ROS2 for Robots

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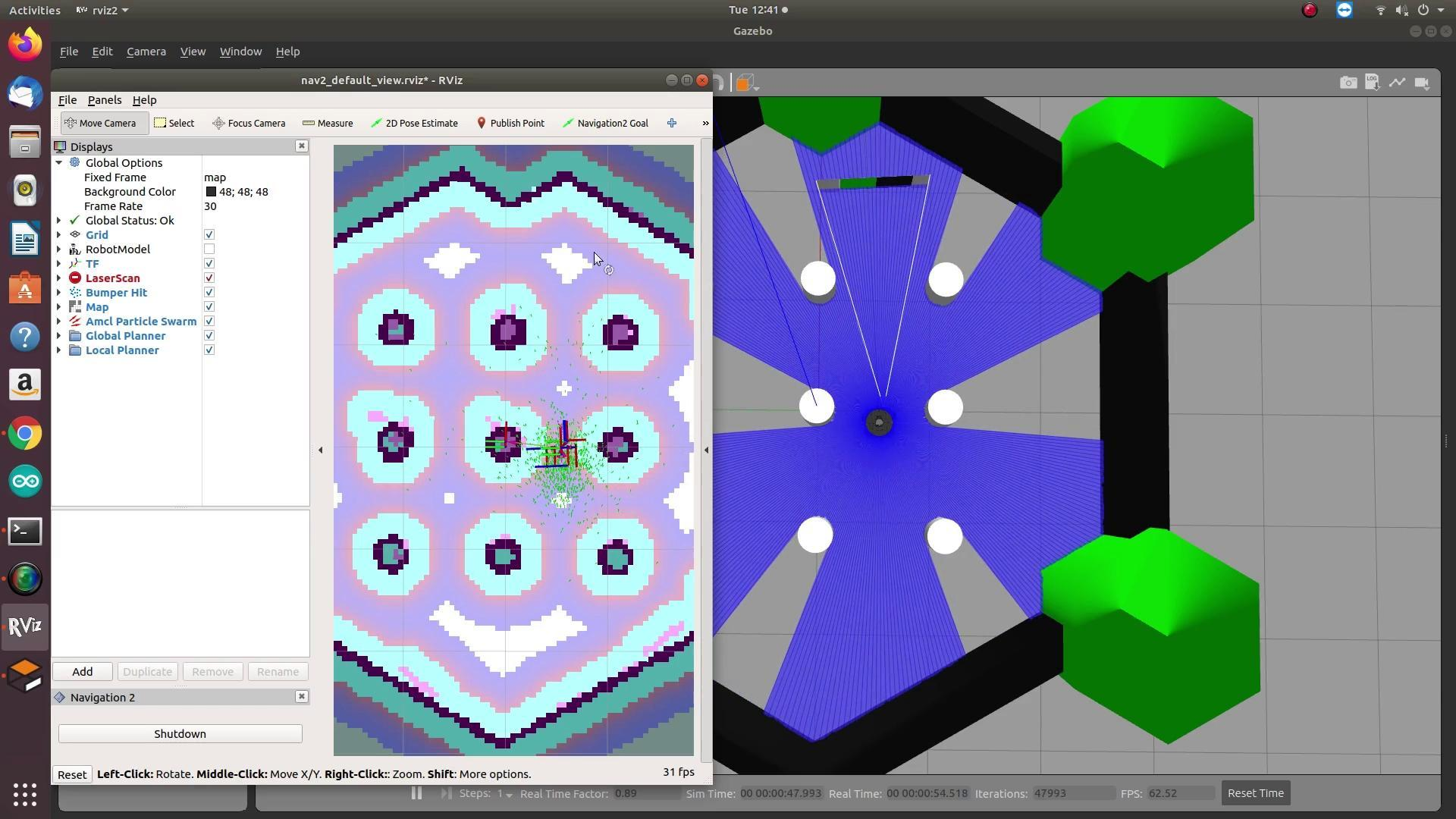
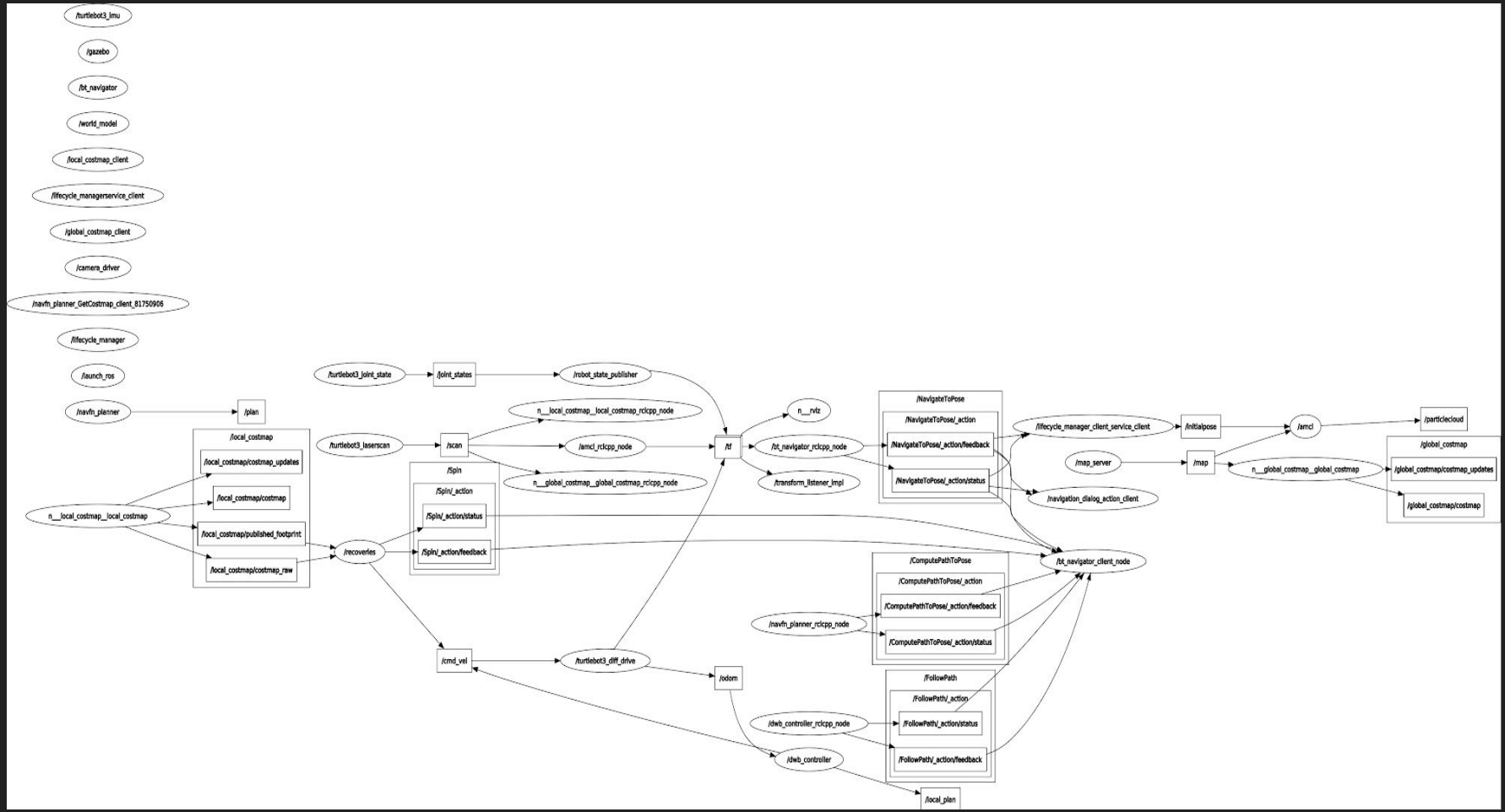
1. Turtlebot Simulation in Navigation

- 2-D pose estimation (rviz)
- 2-D navigation goal
- Turtlebot3 follows path and arrives at destination
- If unexpected obstacle blocks the path
    - Robot can detect them to avoid


Activities
rviz2
Tue 12:41
Gazebo
File Edit Camera View Window Help
nav2_default_view.rviz* - RViz
File Panels Help
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
Publish Point
Navigation2 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
Local Planner
Add
Duplicate
Remove
Rename
Navigation 2
Shutdown
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click:: Zoom. Shift: More options.
31 fps
Steps: 1
Real Time Factor: 0.89
Sim Time: 00 00:00:47.993
Real Time: 00 00:00:54.518
Iterations: 47993
FPS: 62.52
Reset Time

2. Turtlebot graphs and layers

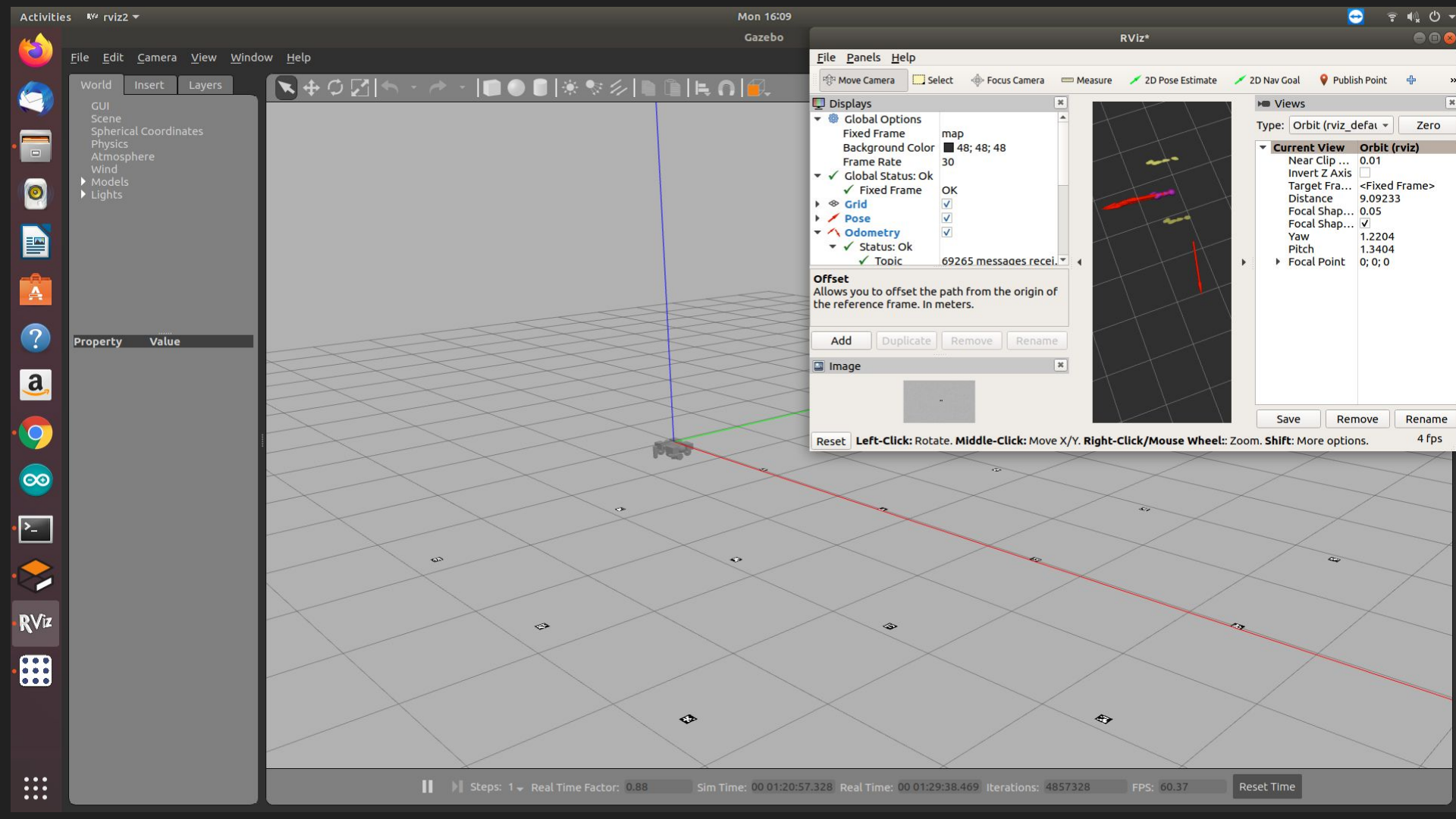
- Turtlebot3 uses:
  - Robot’s encoder
  - IMU sensor
  - Distance sensor
- Saved map-> contains field info -> use in node


/turtlebot3_imu
/gazebo
/bt_navigator
/world_model
/local_costmap_client
/lifecycle_managerservice_client
/global_costmap_client
/camera_driver
/navfn_planner_GetCostmap_client_81750906
/lifecycle_manager
/launch_ros
/navfn_planner
/plan
/local_costmap
/local_costmap/costmap_updates
/local_costmap/costmap
/local_costmap/published_footprint
/local_costmap/costmap_raw
n__local_costmap__local_costmap
/turtlebot3_joint_state
/joint_states
/robot_state_publisher
/turtlebot3_laserscan
/scan
n__local_costmap__local_costmap_rclcpp_node
/amcl_rclcpp_node
n__global_costmap__global_costmap_rclcpp_node
/Spin
/Spin/_action
/Spin/_action/status
/Spin/_action/feedback
/recoveries
/tf
n__rviz
/bt_navigator_rclcpp_node
/transform_listener_impl
/NavigateToPose
/NavigateToPose/_action
/NavigateToPose/_action/feedback
/NavigateToPose/_action/status
/lifecycle_manager_client_service_client
/navigation_dialog_action_client
/InitialPose
/amcl
/particlecloud
/map_server
/map
n__global_costmap__global_costmap
/global_costmap
/global_costmap/costmap_updates
/global_costmap/costmap
/bt_navigator_client_node
/ComputePathToPose
/ComputePathToPose/_action
/ComputePathToPose/_action/feedback
/ComputePathToPose/_action/status
/navfn_planner_rclcpp_node
/cmd_vel
/turtlebot3_diff_drive
/odom
/FollowPath
/FollowPath/_action
/FollowPath/_action/status
/FollowPath/_action/feedback
/dwb_controller_rclcpp_node
/dwb_controller
/local_plan

3. ROS2 Navigation stack

- Navigation 2: send robot to a designated destination in a given environment
  - Uses data created in ROS2 SLAM
- Control over params: max-min vel, rot. vel,accel, tolerance
- Global Planner- global plan
  - Requires a map of the environment to calculate the best route
- Local Planner
  - Transform global path -> suitable waypoints
  - Creates new waypoints -> dynamic obstacles; vehicle constraints
- Use of navigation stack on an arbitrary robot
  - ROS required
  - TF transform tree (tf-maintains the relationship between coordinate frames in a tree structure buffered in time, and lets the user transform points, vectors, etc between any two coordinate frames at any desired point in time.)
  - Sensor data using correct ROS message type
  - Needs to be configured for shapes and dynamics of a robot to perform at a high level
  - Planar laser mounted somewhere on the mobile base (map building and localization); docs.

4. Orca 2 Simulation


Activities
rviz2
Mon 16:09
Gazebo
File Edit Camera View Window Help
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Atmosphere
Wind
Models
Lights
Property Value
RViz*
File Panels Help
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Options
Fixed Frame map
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
Pose
Odometry
Status: Ok
Topic 69265 messages recei...
Offset
Allows you to offset the path from the origin of the reference frame. In meters.
Add Duplicate Remove Rename
Image
Views
Type: Orbit (rviz_defa
Zero
Current View Orbit (rviz)
Near Clip ... 0.01
Invert Z Axis
Target Fra... <Fixed Frame>
Distance 9.09233
Focal Shap... 0.05
Focal Shap...
Yaw 1.2204
Pitch 1.3404
Focal Point 0; 0; 0
Save Remove Rename
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
4 fps
Steps: 1
Real Time Factor: 0.88
Sim Time: 00 01:20:57.328
Real Time: 00 01:29:38.469
Iterations: 4857328
FPS: 60.37
Reset Time

Default - rqt

File Plugins Running Perspectives Help

Topic Monitor

Topic	Type
/barometer	orca_msgs/msg/Barometer
/battery	orca_msgs/msg/Battery
/clicked_point	geometry_msgs/msg/PointStamped
/clock	rosgraph_msgs/msg/Clock
/control	orca_msgs/msg/Control
/depth	orca_msgs/msg/Depth
/fcam_f_base	geometry_msgs/msg/PoseWithCovarianc
/fiducial_map	fiducial_vlam_msgs/msg/Map
/fiducial_markers	visualization_msgs/msg/MarkerArray
/fiducial_observations	fiducial_vlam_msgs/msg/Observations
/filtered_path	nav_msgs/msg/Path
/forward_camera/camera_info	sensor_msgs/msg/CameraInfo
/forward_camera/camera_pose	geometry_msgs/msg/PoseWithCovarianc
/forward_camera/image_marked	sensor_msgs/msg/Image
/forward_camera/image_raw	sensor_msgs/msg/Image
/forward_camera/parameter_events	rcl_interfaces/msg/ParameterEvent
/forward_camera/rosout	rcl_interfaces/msg/Log
/ground_truth	nav_msgs/msg/Odometry
/imu/data	sensor_msgs/msg/Imu
/initialpose	geometry_msgs/msg/PoseWithCovarianc
/joint_states	sensor_msgs/msg/JointState
/joy	sensor_msgs/msg/Joy
/lcam_f_base	geometry_msgs/msg/PoseWithCovarianc
/leak	orca_msgs/msg/Leak
/left_camera/camera_info	sensor_msgs/msg/CameraInfo
/left_camera/camera_pose	geometry_msgs/msg/PoseWithCovarianc
/left_camera/image_marked	sensor_msgs/msg/Image
/left_camera/image_raw	sensor_msgs/msg/Image
/left_camera/parameter_events	rcl_interfaces/msg/ParameterEvent
/left_camera/rosout	rcl_interfaces/msg/Log
/mission/_action/feedback	orca_msgs/action/Mission_FeedbackMess
/mission/_action/status	action_msgs/msg/GoalStatusArray
/move_base_simple/goal	geometry_msgs/msg/PoseStamped
/odom	nav_msgs/msg/Odometry
/parameter_events	rcl_interfaces/msg/ParameterEvent
/planned_path	nav_msgs/msg/Path
/rcam_f_base	geometry_msgs/msg/PoseWithCovarianc
/right_camera/camera_info	sensor_msgs/msg/CameraInfo
/right_camera/camera_pose	geometry_msgs/msg/PoseWithCovarianc
/right_camera/image_marked	sensor_msgs/msg/Image
/right_camera/image_raw	sensor_msgs/msg/Image
/right_camera/parameter_events	rcl_interfaces/msg/ParameterEvent
/right_camera/rosout	rcl_interfaces/msg/Log
/robot_description	std_msgs/msg/String
/rosout	rcl_interfaces/msg/Log
/tf	tf2_msgs/msg/TFMessage
/tf_static	tf2_msgs/msg/TFMessage
/thrust_markers	visualization_msgs/msg/MarkerArray

Image View

left 0°

Console

Displaying 20000 messages Fit Columns

#	Message	Severity	Node
#79234	6dof pose filter	Info	filter_node
#79233	found marker(s)	Info	filter_node
#79232	start filter, stamp {1...	Info	filter_node
#79231	start filter, stamp {4...	Info	filter_node
#79230	6dof pose filter	Info	filter_node
#79229	found marker(s)	Info	filter_node

Exclude Messages...

...with severities: Debug Info Warn Error

Highlight Messages...

...containing: Regex

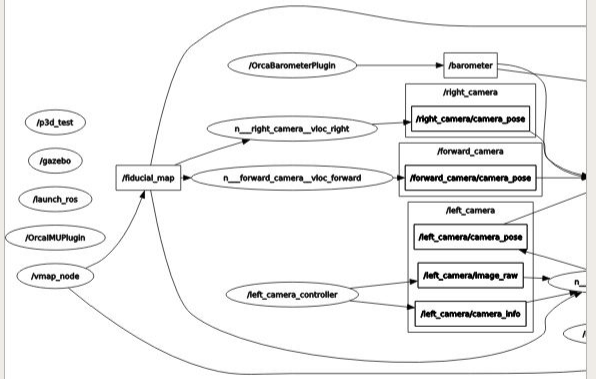
RQT

Node Graph

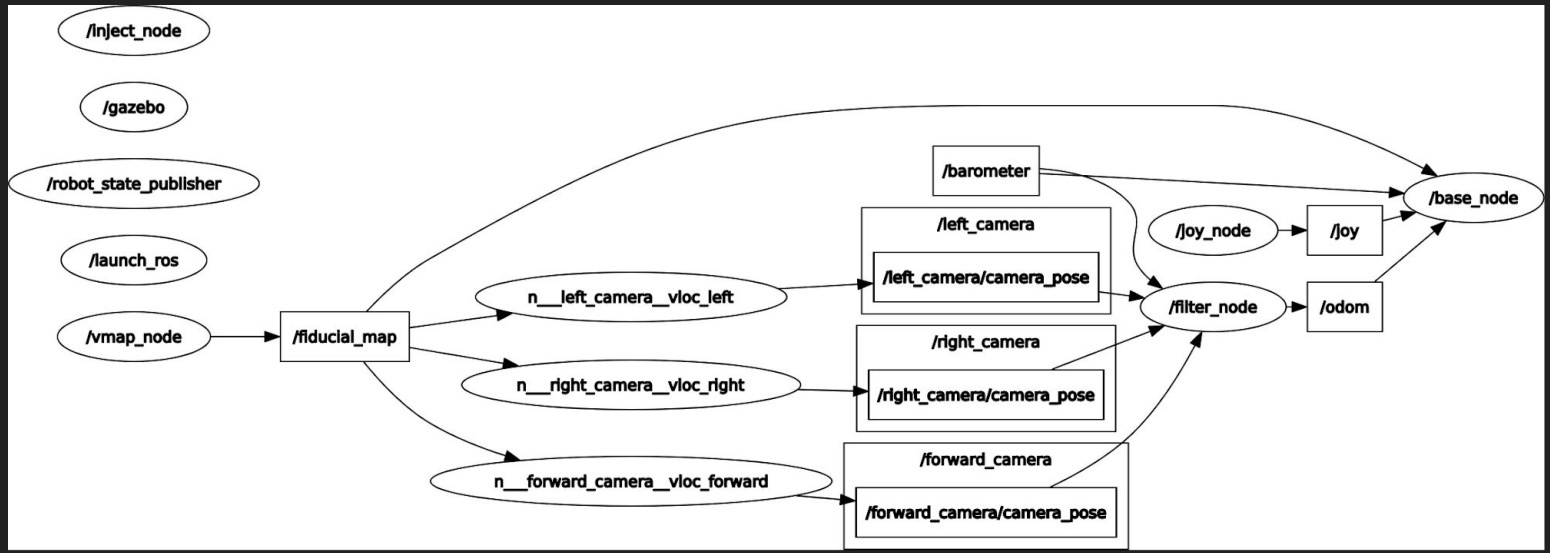
Nodes/Topics (all) / /

Group: 2 Namespaces Actions tf Images Highlight Fit

Hide: Dead sinks Leaf topics Debug tf Unreachable Params



Ros2 graph of current Orca implementation



5. ORCA2 Drivers and layers

1. Orca_msgs :
   a. Can set mission goals in rviz
   b. Support mission actions
      - msg/Barometer.msg
      - msg/Battery.msg
      - msg/Control.msg
      - msg/Depth.msg
      - msg/Efforts.msg
      - msg/Leak.msg
      - msg/Proc.msg
      - msg/Pose.msg
      - msg/PoseStamped.msg

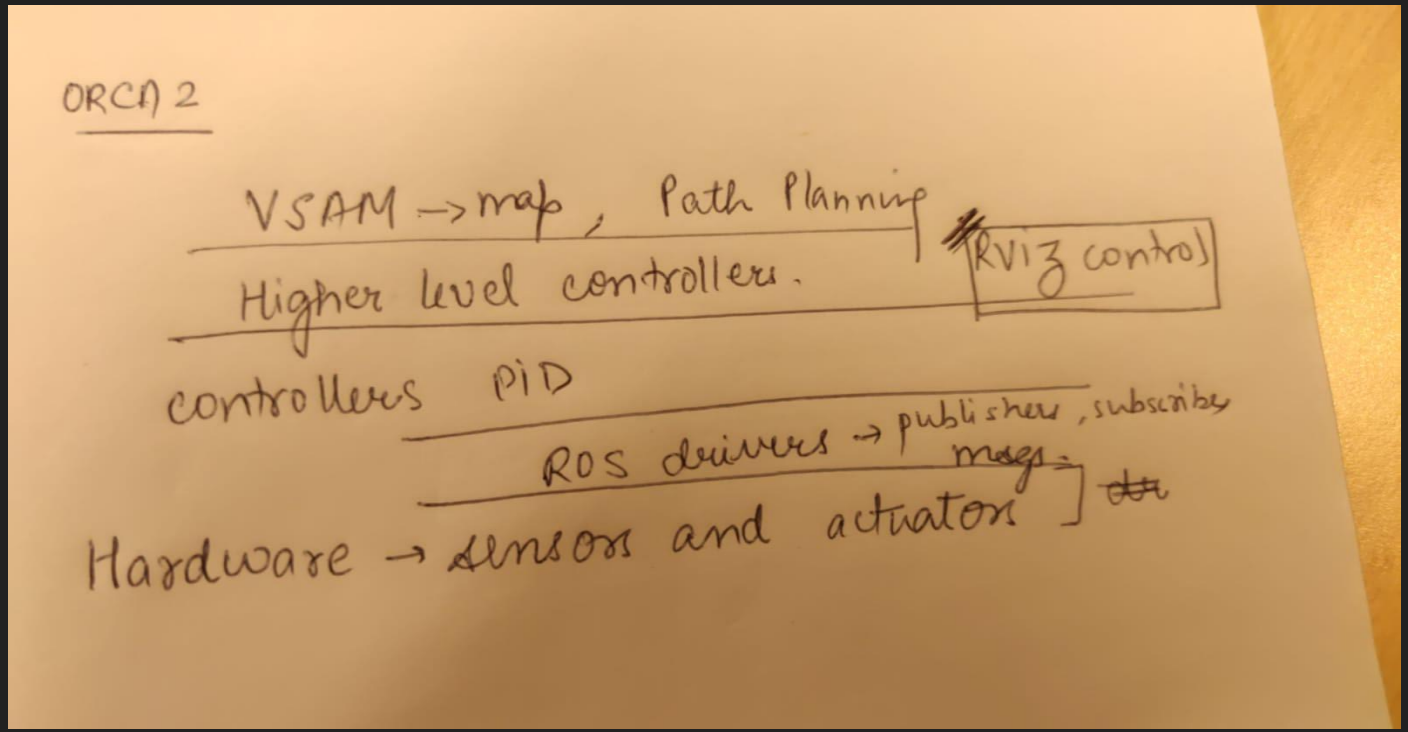
5. ORCA2 Drivers and layers

1. Orca_description :
   a. URDF file provided for Orca2
2. Orca_base (Orca control loop)
   a. PID controllers
   b. High-level controllers: calculate the pose error and pass it to the 4 PID controllers.
   c. Trajectory planner and feedforward
   d. Pololu Maestro : send PWM messages to the ESCs
   e. Forces modelled : gravity, buoyancy, thruster translation forces, vehicle drag
   f. Modes: disarmed, manually controlled thrusters, hold in z position(PID), Mission AUV
   g. VSLAM, a* path planning

5. ORCA2 Drivers and layers

1. Orca_drivers (for hardware interface)
    a. Rpi, USB camera
    b. Barometer
    c. depth
    d. Maestro
    e. Mraa
    f. Joystick-teleoperation
    g. Leak sensor

Orca2 Layers



Suggestions for Rosification with BlueROV (from ORCA developers)

3 ways to ROSify a BlueROV2:

- Use the existing hardware (Pixhawk) and software (ArduSub), and use mavros to move messages from the MAV message bus to/from ROS. See BlueRov-ROS-playground for a good example of this method. This is the fastest way to integrate ROS with the BlueROV2.
- Port ROS to the Pixhawk and NuttX, and run a ROS-native driver on the Pixhawk.
- Provide a ROS-native driver running on Linux, such as the Raspberry Pi 3. You'll need to provide a small device controller, such as the Pololu Maestro, and an IMU, such as the Phidgets IMU. This is the Orca design.

Navigation stack for other underwater Robots? (if time permits)