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MoveIt and the rest of ROS:

Perception, Control, and Simulation

ROSWorld October 2021 - Mobile Manipulation Workshop

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Outline

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- A brief Overview of ROS Communication
- How does a mobile manipulator work, how different pipelines connect?
- Navigation
- Perception
- Simulation and Control

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A Brief Overview of ROS Communication

Pub/Sub Basics

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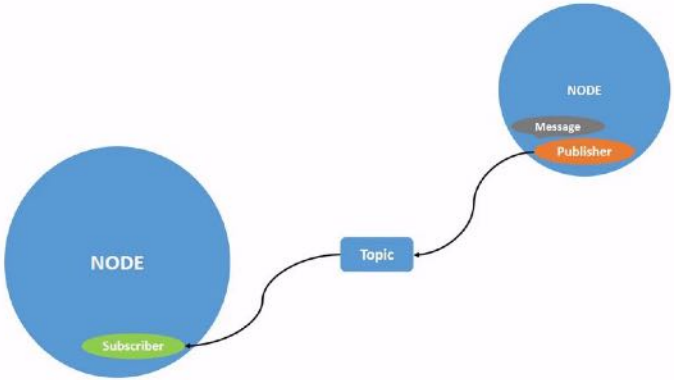
Pub/Sub Topics, Services and Actions are the primary communication patterns used in ROS and also MoveIt!

Helpful command line tools:

- *rostopic list*
- *rostopic echo <topic_name>*
- *rostopic hz <topic_name>*

ros2 topic list
ros2 topic echo
....



Understanding ROS2 topics

Remembering Actions

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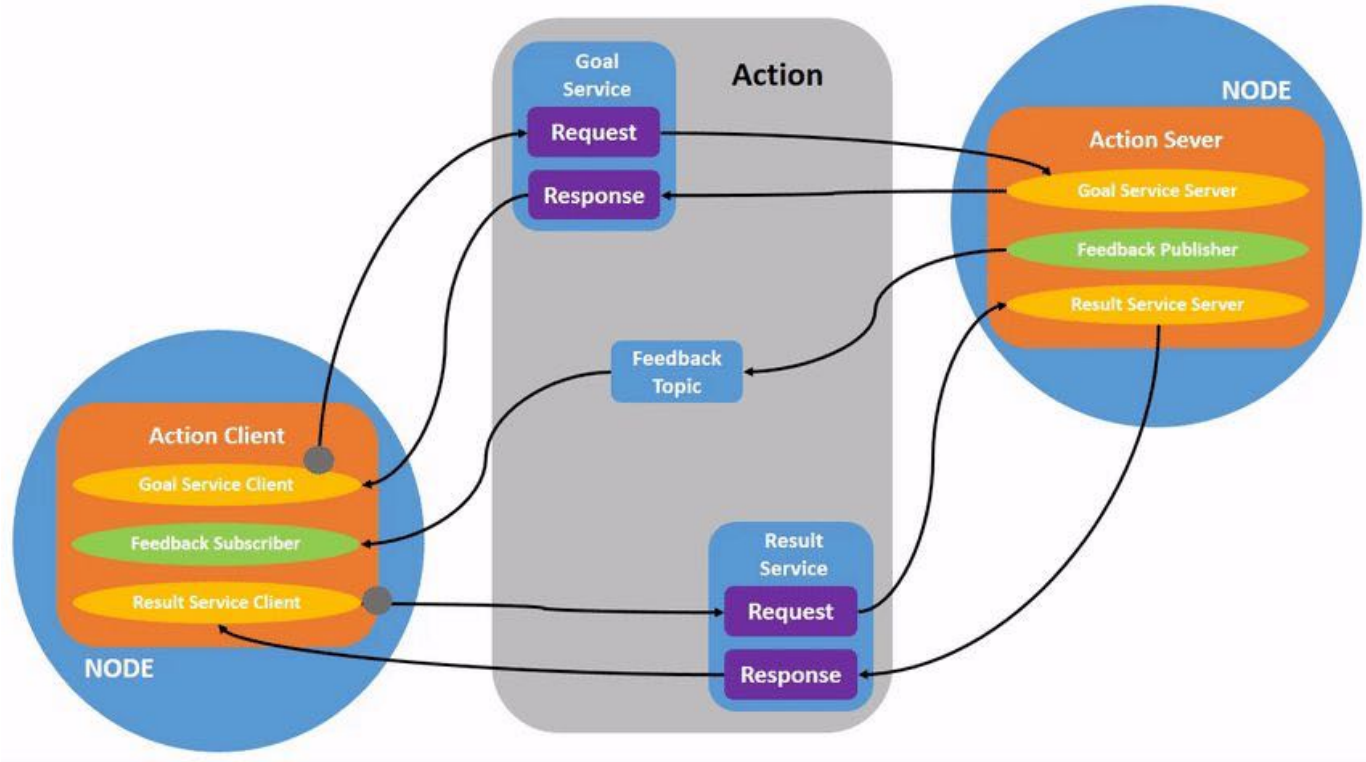

How does MoveIt Communicate with ROS

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```python
from control_msgs.action import FollowJointTrajectory
from trajectory_msgs.msg import JointTrajectory
import rclpy
from rclpy.action import ActionServer, server
from rclpy.node import Node
from math import sqrt


class FollowJointTrajectoryActionServer(Node):

    def __init__(self):
        super().__init__('follow_joint_trajectory_action_server')
        self._joint_trajectory_publisher = self.create_publisher(JointTrajectory, '/joint_trajectory', 10)
        self._action_server = ActionServer(
            self,
            FollowJointTrajectory,
            '/stretch_controller/follow_joint_trajectory',
            self.execute_callback)

    def execute_callback(self, goal_handle: server.ServerGoalHandle):
        self.get_logger().info('Executing goal...')
        result = FollowJointTrajectory.Result()
        trajectory = goal_handle.request.trajectory # type: JointTrajectory
        self._joint_trajectory_publisher.publish(trajectory)
        goal_handle.succeed()
        return result

def main(args=None):
    rclpy.init(args=args)
    follow_joint_trajectory_action_server = FollowJointTrajectoryActionServer()
    rclpy.spin(follow_joint_trajectory_action_server)

if __name__ == '__main__':
    main()
```

- MoveIt Uses Actions to send the robot / simulation planned joint trajectories.
- Typically MoveIt is the client and server is opened up by ros(2)_control.
- You can also use your own FollowJointTrajectory server as well!

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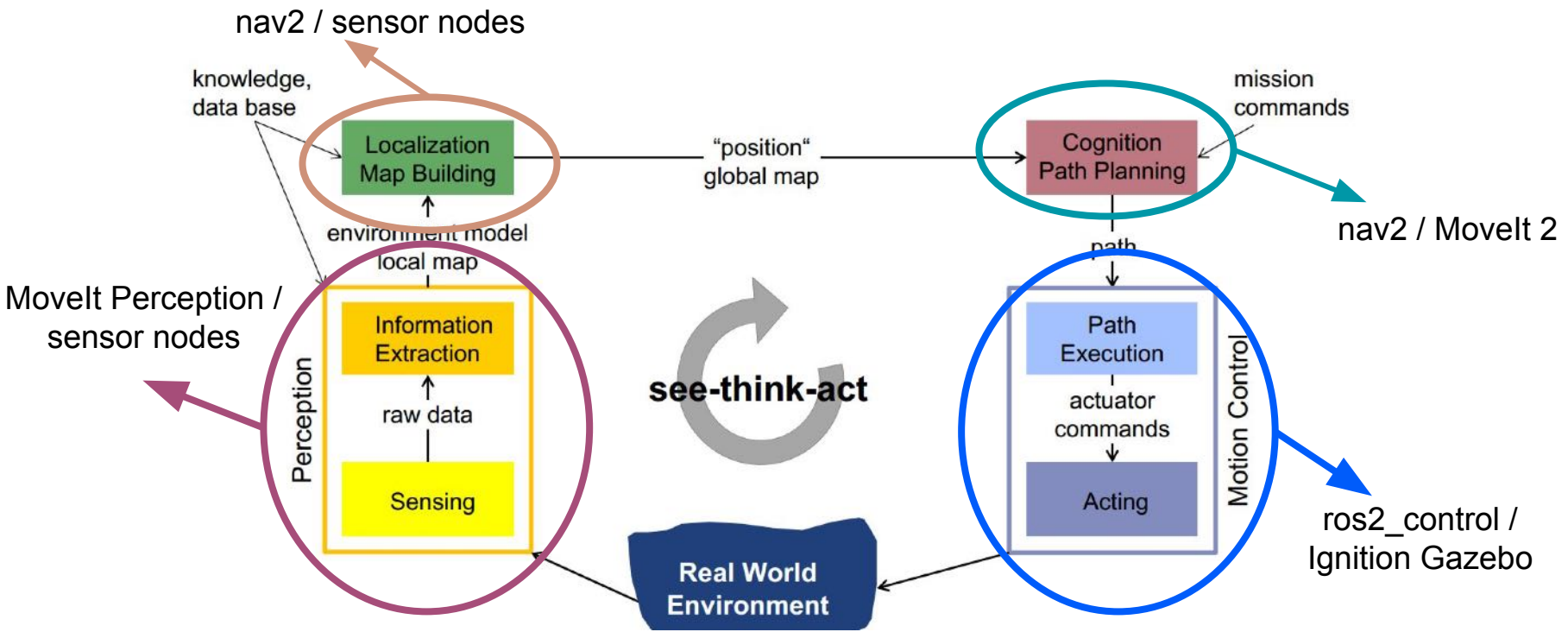
How does a mobile manipulator work, how different pipelines connect?

Mobile Manipulation Work Cycle



Credit: ETH Zurich Mobile Robot Lecture Notes: https://asl.ethz.ch/education/lectures/autonomous_mobile_robots.html

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Perception

MoveIt Calibration

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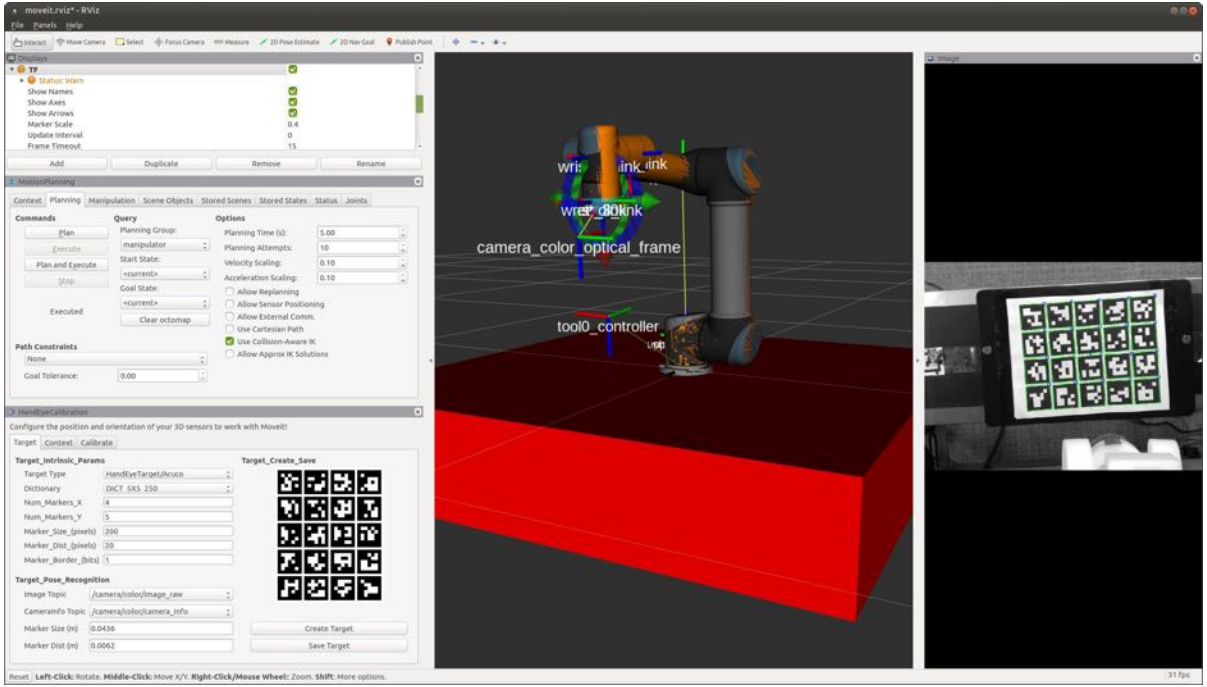

Perform hand-eye calibrations in RViz

Generate a target image to print

Move arm, acquire 5+ sample poses

Export EEF->camera transform

Octomap and Collision Awareness

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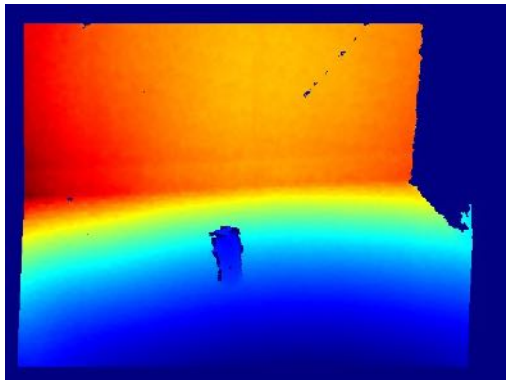
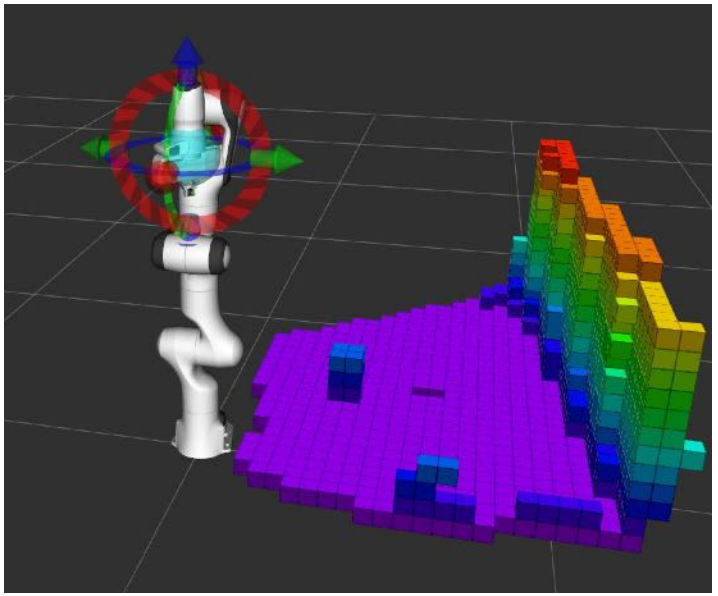
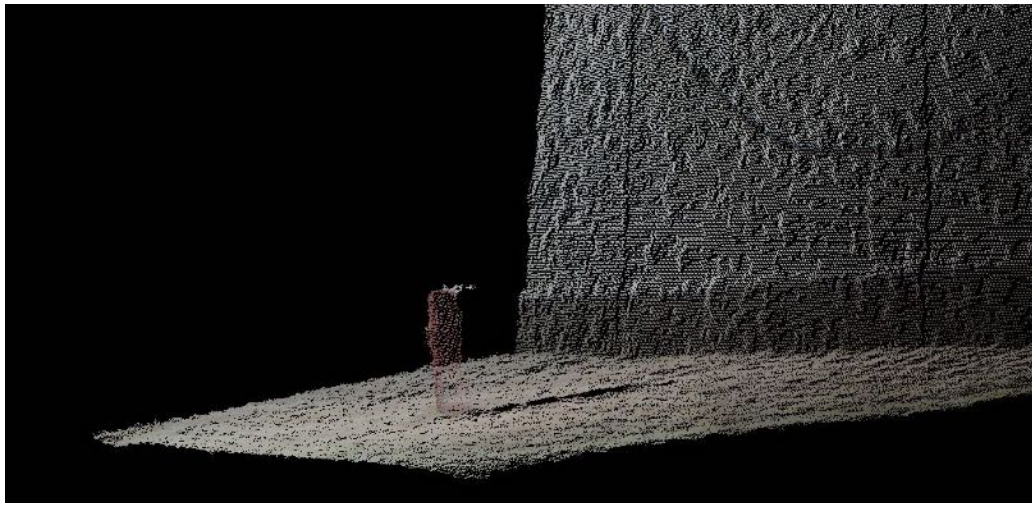
3D occupancy map
for collision checking

Update from depth
map or point cloud







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Navigation

Mobile Base Planning in MoveIt 2

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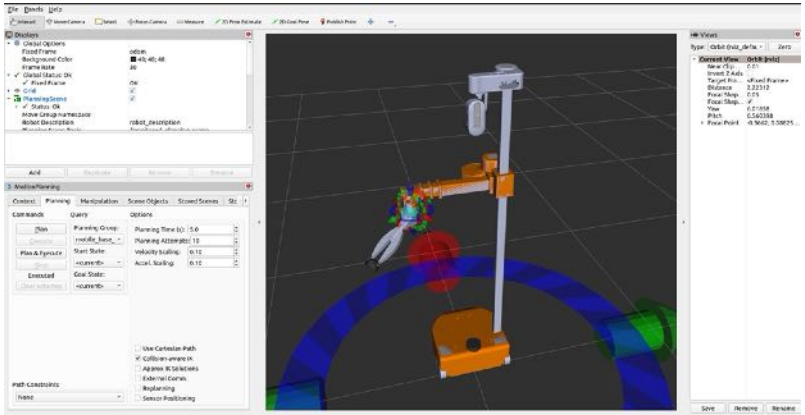
- Holonomic movements were supported for a long time (quadcopters, holonomic robots)
- Stretch is a differential drive robot so PickNik has added a new differential drive motion model to the planar joints.
- Basically a virtual joint defined in SRDF that publishes valid cmd_vel commands.
-

```
<virtual_joint     name="position"   type="planar"   parent_frame="odom"   child_link="base_link"/>
<joint_property    joint_name="position"    property_name="motion_model"    value="diff_drive"    />
<joint_property joint_name="position" property_name="min_translational_distance" value="0.05" />
```



Using nav2 with MoveIt 2

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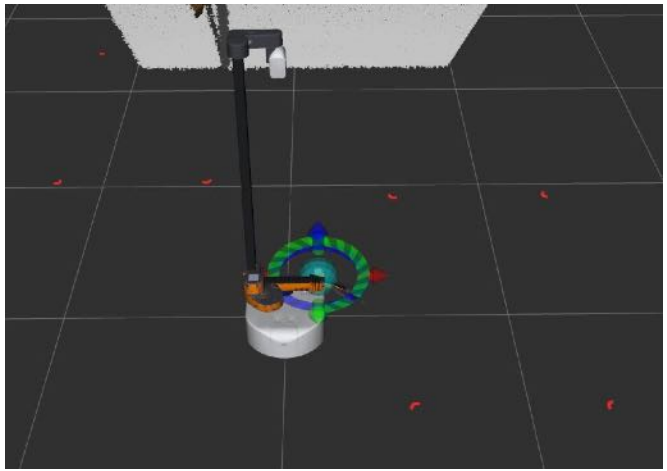
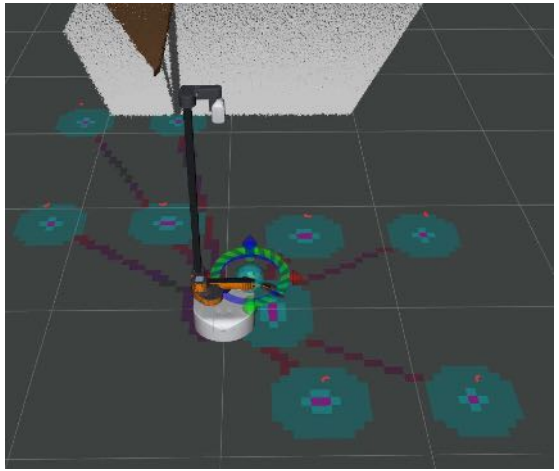
- MoveIt 2 perception pipeline support PointCloud messages that LIDARs usually publish.
- But, in navigation we might want to take more than pointclouds: such as inflation layer.
- MoveIt 2 does not support navigation layers and is not meant to be a replacement for navigation2.
- Using nav2_simple_commander we can give the MoveIt generated waypoints and let nav2 execute the trajectory for us instead of MoveIt if desired.





Using nav2 with MoveIt 2

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```
def execute_callback(self, goal_handle: server.ServerGoalHandle):
    self.get_logger().info('Executing goal...')
    result = FollowJointTrajectory.Result()
    trajectory = goal_handle.request.trajectory # type: JointTrajectory
    self._joint_trajectory_publisher.publish(trajectory)
    multidof_trajectory = goal_handle.request.multi_dof_trajectory # type: MultiDOFJointTrajectory
    goal_pose = PoseStamped()
    goal_pose.header.frame_id = "odom"
    goal_pose.header.stamp = self.get_clock().now().to_msg()
    goal_pose.pose.position.x = multidof_trajectory.points[-1].transforms[0].translation.x
    goal_pose.pose.position.y = multidof_trajectory.points[-1].transforms[0].translation.y
    goal_pose.pose.position.z = multidof_trajectory.points[-1].transforms[0].translation.z
    goal_pose.pose.orientation.x = multidof_trajectory.points[-1].transforms[0].rotation.x
    goal_pose.pose.orientation.y = multidof_trajectory.points[-1].transforms[0].rotation.y
    goal_pose.pose.orientation.z = multidof_trajectory.points[-1].transforms[0].rotation.z
    goal_pose.pose.orientation.w = multidof_trajectory.points[-1].transforms[0].rotation.w
    print("Target pose:", goal_pose.pose)
    self.nav.goToPose(goal_pose)
    goal_handle.succeed()
    return result
```

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Simulation and Control

Stretch's Sensors

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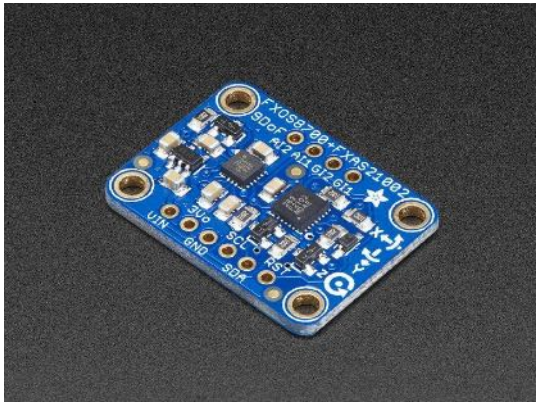
- Head
  - Intel Realsense D435i
  - 4 channel ReSpeaker MicArray V2.0
  - 8W stereo audio out w/volume adjust
- Base
  - RPLidar A1
  - 9 DoF IMU
- Wrist
  - 3 DoF Accelerometer
- Force sensing (via motor current) on arm and lift
- Aruco tags



Stretch's Sensors

- Most of the sensors are ported and working quite well in Ignition Gazebo.
- Use gazebo and sensor tags, same with ROS and Gazebo Classic.
- Realsense, LIDAR and all the IMUs are simulated.
- Force sensing not implemented yet but now possible with Ignition Fortress!
- ReSpeaker MicArray not simulated but possible through a ROS2 node that connects to simulator PC's microphone and speaker.

Simulating and Controlling Stretch in Ignition Gazebo and ROS 2

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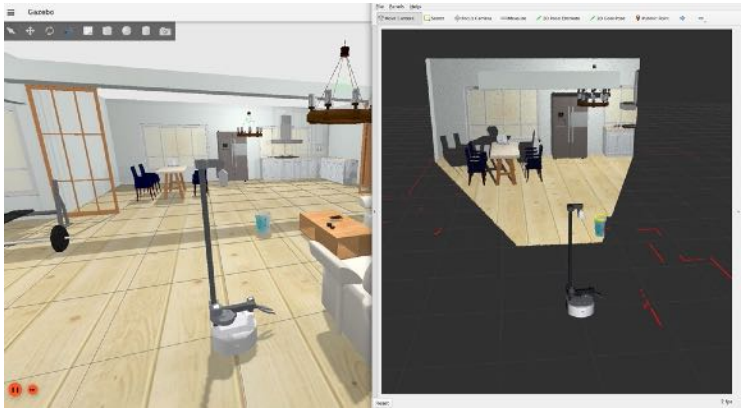
Here is what changed since ROS1 and Gazebo Classic:

- You can still use xacros or urdfs
- You can still use gazebo tags (sensor etc.) in xacros (see http://sdformat.org/spec?elem=sensor&ver=1.8 for sensor parameters)
- You might need to add some system plugins to your world file
- Joint trajectory plugin is great to control joints, joint states plugin is great publishing joint states until ign_ros2_control is here https://github.com/ignitionrobotics/ign_ros2_control/pull/1.
- Tune gains from joint_trajectory plugin until ros2_control arrives.
- ign_ros_bridge for ROS <-> IGN communication
- Porting existing worlds is super easy to Ignition (See aws_robomaker_small_house in action!)



Putting Everything Together with Guided Exploration!

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Thanks!

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