Parking Management Bot

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https://github.com/ApurvK032/Autonomous-Car-Parking-Bot.git

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Problem Statement

- Poorly parked vehicles waste space and slow down parking operations

- Our robot automates detection and repositioning for faster, more organized parking lots.

Project Overview

Autonomous robot to detect, navigate to, and relocate misparked vehicles

ENVIRONMENT:

- 40m×40m parking lot, 6 spaces, 3 test vehicles
- Overhead camera for global perception

COMPONENTS:

- Navigation bot (mecanum wheels) → Towing bot (0.35m lift)
- Overhead camera + LiDAR sensor

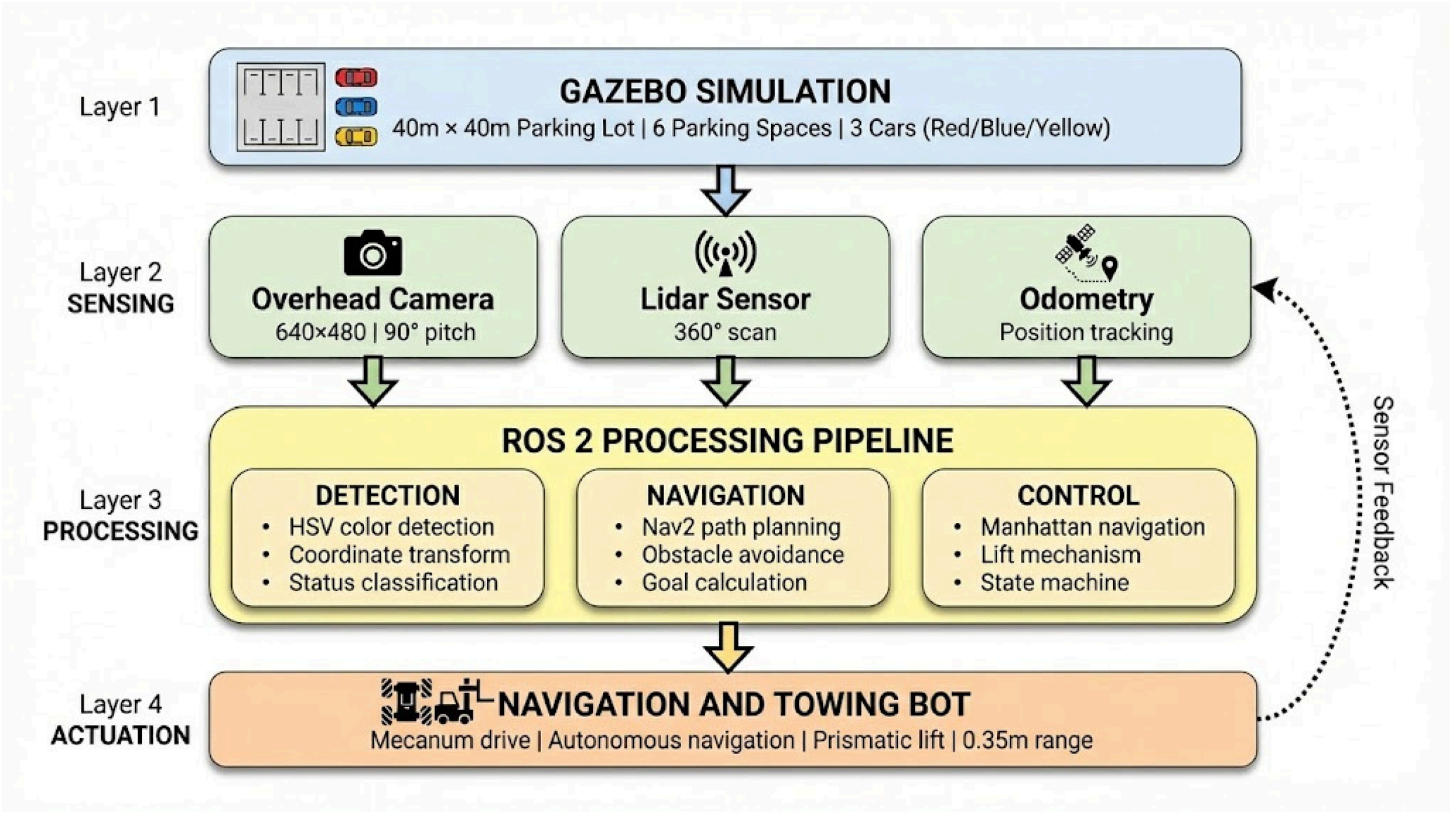
TECH STACK:

- ROS 2 Humble + Gazebo + OpenCV + Nav2 + ros2_control

WORKFLOW:

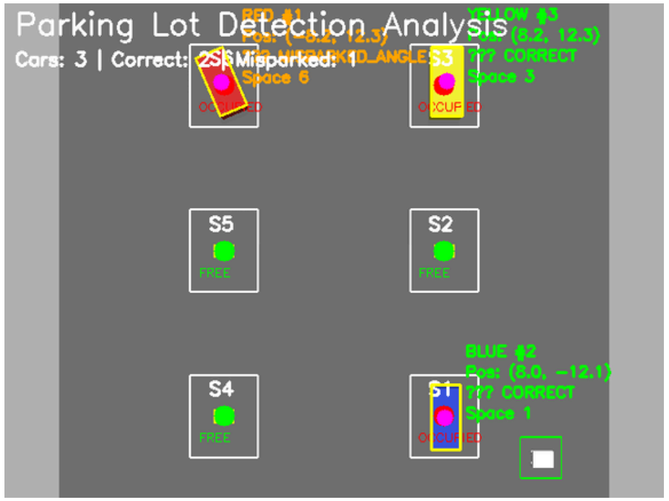
- Detection → Navigation → Approach → Lift → Relocate

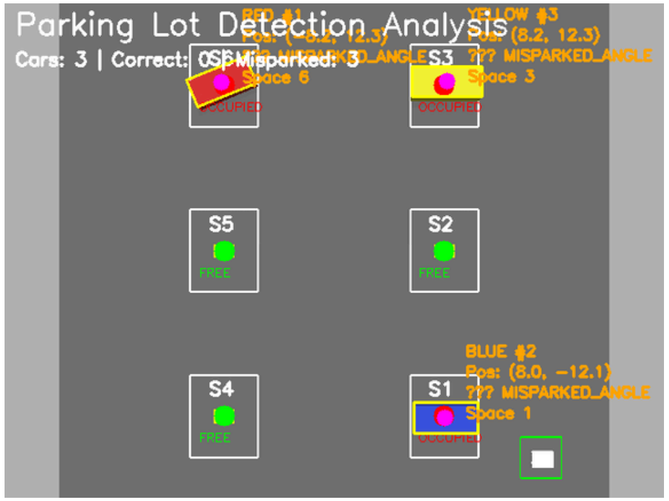
System Architecture



Phase 1 - Detection System

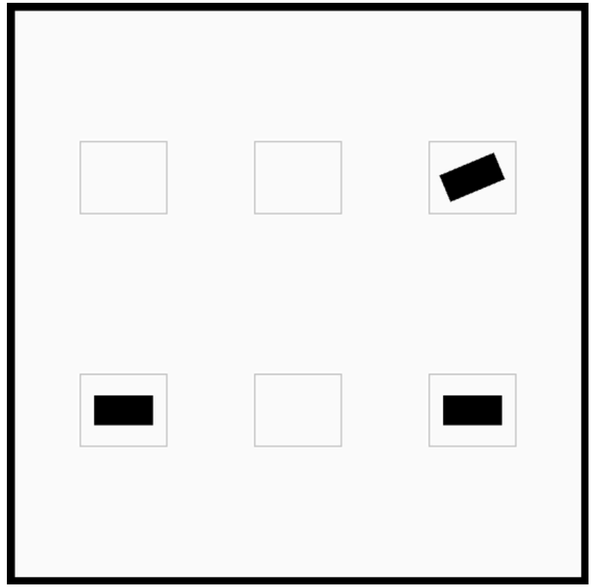
- - HSV color-based detection identifies all vehicles with ±0.1° orientation accuracy
- Automatic classification: CORRECT (green) vs MISPARKED (red/orange) based on position and angle tolerance
- Real-time visualization shows parking space occupancy and vehicle status for monitoring

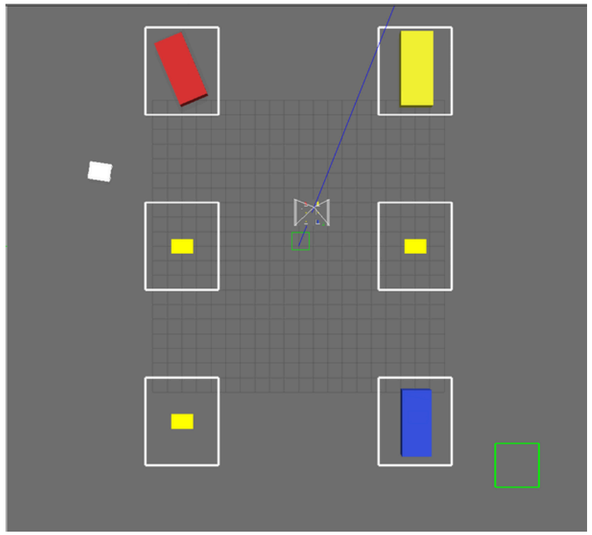


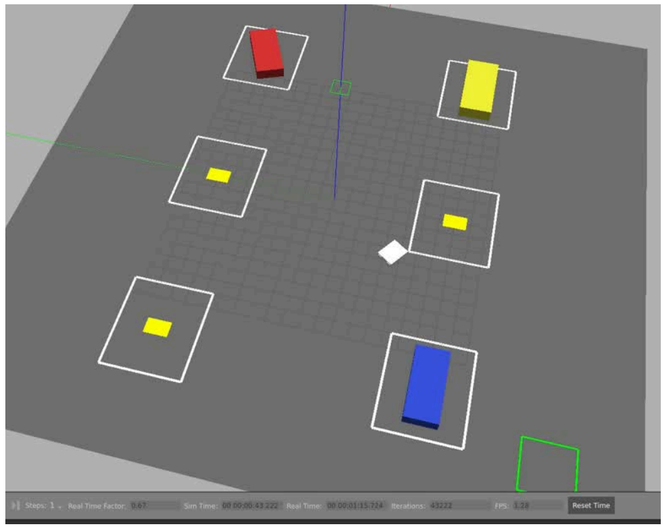


Phase 2 - Navigation

- Nav2 Integration: Path planning with A*
- Static Map: 40×40m occupancy grid
- Obstacle Avoidance: Other parked cars as obstacles
- Goal Calculation: 3.5m behind misparked car
- Success: Autonomous navigation from home (-15,-15) to target

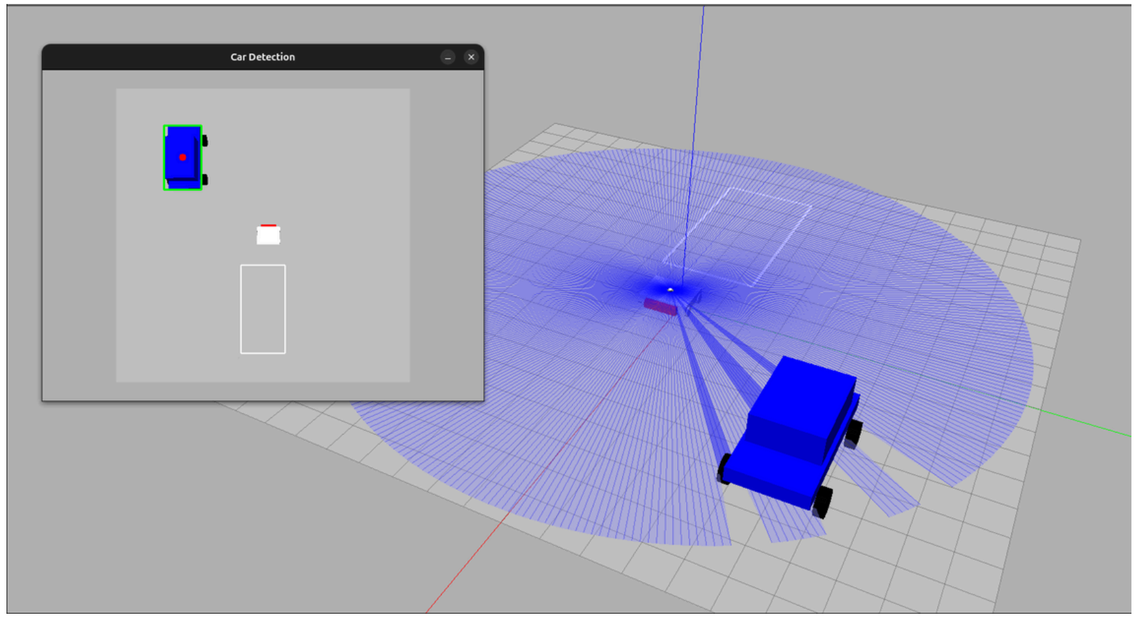


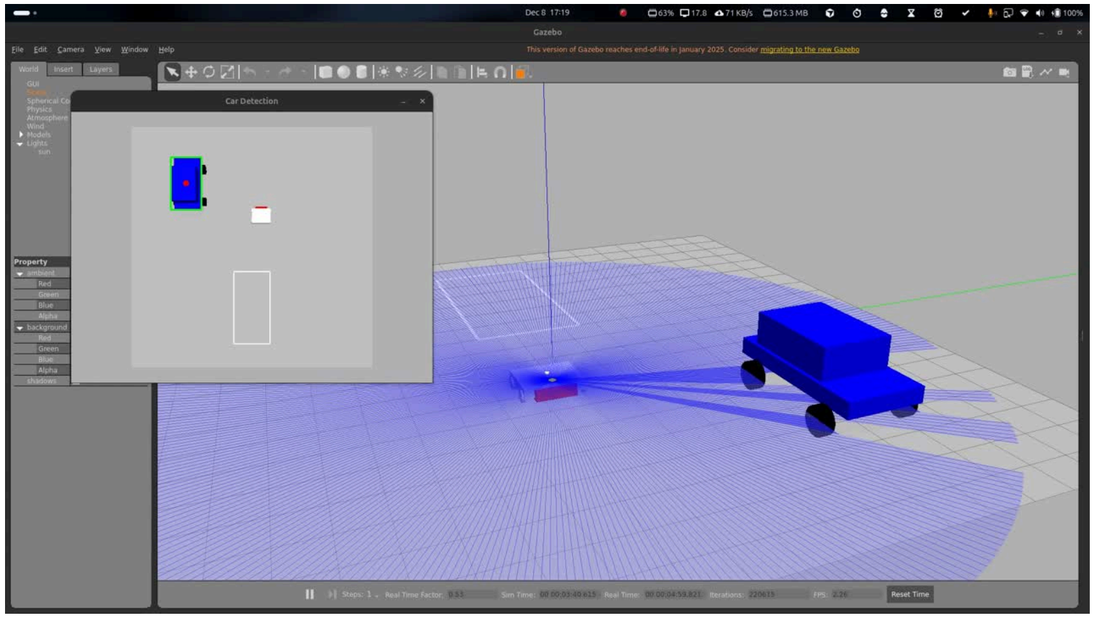




Phase 3 - Precise Approach

- Manhattan Navigation: Move X-axis first, then Y-axis
- Speed Control: 2.0 m/s when far, 0.5 m/s when close
- Positioning: Navigate to exact car center (±0.10m)
- Lidar Safety: Emergency stop if obstacle < 0.3m





Phase 4 - Lift Mechanism

Hyundai motor work

Current Status and Future Work

Detection system (Phase 1)
Navigation system (Phase 2)
Precise approach (Phase 3)
Lift mechanism (Phase 4)

Towing to correct parking spot
Car lowering and detachment
Multi-car handling

Future Extensions:

- Dynamic environments (moving obstacles)
- Human detection & safety
- Multi-robot coordination

Lessons Learned and Conclusion

Autonomous detection system with very good accuracy
Robust navigation using ROS 2 Nav2 stack
Innovative physics-based lifting mechanism
Complete system integration (95% complete)

- Solved complex coordinate transformation challenge
- Modular architecture for systematic validation

IMPACT

THANK YOU!!