Autonomous Parking System Based on Reinforcement Learning

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INTRODUCTION

◆ Background

- Recently, with increasing interest in autonomous vehicles, research has been conducted to replace tasks previously performed by drivers.
- Autonomous parking is gaining attention as a solution to the challenge of parking in complex environments, which often poses difficulties for novice drivers.

◆ Objectives

- Parking space recognition and autonomous parking using only a camera

METHOD

◆ Mechanism

Gmapping
- Global Mapping while driving through an indoor parking space
- Saving Map for regularly visited locations (e.g., Apartment parking lots)

Semantic Segmentation
- Indicating the area of objects in the image
- Assigning available parking spaces as the destination

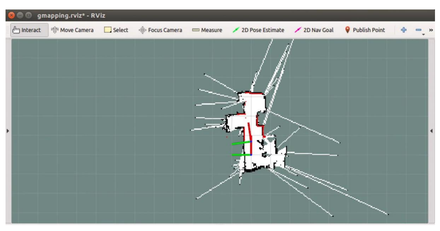
Waypoint Navigation
- Setting a path to reach the target destination
- Utilizing Local Map and Depth information

◆ Test

WeGo-LIMO

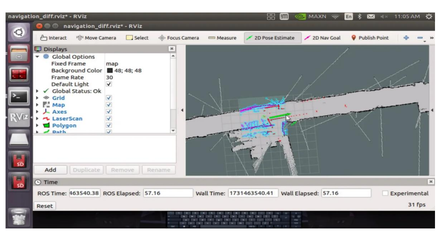
Using the LIMO robot with Ubuntu 18.04 and ROS1 Melodic for autonomous driving simulation.
D435i camera attached to the LIMO is used, and the detection model was developed using a dataset created by labeling real-world data. (YOLOv11)

◆ Algorithm

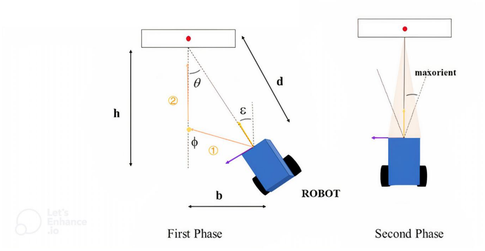


Gmapping

Semantic Segmentation



Navigation



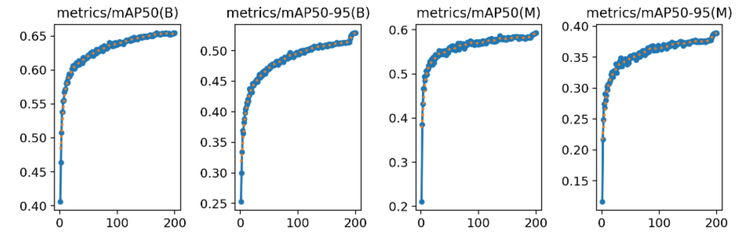
Pose Estimation

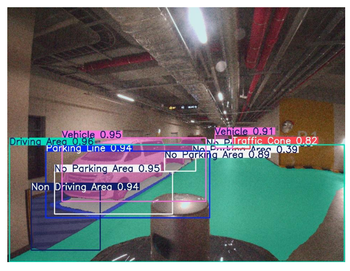
RESULT&DISCUSSION

◆ Gmapping

- ✓ In Gazebo, Gmapping results in a clean Global Map.
- ✓ When Gmapping with LIMO, outliers are present due to texture, illumination, and other issues.
- ✓ Navigation process using Global + Local Map → Successfully detecting obstacles and waypoint

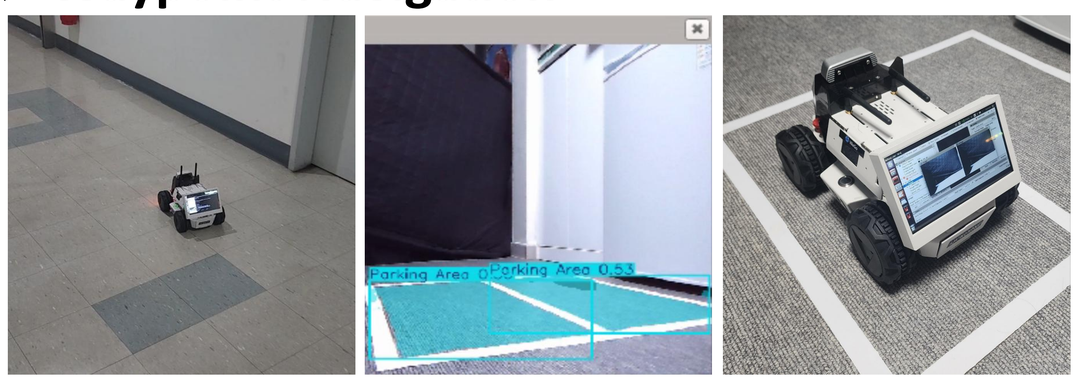
◆ Semantic Segmentation





- ✓ YOLO v11s-seg model deployed for real-time instance segmentation of parking spaces and obstacles
- ✓ Model trained on custom parking lot dataset to detect: Available parking spaces, Occupied parking spaces, Lane markings, Obstacles (vehicles, pillars, walls)
- ✓ Precise boundary information improves parking space selection
- ✓ Enhanced obstacle avoidance during parking maneuvers

◆ Waypoint Navigation



- ✓ It is possible to position the LIMO at a waypoint with desired pose.
- ✓ Designate a detected parking area as the goal.
- ✓ Estimate the current pose of the LIMO and move along a parking route without contacting obstacles.

EXPECTATION

◆ Research Insights

Achievements
- Accurate real-time semantic segmentation using YOLOv11s-seg model
- Successful environment mapping with Gmapping in simulation
- Stable autonomous navigation with effective obstacle avoidance

Limitations
- Performance degradation in extreme lighting conditions (too bright/dark)
- Mapping quality affected by real-world lighting and texture variations

◆ Next Goal

- Integration with reinforcement learning for improved decision making
- Model optimization for various environmental conditions
- Performance evaluation under different lighting conditions