Guide to help you set up and implement SLAM using LIDAR data in ROS 2

Prerequisites

- **ROS 2 Installation**: Ensure you have ROS 2 installed on your system (e.g., ROS 2 Foxy, Galactic, Humble).
- **LIDAR Sensor**: A physical LIDAR sensor or a simulated one (e.g., in Gazebo).
- **Robot Platform**: A mobile robot equipped with a LIDAR sensor.
- **Basic Knowledge**: Familiarity with ROS 2 concepts, LIDAR operation, and SLAM principles.

Step-by-Step Guide

1. Set Up Your ROS 2 Workspace

Create a new ROS 2 workspace or use an existing one.

bash
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mkdir -p ~/ros2_ws/src
cd ~/ros2_ws
colcon build
source install/setup.bash

2. Install Necessary Packages

SLAM Toolbox

The SLAM Toolbox is a popular package for SLAM in ROS 2.

bash
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sudo apt update
sudo apt install ros-<distro>-slam-toolbox

Replace <distro> with your ROS 2 distribution name (foxy, galactic, humble, etc.).

Navigation2 (Optional for Autonomous Navigation)

bash
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sudo apt install ros-<distro>-nav2-bringup

3. Configure Your LIDAR Sensor

Physical LIDAR

- **Connect the Sensor**: Attach your LIDAR sensor to your robot or computer.
- **Install Drivers**: Install any necessary drivers or ROS 2 nodes that publish LIDAR data.
- **Verify Data**: Use ros2 topic list and ros2 topic echo /scan to ensure data is being published.

Simulated LIDAR in Gazebo

- **Install Gazebo**: If not already installed.
- **Launch a Robot Simulation**: Use a robot model with a LIDAR sensor.
- **Verify Data**: As with a physical sensor, ensure that /scan topic is publishing data.

4. Verify LIDAR Data Publication

Ensure that the LIDAR data is available on the /scan topic.

bash
Copy code
ros2 topic list
ros2 topic echo /scan

5. Launch SLAM Toolbox for Mapping

Create a launch file or use the existing ones provided by SLAM Toolbox.

Using the Provided Launch File

bash
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ros2 launch slam_toolbox online_async_launch.py

Customizing SLAM Parameters

Create a YAML configuration file (slam_toolbox_params.yaml):

yaml
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slam_toolbox:
  ros__parameters:
    use_sim_time: false
    slam_mode: true
    map_file_name: ""
    resolution: 0.05
    scan_topic: /scan
    base_frame: base_link
    odom_frame: odom

map_frame: map
mode: mapping

Launch with your custom parameters:

bash
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ros2 launch slam_toolbox online_async_launch.py params_file:=/path/to/slam_toolbox_params.yaml

6. Visualize Mapping in RViz2

Launch RViz2 to see the mapping process in real-time.

bash
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rviz2

- **Set Fixed Frame**: Set the fixed frame to map.
- **Add Displays**:
  - **Map**: Displays the generated occupancy grid map.
  - **LaserScan**: Visualizes LIDAR scans.
  - **TF**: Shows the transformation frames.
  - **RobotModel**: If you have a URDF of your robot.

7. Move the Robot to Build the Map

Teleoperation

Use keyboard or joystick teleoperation to control the robot.

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sudo apt install ros-<distro>-teleop-twist-keyboard
ros2 run teleop_twist_keyboard teleop_twist_keyboard

Autonomous Exploration (Optional)

Implement an exploration algorithm or use existing packages to automate the mapping process.

8. Save the Generated Map

Once you have mapped the environment, save the map for future use.

bash
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ros2 run nav2_map_server map_saver_cli -f my_map

This will generate my_map.yaml and my_map.pgm files.

9. Use the Map for Localization

Switch SLAM Toolbox to localization mode to use the saved map.

Modify Parameters for Localization

Update your slam_toolbox_params.yaml:

yaml
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```
slam_toolbox:
  ros__parameters:
    use_sim_time: false
    slam_mode: false
    map_file_name: "/path/to/my_map.yaml"
    localization_mode: true
    scan_topic: /scan
    base_frame: base_link
    odom_frame: odom
    map_frame: map
    mode: localization
```

Launch SLAM Toolbox in Localization Mode

bash
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```
ros2 launch slam_toolbox online_async_launch.py params_file:=/path/to/slam_toolbox_params.yaml
```

10. Verify Localization

- **RViz2 Visualization**: Ensure the robot's pose aligns with the map.
- **Test Movements**: Move the robot and observe if it localizes correctly.

11. Integrate with Navigation2 for Autonomous Navigation (Optional)

Configure Navigation2

Create a nav2_params.yaml file with necessary configurations.

Launch Navigation2

bash
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```
ros2 launch nav2_bringup navigation_launch.py params_file:=/path/to/nav2_params.yaml
```

Set Goals in RViz2

- **Add Goal Tool**: In RViz2, use the "2D Nav Goal" tool to send navigation goals.
- **Monitor Navigation**: Observe the robot autonomously navigating to the goal while avoiding obstacles.

References

- **SLAM Toolbox GitHub**: https://github.com/SteveMacenski/slam_toolbox
- **Navigation2 Documentation**: https://ros2-industrial-workshop.readthedocs.io/en/latest/_source/navigation/ROS2-Navigation.html
- **ROS 2 Tutorials**: https://docs.ros.org/en/foxy/Tutorials.html