Robot Operating System (ROS2)

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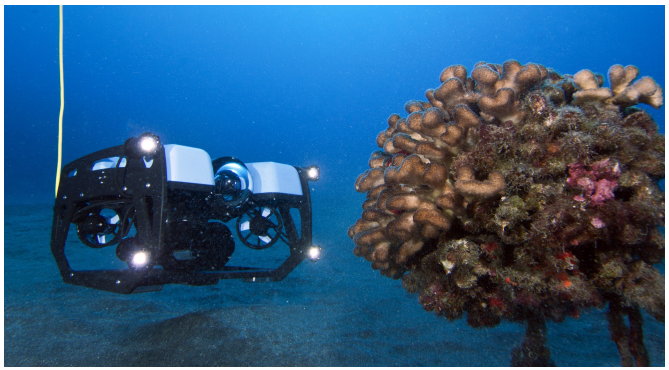
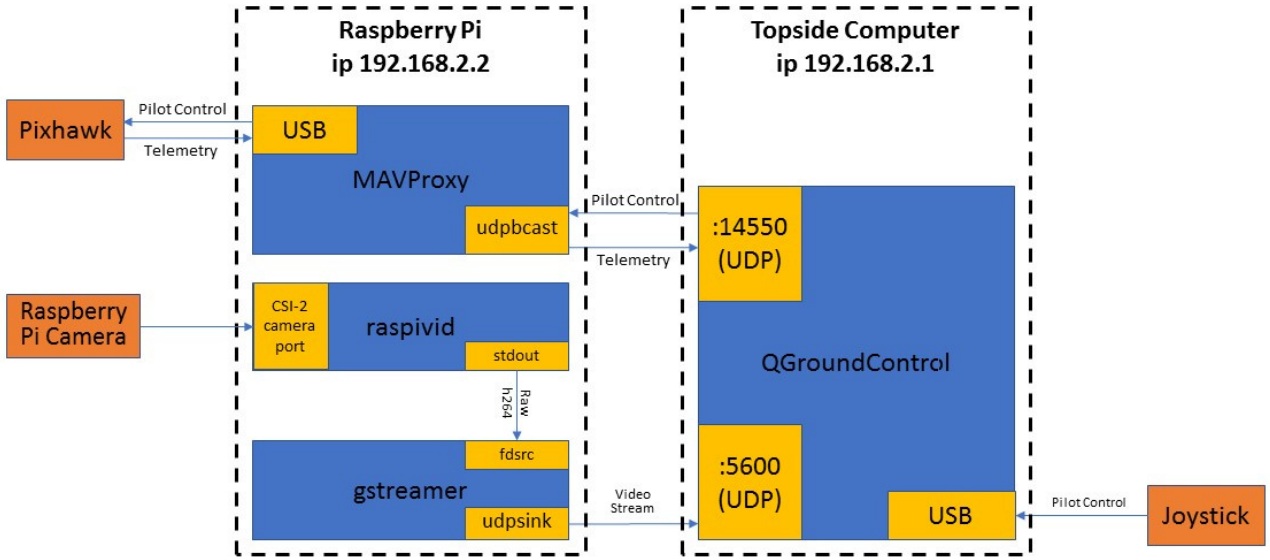
BlueRov2

Goal of this session:

- Learn basic workflow using ROS2
- Learn industry standard tools
- Understand the challenges and difficulties of deploying a robot in simulation



BlueRov2 Architecture



- Gazebo is a simulation tool for robotic systems.
  - A robust physics engine
  - High-quality graphics
  - Convenient programmatic and graphical interfaces
- It can be used as a standalone application or integrated as a ROS package.
- Gazebo Garden (Gazebo Classic (EOL january 2025) $\rightarrow$ Ignition $\rightarrow$ Gazebo)

Gazebo tutorials

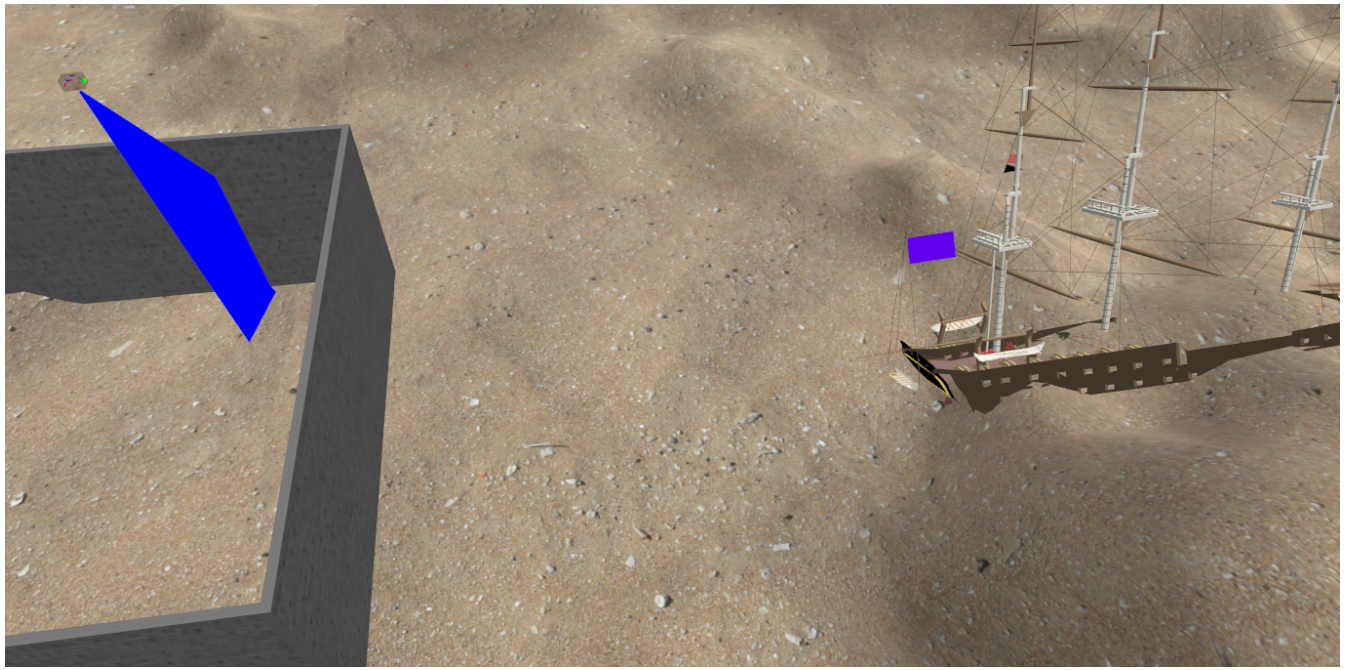
https://gazebosim.org/docs/garden/tutorials
https://classic.gazebosim.org/tutorials

To run a Gazebo simulation you need:

- A world file
  - A file with extension .world that contains all the elements in a simulation, including robots, lights, sensors, and static objects
  - Formatted using the Simulation Description Format (SDF).
- Model files
  - SDF files used to describe objects and robots
  - One object per file - only a single <model>... </model>

The components of a model are:

- Links
  - Physical properties of one body of the model
  - Geometry used for collision checking
  - Visual elements (optional)
  - An inertial element to describe the dynamic properties of the link(such as mass and rotational inertia matrix)
  - Sensor elements for use in plugins (optional)
  - Light elements to describe light sources attached to the link (optional)
- Joints (optional): A joint connects two links (parameters such as axis of rotation, and joint limits)
- Plugins (optional): A plugin is a shared library created by a third party to control a model



Model and underwater world for BlueRov2

https://github.com/clydemcqueen/bluerov2_ignition
https://github.com/remaro-network/remaro_worlds

- To run a gazebo simulation of underwater vehicles we need:
  - BuoyancyPlugin, HydrodynamicsPlugin and ThrusterPlugin
  - ardupilot_gazebo plugin for ardupilot-gazebo communication

gazebo plugins

https://github.com/ardupilot/ardupilot_gazebo/

S.I.T.L (Software In The Loop)

- The SITL (software in the loop) simulator allows you to run Plane, Copter or Rover without any hardware.
- SITL allows you to run ArduSub. It is a build of the autopilot in C++ that allows you to test the behaviour of the vehicle.
- SITL can simulate:
  - multi-rotor aircraft
  - fixed wing aircraft
  - ground vehicles
  - underwater vehicles
  - camera gimbals
  - antenna trackers
  - wide variety of optional sensors, such as Lidars and optical flow sensors

Advantages of ArduSub

- Access to the full range of development tools
- Extensive capabilities out of the box including feedback stability control, depth and heading hold, and autonomous navigation.
- ArduSub works seamlessly with Ground Control Station software that can monitor vehicle telemetry and perform powerful mission planning activities.

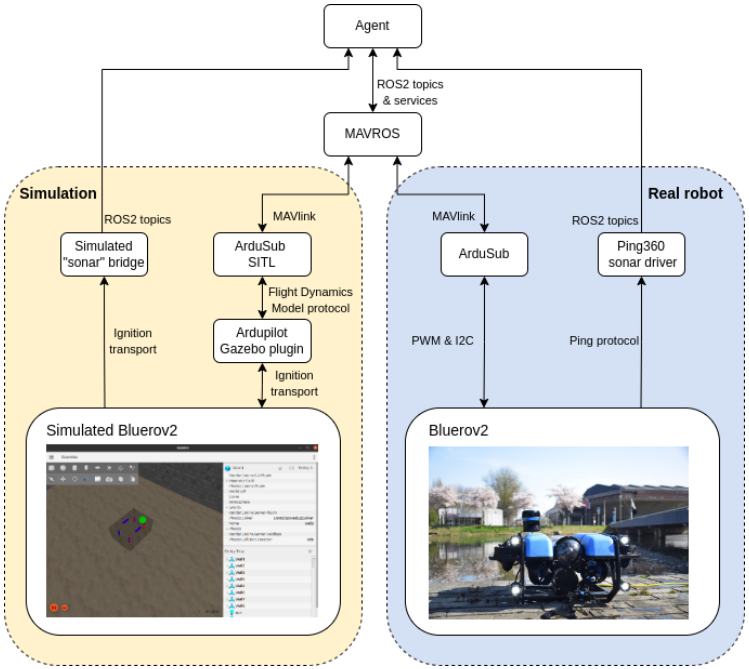
MAVLink

- MAVLink is a very lightweight messaging protocol for communicating with drones (and between onboard drone components)
- MAVLink follows a modern hybrid publish-subscribe and point-to-point design pattern

- Key Features
  - Very efficient.
  - Very reliable.
  - Many different programming languages can be used, running on numerous microcontrollers/operating systems
  - Allows up to 255 concurrent systems on the network (vehicles, ground stations, etc.)
  - Enables both offboard and onboard communications (e.g. between a GCS and drone, and between drone autopilot and MAVLink enabled drone camera).

Mavros2

- A package that provides a communication driver for various autopilots with MAVLink communication protocol. Additional it provides UDP MAVLink bridge for ground control stations (e.g. QGroundControl).


Agent
ROS2 topics
& services
MAVROS
Simulation
ROS2 topics
MAVlink
Simulated
"sonar" bridge
ArduSub
SITL
Flight Dynamics
Model protocol
Ignition
transport
Ardupilot
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Ignition
transport
Simulated Bluerov2
Real robot
MAVlink
ROS2 topics
ArduSub
Ping360
sonar driver
PWM & I2C
Ping protocol
Bluerov2

bluerov2.py(bluerov2_agent)

```
1  import sys
2  import rclpy
3  from rclpy.node import Node
4  from rclpy.qos import QoSProfile
5  from mavros_msgs.msg import State
6  from mavros_msgs.srv import CommandBool
7  from mavros_msgs.srv import SetMode
8  from rcl_interfaces.srv import SetParameters
9  from rcl_interfaces.msg import Parameter
10 from rcl_interfaces.msg import ParameterType
11 from geometry_msgs.msg import PoseStamped
12 from mavros_msgs.msg import OverrideRCIn
13 from sensor_msgs.msg import LaserScan
14
15 class BlueRovInterface(Node):
16     def __init__(self, node_name='bluerov_interface'):
17         super().__init__(node_name)
18         self.status = State()
19         self.state_sub = self.create_subscription(
20             State, 'mavros/state', self.status_cb, 10)
21
22         self.local_pos = PoseStamped()
23         self.local_pos_received = False
24         local_position_sub_qos = QoSProfile(
25             reliability=rclpy.qos.ReliabilityPolicy.BEST_EFFORT, depth=5)
26         self.local_position_sub = self.create_subscription(
27             PoseStamped,
28             'mavros/local_position/pose',
29             self.local_pos_cb,
30             local_position_sub_qos)
31
```

bluerov2.py(bluerov2_agent)

```
1
2           self.rc_override_pub = self.create_publisher(
3               OverrideRCIn, 'mavros/rc/override', 10)
4
5           self.override_timer = None
6           self.pitch = 0
7           self.roll = 0
8           self.throttle = 0
9           self.yaw = 0
10          self.forward = 0
11          self.lateral = 0
12          self.camera_pan = 0
13          self.camera_tilt = 0
14          self.light_level1 = 0
15          self.light_level2 = 0
16          self.video_switch = 0
17
18      def status_cb(self, msg):...
19
20      def local_pos_cb(self, msg):...
21
22      def call_service(self, srv_type, srv_name, request):...
23
24      def set_mavros_param(self, name, type, value):...
25
26      def set_mode(self, mode):...
27
28      def arm_motors(self, arm_motors_bool):...
29
30      def rc_override_publish_cb(self):...
31
```

bluerov2.py(bluerov2_agent)

```
    # arguments should be a normalized float value ranging from -1 to 1
    # 0 is translated to 1500 pwm, -1 to 1100, and 1 to 1900
    def set_rc_override_channels(self, pitch=0, roll=0, throttle=0, yaw=0,
                                 forward=0, lateral=0, camera_pan=0,
                                 camera_tilt=0, light_level1=0,
                                 light_level2=0,video_switch=0):...

    def toogle_rc_override(self, run_boolean):...


def mission(ardusub):

    service_timer = ardusub.create_rate(2)
    while ardusub.status.mode != "MANUAL":
        ardusub.set_mode("MANUAL")
        service_timer.sleep()

    print("Manual mode selected")

    while ardusub.status.armed == False:
        ardusub.arm_motors(True)
        service_timer.sleep()

    print("Thrusters armed")
```

bluerov2.py(bluerov2_agent)

```
1
2       print("Initializing mission")
3
4       timer = ardusub.create_rate(0.5) # Hz
5
6       ardusub.toogle_rc_override(True)
7       ardusub.set_rc_override_channels(forward=0.5)
8       timer.sleep()
9       ardusub.set_rc_override_channels(lateral=0.5)
10      timer.sleep()
11      ardusub.set_rc_override_channels(forward=-0.5)
12      timer.sleep()
13      ardusub.set_rc_override_channels(lateral=-0.5)
14      timer.sleep()
15      ardusub.set_rc_override_channels(lateral=0)
16      ardusub.toogle_rc_override(False)
17
18      print("Mission completed")
```

bluerov2.py(bluerov2_agent)

```
1
2   if __name__ == '__main__':
3    print("Starting Bluerov agent node")
4
5    # Initialize ros node
6    rclpy.init(args=sys.argv)
7
8    ardusub = BlueRovInterface("ardusub_node")
9
10   thread = threading.Thread(target=rclpy.spin, args=(ardusub, ),
11   daemon=True)
12   thread.start()
13
14   mission(ardusub)
15
16   ardusub.destroy_node()
17   rclpy.shutdown()
18   thread.join()
19
```

- Instructions how to run the node with docker:

GitHub Repository

https://github.com/vilmamuco/bluerov2_exercise

- Publish an approximation of the height of the wall using the sonar data (try to use the ALT_HOLD mode).
- Before starting the exercise run the following command on the lab computers:

```
1 chmod 777 /tmp/.X11-unix/X[0-1]
```

Tip

Use the command line to find the topic and the field of the message.

Thank you!!!
Questions?

References

https://docs.ros.org/en/jazzy/index.html
https://discuss.bluerobotics.com
https://github.com/remaro-network/tudelft_hackathon
https://sir.upc.edu/projects/rostutorials/
https://ardupilot.org/
http://wiki.ros.org/mavros
https://www.ardusub.com/
http://classic.gazebosim.org/tutorials
https://docs.docker.com/