Danmarks Tekniske Universitet

DTU

34755 Building dependable robot systems Spring 24 Report | Group 110

Authors

Xingyi Liu - s232258
Huan Hu - s232179
Yuxuan Ma - s232172
Yiming Zhang - s232896
Dong Yun - s232293
Yuansheng Zhou - s232925
Zekun Wang - s232272

February 16, 2024

Contents

1 Introduction

1.1 Group introduction

Xingyi Liu: MSc student in Autonomous Systems.

Huan Hu: MSc student in Electrical Engineering.Focus on Robotics Control and Reinforcement Learning.

Yuxuan Ma: MSc student in Electrical Engineering.Focus on Machine learning and signal processing.

Yiming Zhang: MSc student in Autonomous Systems.

Dong Yun: MSc student in Autonomous Systems.

Yuansheng Zhou: MSc student in Autonomous Systems.

Zekun Wang: MSc student in Autonomous Systems.

1.2 Project vision

Complete all tasks and get more points. Best Video Prize is our dream!

1.3 Project planning

1.3.1 Double diamond

Here is how the Double Diamond works,In the first diamond, we seek to understand the problem deeply. Instead of making assumptions, we engage with people affected by the issue. Through conversations and observation, we gain insights that help us define the challenge more effectively.The second step is Define.we redefine the problem. This step encourages us to look at the challenge from different angles and consider alternative perspectives.Next step is Develop.The second diamond encourages divergent thinking. We explore various answers to the well-defined problem. Inspiration comes from diverse sources, and co-designing involves collaborating with different stakeholders.Lastly,in the final stage we test out solutions at a small scale. We discard what doesn't work and refine what does.Importantly, this process isn't linear; it's iterative.We learn, adapt, and continuously improve our ideal plan.

The framework for innovation also emphasizes four core principles:

· Put People First: Understand the needs, strengths, and aspirations of those using a service.

· Communicate Visually and Inclusively: Foster shared understanding of problems and ideas.

· Collaborate and Co-create: Work together, drawing inspiration from others.

· Iterate: Spot errors early, minimize risk, and build confidence in ideal.

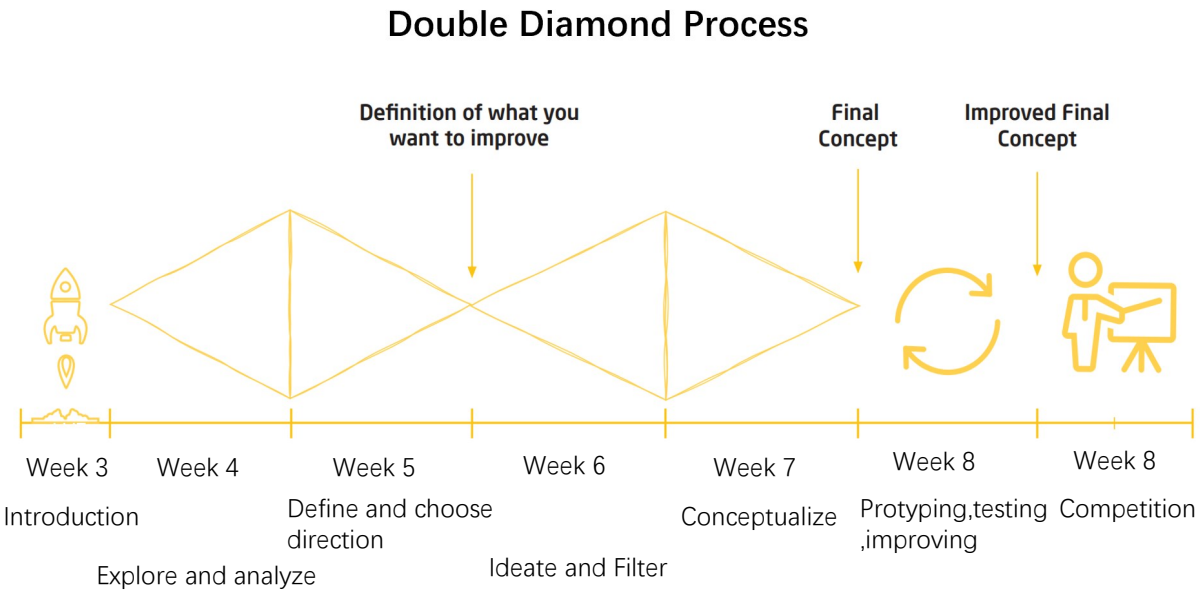


Figure 1: Double diamond process

1.3.2 Scrum and Sprint

Scrum is an agile framework that helps teams deliver complex products in an iterative and adaptive way.Sprint is a time-boxed period, usually one month or less,in which the Scrum team works on a set of product features that can be delivered as a valuable increment.

We will follow these steps:

Define a product goal that describes the desired outcome of the product development.

Create a product backlog that contains the ordered list of work items that are needed to achieve the product goal.

Plan a sprint by selecting a sprint goal that aligns with the product goal and a subset of product backlog items that can be completed within the sprint time frame.

Execute the sprint by having daily scrum meetings where the developers coordinate their work and report their progress and impediments.

Review the sprint by demonstrating the increment to the product owner and other stakeholders and collecting feedback for improvement.

Retrospect the sprint by identifying what went well, what went wrong, and what can be done better in the next sprint.

2 Cooperation Plan

For cooperation plan, we list a table.

Table 1: Cooperation Plan

Time to work	On the class: 4h Off class: Thursday afternoon and evening: 5-8h
Way to contact	Group on teams
Code repository	Gitlab
Work place	On class: building 329 Off class: building 325 or DTU library
People for final test	Xinyi Liu: For camera test. Yiming Zhang, Huan Hu: For drive control test. Dongyun: Zekun Wang: For camera test.
People for competition	Xingyi Liu, Huan Hu, Yuxuan Ma, Yiming Zhang, Dong Yun, Yuansheng Zhou, Zekun Wang

3 Project Plan

3.1 Tasks to do and who to do it

3.1.1 Perception

person in charge: Xinyi Liu, Yuxuan Ma

- **Camera calibration**: Print the test pattern and capture it from different directions. Establish the mapping and calculate the camera matrix and distortion parameters. Evaluate the result by taking new photos using this system matrix.
- **ArUco codes detection**: Debug the opencv code, detect the ArUco code and get the pose of the robot.
- **Golf detection**: Detect and position the orange golf ball.

3.1.2 Gripper design and debugging

person in charge:Yuansheng Zhou , Zekun Wang

- **Design Gripper**: Design the appropriate fixture to complete the Package delivery task

3.1.3 Challenge: Passing the guillotine gate

person in charge: Yuxuan Ma

- **configure a timer**: Set up a internal timer to calculate the exact time when the guillotine gate fell.Then our robot can decide which time it will pass through with a pre-calculated speed.

3.1.4 Challenge: Passing the axe gate

person in charge: Yiming Zhang, Huan Hu

- **Position detection**: Detect axe gate position.
- **Drive control**: When the axe gate blocks the way, we need make sure that our robot could autonomously adjust the rules of the drive and passes at the right time.

3.1.5 Challenge: Uphill and downhill

person in charge: Dong Yun, Yuansheng Zhou

- **Drive control**: Different slopes have varying effects on the robot's traction. The control system needs to be able to adapt to these changes to control speed and direction precisely.

3.1.6 Challenge: Passing the closed tunnel

person in charge: Huan Hu, Yiming Zhang

- **Position detection**: Detect the position to open the robotic arm we designed.
- **design external mechanisms for pushing door**: Our goal was to design a structure like a long pole to push closed doors. It will also make us more efficient by being able to naturally push closed doors open without having to do any extra recognizing while our robot are cruising the line walk.

3.1.7 Challenge: Racetrack

person in charge: Huan Hu, Yiming Zhang

- **motor Speed control**: Modify the code to control robot speed to make sure that it will run through the track at a moderate speed not very slow and not very fast(obviously,its hard to achieve stability at a high speed).

3.1.8 Challenge: Passing the three gates

person in charge: Dong Yun, Yuansheng Zhou

- Don't hit the circlingh robot, must perfectly return to the way it entered.

3.1.9 Challenge: Put the golf ball into the hole

person in charge: Zekun Wang, Xinyi Liu, Yuxuan Ma

- Clamp the golf ball and put it into the very narrow hole. Don't let the robot fall off the platform.

3.1.10 Challenge: Mini golf

person in charge: Yuxuan Ma, Xinyi Liu, Zekun Wang

- **Golf ball detection**: Modify the code to make sure the camera on the robot can recognize the mini golf ball.

3.1.11 Challenge: Package delivery

person in charge: Zekun Wang, Xinyi Liu, Yuxuan Ma

- **Pattern detection**: Recognize the ArUco pattern on boxes which cover balls and carry them to corresponding area in front of three different little house.

3.2 Task dependency and timeline

3.2.1 Task dependency

We listed the tasks need to do for complete the competition as shown in figure. Stage 1 includes the most basic tasks that need to be finished at first, and they are the Prerequisites for the subsequent challenges. Stage 2 is divided into two parts. Two group of people will start to do them in parallel.

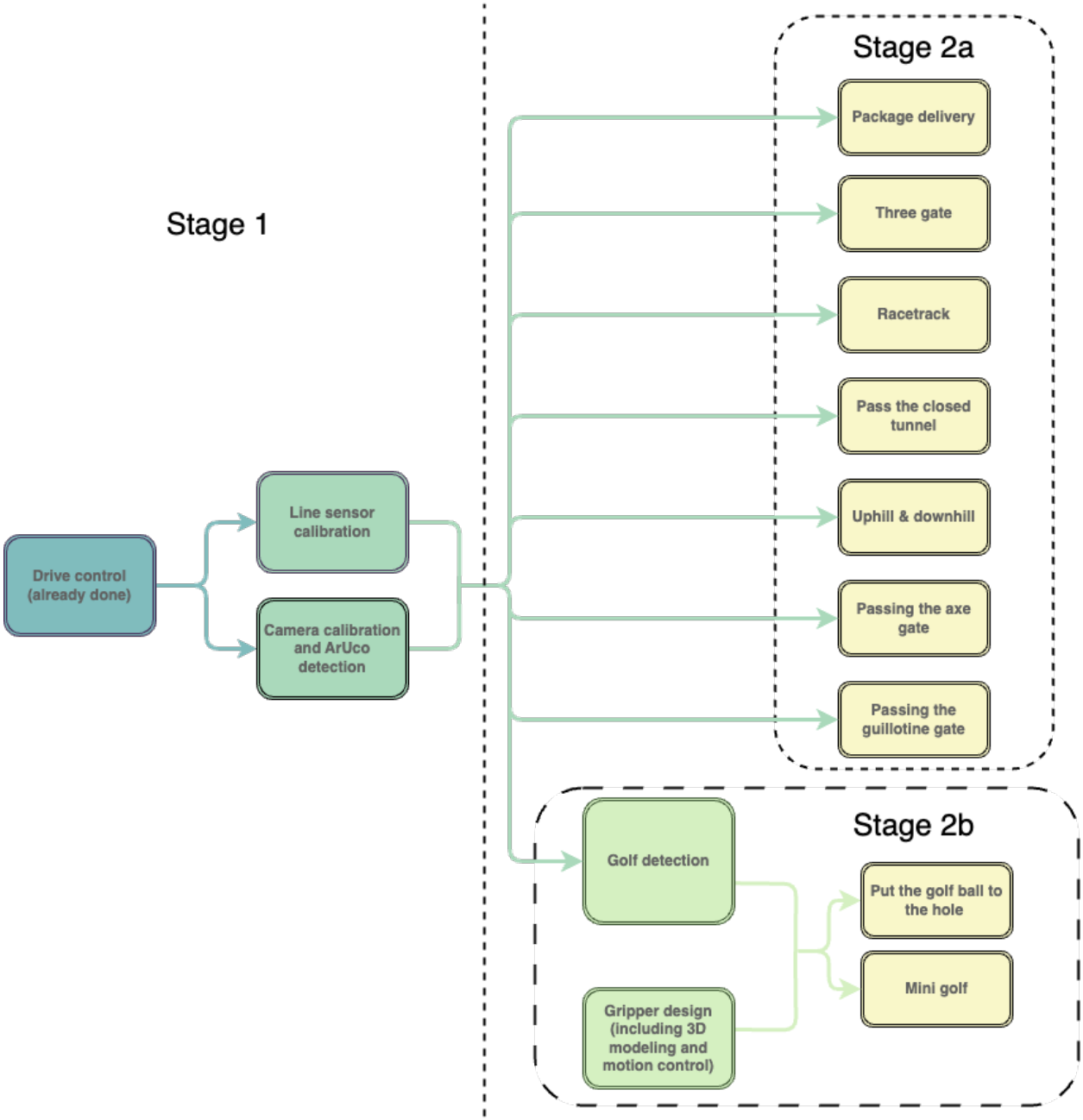
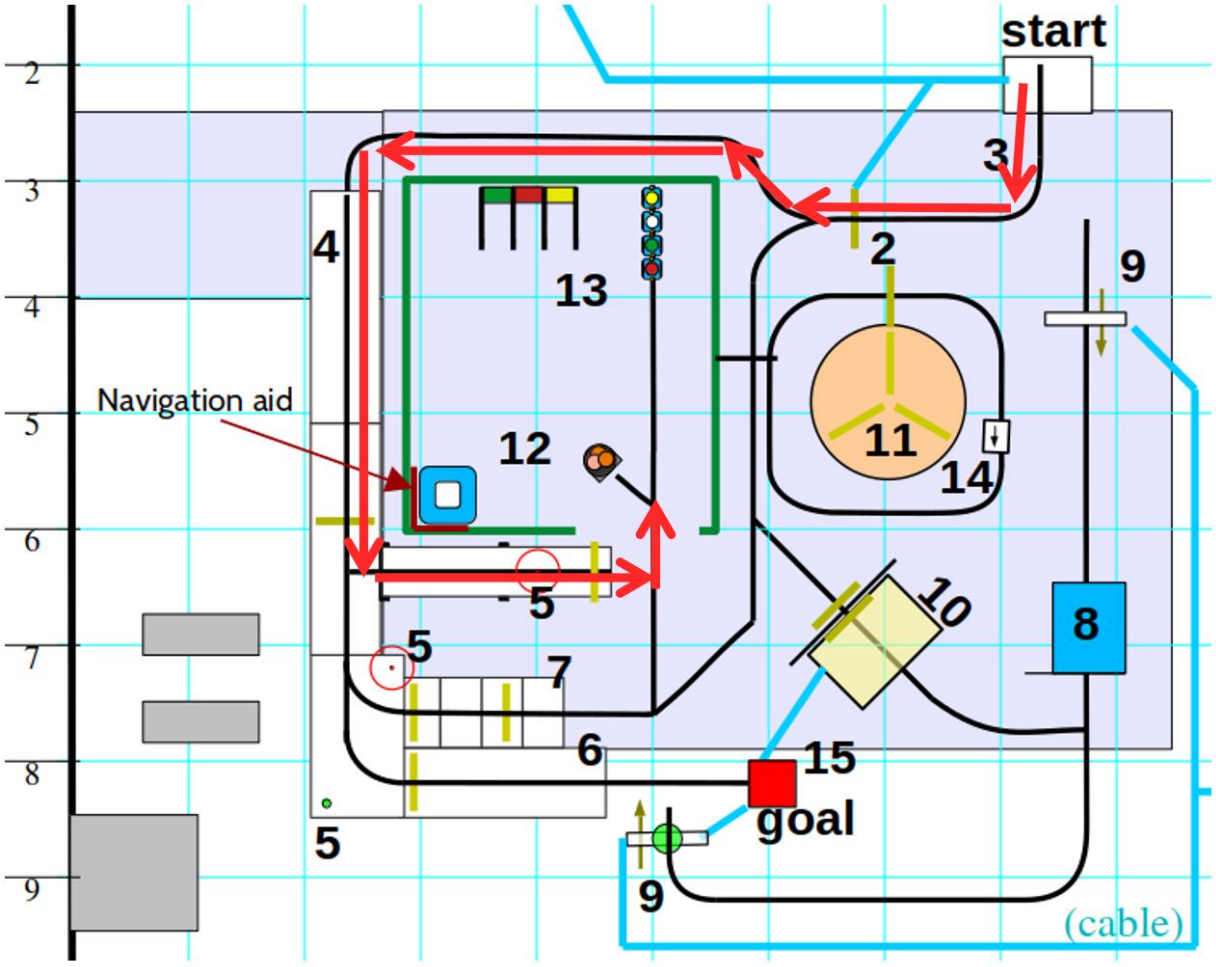


Figure 2: Task Dependency

3.2.2 Modular decomposition of task processes

1.Passing the guillotine gate,then uphill the slope and downhill from seesaw



Make sure the robot recognizes the first white line after going downhill and turns right to enter the mini golf.

2.Mini-golf and Package delivery

Procedure:

2.1 Push down the ball dispenser

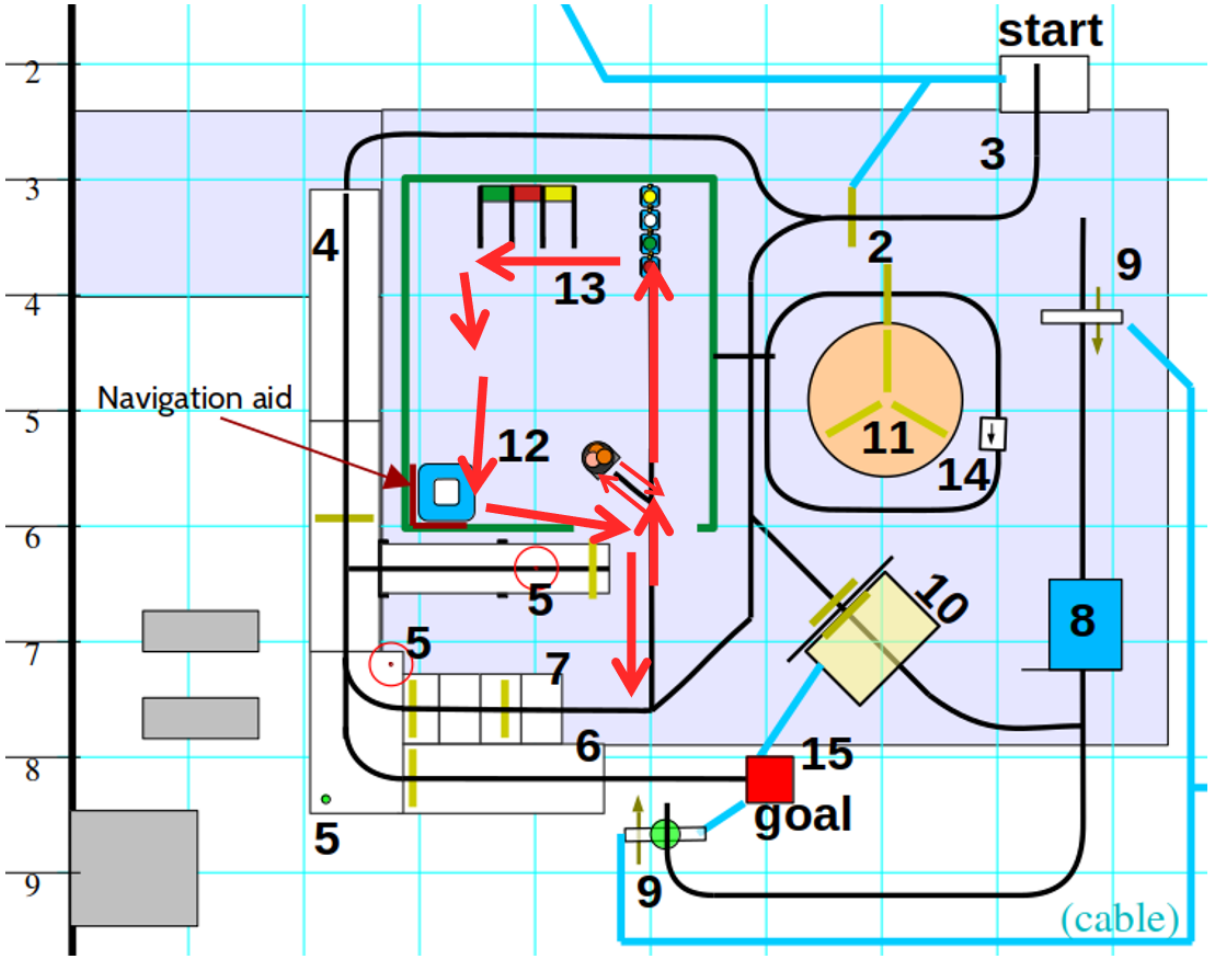
2.2 Back to the main road and go straight the packages

2.3 Use the clamp on the robot to carry one package at a time. If it is identified as a white ball package, it will be clamped and moved to the right side of the white line to avoid interfering with subsequent clamping work.

After each handling is completed, step back 20cm and then turn 90 degrees to the right to move forward. After recognizing the white line, turn 90 degrees to the left and continue to pick up the next package. The handling task is judged to be over after four picking and placing operations.

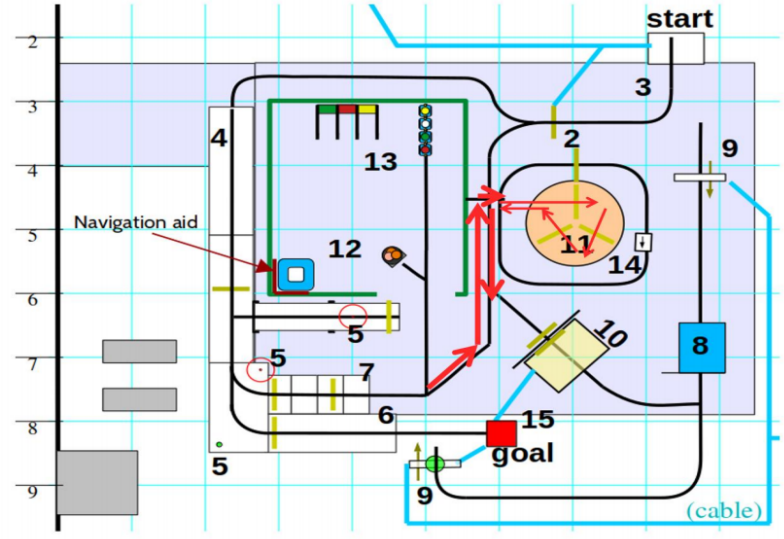
2.4 Identify and pick up loose golf balls or push as many golf balls as possible to a designated

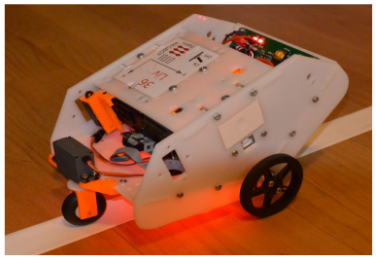
area(Method to be determined), then exit this area when finished.



Attention: Emergency procedures may be required. This is to prevent the robot from getting stuck in this area and making it difficult to complete subsequent tasks. (For example, after a certain task is completely blocked, the task is changed to a sweeping robot strategy (driving forward, turning left 90 degrees when encountering an obstacle, until it encounters a white line and starts to follow the path again and then leaves the area)

3.Passing the 3-gate





When identifying discs, we need to pay attention to the fact that the competition is held in a gymnasium with a light yellow wooden floor, while the test venue is a black asphalt ground. Maybe machine vision has a certain impact on the recognition of dark discs?

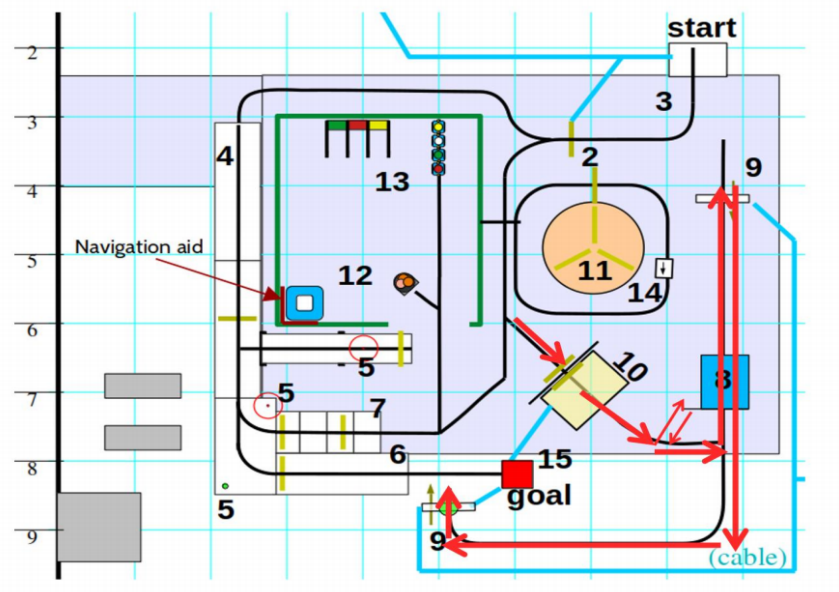
When identifying discs, we need to pay attention to the fact that the competition is held in a gymnasium with a light yellow wooden floor, while the test venue is a black asphalt ground. Maybe machine vision has a certain impact on the recognition of dark discs? In addition, we must also pay attention not to collide with the door frame or the samll autonomous robot on the roundabout.

(From rules: The robot must not be touched and it gives -1 point for each touch (up to a maximum of -2 points). The speed will not be constant but be within the range of 0 to 50 cm/sec with an average speed of approximately 30 cm/sec over 20 seconds)

4. Passing the axe gate and complete racetrack

After passing through the ax door, try to use a clamp or another designed expansion structure to open the door smoothly on the curve leading to the tunnel (or other methods).

After completing the racetrack, you can choose to have the robot drive forward and then turn right and directly press the terminate button to end the race. The final process is to be determined.



If we wanted more points, maybe consider walking up the platform again and going down the ramp for one more point after completing all the main items.

This is only the current preliminary process plan, and the specific process may be changed during subsequent discussions and testing.

Before the sixth week, the above four parts of work were carried out by different combinations of members at different times of the week to improve team work efficiency. A short meeting will be carried out for teamates discussion on each Friday.

3.3 Coordinating roles

PMO (Project Management Officer): Responsible for project management and schedule monitoring.– Zekun Wang

QAO (Quality Assurance Officer): Responsible for quality assurance and acceptance of results.– Huan Hu

CPO (Chief Product coordinator): Ensure all chosen challenges are handled before the competition. – Yuxuan Ma

CTO (Chief Test manager): Prepare test site, coordinate testers time, record test result. – Xingyi Liu

SLO (Software Library officer): Manage code iteration –Dong Yun

HLO (Hardware Library officer): Manage hardware, keep the robot –YuanshengZhou

CCO (Chief Communication Officer, internal and external): Communicate with other team members, introduce our idea to others. –Yiming Zhang

4 Challenge Allocation

Code iteration update management

4.1 List group members and allocated report challenge

Xingyi Liu - s232258: Challenge of Mini golf.

Huan Hu - s232179: Challenge of closed tunnel and racetrack.

Yuxuan Ma - s232172: Challenge of detection of ArUco markers.

Yiming Zhang - s232896: Challenge of racetrack, axe gate and closed tunnel.

Dong Yun - s232293: Challenge of roundabout.

Yuansheng Zhou - s232925: Challenge of uphill and downhill the platform.

Zekun Wang - s232272: Challenge of package delivery.