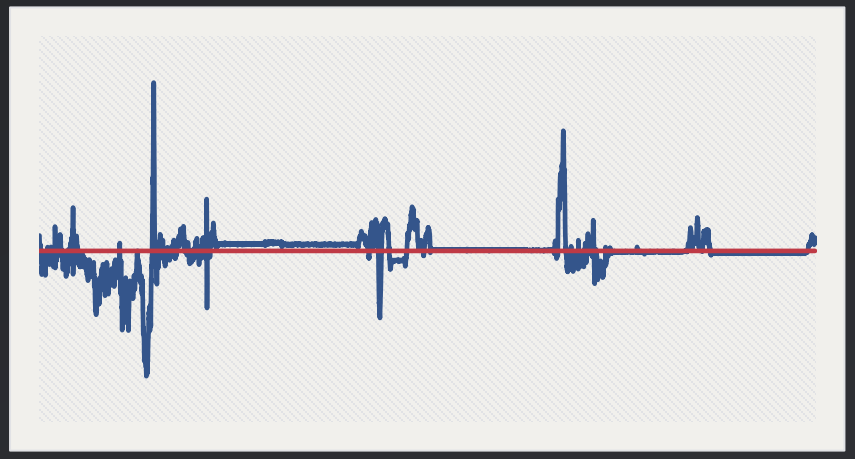
Patrol Experiment – System Identification

Simulink PID Tuner



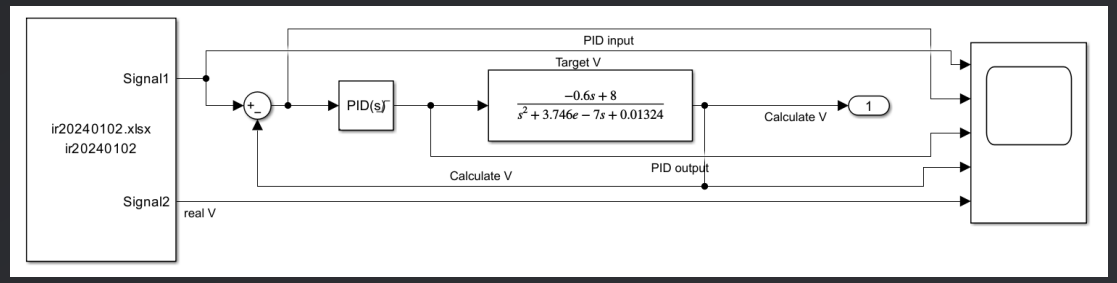
Speed = 70%
P = 0.88,
I = 0.0068,
D = 0.16

Manually Adjust

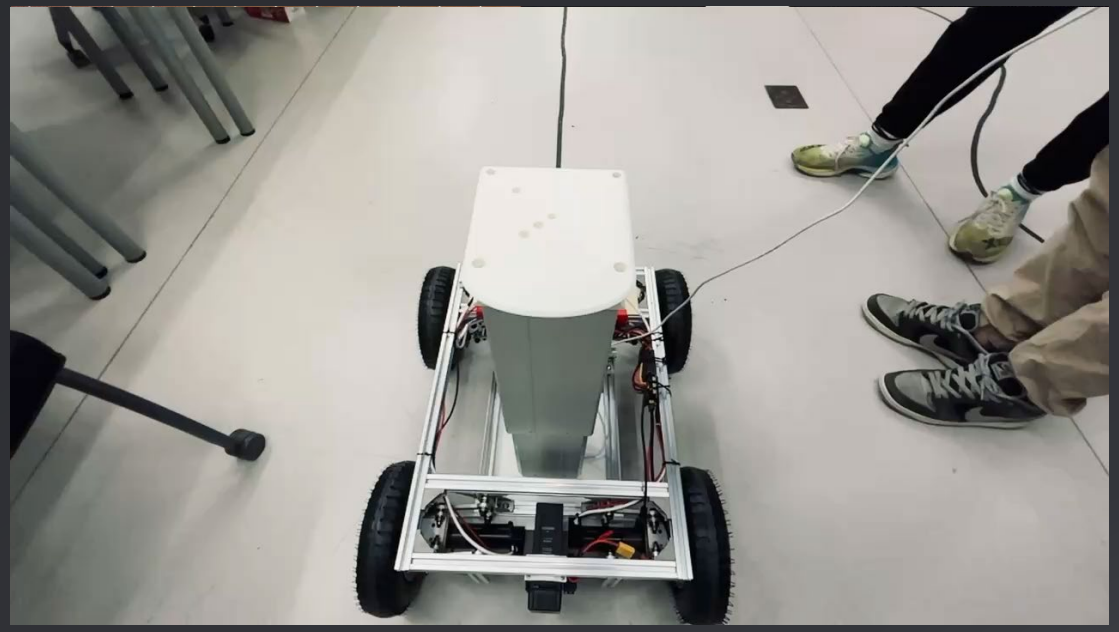


Speed = 100%
P = 1.0,
I = 0,
D = 0.2

Simulink Simulation



Experiment Video



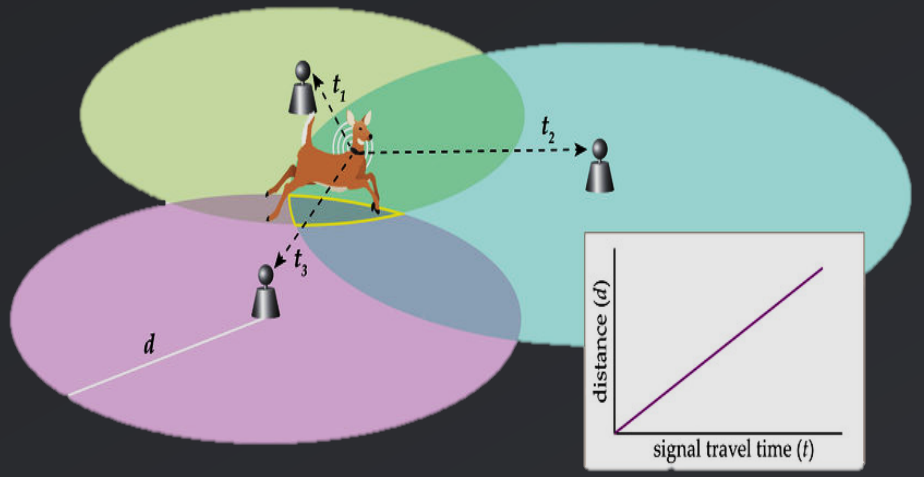
Follow-up Control

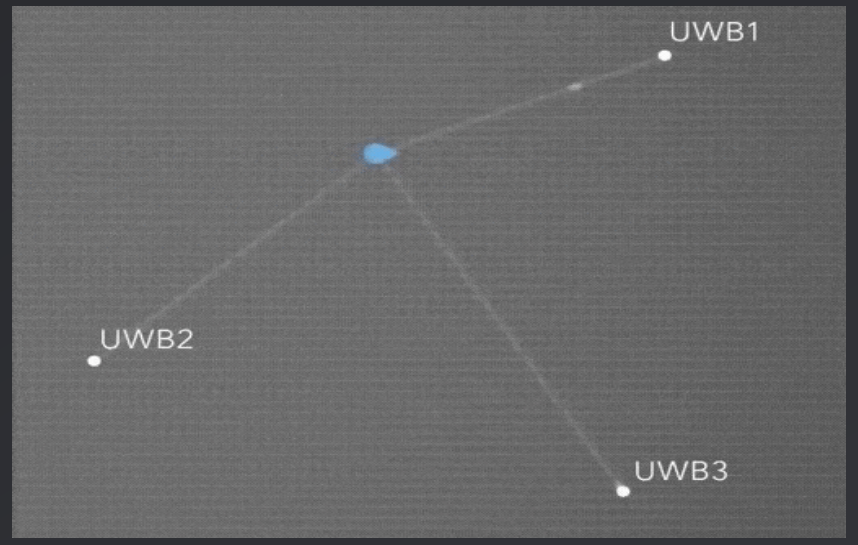
Ultra Wide-Band (UWB) is a new wireless communication technology that has become increasingly popular in recent years.

WHY UWB?

For it can provide positioning accuracy of several centimeters.

How do we locate?





Control Objectives:

UYCL 360 should face 125cm behind the Operator

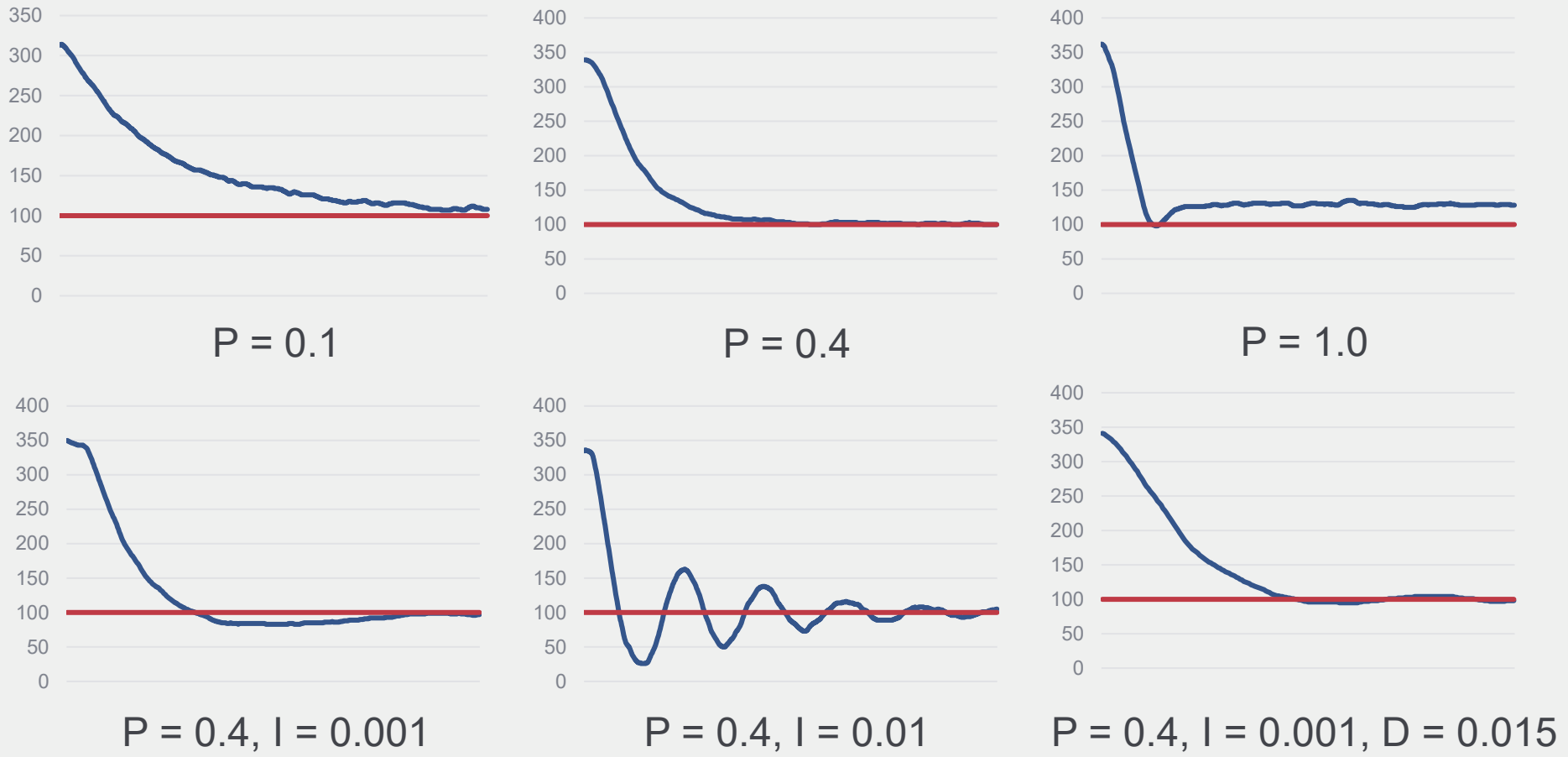
Control Ideas:

1. Make angle = 90°, and distance = 125cm.
2. Make left and right wheels keep distance = 125cm.

Utilities the second one

Follow-up PID Experiment Positional PID controller

After all the former processes (Opened-loop, System Identification, Matlab Simulink, Closed-loop Simulation, PID tuner), we make final parameter adjustments.



PID Type:

- Positional PID

Steps:

- P value
- I value
- D value

Follow-up PID Experiment Positional PID controller

Interact with UYCL 360

HOW TO Interact with UYCL 360

HOW TO Interact with UYCL 360

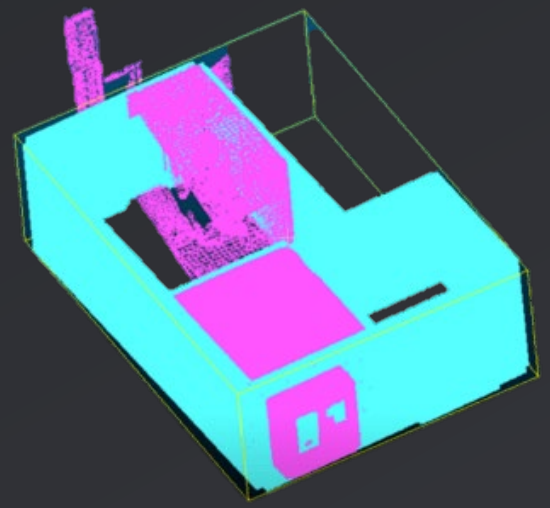
From **UCL 360**

To **UYCL 360**

User interface display

From UCL 360

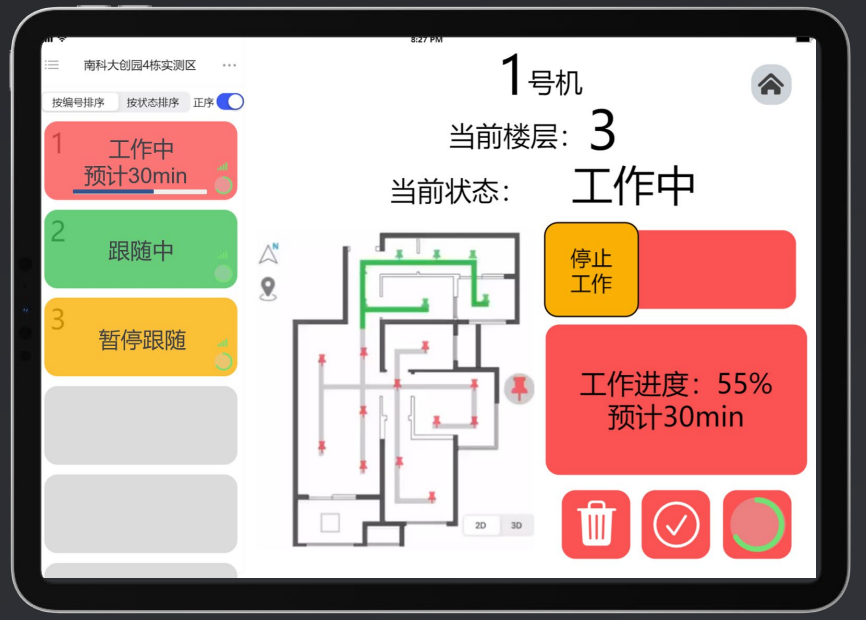
- App Design
  - Interaction object：single device
  - User operation：operate simultaneously
  - Working Skills：spatial splicing



To UYCL 360

- App Design
  - Interaction object：multiple devices
  - User operation：task management
  - Working Skills：machine assigning

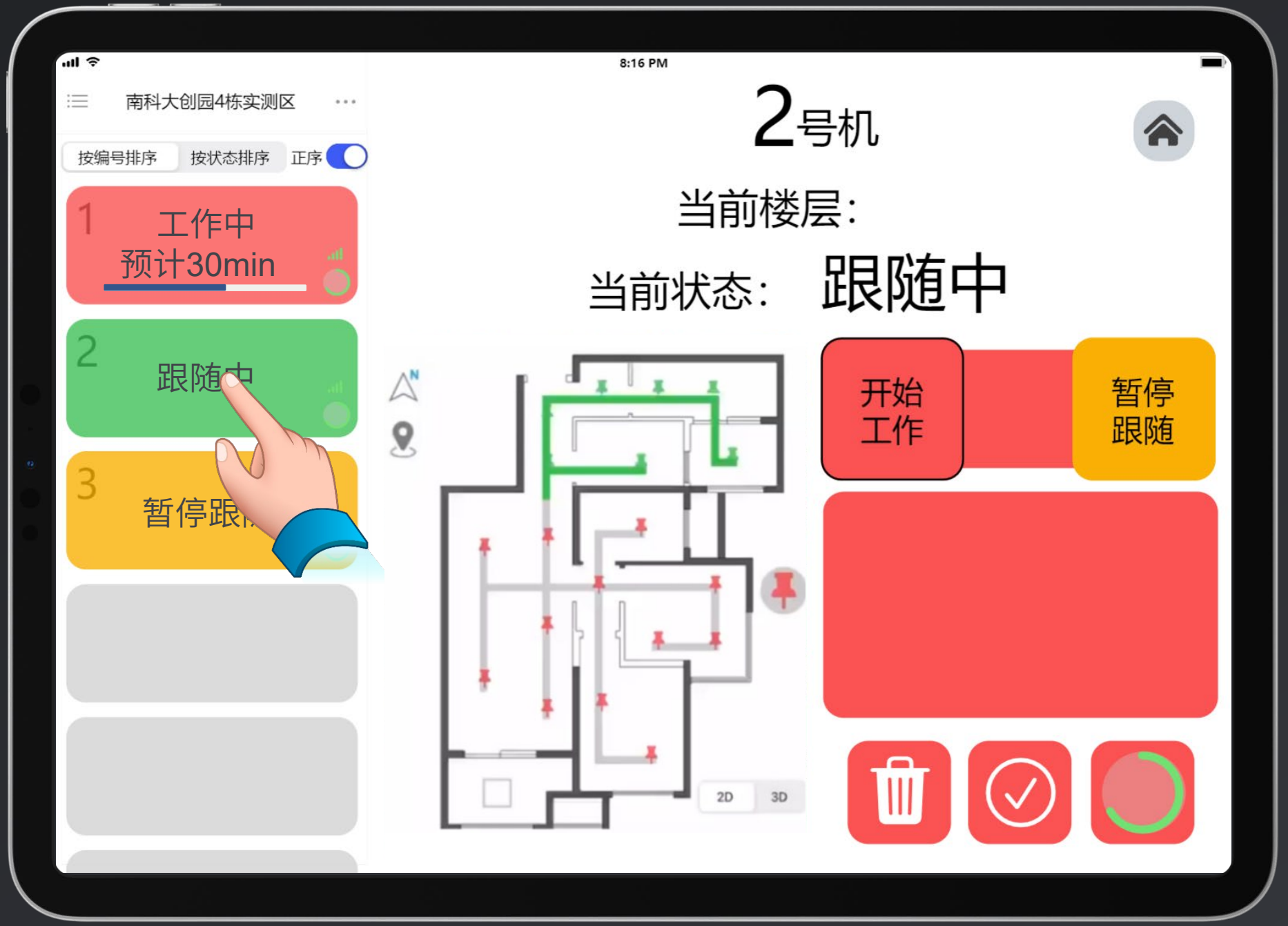
Interaction Better



- App Design
  - Interaction object：multiple devices
  - User operation：machine management
  - Working Skills：task assigning
  - Useability Test and Feedback
  - More Visible and Easy to Interact


南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：工作中
停止
工作
工作进度：55%
预计30min
2D
3D

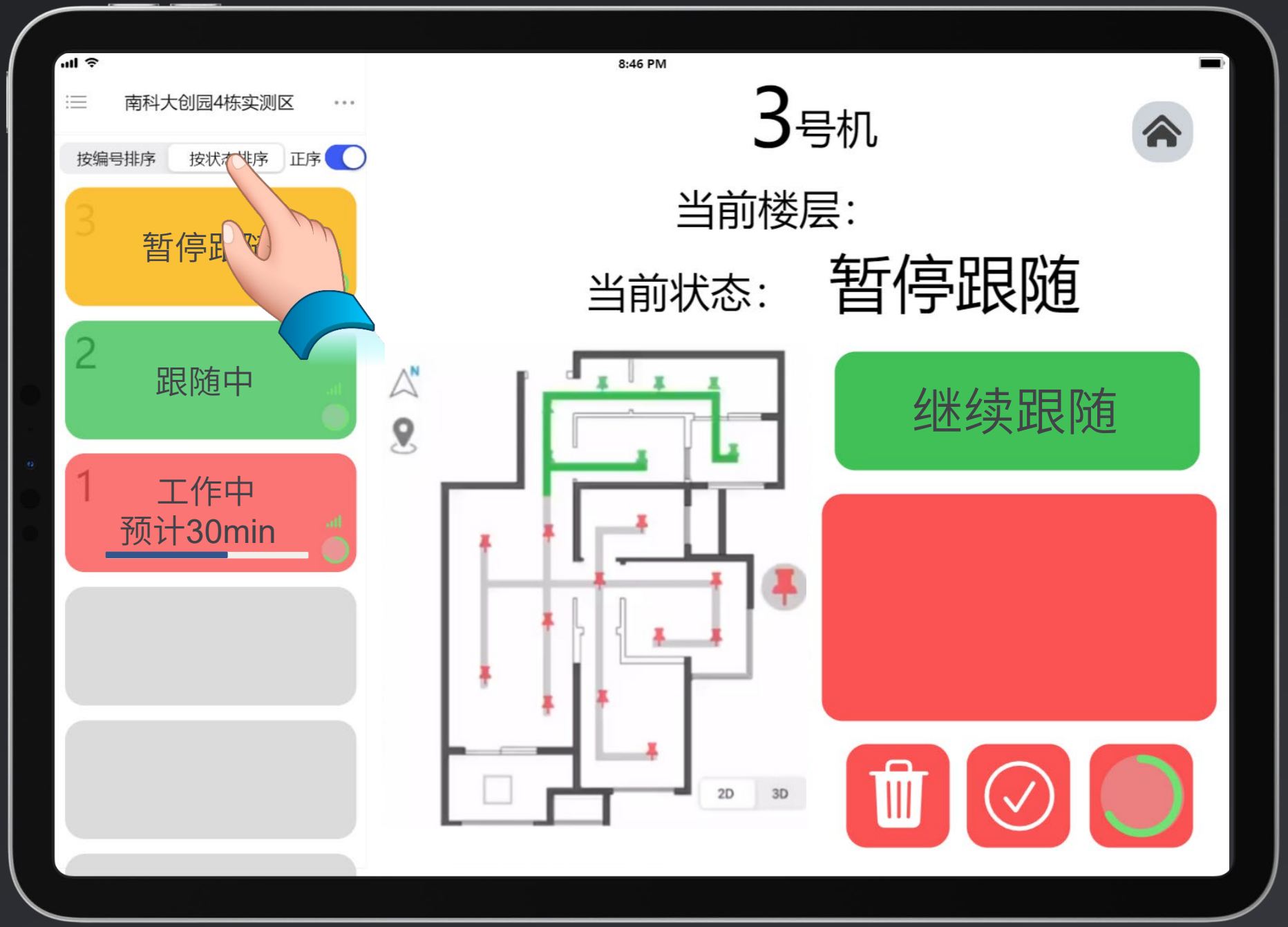

南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：工作中
停止
工作
工作进度：55%
预计30min
2D
3D


8:16 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟
2号机
当前楼层:
当前状态:
跟随中
开始
工作
暂停
跟随
2D
3D

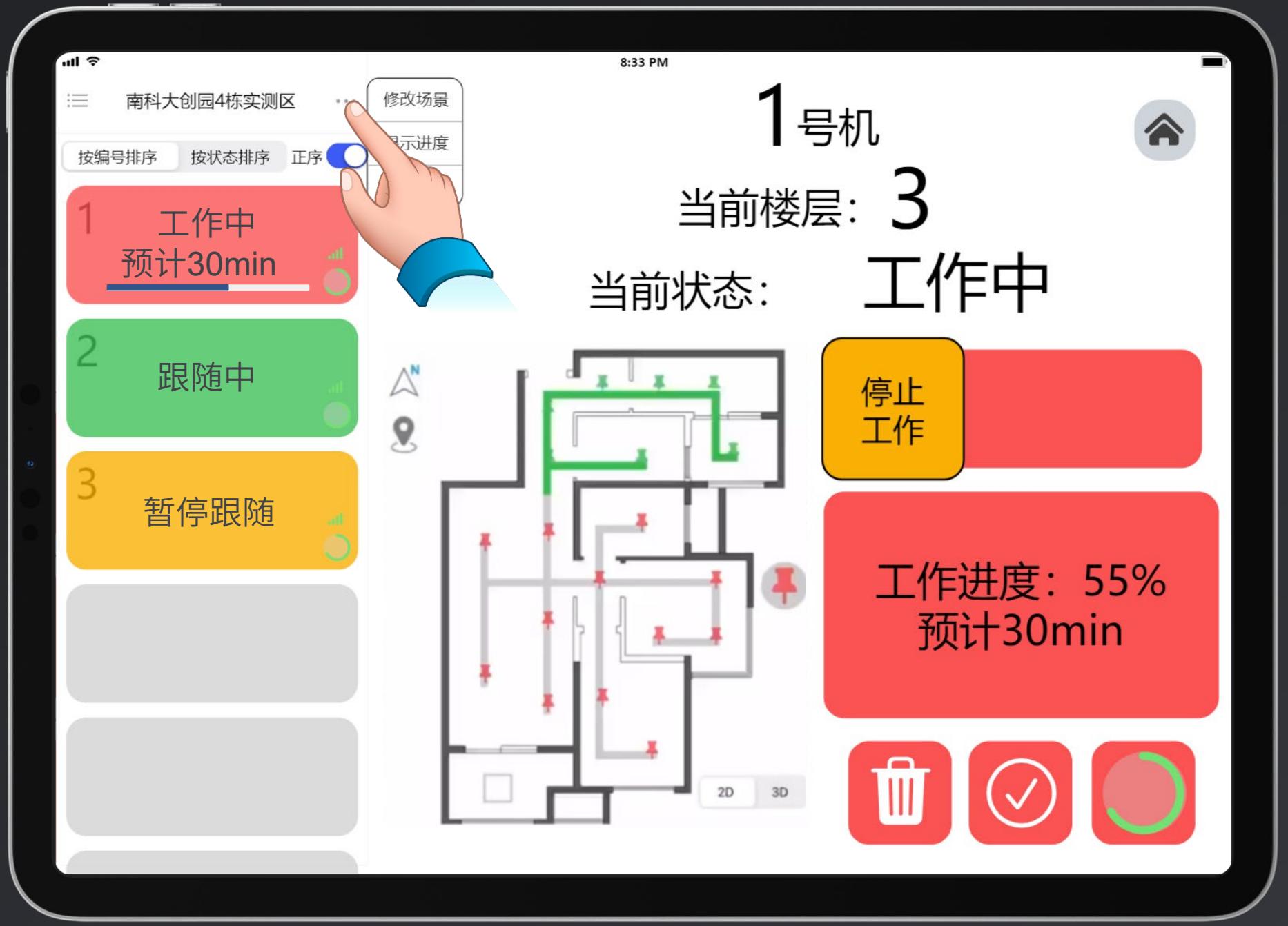

10:52 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
3号机
当前楼层:
当前状态:
暂停跟随
继续跟随
2D
3D


南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
停止
工作
工作进度：55%
预计30min
2D
3D


8:27 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计
min
2
跟随
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
停止
工作
工作进度：55%
预计30min
2D
3D


8:46 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
3
暂停跟随
2
跟随中
1
工作中
预计30min
3号机
当前楼层:
当前状态:
暂停跟随
继续跟随
2D
3D


8:43 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
停止
工作
工作进度：55%
预计30min
2D
3D


8:33 PM
南科大创园4栋实测区
修改场景
按编号排序
按状态排序
正序
1 工作中
预计30min
2 跟随中
3 暂停跟随
1号机
当前楼层：3
当前状态：工作中
停止
工作
工作进度：55%
预计30min
2D
3D

南科大创园4栋实测区

按编号排序 按状态排序 正序

1 工作中
预计30min

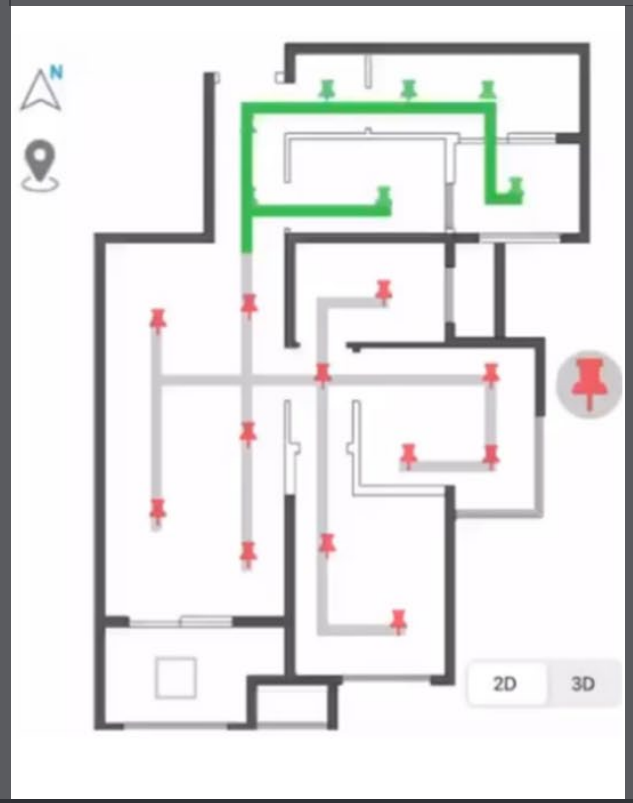
2 跟随中

3 暂停跟随

1号机

当前楼层：3

当前状态：工作中

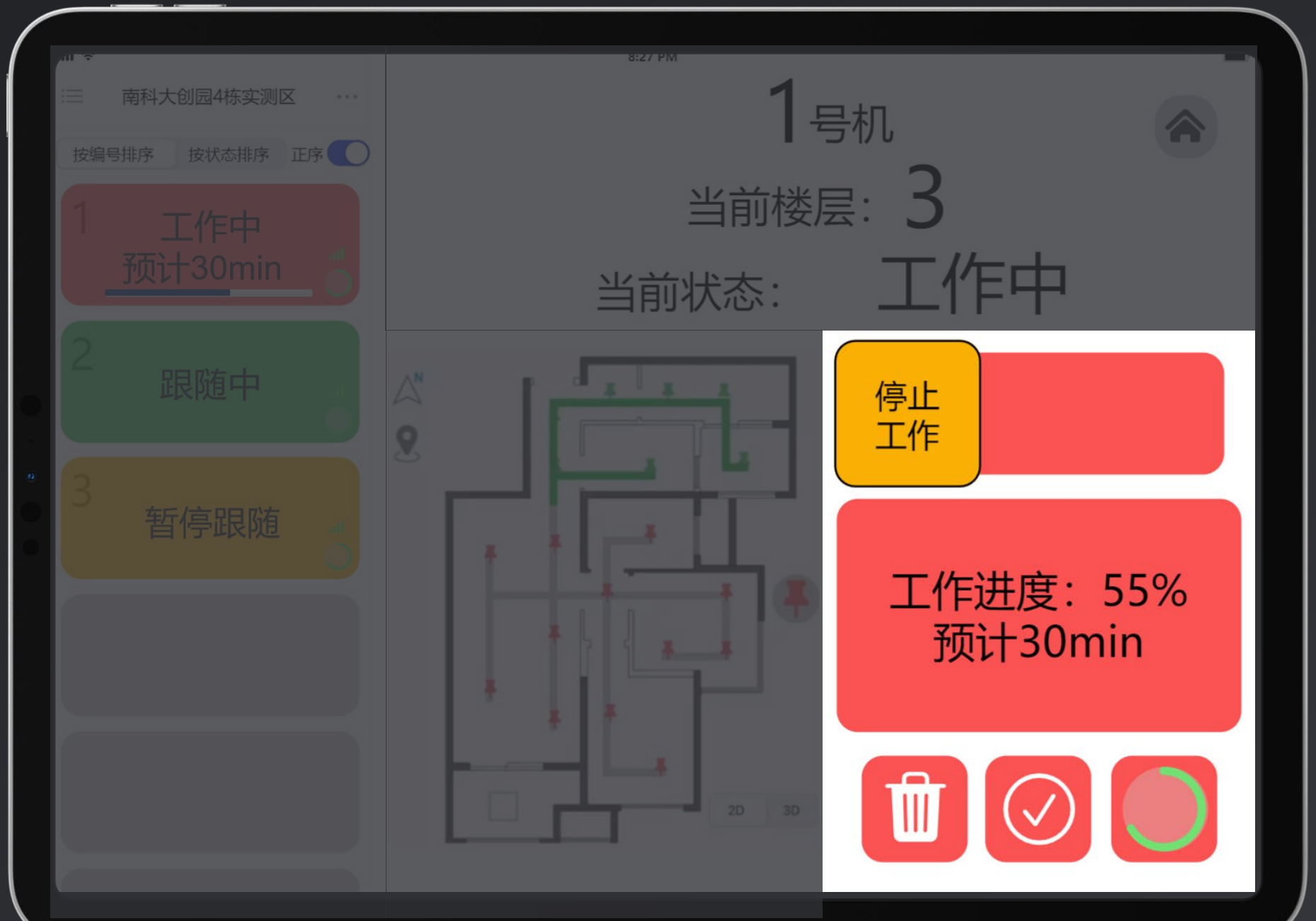


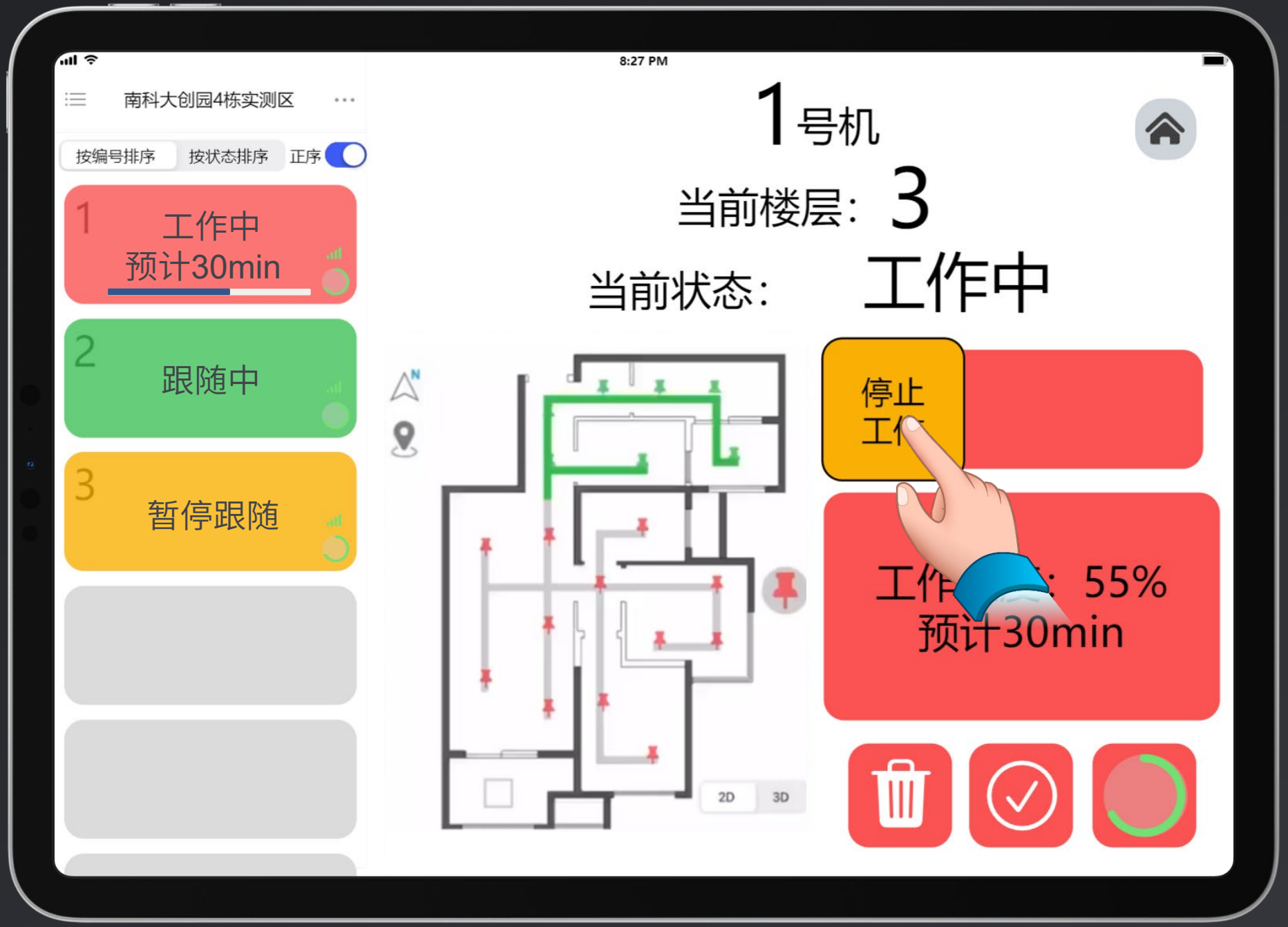
停止
工作

工作进度：55%
预计30min


8:27 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
停止
工作
工作进度：55%
预计30min
2D
3D


5:53 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
双击返回
N
2D


南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：工作中
2D
3D
停止
工作
工作进度：55%
预计30min


8:27 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
停止
工作
工作：55%
预计30min
2D
3D

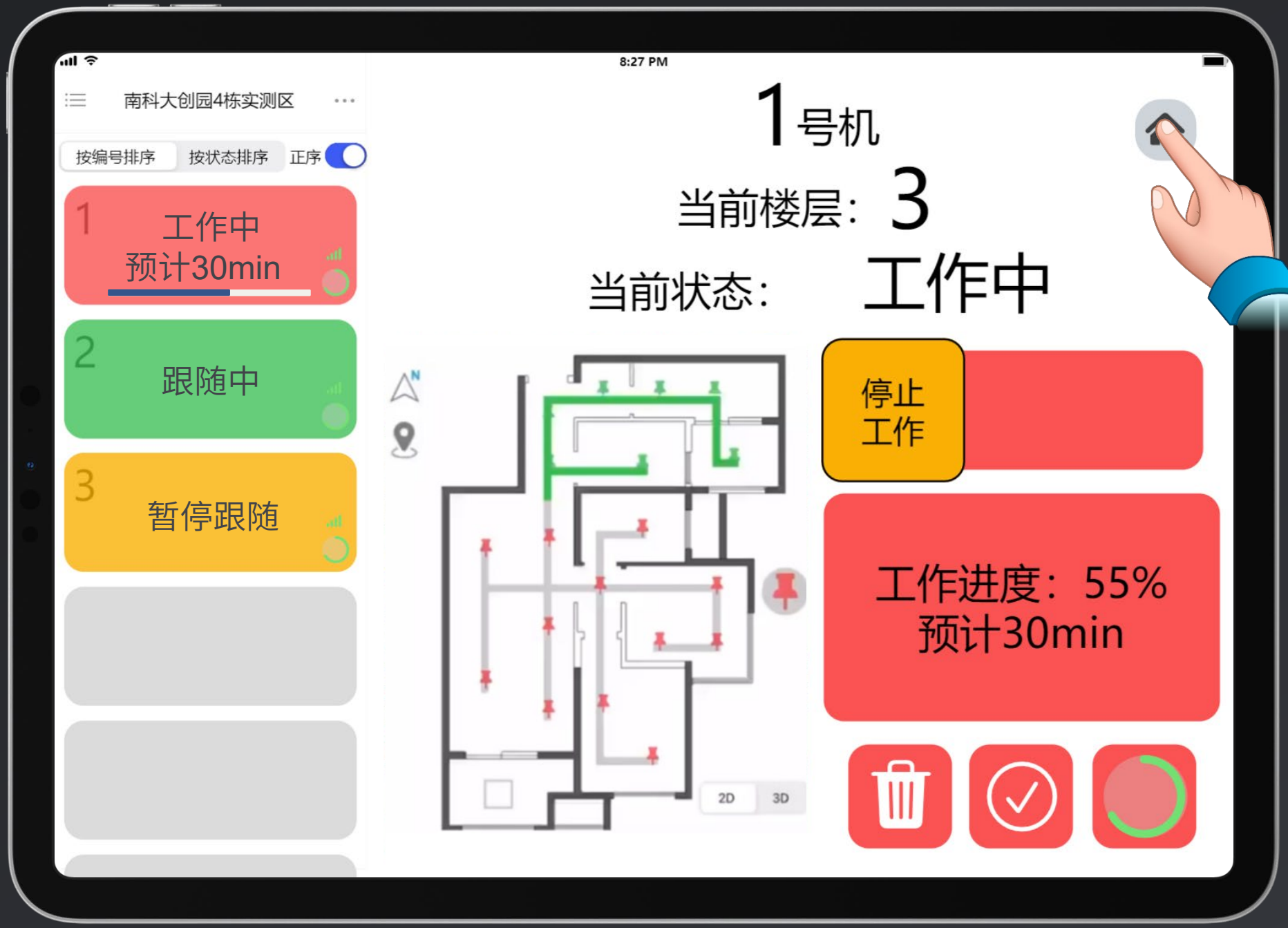

11:06 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作结束
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：工作结束
继续跟随
2D
3D


11:10 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
跟随中
2
跟随中
3
暂停跟随
1号机
当前楼层:
当前状态:
跟随中
开始
暂停
跟随
2D
3D


10:58 AM
南科大创园4栋实测区
1号机
按编号排序
按状态排序
正序
1 工作中
等待分配楼层
2 跟随中
3 暂停跟随
当前楼层:
当前状态: 工作中
请分配楼层:
取消
确
停止
工作
2D
3D


10:52 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
3号机
当前楼层:
当前状态:
暂停跟随
继续跟随
2D
3D

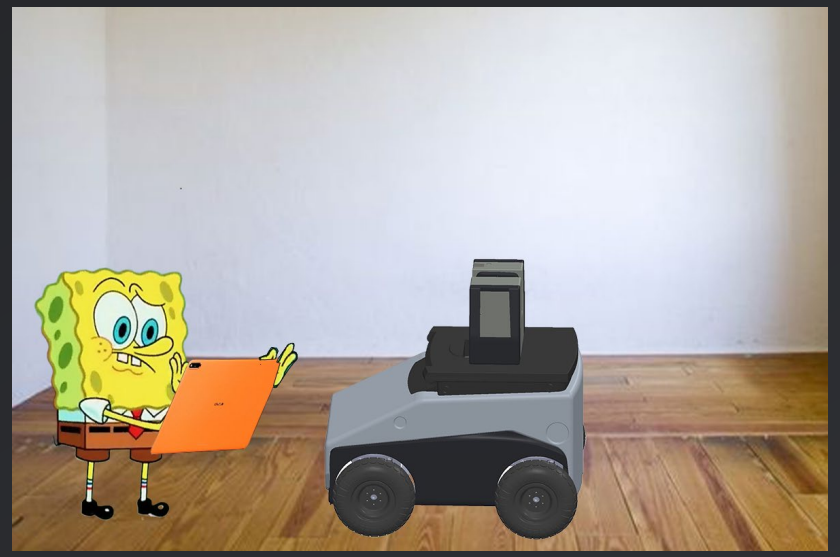

11:15 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
跟随中
3号机
当前楼层:
当前状态:
跟随中
开始
工作
暂停
跟随
2D
3D


8:27 PM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：工作中
停止
工作
工作进度：55%
预计30min
2D
3D


11:33 AM
南科大创园4栋实测区
按编号排序
按状态排序
正序
1
工作中
预计30min
2
跟随中
3
暂停跟随
1号机
当前楼层：3
当前状态：
工作中
提醒
是否返回主页
取消
确认
暂停
工作
2D
3D

Operation display: Story Board

Operation display: Story Board



电池续航持久

轻量化

物联网支撑多机多维度
异步协同工作

小车智能跟随

终端智能调度与实时管理app

巡线

升降

扫描仪实现

PID控制

PID Controller

双层壳体

一手掌控

高精度3D扫描重建和环路闭合算法

感性工学测算与人因工程考量

技感与可靠感

AIGC辅助壳体设计，兼具科技

Specially

Presented by

Angelyn

Liyuan Wen

Linyuan Xue

Zhongtian Mo

Zongze Li

Jun Huang

Specially

Presented by GROUP 3

Specially

Presented by GROUP 3 in SDIM

Thank You

January 4th, 2024

Angelyn Linyuan Xue Zongze Li
Liyuan Wen Zhongtian Mo Jun Huang

UNRE SUSTech Southern University of Science and Technology SIAT