# 이동로봇 튜토리얼 4강

ROS2 Nav2 Simulation

# 목차

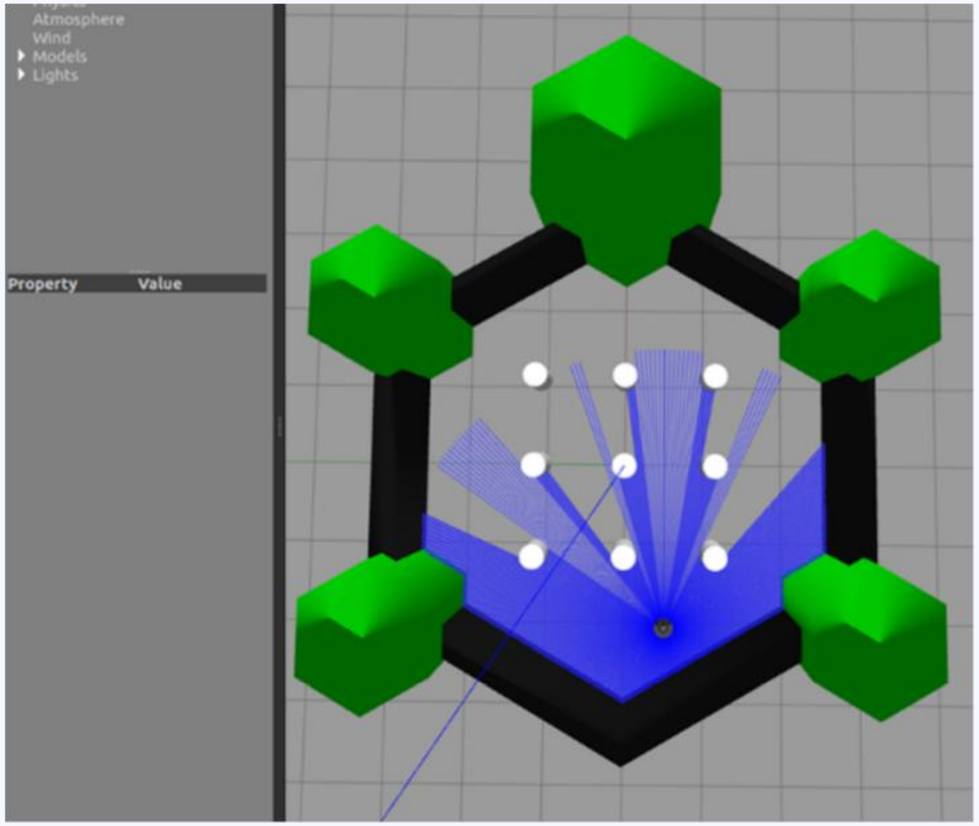
# 강의 개요

## ROS2 Nav2 시뮬레이션 실습 소개

- 실습 환경: Ubuntu 22.04 + ROS2 Humble + Gazebo + RViz
- 로봇 플랫폼: TurtleBot3 Waffle
- 학습 목표: Nav2 bringup, 목표 주행, Controller 교체 및 튜닝
- 핵심 실습: DWB, RPP, MPPI 교체

- 동일한 지도와 파라미터 환경에서 로컬 플래너 교체
- 주행 반응성과 안정성 비교
- Unity 시뮬레이션 확장 실습

# Gazebo + Nav2 시뮬레이션 환경



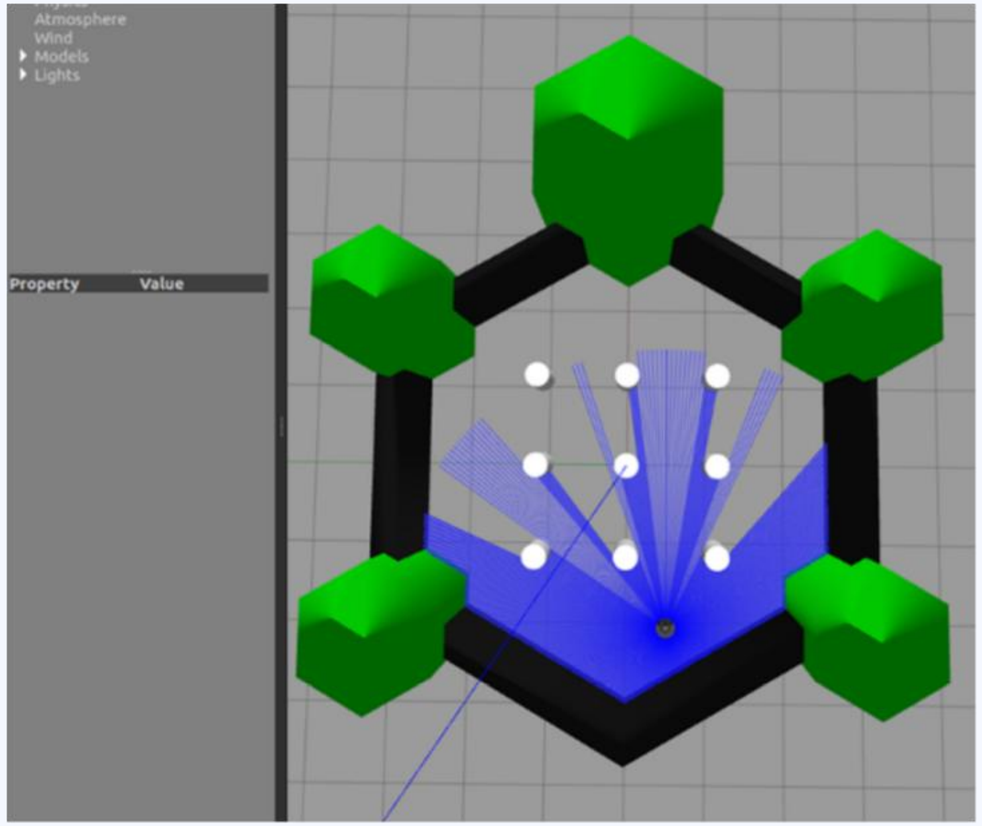

## ✓ 시뮬레이션 환경 설정

https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation/#gazebo-simulation

Gazebo 환경에서 Turtlebot3 waffle 기반 Nav2 주행 시뮬레이션

```
$ mkdir -p ~/turtlebot3_ws/src
$ cd ~/turtlebot3_ws/src
$ git clone https://github.com/san2642/ROS2_Tutorial_Navigation2.git .
```

# Gazebo + Nav2 시뮬레이션 환경




## ✓ 시뮬레이션 주행 실습

$ export TURTLEBOT3_MODEL=waffle

$ ros2 launch turtlebot3_gazebo turtlebot3_world.launch.py

$ ros2 launch turtlebot3_navigation2 navigation2.launch.py map:=/home/home/turtlebot3_ws/src/turtlebot3_navigation2/map/map.yaml params_file:=/home/home/turtlebot3_ws/src/turtlebot3_navigation2/param/mppi.yaml use_sim_time:=true

>>> mppi.yaml 부분을 rpp, dwa로 변경하며 local planner 테스트

# MPPI Local Planner

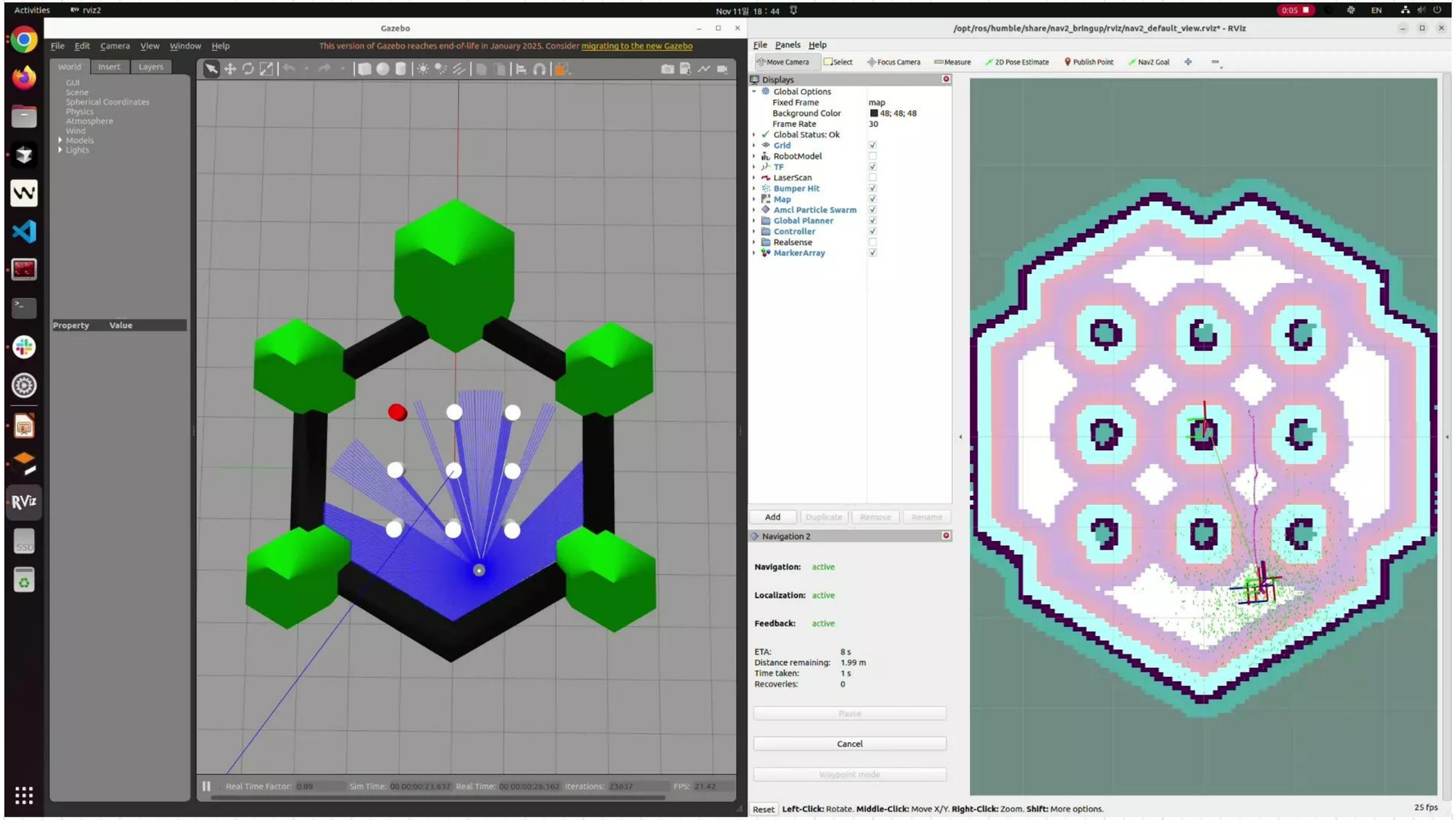
```yaml
controller_server:
  ros__parameters:
    controller_frequency: 20.0
    FollowPath:
      plugin: "nav2_mppi_controller::MPPIController"
      time_steps: 56
      model_dt: 0.05
      batch_size: 2000
      vx_std: 0.2
      vy_std: 0.2
      wz_std: 0.4
      vx_max: 0.5
      vx_min: -0.35
      vy_max: 0.5
      wz_max: 1.9
      ax_max: 3.0
      ax_min: -3.0
      ay_min: -3.0
      ay_max: 3.0
      az_max: 3.5
      iteration_count: 1
      prune_distance: 1.7
      transform_tolerance: 0.1
      temperature: 0.3
      gamma: 0.015
      motion_model: "DiffDrive"
      visualize: true
      reset_period: 1.0 # (only in Humble)
      regenerate_noises: false
      TrajectoryVisualizer:
        trajectory_step: 5
        time_step: 3
      AckermannConstraints:
        min_turning_r: 0.2
      critics: ["ConstraintCritic", "CostCritic", "GoalCritic", "GoalAngleCritic", "PathAlignCritic", "PathFollowCritic"
      ConstraintCritic:
        enabled: true
        cost_power: 1
        cost_weight: 4.0
```

## ✓ mppi.yaml

- 모델 예측 기반 확률 제어
- 수백 개의 경로를 시뮬레이션 후 최소 비용 선택

- 주요 파라미터
  - batch_size: 샘플 궤적 수
  - time_steps: 예측 시간 구간
  - temperature: 탐색 확률 분포 제어

# MPPI 시뮬레이션 영상



# DWB Local Planner

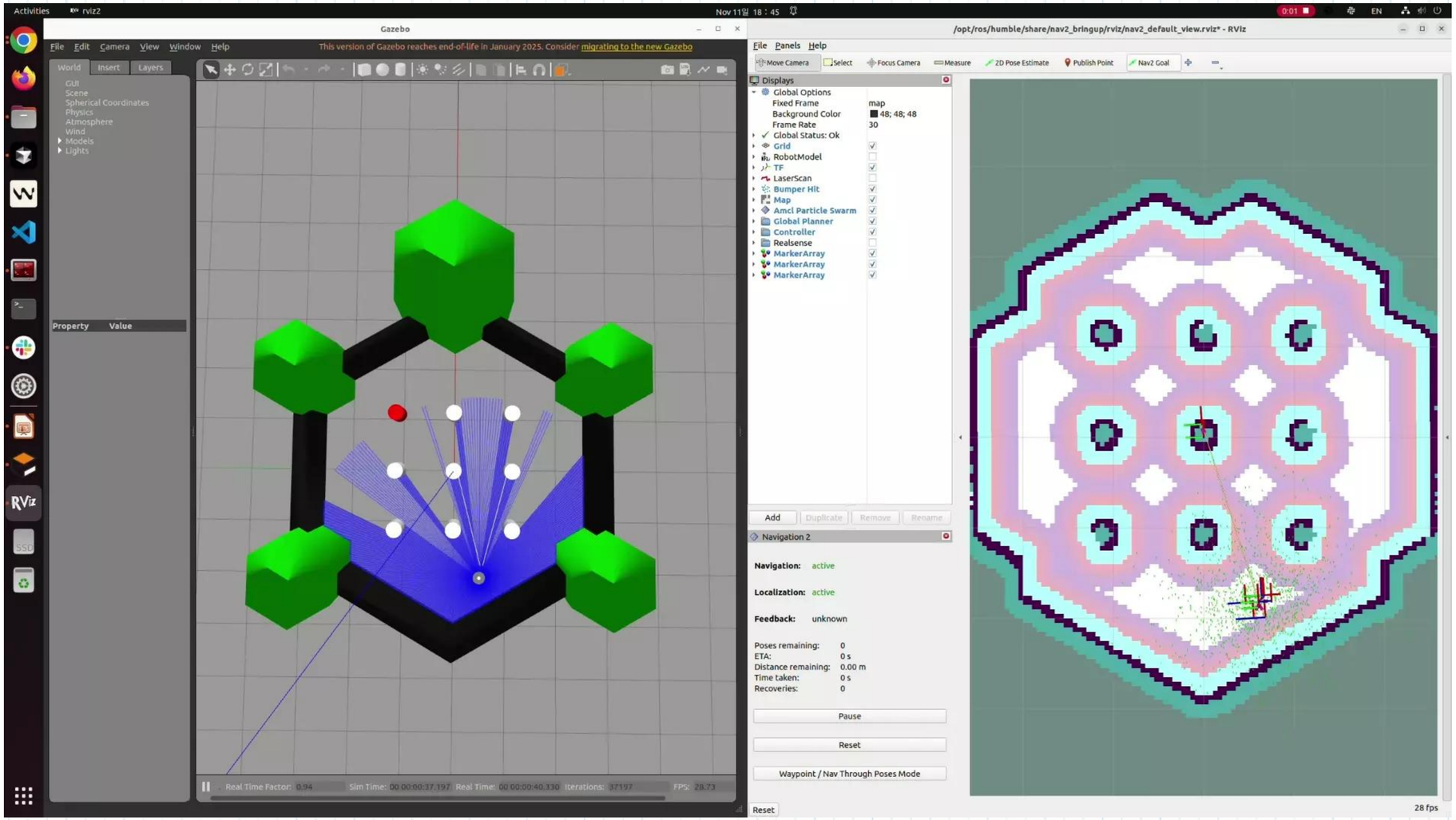
```yaml
# DWB parameters
FollowPath:
  plugin: "dwb_core::DWBLocalPlanner"
  debug_trajectory_details: True
  min_vel_x: 0.0
  min_vel_y: 0.0
  max_vel_x: 0.26
  max_vel_y: 0.0
  max_vel_theta: 1.0
  min_speed_xy: 0.0
  max_speed_xy: 0.26
  min_speed_theta: 0.0
  # Add high threshold velocity for turtlebot 3 issue.
  # https://github.com/ROBOTIS-GIT/turtlebot3_simulations/issues/75
  acc_lim_x: 2.5
  acc_lim_y: 0.0
  acc_lim_theta: 3.2
  decel_lim_x: -2.5
  decel_lim_y: 0.0
  decel_lim_theta: -3.2
  vx_samples: 20
  vy_samples: 5
  vtheta_samples: 20
  sim_time: 1.7
  linear_granularity: 0.05
  angular_granularity: 0.025
  transform_tolerance: 0.2
  xy_goal_tolerance: 0.25
  trans_stopped_velocity: 0.25
  short_circuit_trajectory_evaluation: True
  stateful: True
  critics: ["RotateToGoal", "Oscillation", "BaseObstacle", "GoalAlign", "PathAlign", "PathDist", "GoalDist"]
  BaseObstacle.scale: 0.02
  PathAlign.scale: 32.0
  PathAlign.forward_point_distance: 0.1
```

## ✓ dwa.yaml

- 직선 경로에서 빠른 반응
- 장애물 회피 우수
- 급회전 시 진동 가능

- 주요 파라미터
  - sim_time: 시뮬레이션 시간
  - vx_samples: 선속도 샘플
  - path_align_scale: 경로 정렬 중요도
  - obstacle_scale: 장애물 회피 가중치

# DWB 시뮬레이션 영상


Activities
rviz2
Nov 11일 18 : 45
Gazebo
File Edit Camera View Window Help
This version of Gazebo reaches end-of-life in January 2025. Consider migrating to the new Gazebo
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Atmosphere
Wind
Models
Lights
Property Value
Real Time Factor: 0.94 Sim Time: 00 00:00:37.197 Real Time: 00 00:00:40.330 Iterations: 37197 FPS: 28.73
/opt/ros/humble/share/nav2_bringup/rviz/nav2_default_view.rviz* - RViz
File Panels Help
Move Camera Select Focus Camera Measure 2D Pose Estimate Publish Point Nav2 Goal
Displays
Global Options
Fixed Frame map
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Grid
RobotModel
TF
LaserScan
Bumper Hit
Map
Amcl Particle Swarm
Global Planner
Controller
Realsense
MarkerArray
MarkerArray
MarkerArray
Add Duplicate Remove Rename
Navigation 2
Navigation: active
Localization: active
Feedback: unknown
Poses remaining: 0
ETA: 0 s
Distance remaining: 0.00 m
Time taken: 0 s
Recoveries: 0
Pause
Reset
Waypoint / Nav Through Poses Mode
Reset
28 fps

# RPP Local Planner

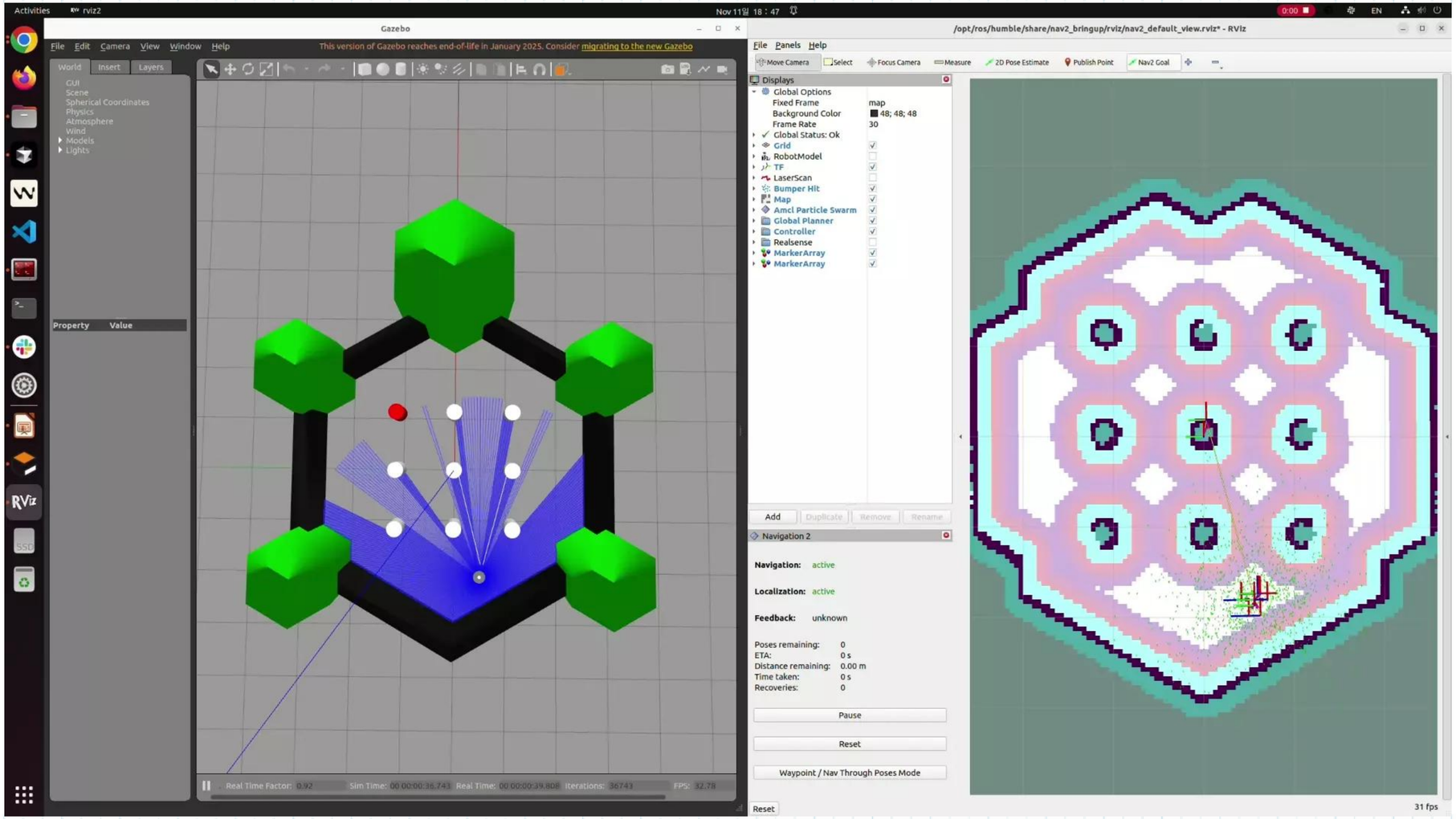
```yaml
progress_checker:
  plugin: "nav2_controller::SimpleProgressChecker"
  required_movement_radius: 0.5
  movement_time_allowance: 10.0
goal_checker:
  plugin: "nav2_controller::SimpleGoalChecker"
  xy_goal_tolerance: 0.25
  yaw_goal_tolerance: 0.25
  stateful: True
FollowPath:
  plugin: "nav2_regulated_pure_pursuit_controller::RegulatedPurePursuitController"
  desired_linear_vel: 0.5
  lookahead_dist: 0.6
  min_lookahead_dist: 0.3
  max_lookahead_dist: 0.9
  lookahead_time: 1.5
  rotate_to_heading_angular_vel: 1.8
  transform_tolerance: 0.1
  use_velocity_scaled_lookahead_dist: false
  min_approach_linear_velocity: 0.05
  approach_velocity_scaling_dist: 0.6
  use_collision_detection: true
  max_allowed_time_to_collision_up_to_carrot: 1.0
  use_regulated_linear_velocity_scaling: true
  use_fixed_curvature_lookahead: false
  curvature_lookahead_dist: 0.25
  use_cost_regulated_linear_velocity_scaling: false
  regulated_linear_scaling_min_radius: 0.9
  regulated_linear_scaling_min_speed: 0.25
  use_rotate_to_heading: true
  allow_reversing: false
  rotate_to_heading_min_angle: 0.785
  max_angular_accel: 3.2
  max_robot_pose_search_dist: 10.0
```

## ✓ rpp.yaml

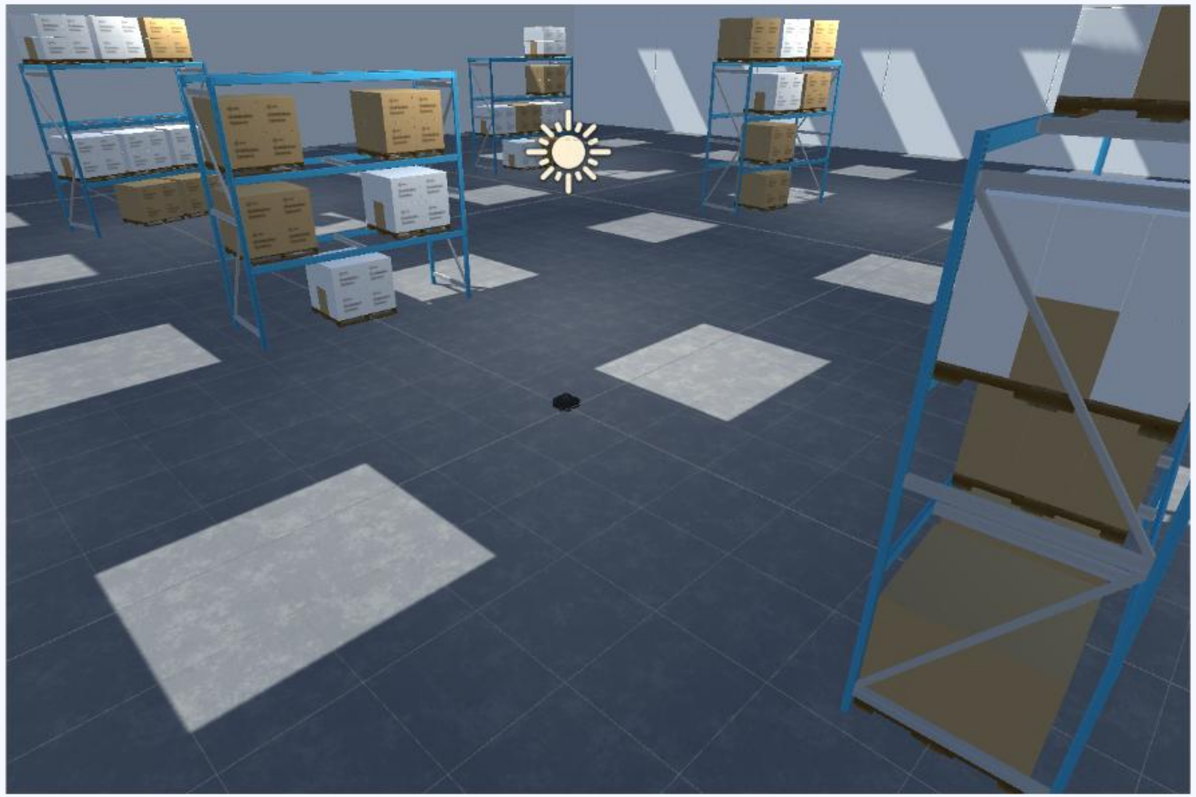
- 매우 부드러운 곡선 추종
- 장애물 근처 자동 감속
- 급선회 시 응답 늦음

- 주요 파라미터
  - lookahead_dist: 목표점 거리
  - use_cost_regulated_linear_velocity_scaling: 장애물 근접 시 감속 여부
  - min_approach_linear_velocity: 최소 접근 속도

# RPP 시뮬레이션 영상


Activities
rviz2
Nov 11일 18 : 47
Gazebo
File Edit Camera View Window Help
This version of Gazebo reaches end-of-life in January 2025. Consider migrating to the new Gazebo
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Atmosphere
Wind
Models
Lights
Property Value
Real Time Factor: 0.92 Sim Time: 00 00:00:36.743 Real Time: 00 00:00:39.808 Iterations: 36743 FPS: 32.78
/opt/ros/humble/share/nav2_bringup/rviz/nav2_default_view.rviz* - RViz
File Panels Help
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
Publish Point
Nav2 Goal
Displays
Global Options
Fixed Frame map
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Grid
RobotModel
TF
LaserScan
Bumper Hit
Map
Amcl Particle Swarm
Global Planner
Controller
Realsense
MarkerArray
MarkerArray
Add
Duplicate
Remove
Rename
Navigation 2
Navigation: active
Localization: active
Feedback: unknown
Poses remaining: 0
ETA: 0 s
Distance remaining: 0.00 m
Time taken: 0 s
Recoveries: 0
Pause
Reset
Waypoint / Nav Through Poses Mode
Reset
31 fps

# 실습 과제 - Unity Nav2 SLAM



## ✓ Unity-ROS2 연동

https://github.com/Unity-Technologies/Robotics-Nav2-SLAM-Example?tab=readme-ov-file

https://unity.com/kr/blog/engine-platform/advance-your-robot-autonomy-with-ros-2-and-unity

- Unity–ROS2 TCP Connector 설정
- Nav2 Bringup → SLAM → Goal Navigation 확인
- Gazebo와의 성능·시각화 비교

# 요약 및 마무리

- Gazebo 기반 TurtleBot3 + Nav2 bringup 실습을 통해 로봇 시뮬레이션 환경 구축

- AMCL 위치 초기화 및 목표 주행으로 기본 내비게이션 이해

- RPP / MPPI / DWB 컨트롤러 교체 및 비교를 통한 로컬 플래너 특성 파악

- 동일한 Nav2 구조에서 다양한 로컬 플래너를 교체하여 환경에 최적화된 주행 가능