自主移動機器人應用與實作
Application and Practice of Autonomous Mobile Robots

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Outline

- Course description
- Course syllabus and grading
- Case studies of mobile robot projects
- Facility and equipment and class room
- First touch of your mobile robot (B119 at New ME Building)

Course description

- This course is developed as a project-based learning (PBL) course.
  - The students are capable of learning the fundamentals of kinematics and wheel odometry, sensor fusion, localization and mapping, path planning, and obstacle detection and avoidance with the autonomous mobile robots.
  - A robotic manipulator kit is installed on the mobile robot to perform autonomous mobile manipulation.
  - This course also introduces robot operating system (ROS) and simpke computer vison methods to efficiently learn the practical implementation aspects of an AMR with robotic manipulators.
- Three PBL topics, including mapping and autonomous mobile robot (AMR) localization, path planning and autonomous navigation, and autonomous object delivery with performing pick-and-place, are arranged to help to improve the hands-on skills and problem-solving capabilities.

Syllabus (before midterm)

週次	日期	單元主題
第1週	2/23	Introduction to autonomous mobile robots (AMR)
第2週	3/1	Robot operating system (ROS)
第3週	3/8	Sensor fusion, localization and mapping
第4週	3/15	Path planning
第5週	3/22	Kinematics and wheel odometry (Prof. Pei-Chun Lin)
第6週	3/29	Proposal of final project
第8週	4/12	Obstacle detection and avoidance

林沛群教授

Syllabus (after midterm)

第10週	4/26	Vison-based object picking with TM Flow/ Small Manipulator
第11週	5/3	Integrated applications of TM robot/ small manipulator and AMR (I)
第12週	5/10	Integrated applications of TM robot/ small manipulator and AMR (II)
第13週	5/17	PBL I: Mapping and AMR localization
第14週	5/24	PBL II: Path planning and autonomous navigation
第15週	5/31	PBL III: Autonomous object delivery with performing pick-and-place
第16週	6/7	Final project presentation

Course grading

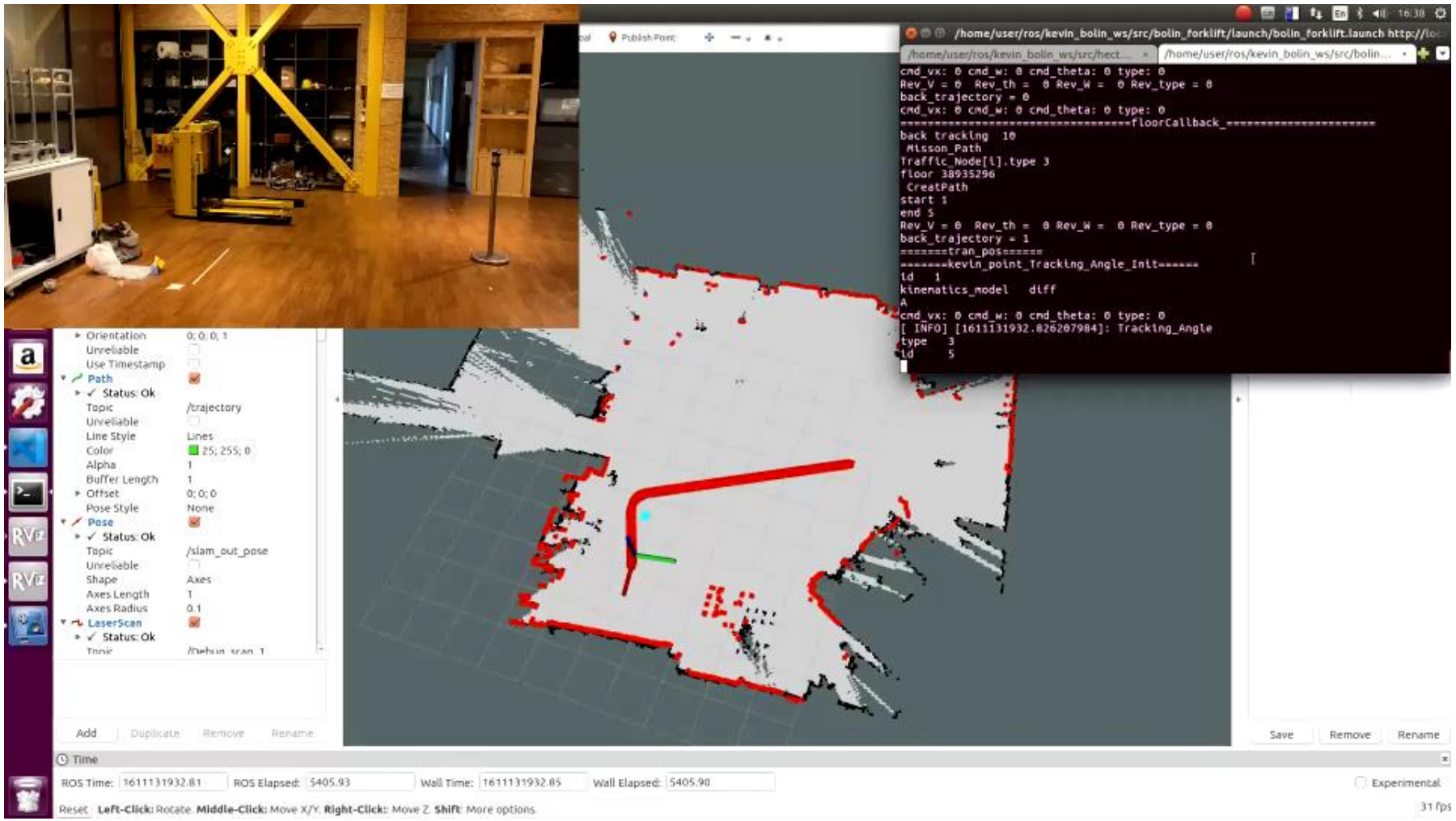
編號	項目	百分比	說明
1	Class attendance and participation 10%	10%	Lectures and labs are counted
2	Midterm exam	25%	Mission competition with coding (team)
3	Final project proposal presentation	10%	Presentation and review on final project proposal (team)
4	Final project report	30%	Presentation and review on final project outcome and achievement (team)
5	Lab exercise achievement	25%	All lab topics are counted

About Mission Competition

- Considering the wafer delivery in a foundry fab, the critical issues are
  - Autonomy: Without the needs of human operation
  - Safety: without any collision with obstacles
  - Smooth and stable: less vibration to reduce the defects of wafers during transpiration
  - Efficiency: Optimal path and high speed (short mission time)
- Test arrangement
  - A transportation from current location to the desired destination
  - Arranging a number of static obstacles
  - A cup of water with full-filled is placed on the mobile robot
  - Grading
    - Time of task
    - Number of collision
    - Remaining water in the cup

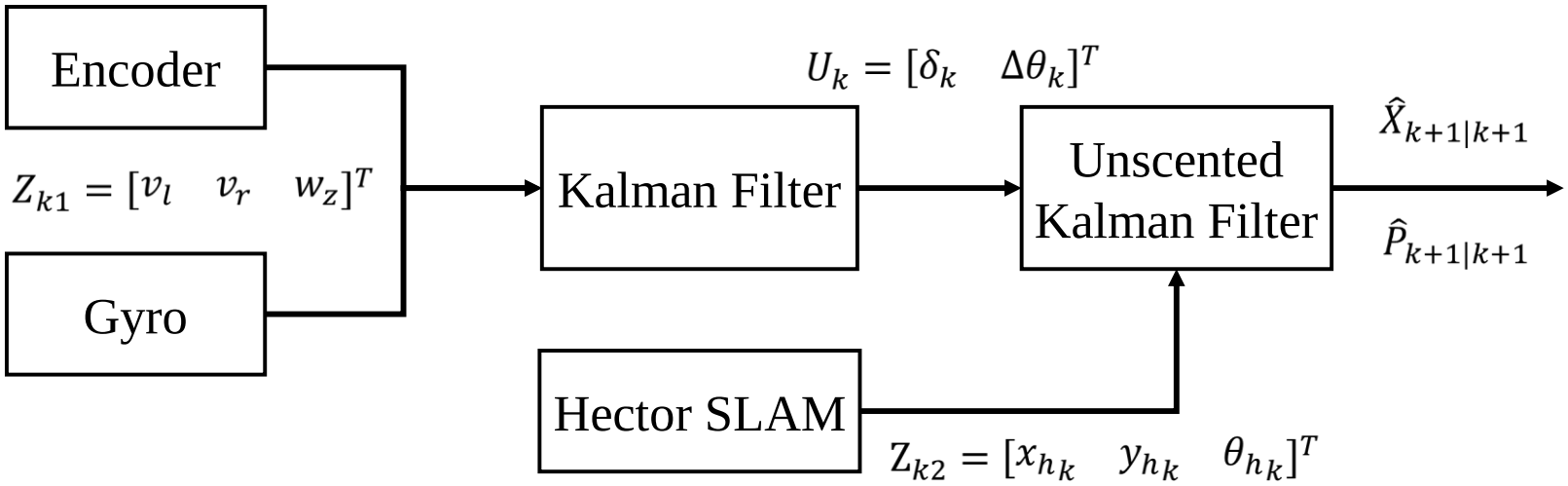
Case Study I: SLAM for a Forklift Mobile Robot

Forklift SLAM and Navigation



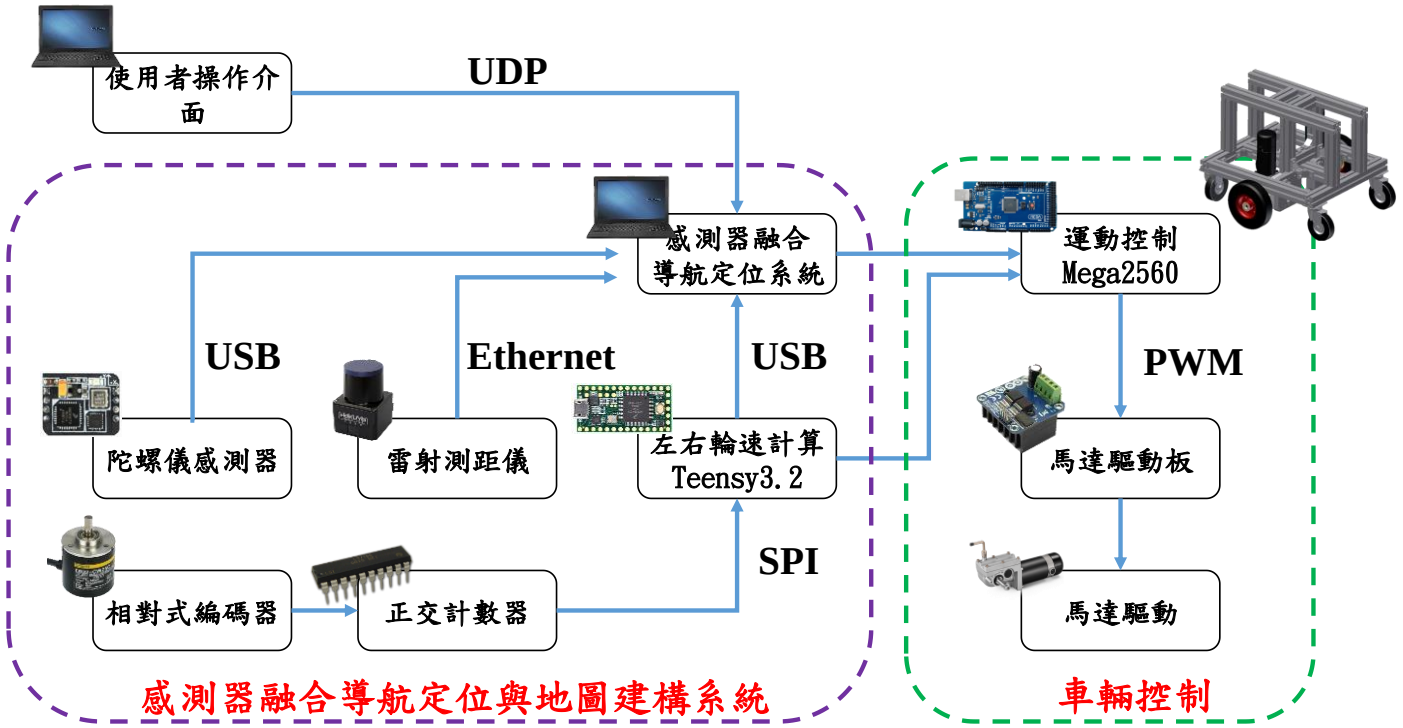
Case Study II: Sensor Fusion

Sensor Fusion

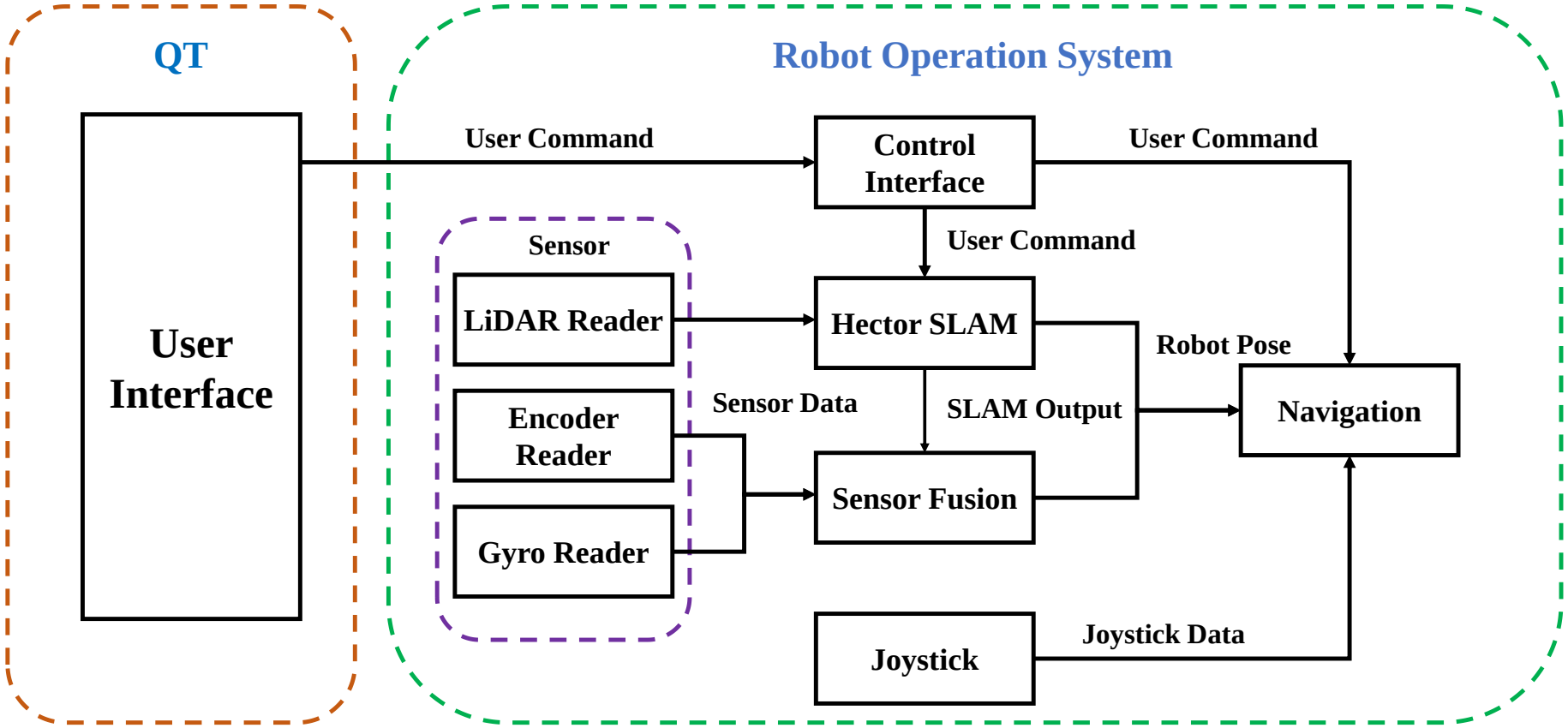


Robot and Components

車體尺寸（mm）	650*510*350
車體淨重（kg）	28
運作電壓（v）	DC-24
空載速度（m/s）	60
車輪直徑（mm）	220
底盤離地高度（mm）	160



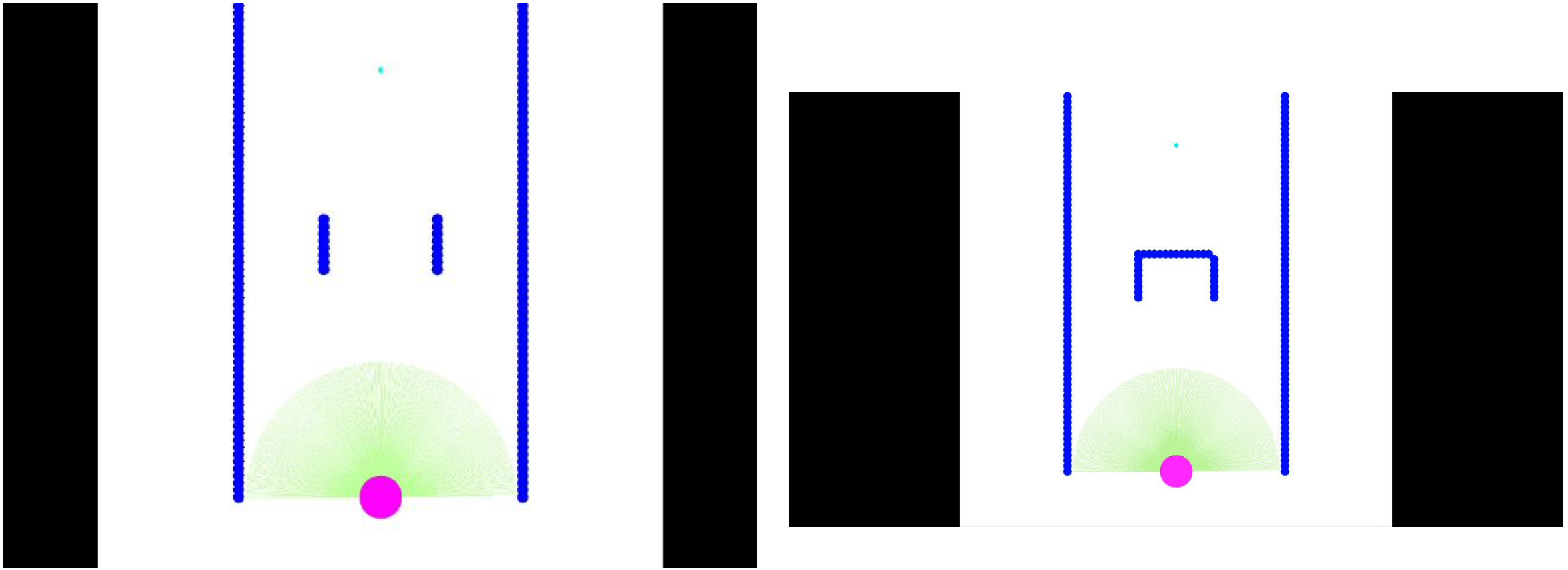
Overall System



Path Comparison

Case Study III: Obstacle Avoidance with Depth Camera

Dynamic Window Approach (DWA)

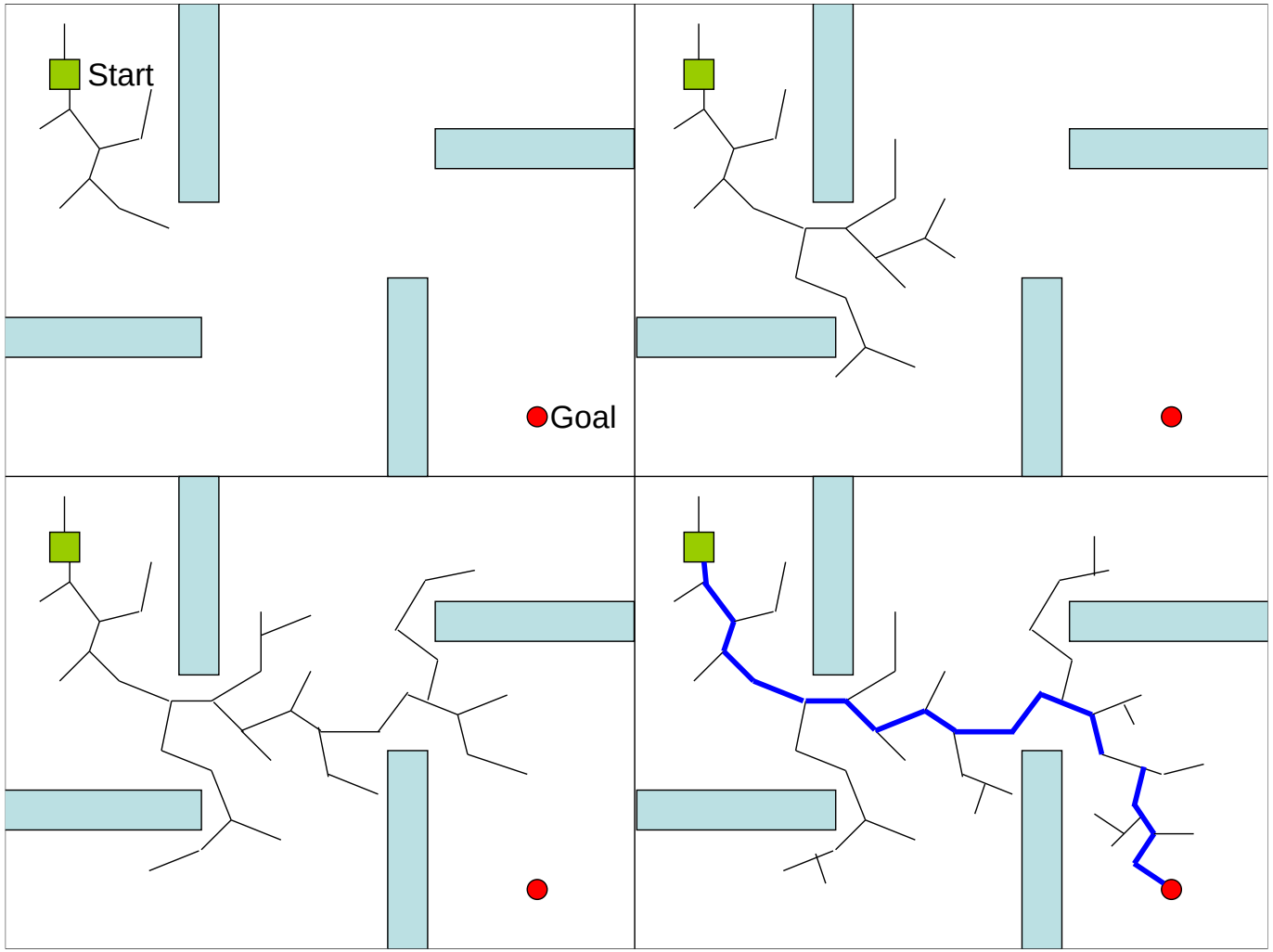


Experiment I

Experiment II

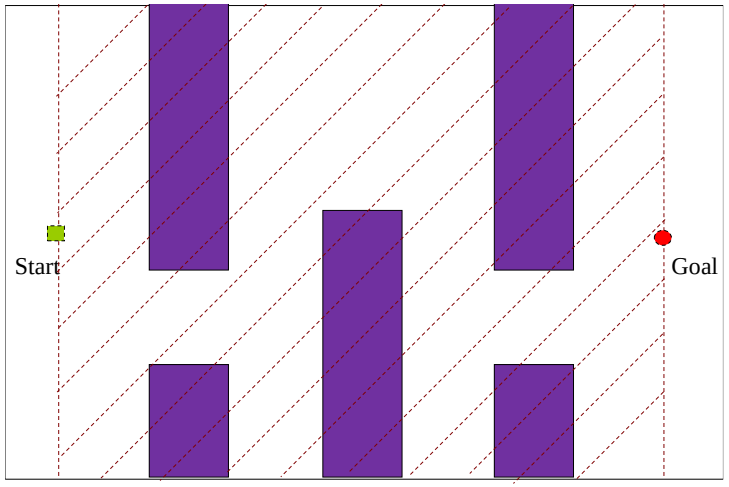
Case Study IV:
Path Planning with RRT

Rapidly-exploring Random Tree



Types of RRTs

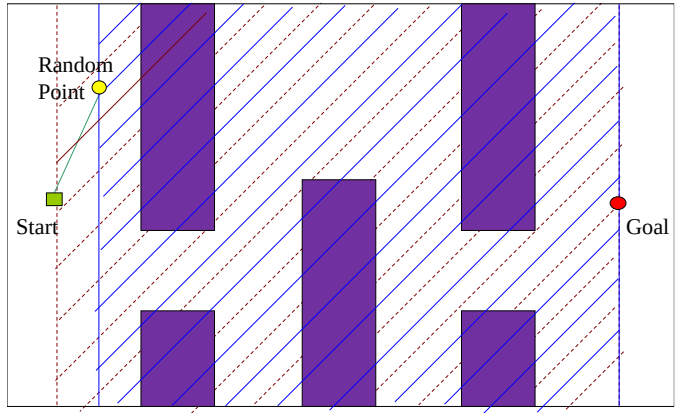
- Basic RRT/ Forward RRF/ Chance RRT



新點在起點與終點之間的區域 產生

Basic RRT

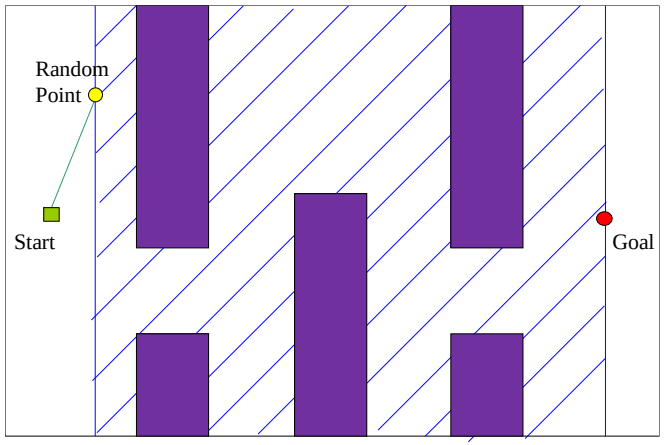
Chance RRT



當機會為P時，新點在前一個新點與終點之間區域 產生

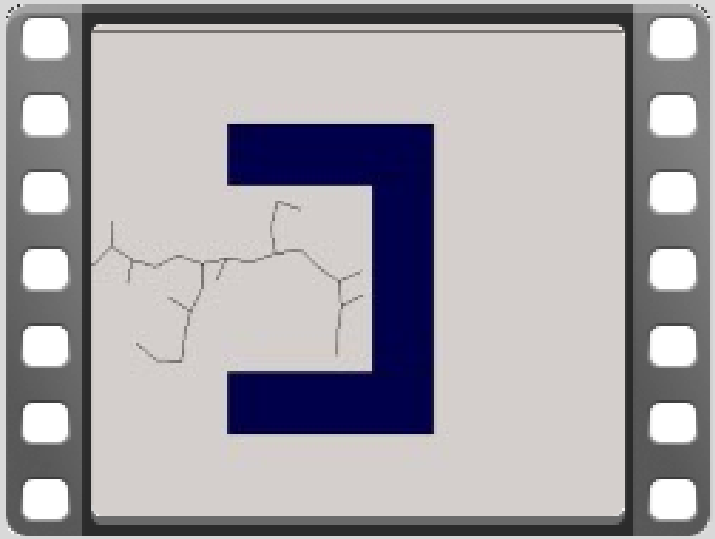
當機會為1-P時，新點在起點與終點之間區域 產生

Forward RRF

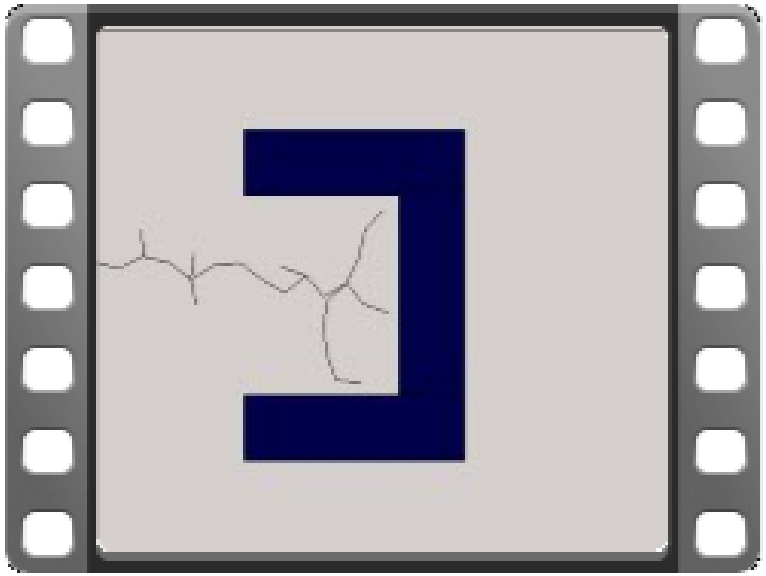


新點在前一個新點與終點之間的區域 產生

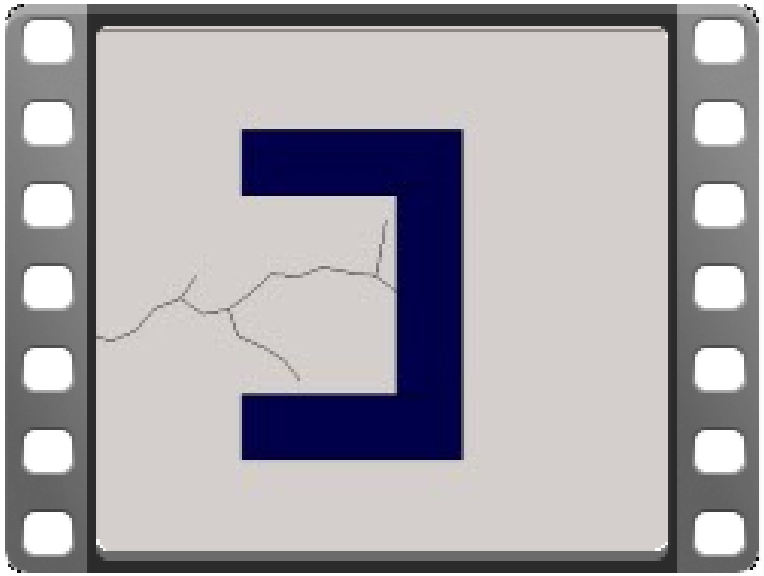
RRT Simulation



BasicRRT



CRRT

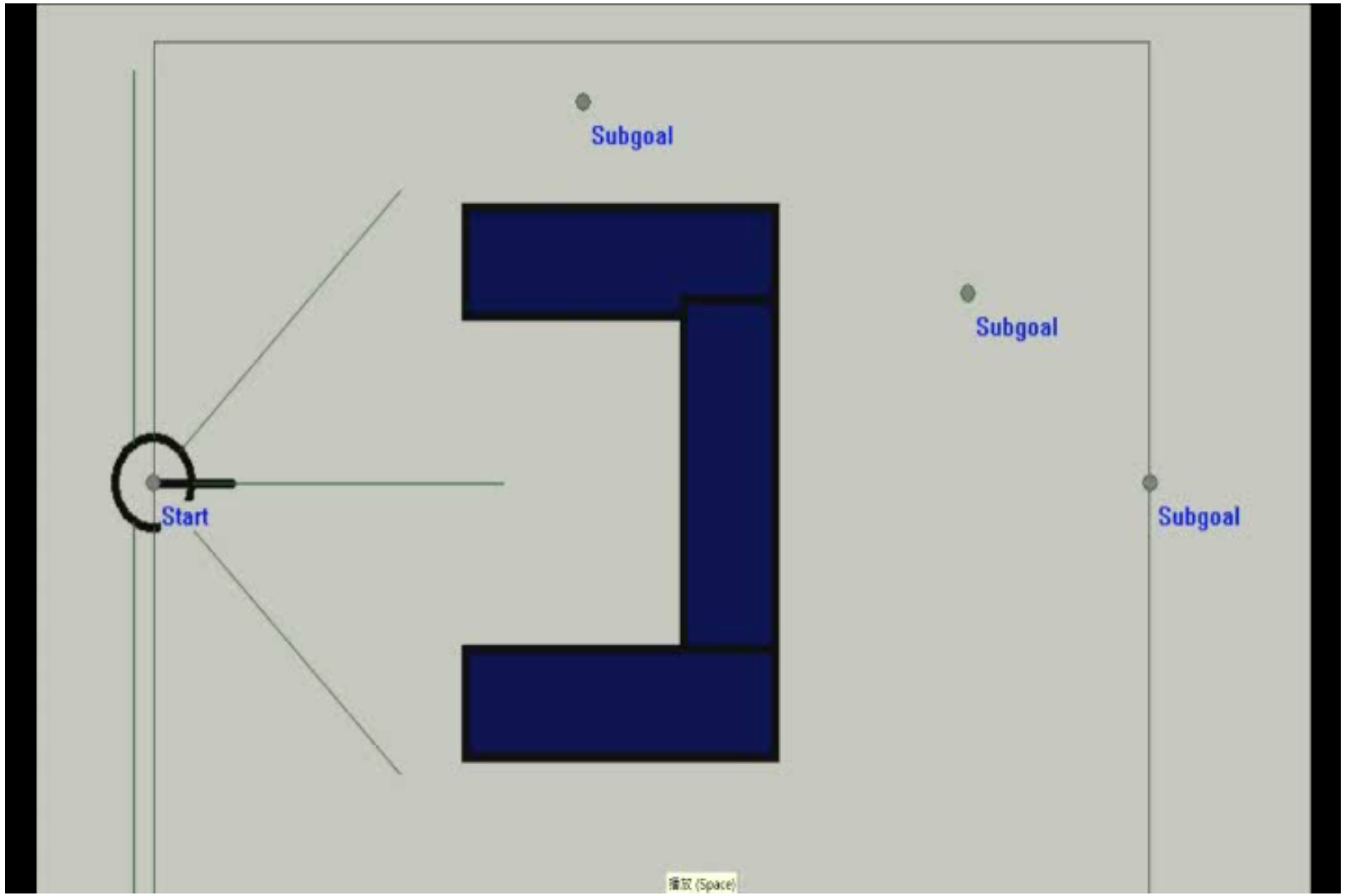


FRRT

Wheelchair Test # 1

- SLAM + RRT

RRT Path Planning with Obstacle Avoidance



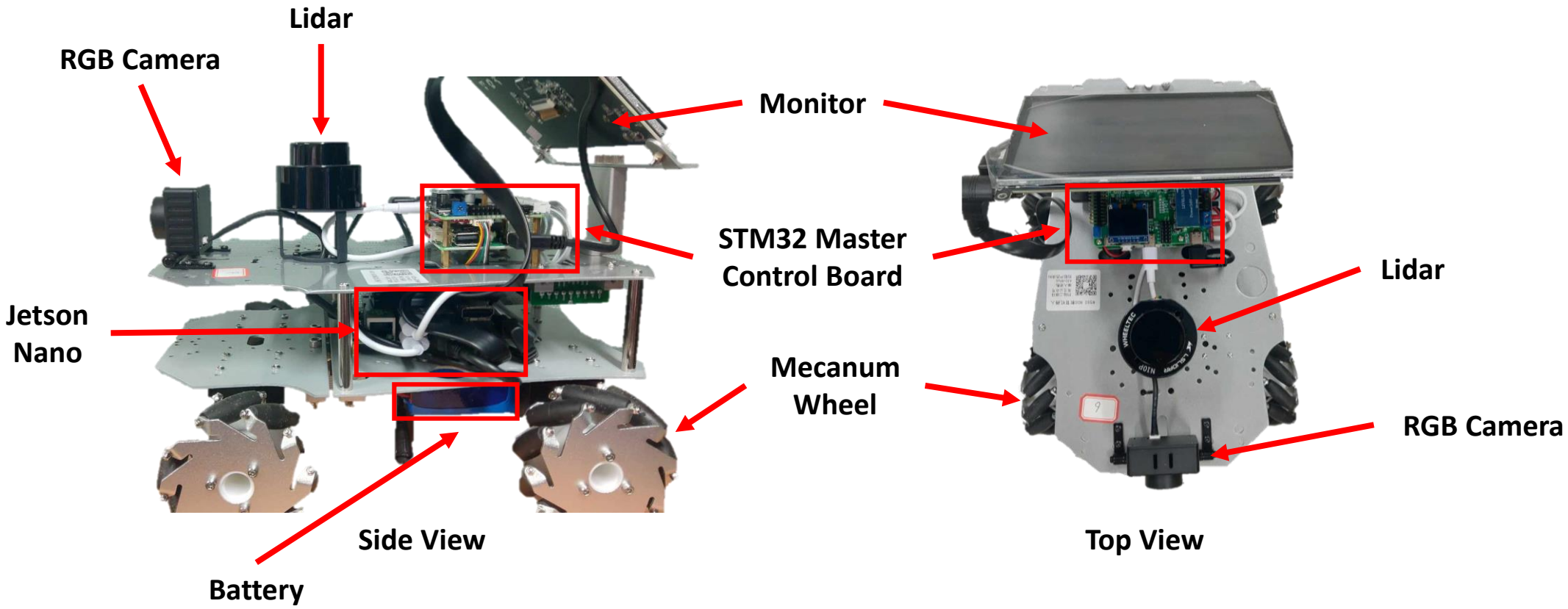
Wheelchair Test # 2

- SLAM + RRT + Obstacle Avoidance

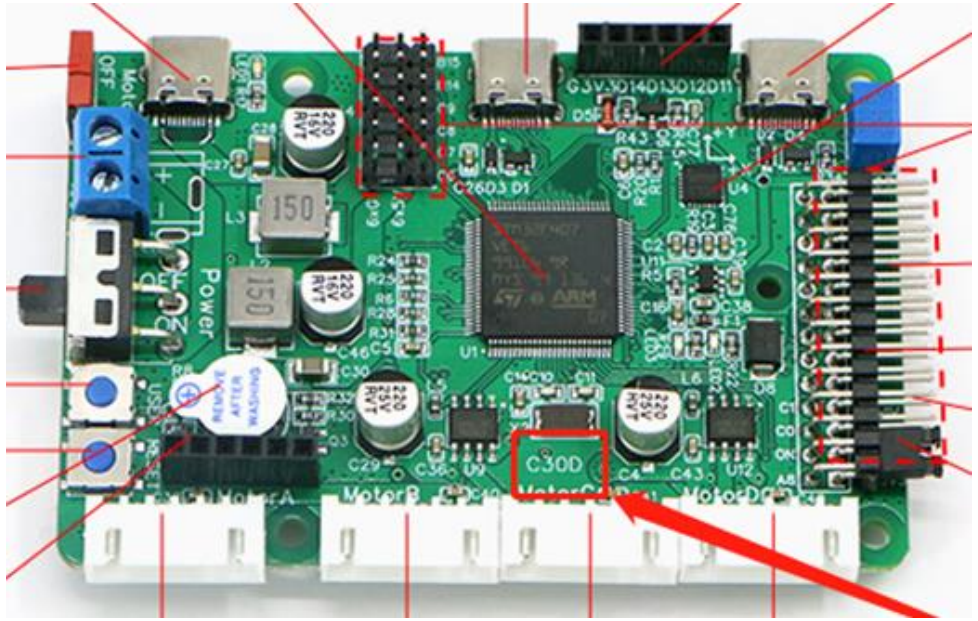
Facility and Equipment and Class Room

Facility/ equipment and classroom

Classroom: 機械新館 B119「機器人實作實驗室」



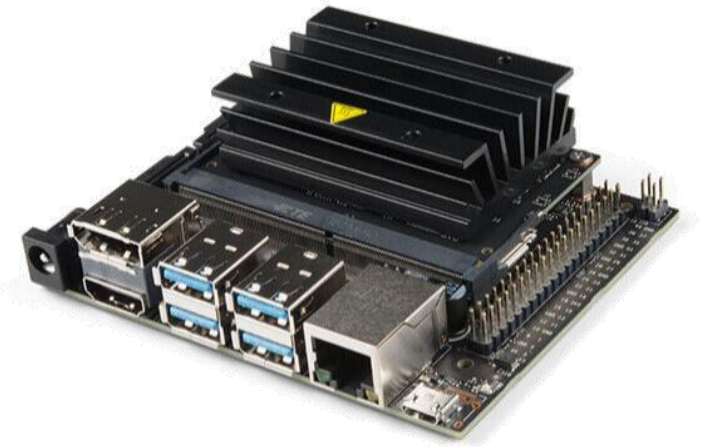
Hardware



STM32 Master Control Board	
CPU	AMR Cortex-M2 32-bit@168MHz
RAM	1MB Flash memory

- Provide the data communication between hardware components (wheels, sensors, monitor, joystick, etc.)

Hardware



Jetson NANO	
CPU	AMR Cortex-A57 64-bit@1.43GHz
GPU	128-coreMaxwell @921MHZ
RAM	4GB 64-bit LPDDR4 @1600MHz
USB Ports	4*USB3.0
Display Ports	2*HDMI 2.0/DP 1.2
GPIO number	40

- Provide computation for ROS, AI IoT applications, embedded application, etc.

Sensors

C70 FOV RGB Camera	
Resolution	720P
FOV	H64.5° X V50°
fps	25fps

- Be used for visual SLAM, object detection, recognition, etc.

Sensors

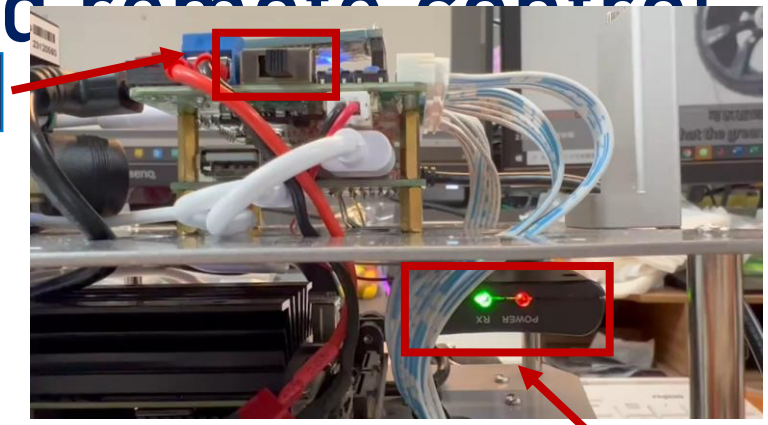
LiDAR N10P	
Radius	25m
Scan frequency	6~12Hz
Sampling time	5400Hz
Angle resolution	0.4°~0.8°
Purpose	suitable for outdoor use

- Be used for mapping, navigation, environment assessment, etc.

AMR Control – PS2 gamepad remote control

1. Open the power of car / gamepad
2. Check if there is enough battery power
3. Check if the connection is successful
4. Press Start button
5. Let's get it started !!

Car power



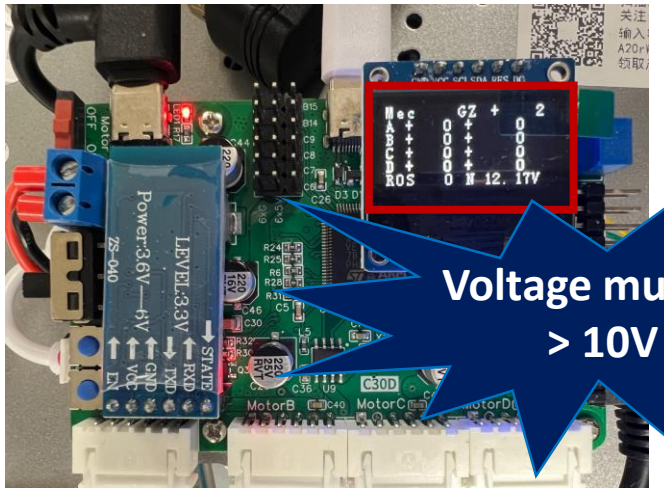
Connection Status Light
- **Flashing**: Not connected
- **Steady**: Connected

Start

Control Speed:
1. HIGH
2. LOW

Control the car to move in all

Control the car

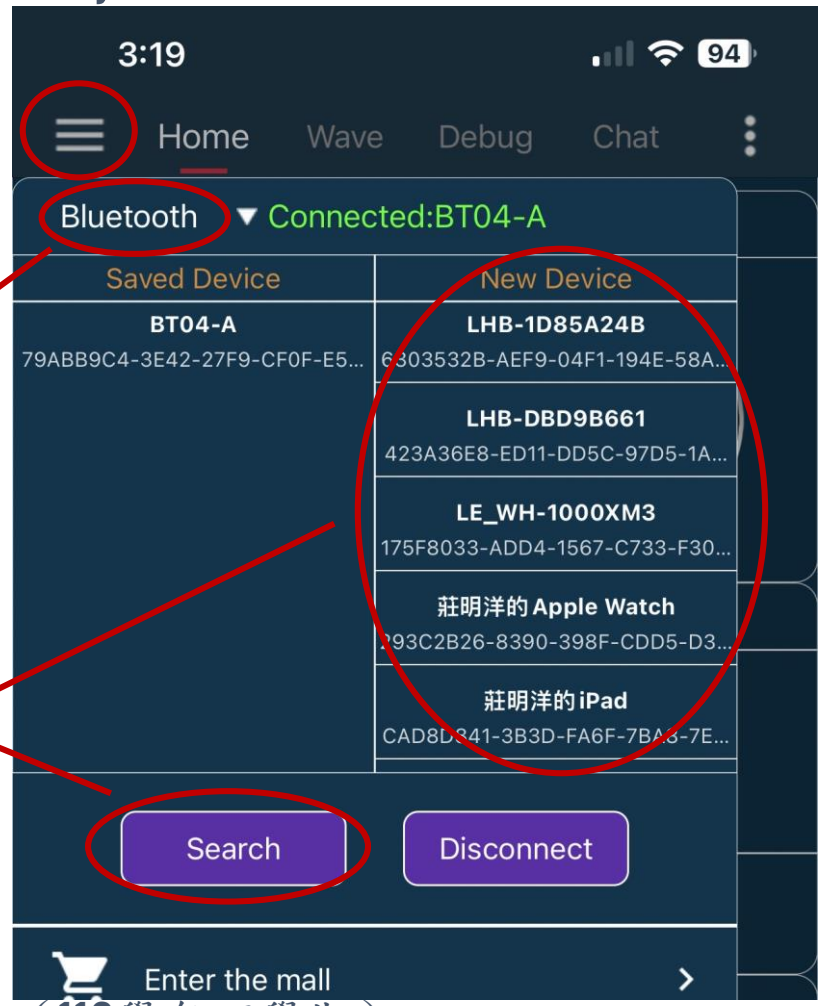


Voltage must be > 10V

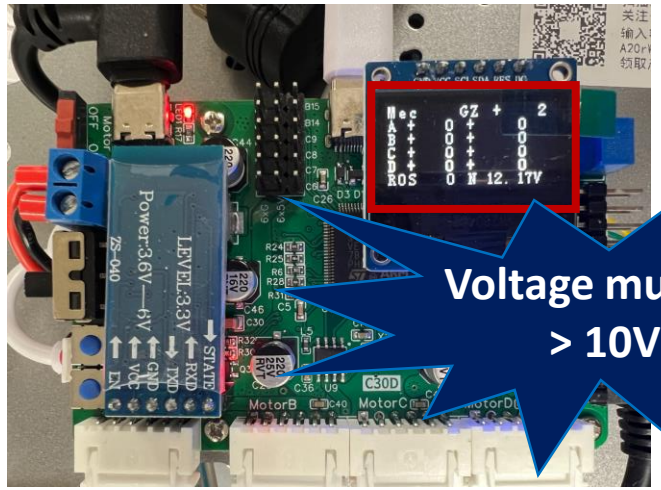
AMR Control – APP Control

1. Open the power of car
2. Check if there is enough battery power
3. Download APP
4. Connect to the car

IOS APP LINK



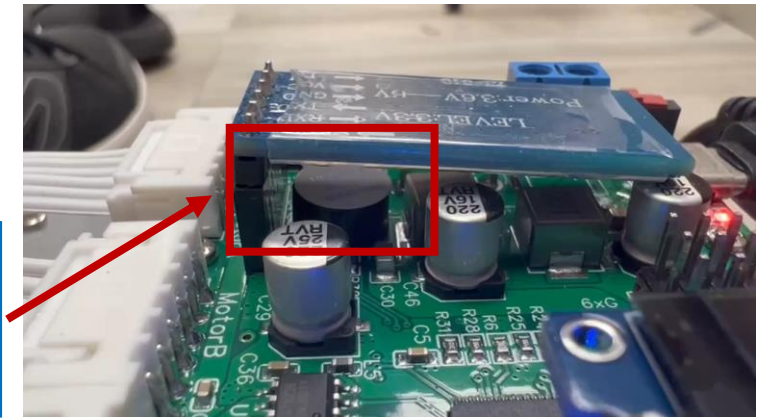
1. Change it to Bluetooth
2. Search the device
3. Choose 「BT04-A」

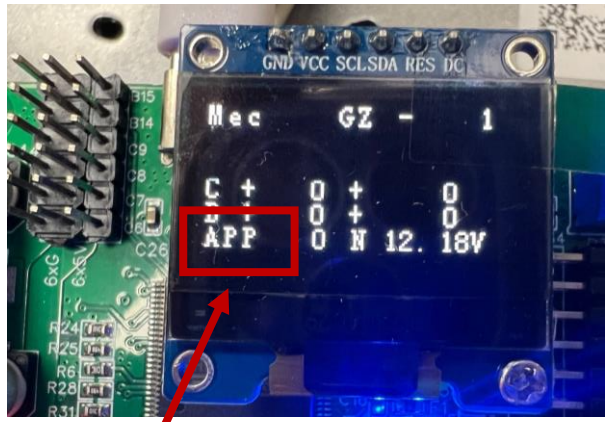


AMR Control – APP Control

5. Check if the connection is successful

Connection Status Light
- **Flashing**: Not connected
- **Steady**: Connected

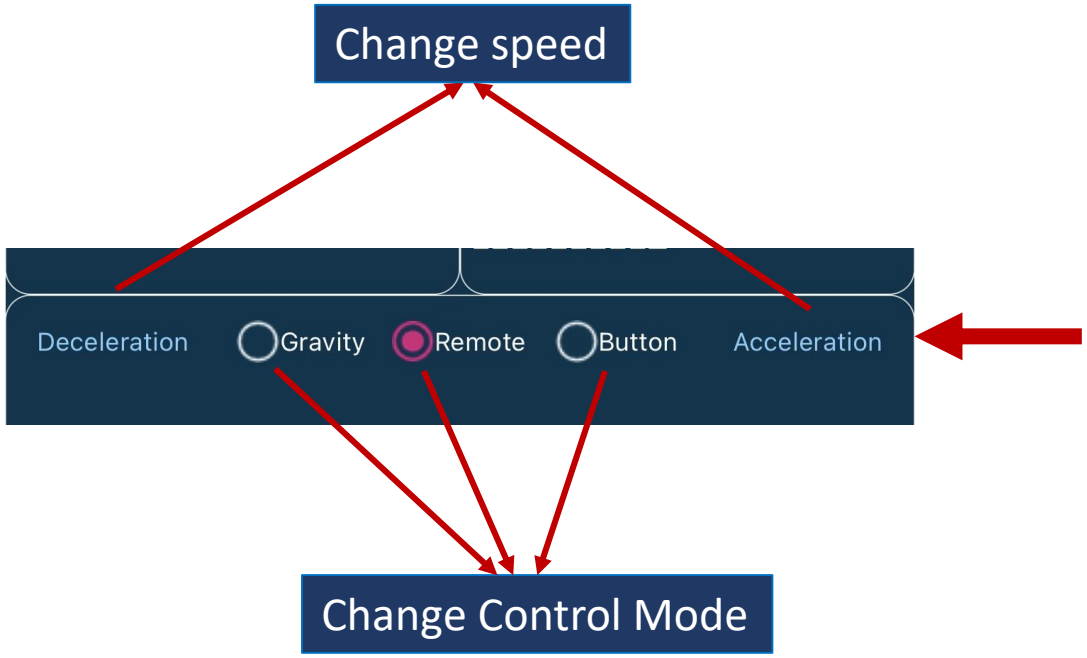


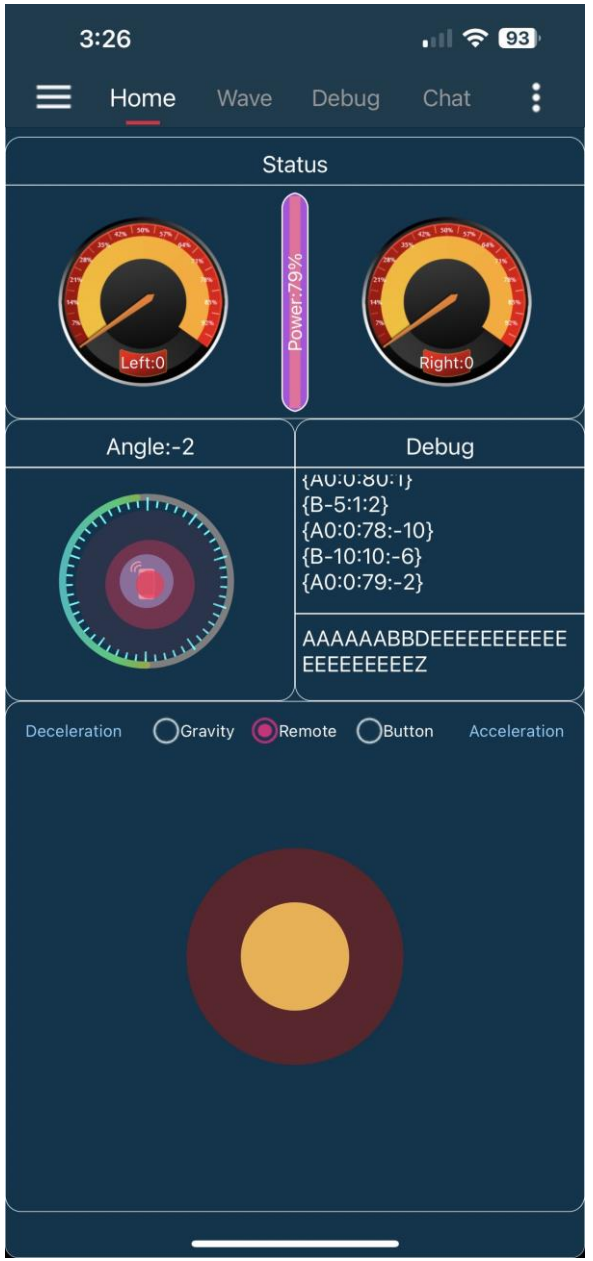


APP Connection

AMR Control – APP Control

6. Let's get it started !!





First Touch of Your Mobile Robot (B119 at New ME Building)

Practice

- Make sure the cables are connected
- Control the car using the APP and PS2 joystick

Welcome to Join This Course!

Q&A