

基於 ROS 2 的智慧除草機模擬

ROS 2-Based Autonomous Lawn Mower Simulation



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Outline

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- **Motivation**
- **System Architecture**
- **Features**
- **Demo**
- **Future Work**

Introduction

What is this project?

- An autonomous lawn mower, built and tested entirely in simulation.
- It records a lawn boundary, plans a full mowing path, and detects objects in its way.

Key Terms

- **ROS 2** — the de-facto open-source framework for robot software; lets independent modules (sensing, planning, control) talk via standard messages.
- **Gazebo** — a 3D physics simulator: a virtual world with a virtual robot.
- **Nav2** — ready-made navigation & lots of plugins.



`/home/dennis/ros2_ws/install/mower_description/share/mower_description/rviz/coverage_demo.rviz* - RViz`

File Panels Help

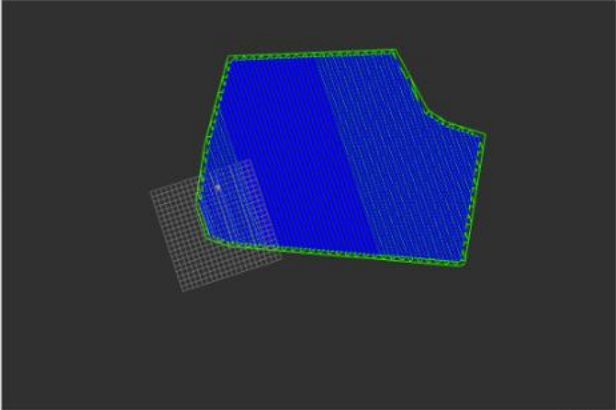
Interact Move Camera Select Focus Camera Measure + -

Displays

- Global Options
 - Fixed Frame: map
 - Background Color: 48; 48; 48
 - Frame Rate: 30

Add Duplicate Remove Rename

Image



Reset 31 fps

rqt_console__Console - rqt

Console

Displaying 33 messages

#	Message	Severity	Node	Stamp	Location
#33	KEY detected (score=0.40) @ map=(1.31, 3.69) -> PAUSE 5.0s	Warn	ball_pause...	23:57:45.2...	/home/...
#32	Control loop missed its desired rate of 20.0000 Hz. Current loop rate...	Warn	controller_...	23:57:39.4...	/src/...
#31	Control loop missed its desired rate of 20.0000 Hz. Current loop rate...	Warn	controller_...	23:57:37.0...	/src/...

Fit Columns

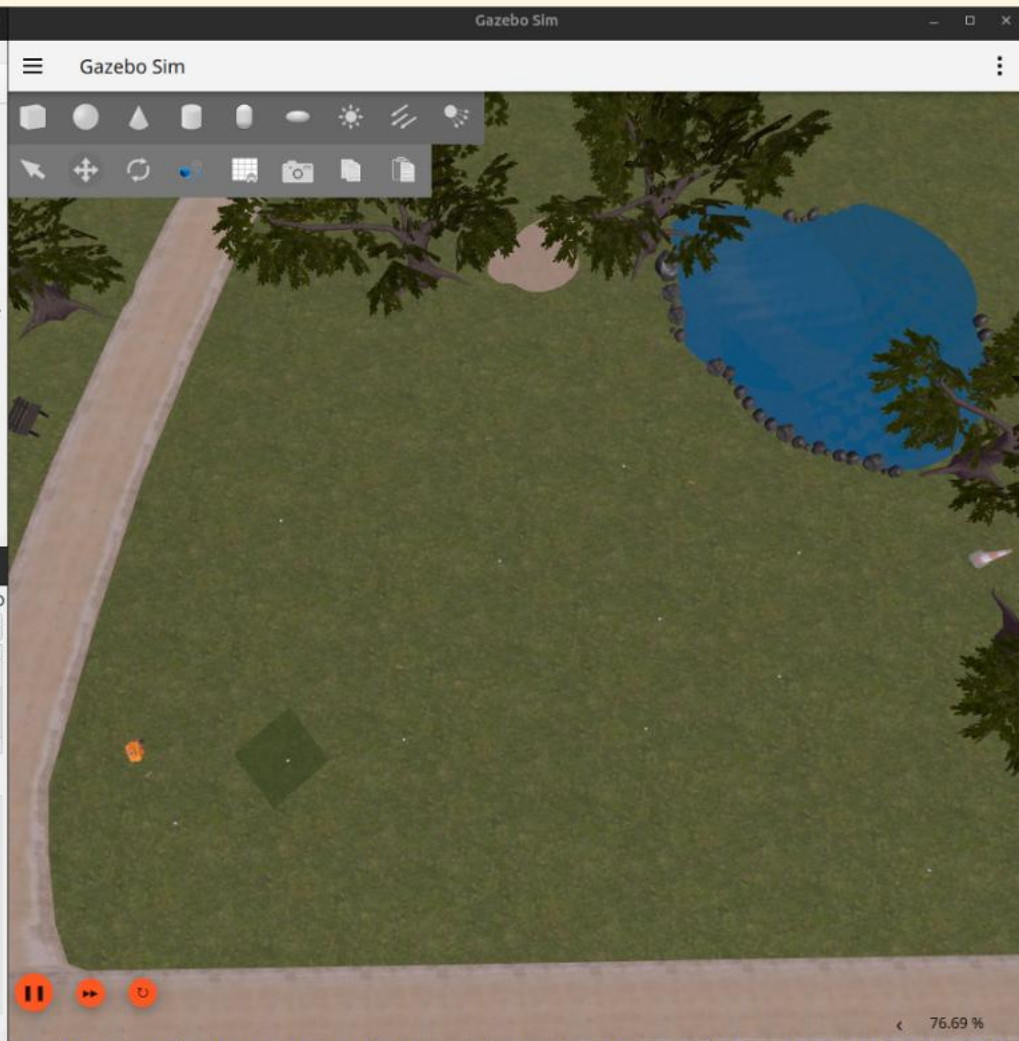
Highlight Messages...

☒ ...containing: detected ☐ Regex

Message:

☒ Custom: Severity: Debug Info Warn Error Fatal Topic:

Node: ball_pause_gate controller_server



Motivation



Why autonomous mowing

- Still mostly manual — backpack / push / ride-on mowers; high labor cost
- Buried-wire robots — reliable boundary, but hours to install, breaks, hard to scale
- Boundary-free robots (rising) — RTK GPS / AI vision define the area in software
 - e.g. **OpenMower** — an open-source solution



push



buried-wire



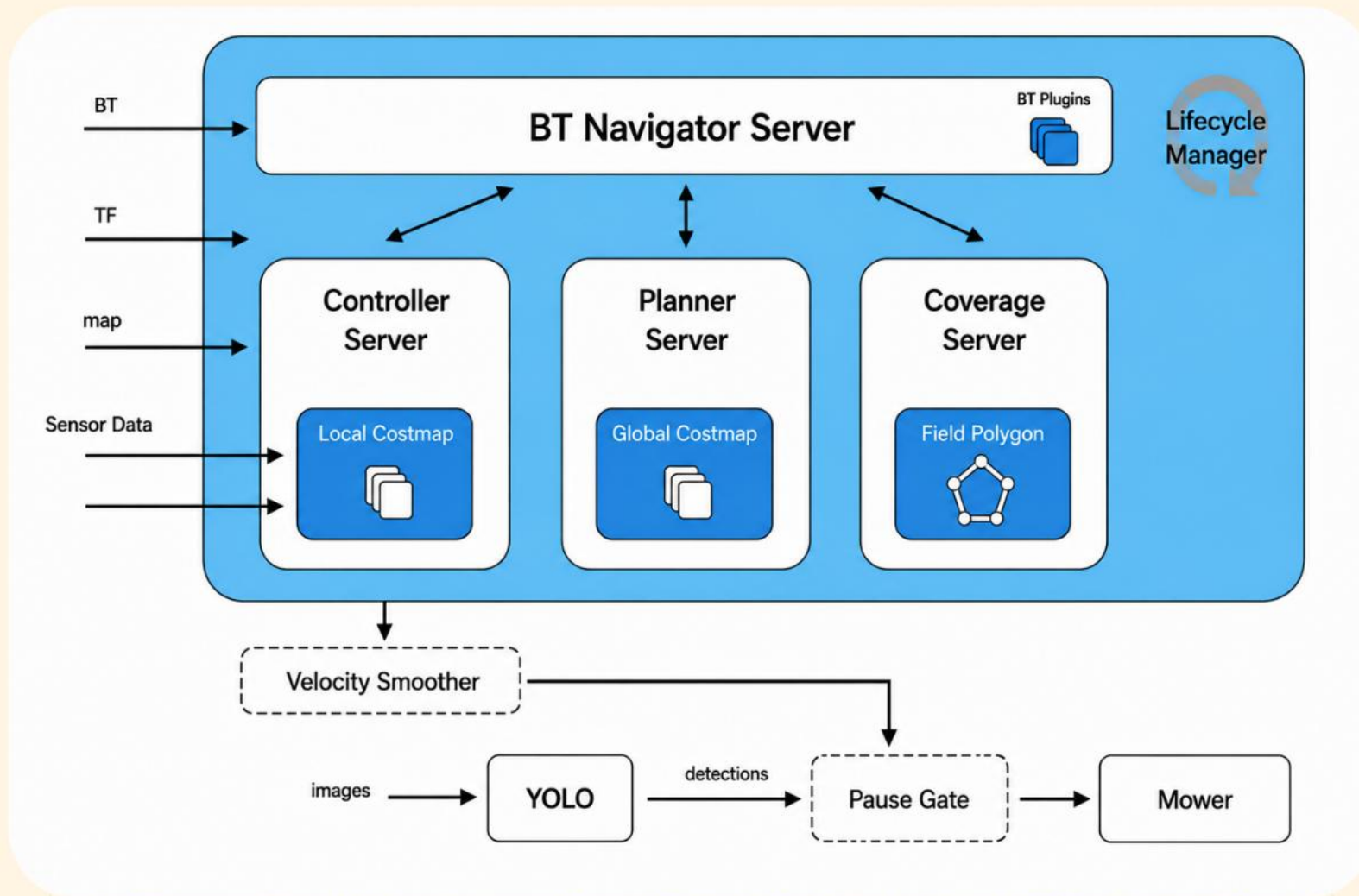
RTK GPS

Why not OpenMower?

- **No ROS 2 solution exists** — prior work (e.g. OpenMower) is ROS 1, hardware-bound
- **I built a working ROS 2 version** — maintained packages + my own glue nodes (recording / coverage / pause)
- **Integration needs deep ROS 2 knowledge**
 - URDF → ROS 2 messaging → ros2_control → sensor bridging →
 - Nav2 → opennav_coverage → joystick & pause

System Architecture



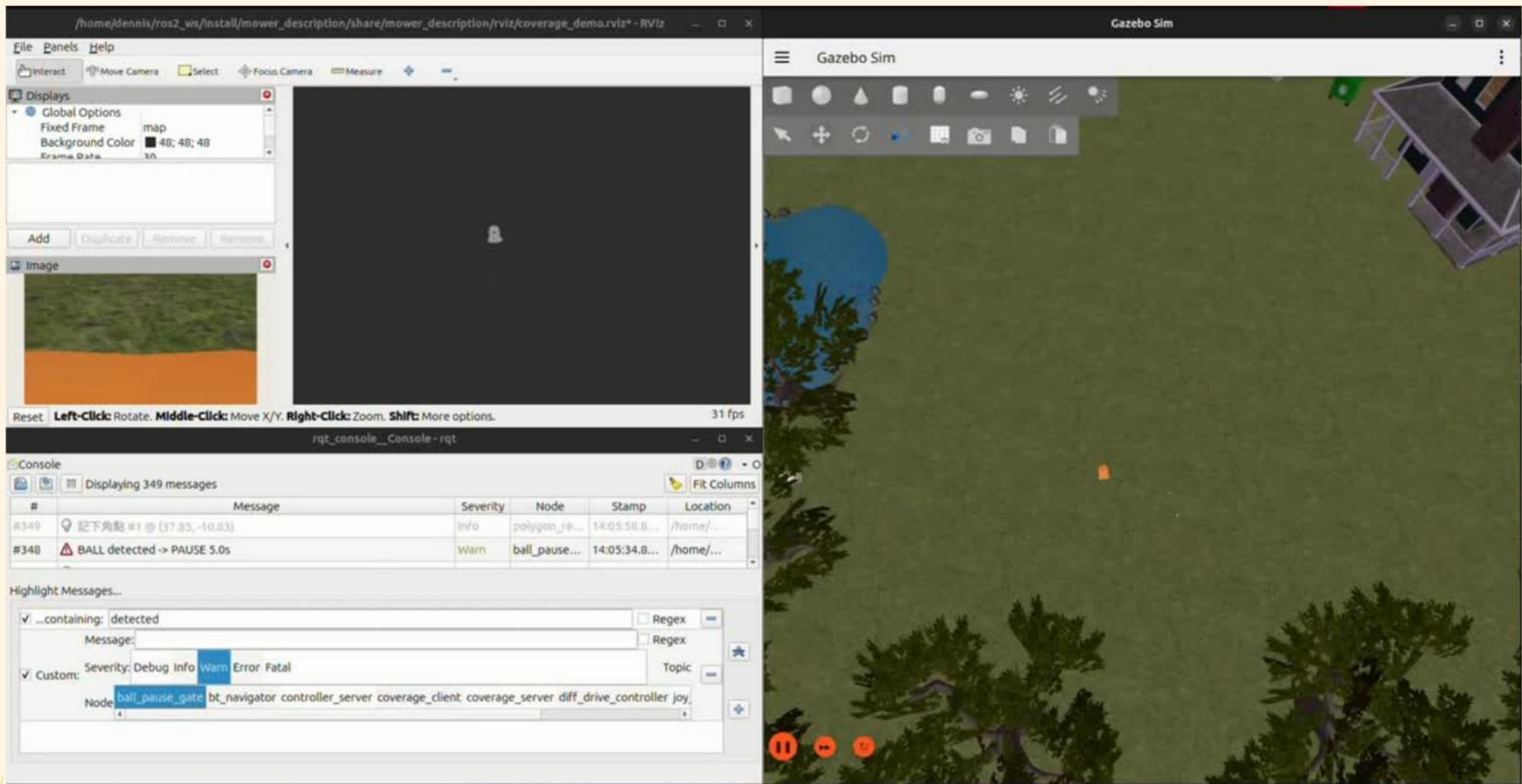


Features

Feature 1 — Boundary Recording (Joystick)

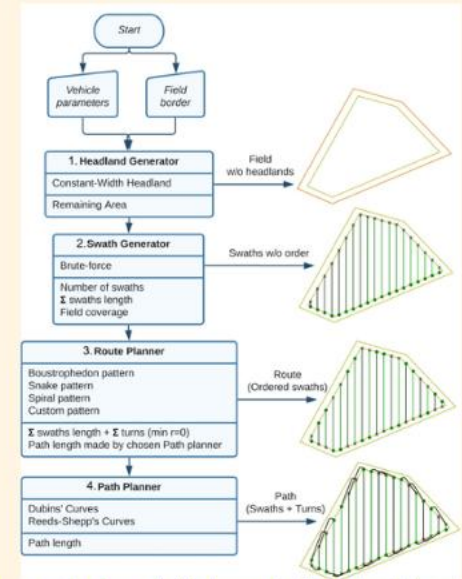
- **Record each corner (A)** — saves the robot's current map position as a vertex
- **Undo the last corner (B)**
- **Save the recorded corners as the mowing boundary polygon (Y)**
- **Start mowing (X)** — send a request to cover the saved area

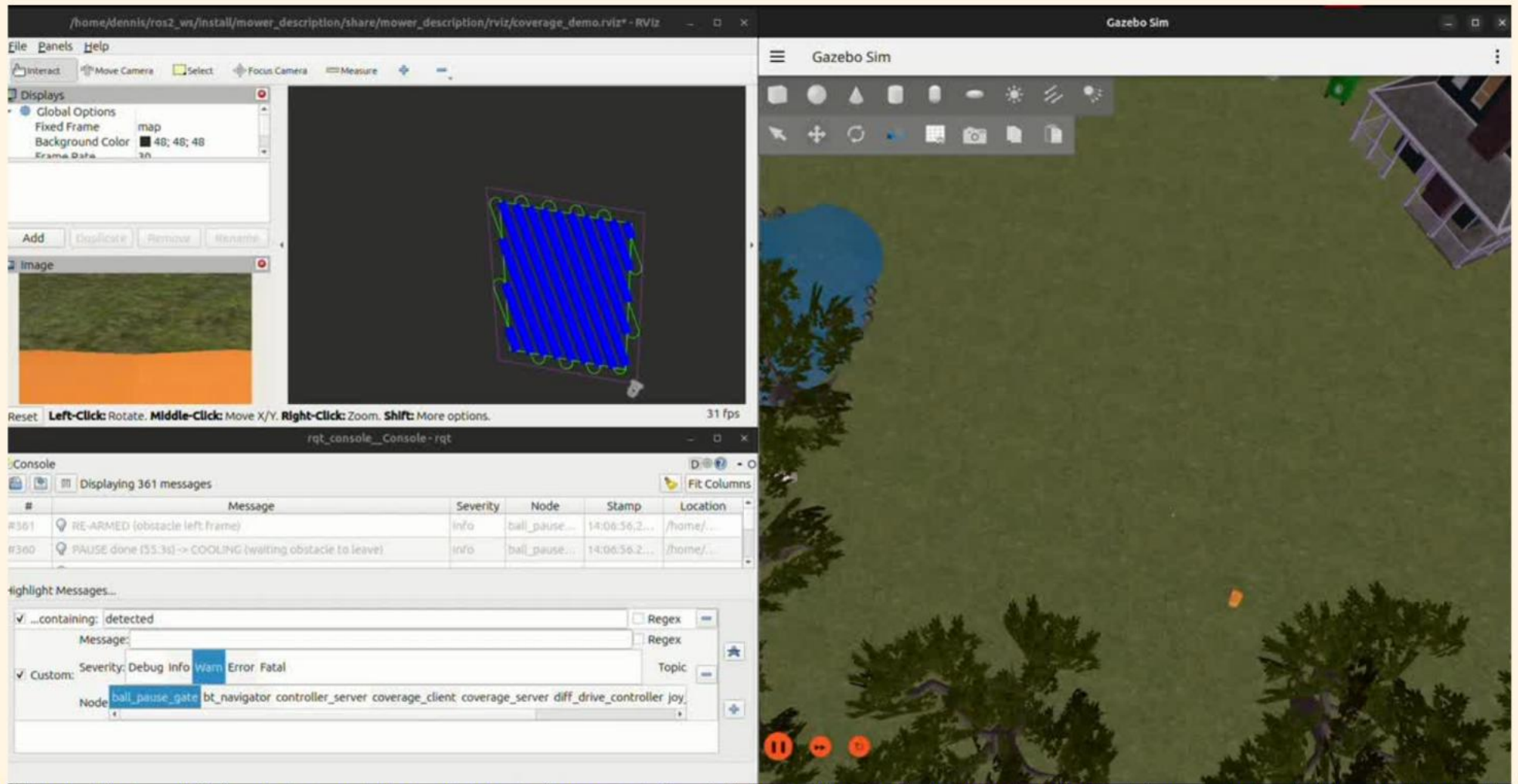




Feature 2 — Coverage Path Planning

- Built on **opennav_coverage** / **Fields2Cover** (F2C)
- Fills the area with back-and-forth swaths from the recorded boundary
- Mower navigates to the start point, then runs the path via Nav2
- Tunable to your desired coverage:
 - Headland width (edge buffer)
 - Swath spacing (overlap between passes)
 - Turn radius (safe turning near the boundary)





Feature 3 — Object Detection & Safety Pause

- Camera + YOLO detects objects in the mowing path (e.g. a ball / a key)
- On detection → stop the blade, stop the robot, and report the object
- Prevents foreign objects from being caught by the cutter — a basic safety layer



/home/dennis/ros2_ws/install/mower_description/share/mower_description/rviz/coverage_demo.rviz* - RViz

File Panels Help

Interact Move Camera Select Focus Camera Measure

Displays

- Global Options
 - Fixed Frame: map
 - Background Color: 48; 48; 48
 - Frame Data: 30

Add Duplicate Remove Remove All

Image

Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click: Zoom. Shift: More options. 31 fps

rviz_console__console - rqt

Console

Displaying 505 messages

#	Message	Severity	Node	Stamp	Location
#505	Control loop missed its desired rate of 20.0000 Hz. Current loop rate...	Warn	controller_...	14:13:27.6...	/src/...
#504	KEY detected (score=0.42) @ map=(41.35, -7.58) -> PAUSE 5.0s	Warn	ball_pause...	14:13:26.6...	/home/...

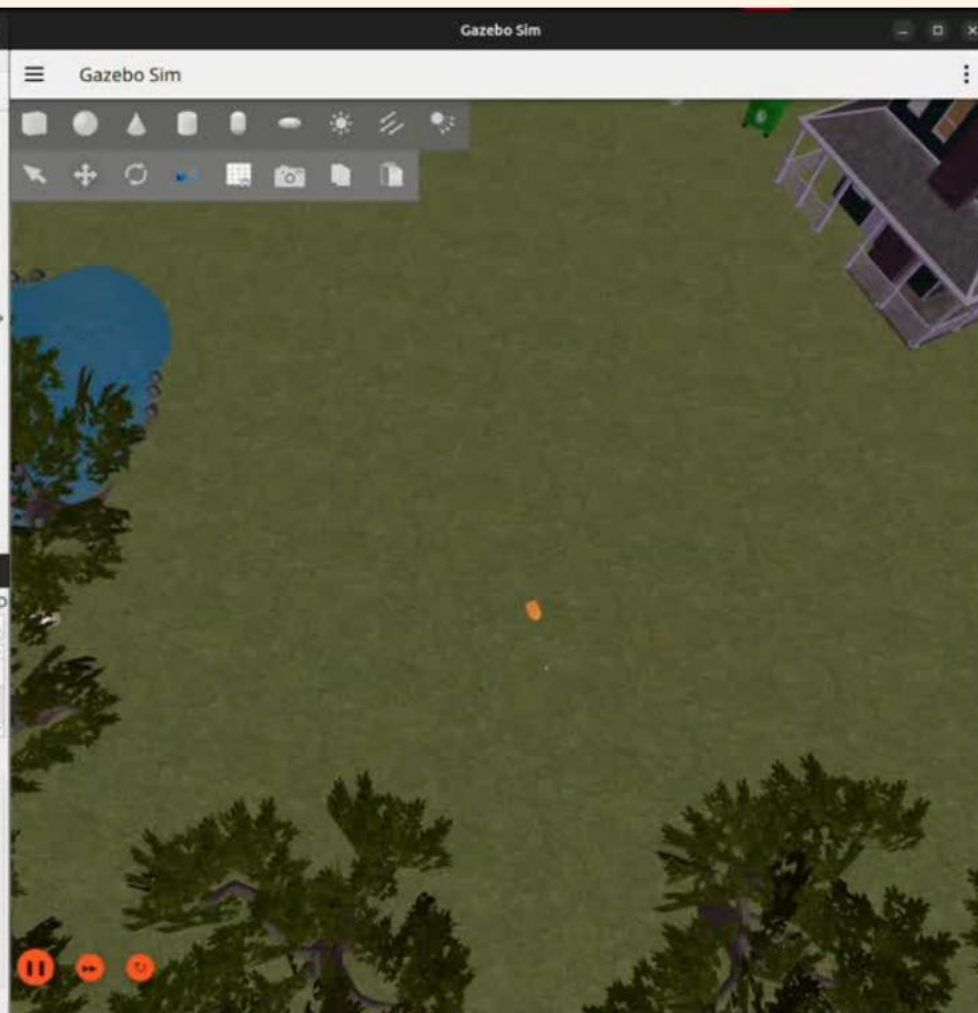
Highlight Messages...

☒ ...containing: detected ☐ Regex

Message: ☐ Regex

☒ Custom: Severity: Debug Info Warn Error Fatal Topic:

Node: ball_pause_gate bt_navigator controller_server coverage_client coverage_server diff_drive_controller joy



Demo

rviz/coverage_demo

File Panels Help

Interact Move Camera Select Focus Camera Measure

Displays

- Global Options
 - Fixed Frame: map
 - Background Color: 48; 48; 48
 - Frame Rate: 30
 - Global Status: Ok
 - Grid: ☒
 - RobotModel: ☒

Add Cut/Paste Remove

Image

Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click: Zoom. Shift: More options. 31 fps

rviz_console_console - rqt

Console

Displaying 149 messages

#	Message	Severity	Node	Stamp	Location
#149	Control loop missed its desired rate of 20.0000 Hz...	Warn	controller_...	15:07:02.4...	/src/...
#148	BALL detected -> PAUSE 5.0s	Warn	ball_pause...	15:07:00.3...	/home/...
#147	Control loop missed its desired rate of 20.0000 Hz...	Warn	controller_...	15:06:58.1...	/src/...

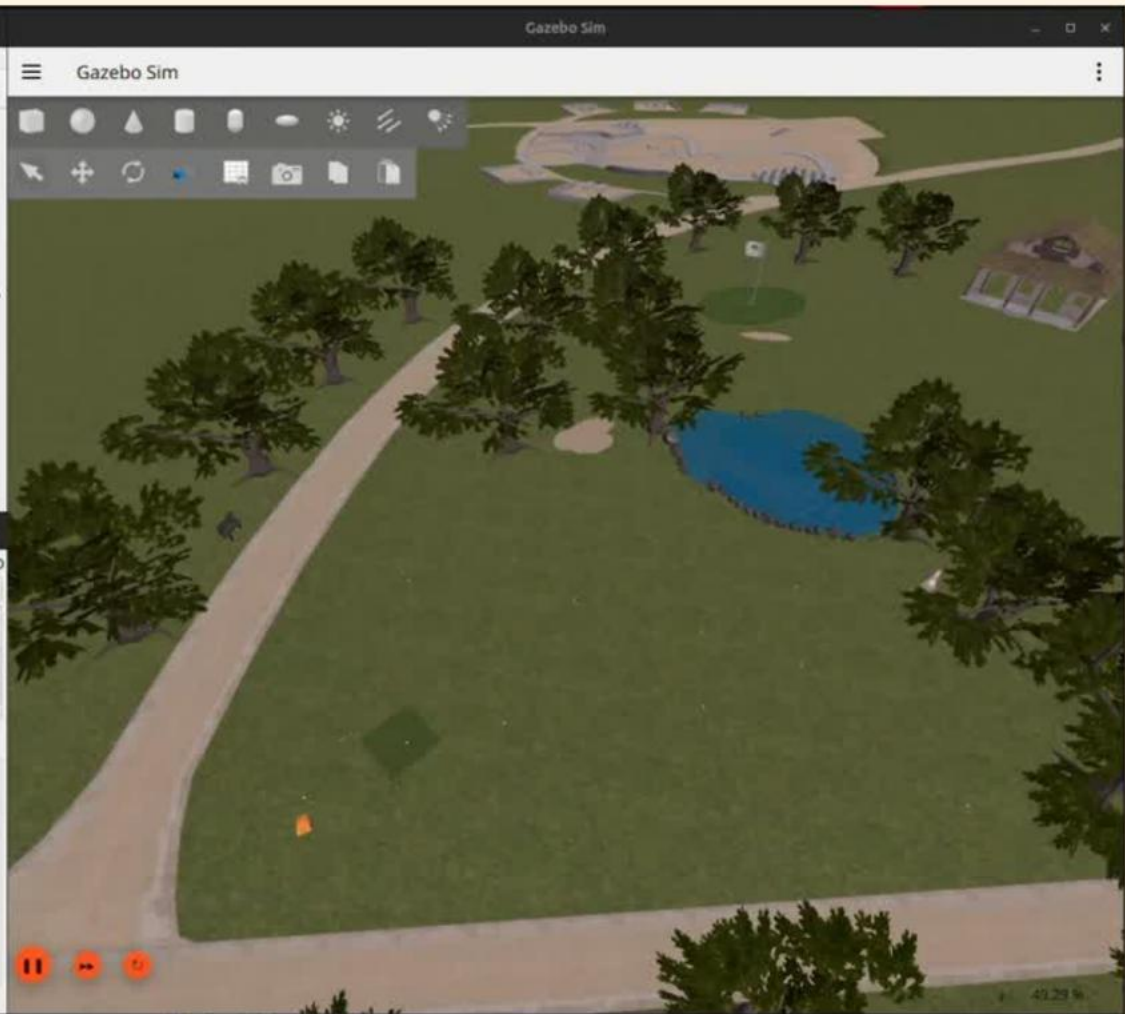
Highlight Messages...

☒ ...containing: detected ☐ Regex

Message:

☒ Custom: Severity: Debug Info Warn Error Fatal ☐ Topic

Node:



Future Work

From simulation toward the real lawn

- Smarter areas — concave boundaries & obstacle cut-outs (skip flower beds, trees)
- Animal-aware safety — depth camera: pause for animals nearby, resume when they leave
- Sim-to-real — deploy onto real hardware (e.g. Modifying **OpenMower**, RTK-equipped) for cm-level localization

