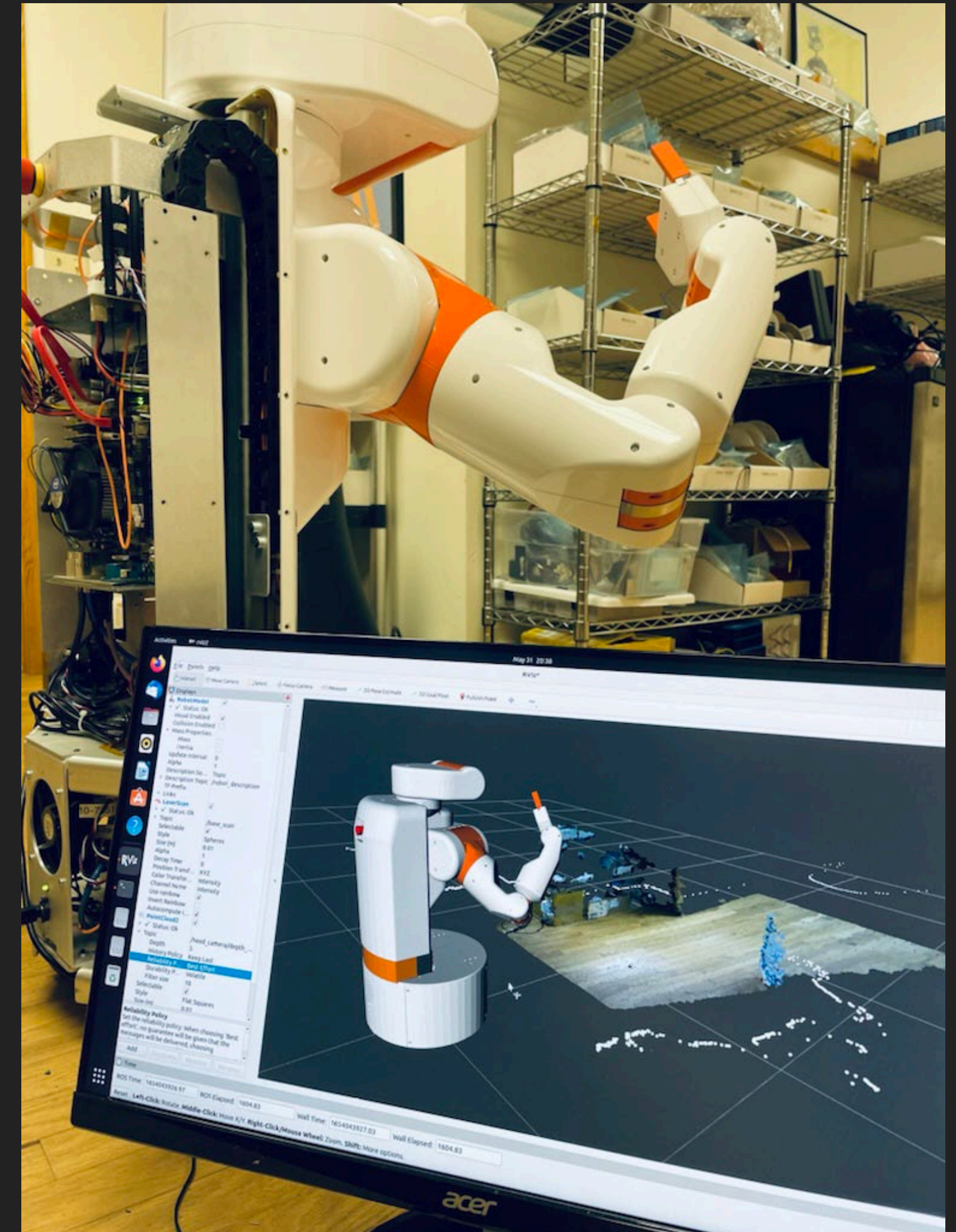


MICHAEL FERGUSON

MIGRATING A MOBILE MANIPULATOR TO ROS 2

TALK OVERVIEW

- ▶ Mobile Manipulation
- ▶ What is the UBR-1?
- ▶ ROS 1 - > ROS 2: Challenges and Features
- ▶ Essential Tools for Mobile Manipulation in ROS 2



UNBOUNDED ROBOTICS UBR-1

- ▶ 2013: Co-founder, CTO
- ▶ 2014: Company bankrupt
- ▶ ...
- ▶ 2020: Robot appears on Craigslist

CL stockton > for sale > electronics - by owner

favorite

hide

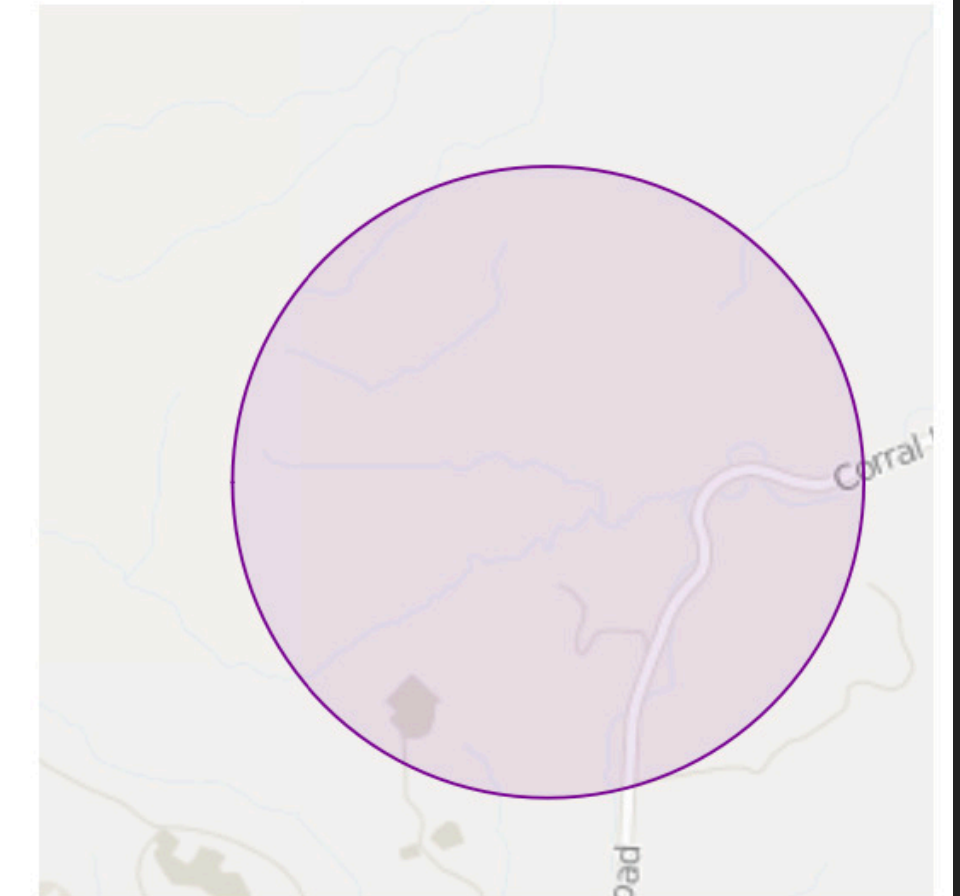


Posted about 13 hours ago on: 2020-04-25 16:29

Contact Information:

Robot prototype - \$5000 (Tracy, CA)

image 1 of 10



condition: new

This prototype robot is now for sale.
It worked when it was put in the box and is from a failed robotic company.
They were going to sell them for \$50,000 and this prototype is yours for the low price of \$5,000.
There may be some spare parts too.
This robot comes with his (her) own storage box.
I believe the lithium battery needs to be recharged at this point.

QR Code Link to This Post



SAVE THE ROBOTS: MORE THAN JUST A BEER NAME

- ▶ Updated from Indigo->Melodic
- ▶ Melodic->Noetic: Python3
- ▶ How hard can it be to go to ROS 2?
- ▶ 4 years later - giving this talk!



ROS 1 - > ROS 2

- ▶ More than just an API change
 - ▶ Different threading models
 - ▶ More fully featured (but also more complex/verbose)
 - ▶ Some late arriving features (lazy subscribers, etc)
- ▶ Many packages took the opportunity to largely re-write/re-architect (ex: Nav2)

UBR-1 ON ROS2 TIMELINE

- ▶ Started with ROS 2 Foxy / 20.04
- ▶ Ported to Humble / 22.04
- ▶ Ported to Iron
- ▶ Ported to Jazzy / 24.04

USE DOCKER/ROCKER TO
OVERCOME OPERATING
SYSTEM MISMATCH



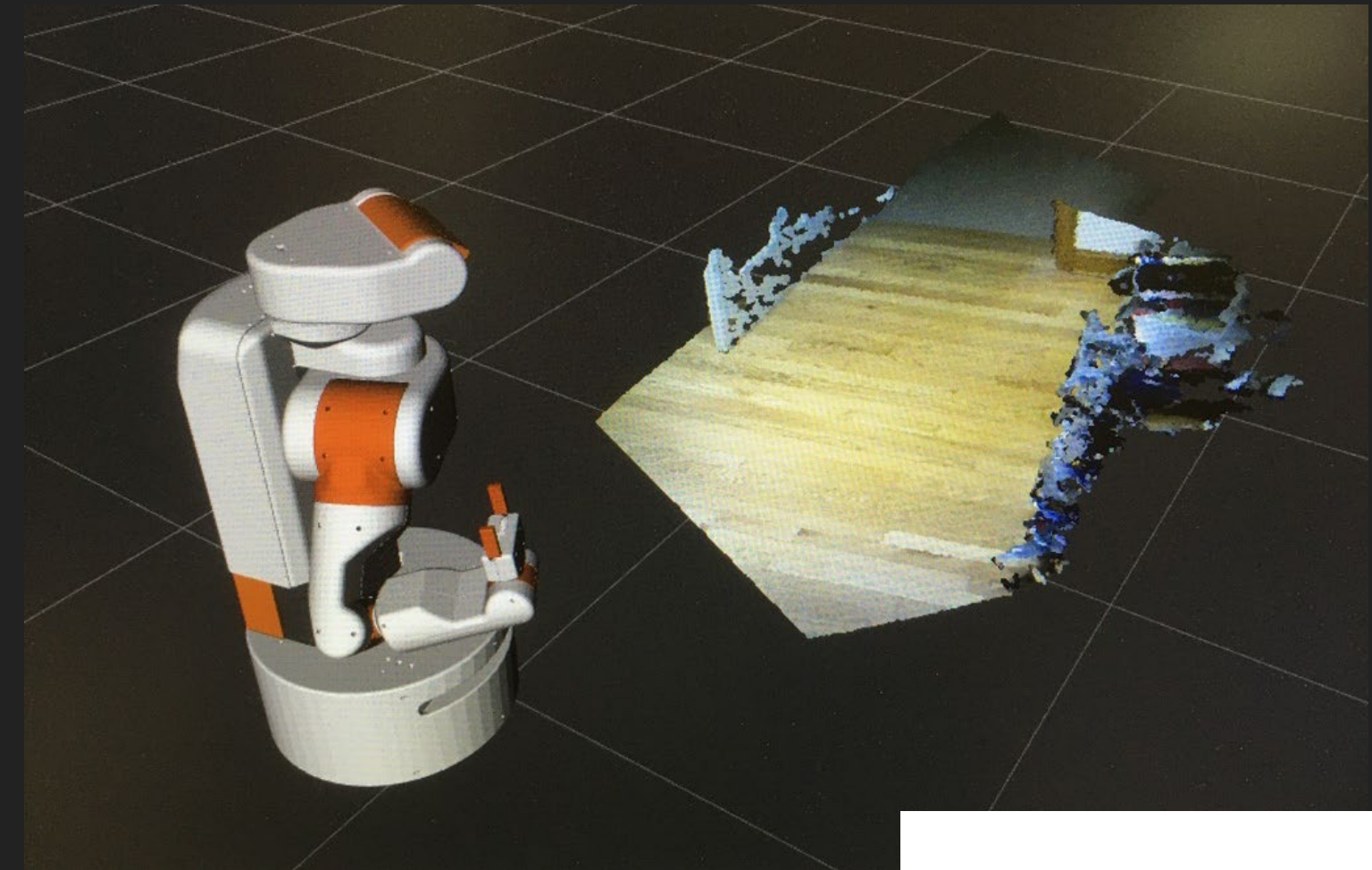
HARDWARE DRIVERS IN ROS2

- ▶ Still a bit like the wild west!
 - ▶ Some are not merged into mainline - have to find the random fork! Stack Exchange and forums help to find these.
 - ▶ Some are not released into Debian packages!
 - ▶ Some features still arriving (lazy subscribers)!
- ▶ I ended up becoming maintainer of `urg_node`, `openni2_camera` packages.



PORTING OPENNI2_CAMERA TO ROS 2

- ▶ Nodelets -> Components (well documented)
 - ▶ Derived from `rclcpp::Node::SharedPtr`
 - ▶ `shared_from_this()` limitations
- ▶ Lazy subscribers - added in Iron/Jazzy. Workaround with timers.
- ▶ `openni2_launch` still not ported

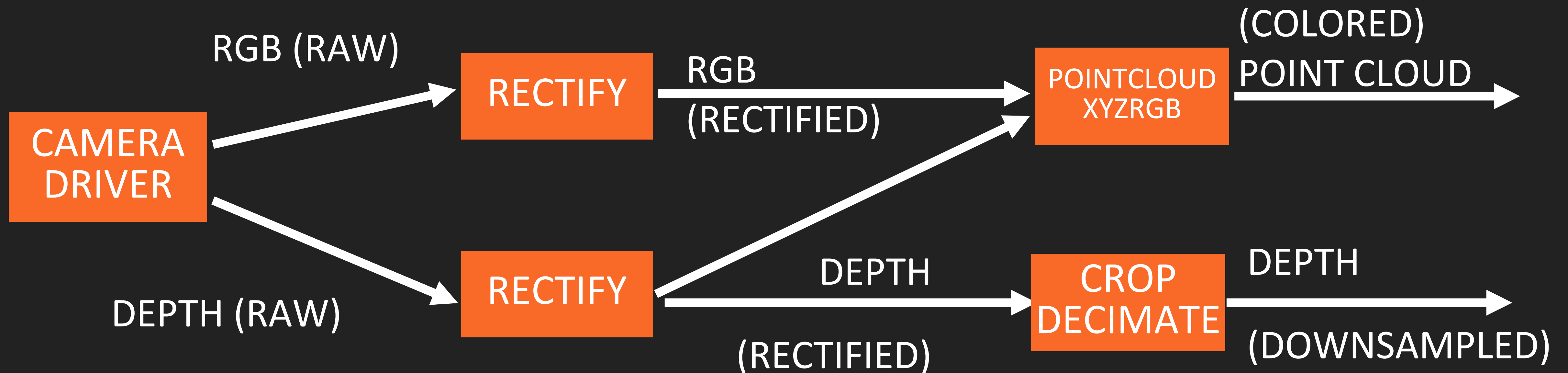


**FULL WRITE
UP:**



IMAGE PIPELINE

- ▶ Transform and preprocess image data
- ▶ Proper ROS 2 components (were nodelets in ROS 1)
 - ▶ Easier to introspect and debug - same performance boost!

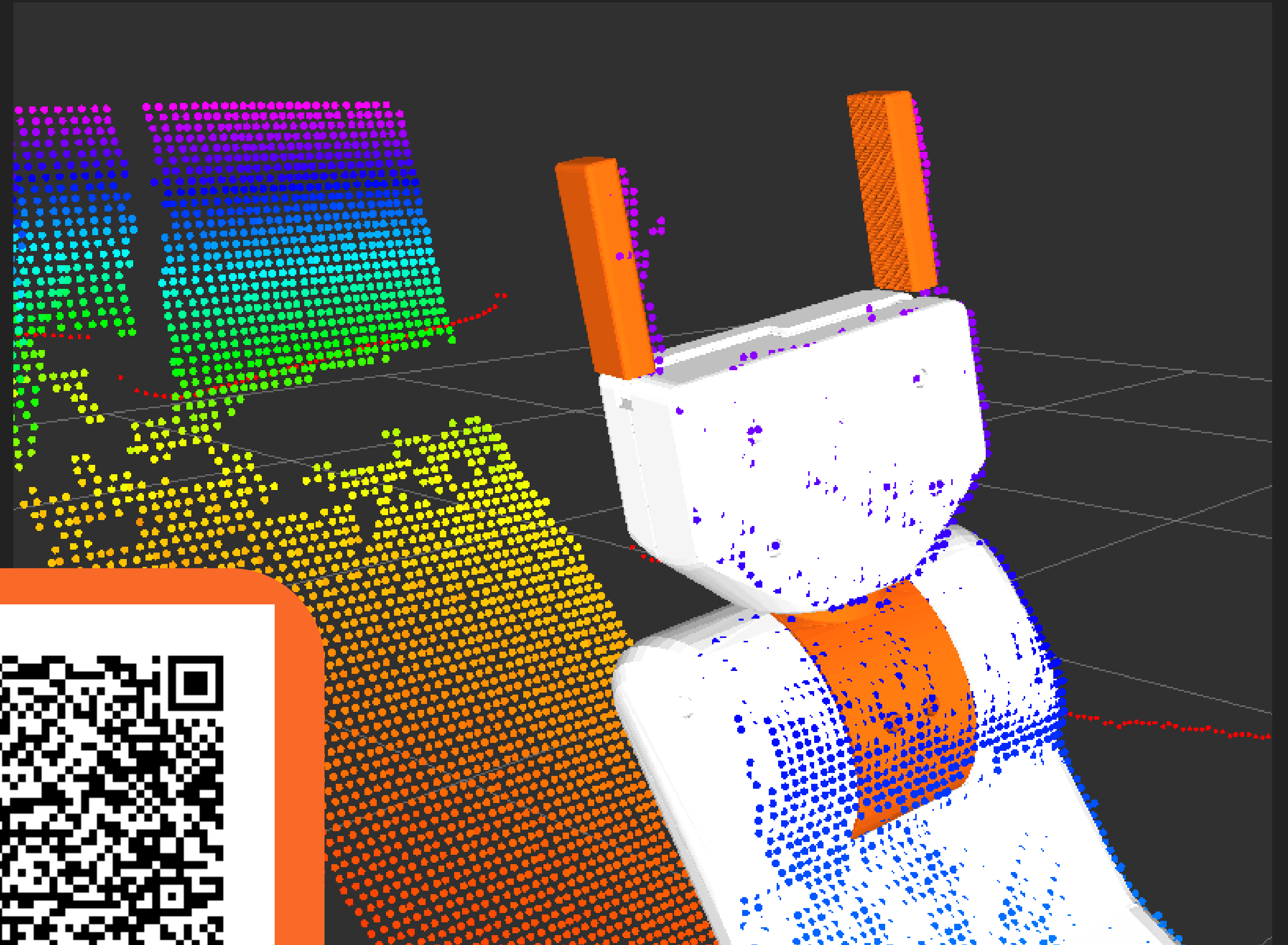


LAUNCH FILES

- ▶ Python-based launch files:
 - ▶ Awesome for complex robots!
 - ▶ Can be overly verbose.
 - ▶ Somewhat poorly documented...

ESSENTIAL MOBILE MANIPULATION TOOLS: CALIBRATION

- ▶ camera_calibration
- ▶ robot_calibration
- ▶ Update all sorts of API when migrating to ROS 2
 - ▶ Parameters had to change format due to XML arrays
 - ▶ See [ros2_cookbook](#):



ESSENTIAL MOBILE MANIPULATION TOOLS: CALIBRATION



ESSENTIAL TOOLS: MAPPING AND LOCALIZATION

- ▶ Some mapping packages not ported to ROS 2 (slam_karto)
- ▶ slam_toolbox does a very good job of mapping
 - ▶ Maps are “transient local” (what was “latched” in ROS 1)
 - ▶ Had to manually adjust the free_thresh for map to look correct
- ▶ Some notes on tuning AMCL on my blog



ESSENTIAL MOBILE MANIPULATION TOOLS: NAVIGATION

- ▶ Nav2 is a major rewrite of the ROS 1 Navigation Stack
- ▶ Behavior Trees allows changing the behavior of what used to be `move_base`
 - ▶ No longer just plan, control, recover
 - ▶ Newly added features like auto docking (See Steve Macenksi's talk at 4:40)

NAVIGATION: CUSTOM CONTROLLERS

- ▶ UBR-1 uses `graceful_controller`, porting to ROS 2 involved:
 - ▶ Changes to how parameters are defined, since they used to be loaded via XML arrays.
 - ▶ Updates for different controller API.
- ▶ Fairly straight forward - and new controller has less code thanks to external components like goal checker (leads to less code duplication between controllers).

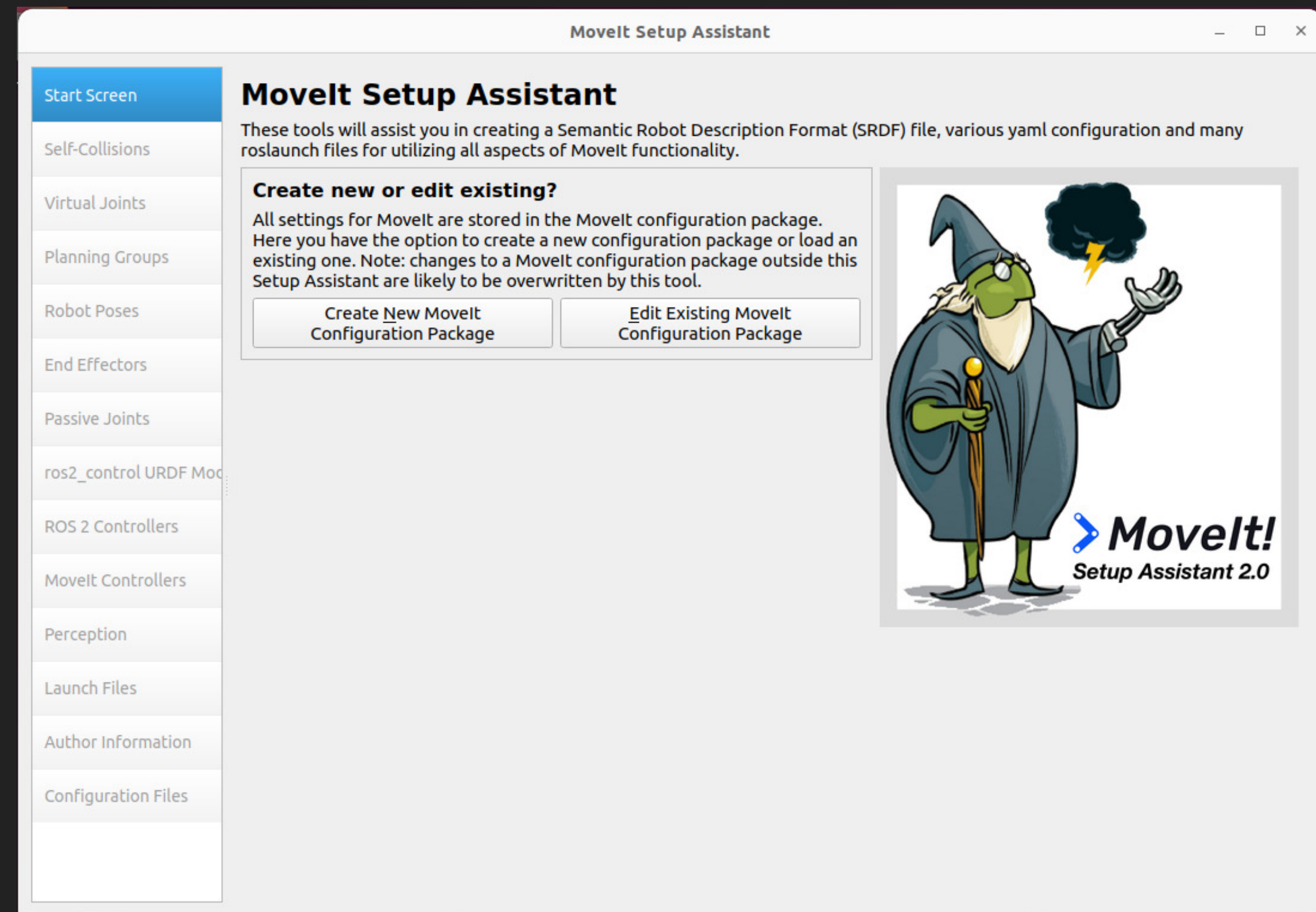
NAVIGATION: CUSTOM COSTMAP LAYERS

- ▶ Mobile manipulator wants to tilt head up and down while navigating in order to get better field of view from sensors
- ▶ Timing isn't always perfectly aligned - need to find the ground plane and remove it for better performance



ESSENTIAL MOBILE MANIPULATION TOOLS: MANIPULATION

- ▶ MoveIt2 - heavy changes to API from ROS 1
- ▶ Pick & Place => MTC
- ▶ Setup Assistant now available!



ESSENTIAL TOOLS: MOVEIT SETUP ASSISTANT

The image displays two overlapping screenshots of the MoveIt Setup Assistant interface. The top-left screenshot shows the 'Optimize Self-Collision Checking' panel, which includes a 'Sampling Density' slider (set to Low) and a table of link pairs. The table lists Link A, Link B, a 'Disabled' checkbox, and the 'Reason to Disable'. The bottom-right screenshot shows the 'Define Planning Groups' panel, where a group named 'arm' is being configured with kinematic parameters like 'Kinematic Solver' (kd_kinematics_plugin/KDLKinematicsPlugin) and 'Kin. Search Resolution' (0.005). A sidebar on the left of the bottom screenshot lists various configuration categories like 'Start Screen', 'Self-Collisions', 'Virtual Joints', etc. A 3D model of a mobile manipulator is visible in the background of both screenshots.

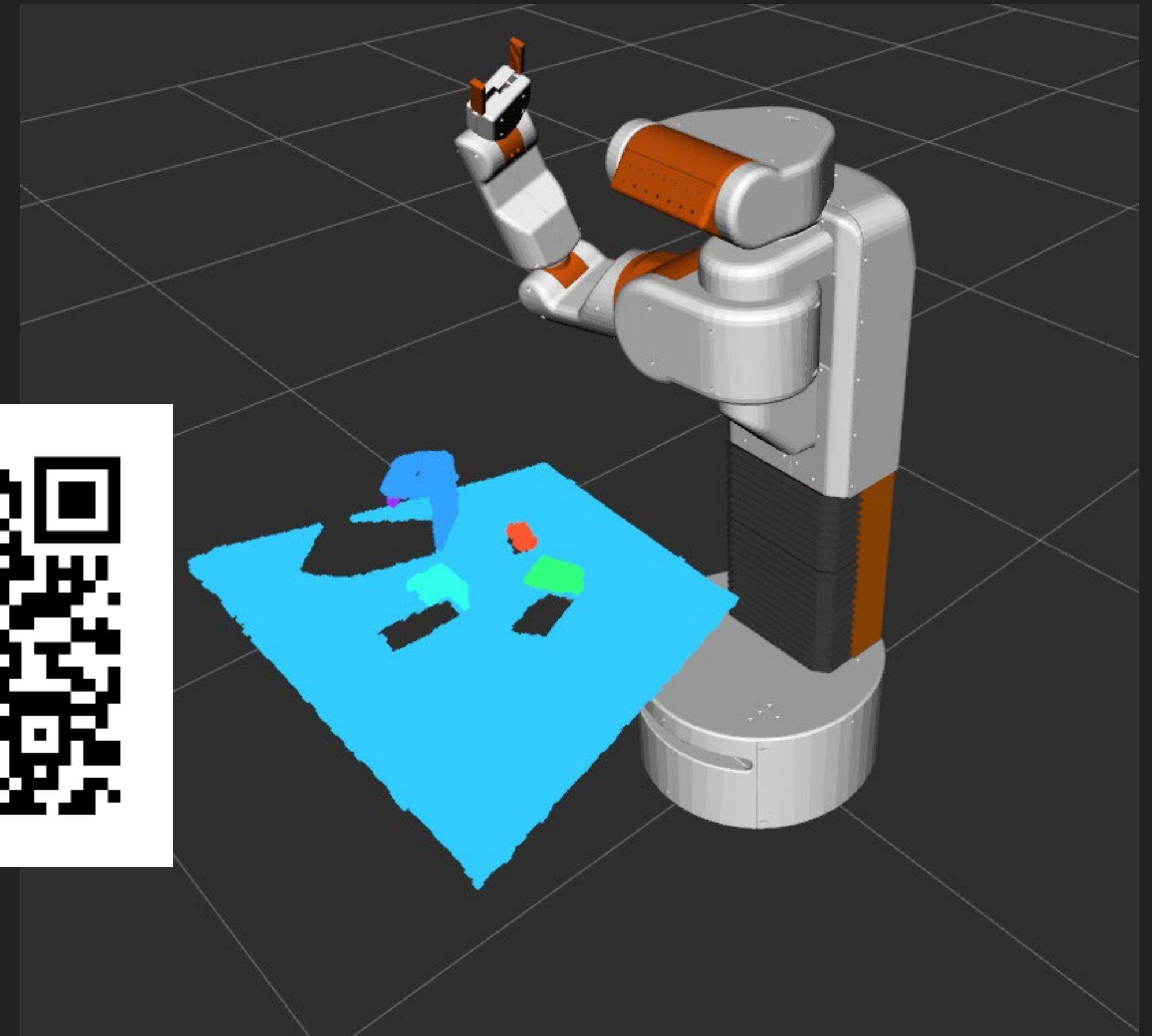
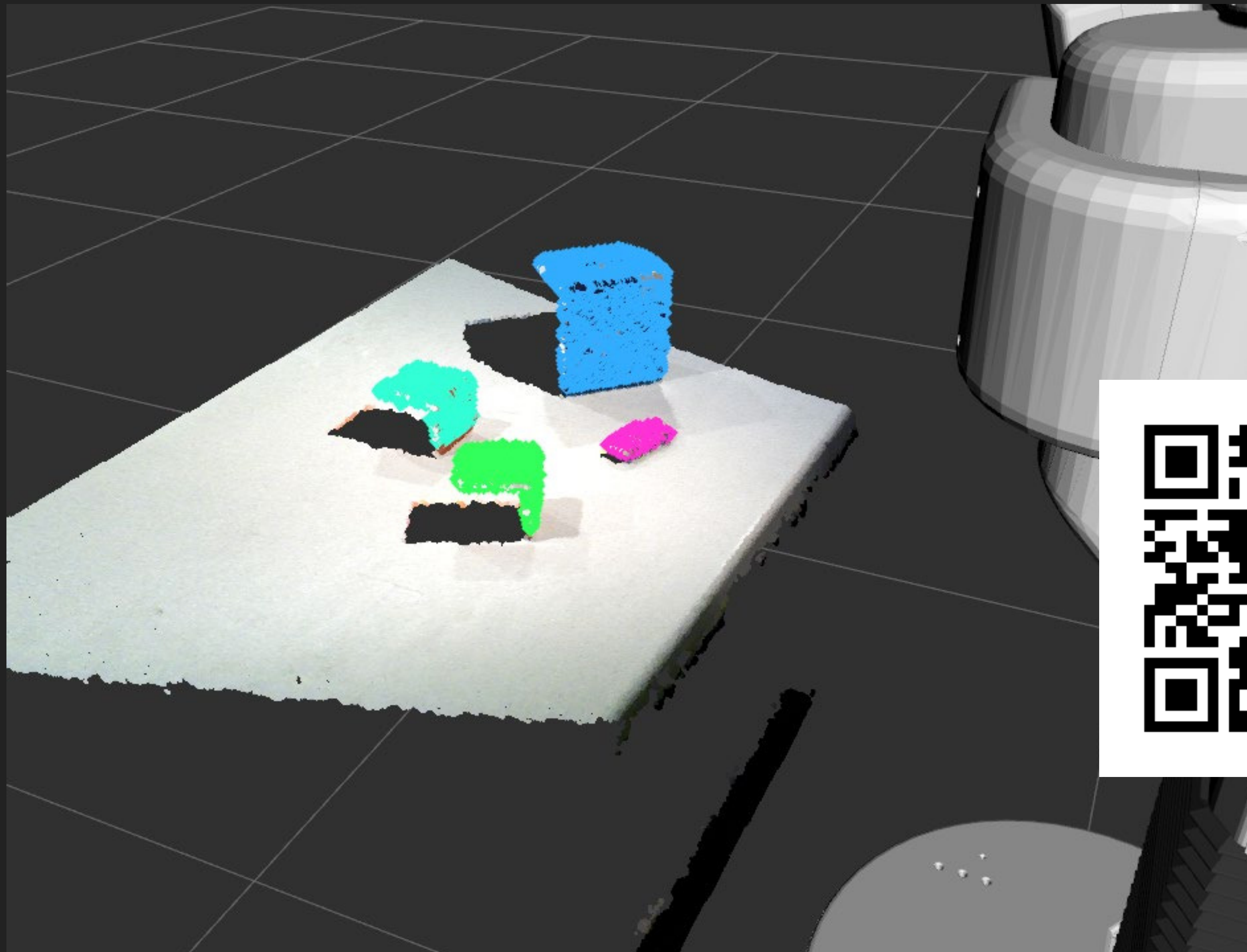
Link A	Link B	Disabled	Reason to Disable
1 base_laser...	bellows_link	<input checked="" type="checkbox"/>	Never in ...
2 base_laser...	elbow_flex...	<input checked="" type="checkbox"/>	Never in ...
3 base_laser...	estop_link	<input checked="" type="checkbox"/>	Never in ...
4 base_laser...	fixed_bello...	<input checked="" type="checkbox"/>	Never in ...
5 base_laser...	fixed_torso...	<input checked="" type="checkbox"/>	Never in ...
6 base_laser...	head_came...	<input checked="" type="checkbox"/>	Never in ...
7 base_laser...	head_pan_l...	<input checked="" type="checkbox"/>	Never in ...
8 base_laser...	head_tilt_link	<input checked="" type="checkbox"/>	Never in ...
9 base_laser...	left_grippe...	<input checked="" type="checkbox"/>	Never in ...
10 base_laser...	right_grippe...	<input checked="" type="checkbox"/>	Never in ...
11 base_laser...	shoulder...	<input checked="" type="checkbox"/>	Never in ...
12 base_laser...	shoulder...	<input checked="" type="checkbox"/>	Never in ...
13 base_laser...	torso...	<input checked="" type="checkbox"/>	Never in ...
14 base_laser...	upper...	<input checked="" type="checkbox"/>	Never in ...

```
Current Groups
- arm
  - joints
  - links
  - Chain
    - torso_lift_link -> wrist_roll_link
  - Subgroups
- arm_with_torso
  - joints
  - links
  - Chain
    - base_link -> wrist_roll_link
  - Subgroups
- gripper
  - joints
    - left_gripper_joint - Prismatic
    - right_gripper_joint - Prismatic
  - links
  - Chain
  - Subgroups
```

SEE TUTORIAL



ESSENTIAL TOOLS: SIMPLE GRASPING




ESSENTIAL MOBILE MANIPULATION TOOLS: MOVEIT2



ROS 2: CONTINUED STRUGGLES

- ▶ QoS and DDS Reliability
 - ▶ Maybe Zenoh? Help test it!
- ▶ Documentation is scattered/sparse



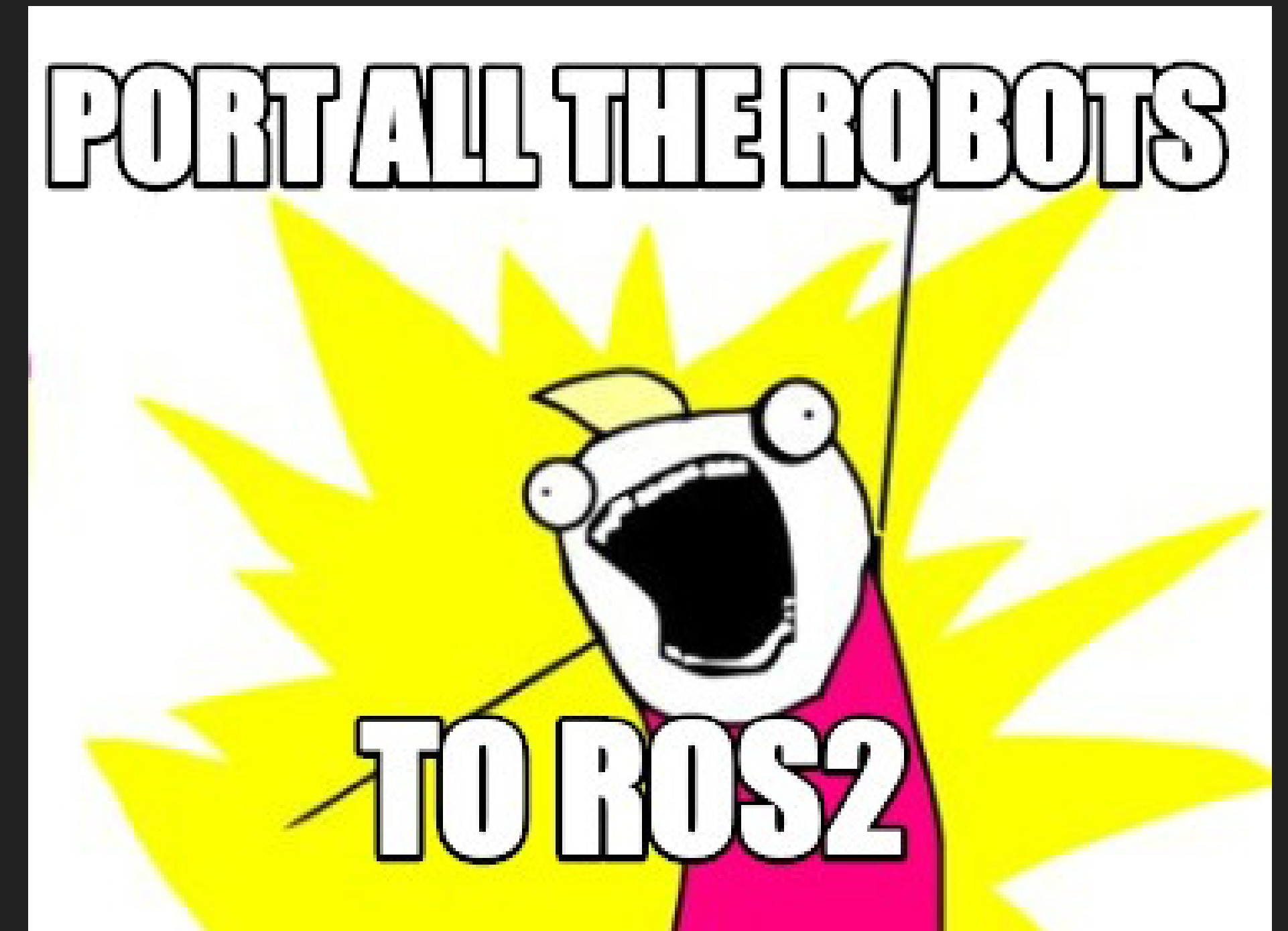
 **ros2_cookbook** Public Pin Unwatch 21 Fork 93 Star 816

- Client Libraries
 - rclcpp [API](#)
 - [Logging](#)
 - [Nodes and Components](#)
 - [Parameters](#)
 - [Point Clouds](#)
 - [Time](#)
 - [TF2](#)
 - [Workarounds](#)
 - rclpy [API](#)
 - [Nodes](#)
 - [Parameters](#)
 - [Time](#)
 - [TF2](#)
- [ros2launch](#)
 - [Python-Based Launch Files](#)
 - [Making a Launch File Executable](#)
 - [Loading Parameters From a File](#)



FUTURE WORK

- ▶ UBR-1 MoveIt2 Blog Post: Posted Now!
- ▶ UBR-1 on Jazzy: In Progress
- ▶ New Gazebo Simulation
- ▶ Actual mobile AND manipulation AT THE SAME TIME





RESOURCES



<http://www.robotandchisel.com/roscon24>

Michael Ferguson