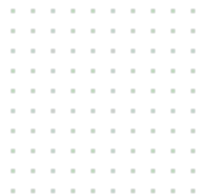




ROS2 를 이용한 로봇암 시뮬레이션

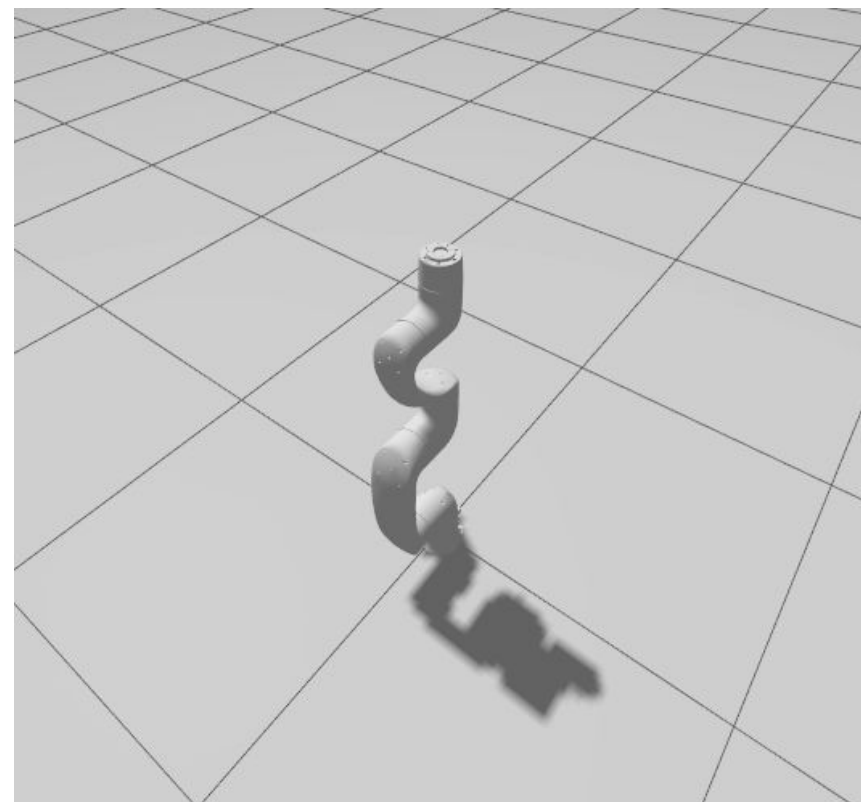
지원자 : 우만경



프로젝트 개요 및 핵심 목표

본 프로젝트는 **ROS2 Humble** 환경에서 Doosan E0509 로봇암의 위치 및 자세 제어를 위한 통합 시스템 구축을 목표로 합니다.

- ✓ **환경:** Ubuntu 22.04 LTS / ROS2 Humble
- ✓ **플랫폼:** Doosan E0509 로봇암 (Gazebo 시뮬레이션)
- ✓ **핵심 기능:** 좌표 이동 실행 및 실시간 상태 모니터링
- ✓ **구현 방법:** Python, doosan-robot2: 서비스/토픽 기반 구현



※ 이미지: Gazebo 시뮬레이션 환경에서의 Doosan E0509 구동 모습

제어 및 피드백 인터페이스

1. 상태 모니터링

로봇의 현재 **Joint 각도(J1~J6)**와 Base 좌표계 기준의 **TCP 위치(X, Y, Z, R, P, Y)**를 실시간으로 피드백 받아 UI에 표시합니다.

2. 실시간 로그 시스템

명령 송신, 서비스 응답, 오류 메시지 등을 하단 로그창에 출력하여 디버깅 편의성을 제공합니다.

3. 비상 정지 및 복구

동작 중 즉각적인 정지(Stop) 및 일시정지(Pause), 재개(Resume) 기능 제어

The screenshot displays a comprehensive robot control interface. On the left, the 'Target Coordinate Input' section allows setting X, Y, Z, RX, RY, and RZ coordinates with a range of -100 to +100 mm/deg. Below this, 'Coordinate Mode' is set to 'Relative - Offset from current TCP'. 'Max Velocity / Acceleration' is configured to 100.0 mm/s and 100.0 mm/s². The 'Target Management' section includes an '+ Add Target' button. The 'Execution Control' section features buttons for 'Run All', 'Run Single', 'Stop', 'Pause', 'Resume', and 'Home Position'. On the right, the 'Connection / Robot Status' section shows the robot is 'Connected' and in 'STATE_STANDBY'. Below this, 'Current Joint Angles (deg)' are listed for J1 through J6. 'Current TCP Position (Base Reference)' shows X: 200.0 mm, Y: 200.0 mm, Z: 823.0 mm, RX: 47.8 deg, RY: 0.0 deg, and RZ: -47.8 deg. The 'Target Position List' table shows three targets: Target 1 (Completed), Target 2 (Moving), and Target 3 (Pending). The 'Real-time Log' section at the bottom displays a sequence of events from 15:52:46 to 15:53:11, including target additions, home position reaching, and motion completion. A 'Clear Log' button is located at the bottom right of the log area.

#	Coordinates (X,Y,Z,RX,RY,RZ)	Vel/Acc	Mode	Status
1	(200.0, 200.0, 823.0, 0.0, 0.0, 0.0)	100/100	Absolute	Completed
2	(500.0, 500.0, 523.0, 0.0, 0.0, 0.0)	100/100	Absolute	i. Moving...
3	(-200.0, -200.0, -200.0, 0.0, 0.0, 0.0)	100/100	Relative	Pending

```
[15:52:46] Target added [Absolute]: (200.0, 200.0, 823.0)
[15:52:55] Target added [Absolute]: (500.0, 500.0, 523.0)
[15:53:04] Target added [Relative]: (-200.0, -200.0, -200.0)
[15:53:07] Moving to home...
[15:53:07] Moving to home position...
[15:53:07] Home position reached
[15:53:07] Motion completed successfully
[15:53:09] Executing 3 targets...
[15:53:09] Motion started
[15:53:09] Target 1/3 [Absolute] vel=100
[15:53:11] Progress: 1/3
[15:53:11] Target 2/3 [Absolute] vel=100
```

데이터 흐름: GUI (사용자 입력) → WorkerThread → Robot Controller → doosan-robot2 (ROS2 Service) → Gazebo

| Gazebo 이슈 해결



Gazebo MoveL 오류

MoveL 사용 시 특정 관절 각도에서 시뮬레이션 오류가 발생하는 문제 확인. 이를 해결하기 위해 **MoveJointx 서비스**를 사용하여 목표 좌표가 내부적으로 역기구학 연산 후 관절 제어 방식으로 전환됩니다.



실시간 TCP 좌표 추적

Gazebo 플러그인에서 TCP 좌표 토픽이 갱신되지 않는 현상 발생. **Fkin 서비스**를 활용하여 JointState 토픽 수신 시마다 현재 좌표를 계산하여 GUI에 시각화하는 우회 로직을 구현했습니다.

동작 시나리오 1: 단일 및 절대, 상대 이동

Gazebo

Model

- Name: ground_plane
- Wind Mode: [toggle]
- Source File Path: ...ion-gazebo6/worlds/empty.sdf
- Model Sdf: [toggle]
- Parent Entity: 1
- Static: [toggle]
- Self Collide: [toggle]

Entity Tree

- > ground_plane
- > sun
- > e0509

Target Coordinate Input

X:	0.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
Y:	0.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
Z:	1123.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RX:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RY:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RZ:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100

Coordinate Mode

- ☒ Absolute - Base origin reference
- ☐ Relative - Offset from current TCP

Max Velocity / Acceleration

Max Velocity: 100.0 mm/s

Max Acceleration: 100.0 mm/s²

Target Management

+ Add Target

Execution Control

Run All Stop Home Position

Run Single Pause Resume

Connection / Robot Status

* Connected State: STATE_STANDBY

Current Joint Angles (deg)

J1: 0.0	J2: 0.0	J3: 0.0
J4: 0.0	J5: 0.0	J6: 0.0

Current TCP Position (Base Reference)

X: 0.0 mm	Y: -0.0 mm
Z: 1123.0 mm	RX: 0.0 deg
RY: 0.0 deg	RZ: 0.0 deg

Target Position List

#	Coordinates (X,Y,Z,RX,RY,RZ)	Vel/Acc	Mode	Status
---	------------------------------	---------	------	--------

Remove Remove All Move Up Move Down

Real-time Log

```
[15:56:12] Target added [Absolute]: (0.0, 0.0, 0.0, 0.0, 0.0, 0.0)
[15:56:12] Executing [Absolute] vel=100
[15:56:12] Single motion started
[15:56:12] Single move [Absolute] vel=100
[15:56:14] Single move completed
[15:56:14] Single motion completed
[15:56:23] Moving to home...
[15:56:23] Moving to home position...
[15:56:27] Home position reached
[15:56:27] Motion completed successfully
[15:56:36] Moving to home...
[15:56:36] Moving to home position...
[15:56:36] Home position reached
[15:56:36] Motion completed successfully
```

Clear Log

동작 시나리오 2: 다중 경로 순차 이동

The screenshot displays the Gazebo simulation environment. On the left, a 3D view shows a robot arm on a grid floor. The top-left toolbar contains icons for camera, move, rotate, and other simulation controls. The bottom-left shows a pause button and a zoom level of 78.29%.

Entity Tree

- Model
 - Name: ground_plane
 - Wind Mode: [off]
 - Source File Path: ...ion-gazebo6/worlds/empty.sdf
 - Model Sdf: [off]
 - Parent Entity: 1
 - Static: [off]
 - Self Collide: [off]
- + Pose
 - Model Canonical Link

Entity Tree

- > ground_plane
- > sun
- > e0509

Target Coordinate Input

X:	0.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
Y:	0.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
Z:	1123.00 mm	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RX:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RY:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100
RZ:	0.00 deg	-100	-10	-1	-0.1	+0.1	+1	+10	+100

Coordinate Mode

- ☒ Absolute - Base origin reference
- ☐ Relative - Offset from current TCP

Max Velocity / Acceleration

Max Velocity: 500.0 mm/s

Max Acceleration: 500.0 mm/s²

Target Management

+ Add Target

Execution Control

Run All Stop Home Position

Run Single Pause Resume

Connection / Robot Status

* Connected State: STATE_STANDBY

Current Joint Angles (deg)

J1: 0.0	J2: 0.0	J3: 0.0
J4: 0.0	J5: 0.0	J6: 0.0

Current TCP Position (Base Reference)

X: 0.0 mm	Y: -0.0 mm
Z: 1123.0 mm	RX: 0.0 deg
RY: 0.0 deg	RZ: 0.0 deg

Target Position List

#	Coordinates (X,Y,Z,RX,RY,RZ)	Vel/Acc	Mode	Status
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Remove Remove All Move Up Move Down

Real-time Log

Clear Log