GAZEBO

Mobile Robotics & Intelligence Lab.

2022.12.27

TA Kiyong Park

ENGINEERING FOR MANKIND KAIST

What is Gazebo?

Gazebo

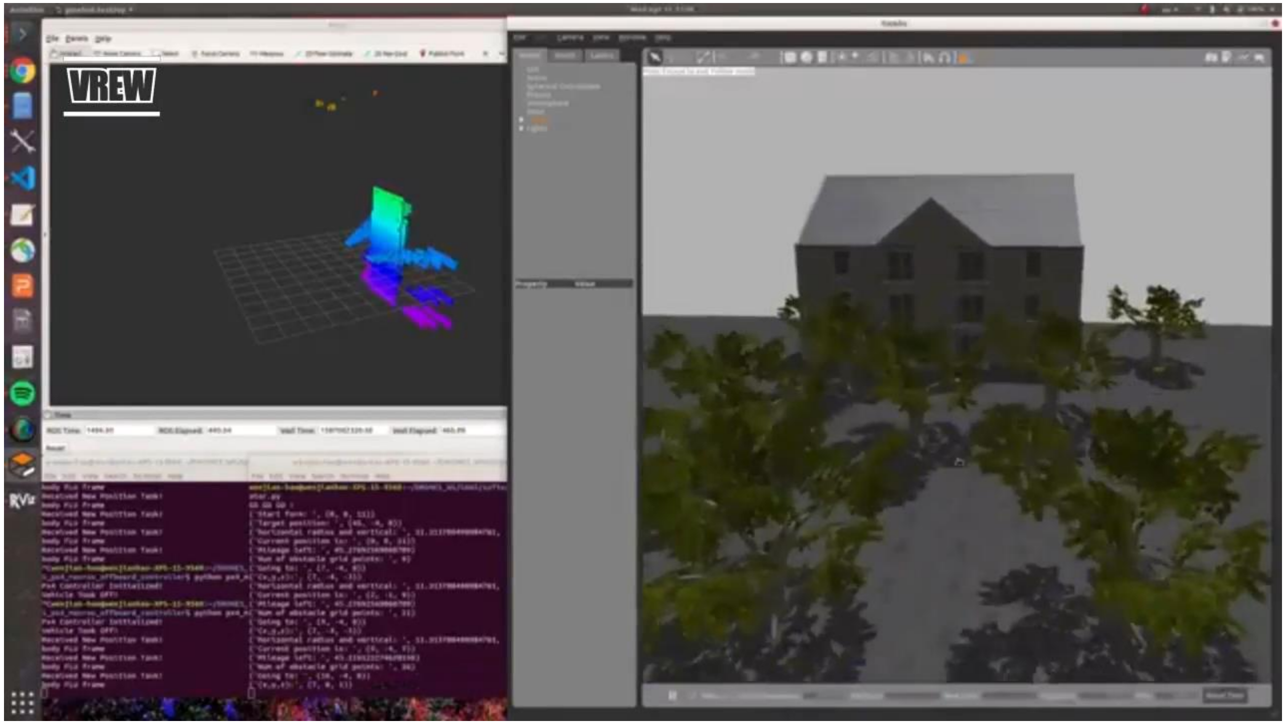


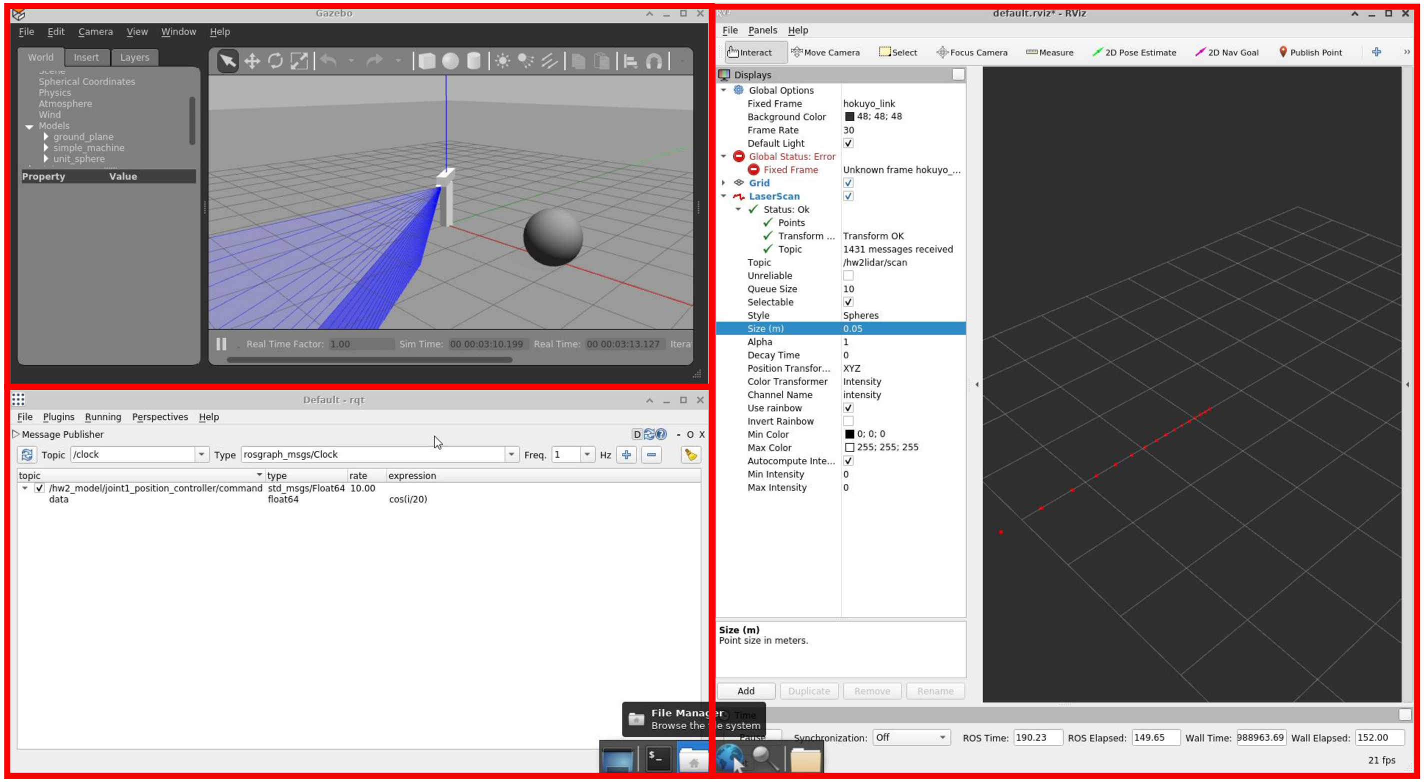
TABLE of CONTENTS

Build a simple machine by URDF

Simple lidar

Simple lidar in gazebo

RViz



rqt

Build a simple machine by URDF

Package structure

Tutorial package

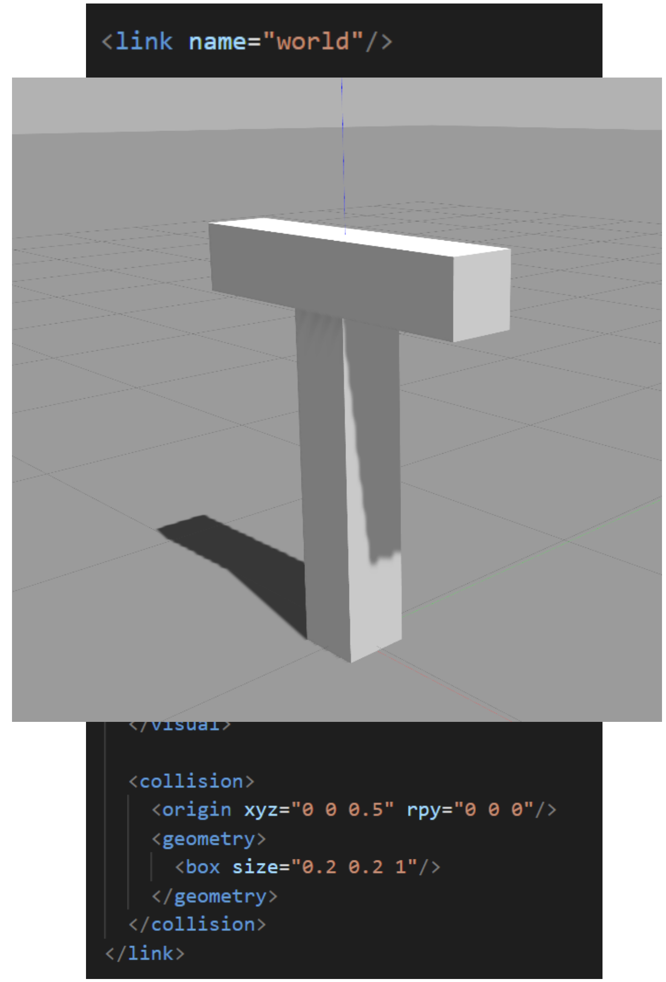
- CMakeLists.txt
- launch
  - spawn.launch — spawn simple lidar in gazebo
  - function.launch — activate controller, state publisher etc
  - param.yaml — can easily adjust parameter
- model.xacro
- package.xml

Build a simple machine by URDF

Create a mechanism

- <link name="world"/>
  - Open <link> and close in one line by ending with / before >
- <link name='link_0'>
- <collision>
  - Sets the dimension that come into contact between other objects
- <visual>
  - Sets the dimension of the appearance of the link
- <inertial>
  - Sets the physical properties such as mass and moment of inertia of the object

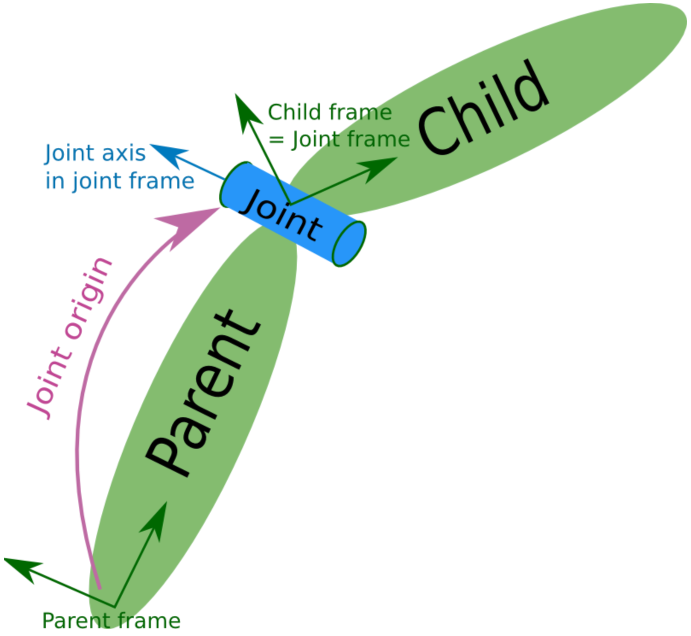
- <joint name="fixed" type="fixed">
  - Open <joint> and set name and types
  - Can be closed by </joint>
  - <joint> requires parent and child links
- <parent link="world"/>
- <child link="link_1"/>



Build a simple machine by URDF

Create a mechanism

- Create another link (link_1)
- Generate a joint between the two links
  - <joint name='link_0_JOINT_0' type='continuous'>
- Set the parent and child links
- You can also use different types such as
  - Revolute : a hinge joint with limited range
  - Prismatic : a sliding joint with limited range
  - Fixed : immovable
- We will add some damping in the joint
  - <dynamics damping="0.7"/>
- To be more specific with the model, add more parameters
  - Refer to http://wiki.ros.org/urdf/XML/joint for possible parameters
- Don't forget to add this at the end of the file!
  - </robot>



Build a simple machine by URDF

Open Gazebo

- There are two ways of starting Gazebo
- One
  - gazebo
- Two (through ROS)
  - roscore
  - rosrun gazebo_ros gazebo
  - (this is just an example)
- We strongly recommend that you use the second method
  - Lets you use the information about the simulation environment when using ROS

Build a simple machine by URDF

View it in Gazebo

- Use roslaunch to see your mechanism using Gazebo
- First create a package
- Name the package tutorial
  - cd ~/catkin_ws/src
  - catkin_create_pkg tutorial controller_manager joint_state_controller robot_state_publisher
  - cd tutorial
  - mkdir config
  - mkdir launch

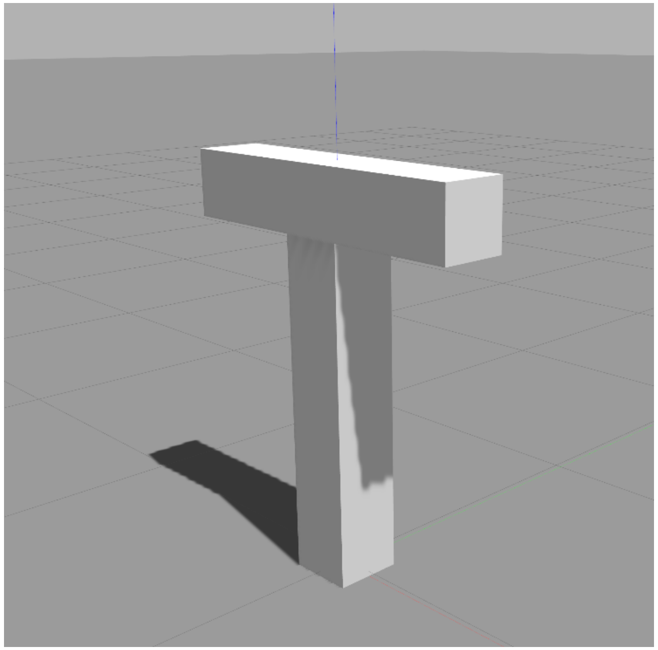
Necessary dependencies to control our machine later

- Create a launch file (spawn.launch)
  - <launch>
  - <param name="robot_description“ command="$(find xacro)/xacro --inorder ‘[DIRECTORY OF YOUR XACRO FILE]/[NAME OF YOUR XACRO FILE].xacro'" />
  - <node name="urdf_spawner" pkg="gazebo_ros" type="spawn_model" respawn="false" output="screen" args="-urdf -model [NAME THAT WILL APPEAR IN GAZEBO] -param robot_description"/>
  - </launch>

Build a simple machine by URDF

View it in Gazebo

- Run the launch file!
  - roslaunch tutorial spawn.launch
- Two links connected by a revolving joint
- We can see this the links and the joints that makes up our mechanism



ROS control

Adding a virtual actuator

- Now let's add a virtual motor on the joint and move it
- Go back to our model.xacro file and the following before the end
  - <transmission name="tran1">
  - <type>transmission_interface/SimpleTransmission</type>
  - <joint name="link_0_JOINT_0">
  - <hardwareInterface>EffortJointInterface</hardwareInterface>
  - </joint>
  - <actuator name="motor1">
- As of now, there is only SimpleTransmission type and EffortJointInterface interface implemented for Gazebo
- Specify the joint that you want to move

ROS control

Adding a Plugin

- We have specified to which joint an actuator will be added
- To control this actuator, we also need to add a plugin
  - Plugin lets you add a lot of functions to your models such as sensors and actuators
  - It also lets you publish or subscribe ROS messages
  - It is possible to design the plugins, but there are many useful plugins available online
- We will be using Gazebo ROS Control for actuation
  - <gazebo>
  - <plugin name="gazebo_ros_control" filename="libgazebo_ros_control.so"> <robotNamespace>/simple_model</robotNamespace>
- Make sure the <robotNamespace> is properly set

ROS control

Back to ROS

- Create param.yaml file
- Here, specify the robot name, controller settings, and controller tuning parameters
  - simple_model:
  - joint_state_controller:
  - type: joint_state_controller/JointStateController
  - publish_rate: 50
  - joint1_position_controller:
  - type: effort_controllers/JointPositionController
  - joint: link_0_JOINT_0
  - pid: {p: 100.0, i: 0.01, d: 10.0}
- Different types of controllers can be implemented
  - effort_controllers/JointEffortController – Desired force or torque command
  - effort_controllers/JointPositionController – Desired position command
  - effort_controllers/JointVelocityController – Desired velocity command

ROS control

Launch ROS control

- Now, the controllers and the motors are set
- Go to launch folder in tutorialpackage
- Create a launch file to start ROS Control (function.launch)
- Load the controller configuration
  - <rosparam file="$(find tutorial)/config/param.yaml" command="load"/>
- Load the controllers
  - <node name="controller_spawner" pkg="controller_manager" type="spawner" respawn="false" output="screen" ns="/simple_model" args="joint1_position_controller joint_state_controller"/>
  - Make sure to also have joint_state_controller
- Convert joint states to TF transforms
  - <node name="robot_state_publisher" pkg="robot_state_publisher“ type="robot_state_publisher“ respawn="false" output="screen">
- Remap the topic name
  - <remap from="/joint_states" to="/simple_model/joint_states" />

ROS control

Launch ROS control

- roslaunch tutorial function.launch
- Check if the controllers are successfully working

```
Loading controller: joint_state_controller
Controller Spawner: Loaded controllers: joint1_position_controller, joint_state_controller
Started controllers: joint1_position_controller, joint_state_controller
```

```
kiyong@kiyong:~/catkin_ws$ rostopic list
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/performance_metrics
/gazebo/set_link_state
/gazebo/set_model_state
/rosout
/rosout_agg
/simple_model/joint1_position_controller/command
/simple_model/joint1_position_controller/pid/parameter_descriptions
/simple_model/joint1_position_controller/pid/parameter_updates
/simple_model/joint1_position_controller/state
/simple_model/joint_states
/tf
/tf_static
```

ROS control

Launch ROS control

- You can see the states of the joints through
  - rostopic echo /simple_model/joint_states topic

```
kiyong@kiyong:~$ rostopic echo /simple_model/joint_states
header:
  seq: 13926
  stamp:
    secs: 296
    nsecs: 891000000
  frame_id: ''
name:
  - link_0_JOINT_0
position: [-0.7208045373568108]
velocity: [-1.3903108362940253]
effort: [12.580823820427245]
---
```

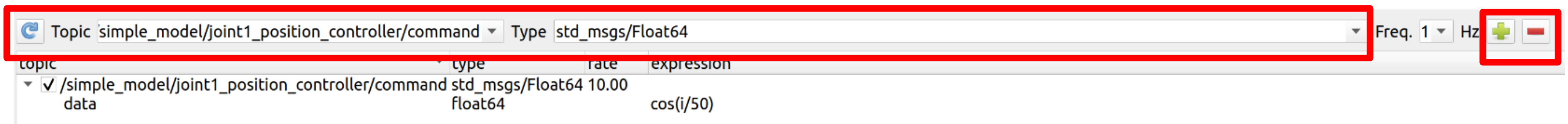
  - Or rqt
  - Go to Plugins -> Topics -> Topic Monitor

/simple_model/joint_states	sensor_msgs/JointState	3.71KB/s	49.85	
effort	float64[]			(4.440892098500626e-14,)
header	std_msgs/Header			
name	string[]			['link_0_JOINT_0']
position	float64[]			(-0.1982488578045869,)
velocity	float64[]			(2.4670063897680337e-14,)

ROS control

Launch ROS control

- Give command input through the topic /command
  - Terminal
  - rostopic pub -1 /simple_model/joint1_position_controller/command std_msgs/Float64 "data: 1.5“
  - Later, you can write nodes that send much more complex topic messages to control your robot
- You can also use RQT to publish to a topic
  - Go to Plugins -> Topics -> Message Publisher



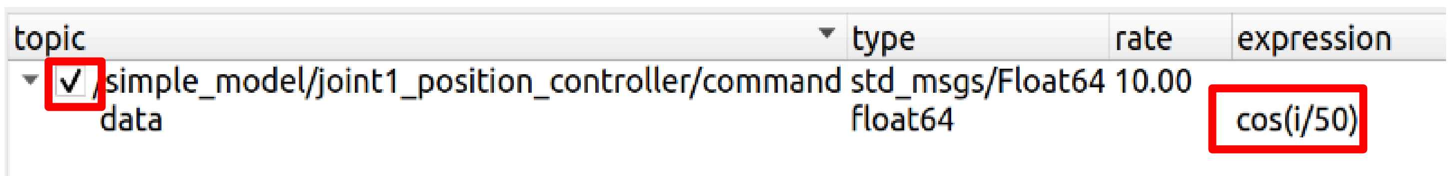
Fill out the topic name
and the message type

Plus adds the publisher
Minus removes it

ROS control

Use RQT to publish command input

- In expression, write the command input you want
  - Being a position controller for a revolving joint, the input is in radians
  - i in rqt publisher is the time step



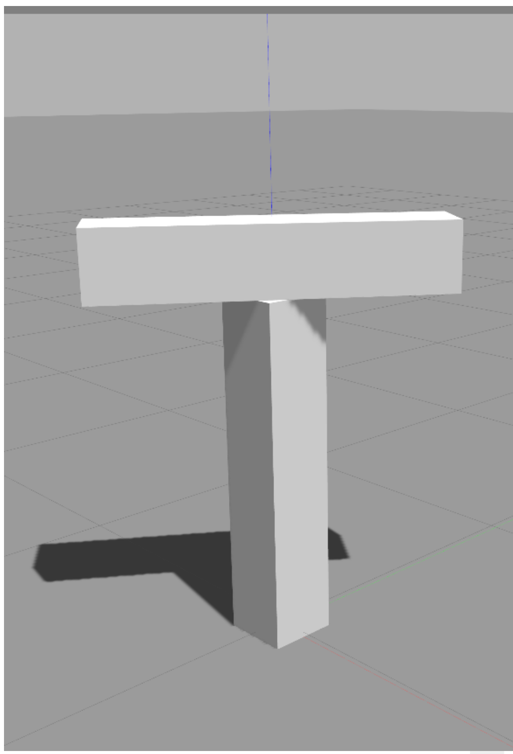
Box should be checked to publish the message

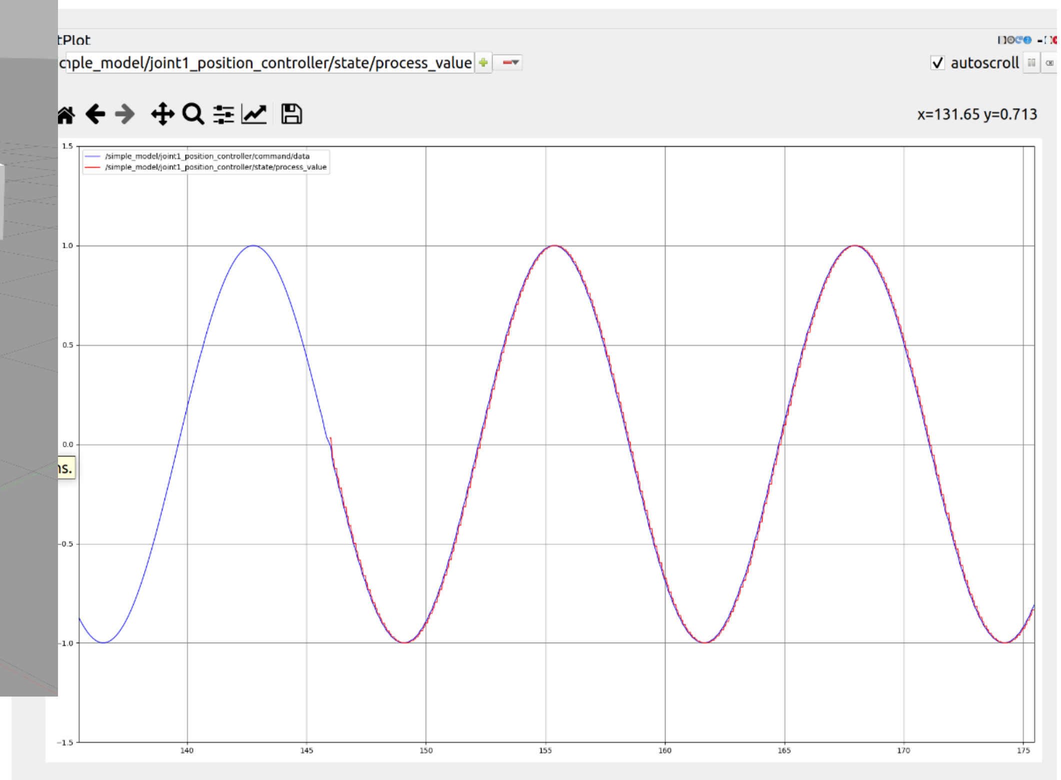
Command input

ROS control

Visualizing the controller performance

- We can see how well the controller does with respect to the reference input
  - Go to Plugins -> Visualization -> Plot





Add sensors

Mobile Robotics & Intelligence Lab.

Add ‘ray’ link and joint

```
<link name='ray’>
  <inertial>
    <origin xyz="0 0 0.05" rpy="0 0 0"/>
    <mass value="0.001"/>
    <inertia
      ixx="0.0166667" ixy="0.0" ixz="0.0“
      iyy="0.0166667" iyz="0.0“
      izz="0.0166667"/>
  </inertial>
  <visual>
    <origin rpy="0 0 0" xyz = "0 0 0.05"/>
    <geometry>
      <cylinder length="0.1" radius = "0.04"/>
    </geometry>
  </visual>
  <collision>
    <geometry>
      <cylinder length="0.1" radius = "0.04"/>
    </geometry>
  </collision>
</link>
```

```
<joint name="link_1_ray" type="fixed">
  <parent link = "link_1"/>
  <child link="ray"/>
  <origin rpy="1.5707 0 0" xyz = "0.5 0 0"/>
</joint>
```

Add sensors

Add ‘ray’ link and joint

```
<gazebo reference="ray">
  <sensor type="ray" name="lidar">
    <pose>0 0 0 1.5707 0 0</pose>
```

Horizontal becomes vertical

```
    <visualize>true</visualize>
```

Enable visualization in GUI

```
    <update_rate>30</update_rate>
    <ray>
      <scan>
```

Horizontal beam

```
        <horizontal>
```

Number of beams

```
          <samples>32</samples>
          <resolution>1</resolution>
          <min_angle>-0.53529248</min_angle>
          <max_angle>0.18622663</max_angle>
        </horizontal>
      </scan>
      <range>
        <min>0.05</min>
        <max>70</max>
        <resolution>0.02</resolution>
      </range>
    </ray>
  </sensor>
</gazebo>
```

Connect to ROS

Just after </ray>

```
<plugin name = "gazebo_ros_head_hokuyo_controller" filename = "libgazebo_ros_laser.so">
  <topicName>/simple_lidar/scan</topicName>
  <frameName>hokuyo_link</frameName>
</plugin>
```

- You can see the pointcloud form through RViz
  - Add by either display type or topic
  - Change the fixed frame to hokuyo_link

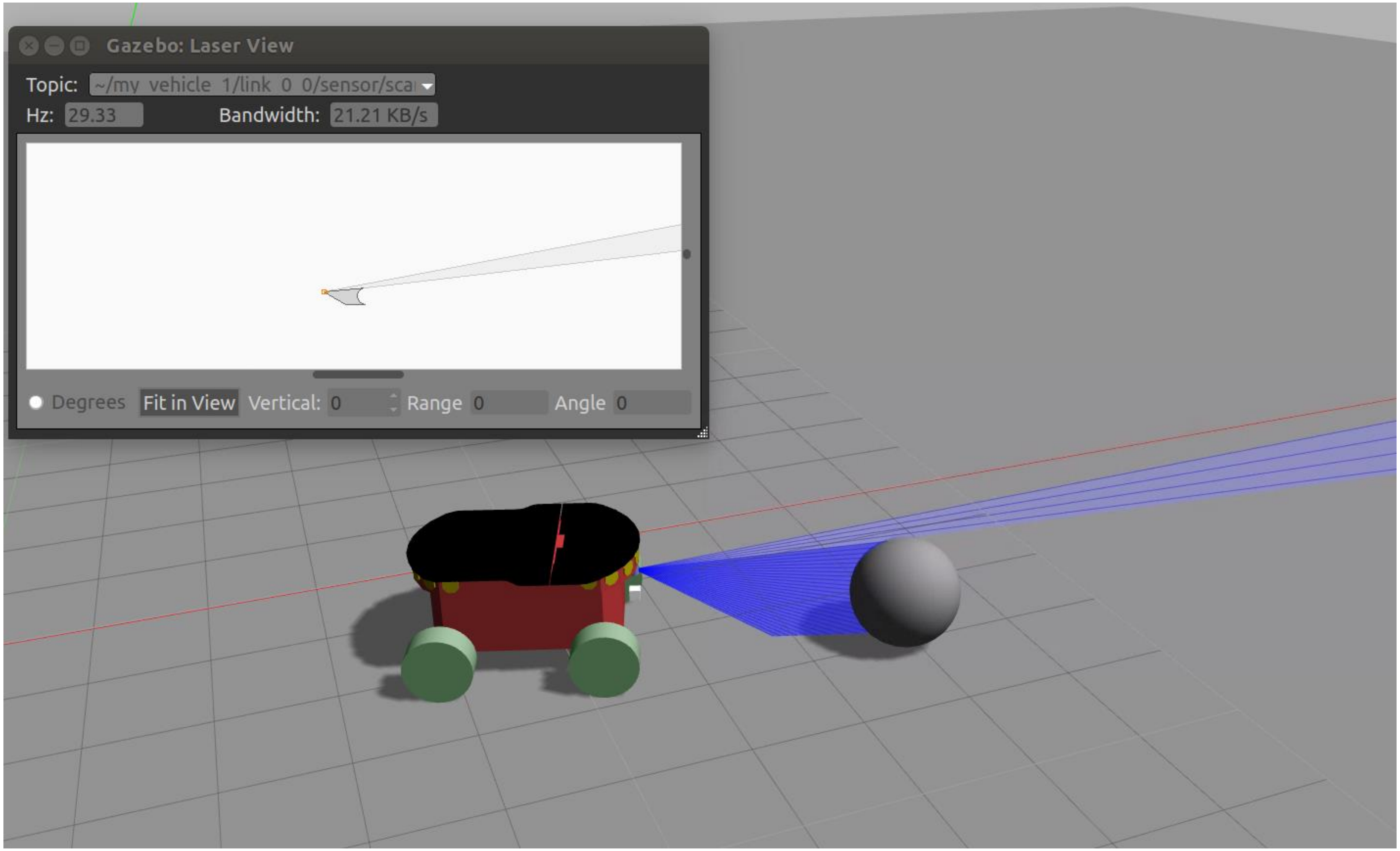
Build a simple machine by Gazebo GUI

Model editor Gazebo GUI

- Last lecture, we learned how to create a model by writing the model line by line
- It is also possible to use GUI in Gazebo to build models as well
- Go to Model Editor

Build a simple machine by Gazebo GUI

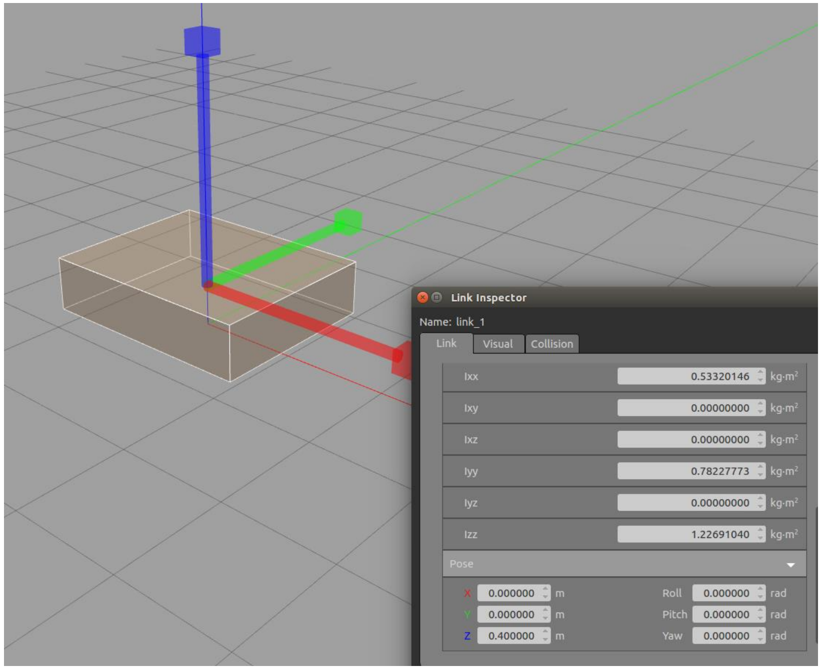
Simple vehicle with lidar



Build a simple machine by Gazebo GUI

Creating a vehicle

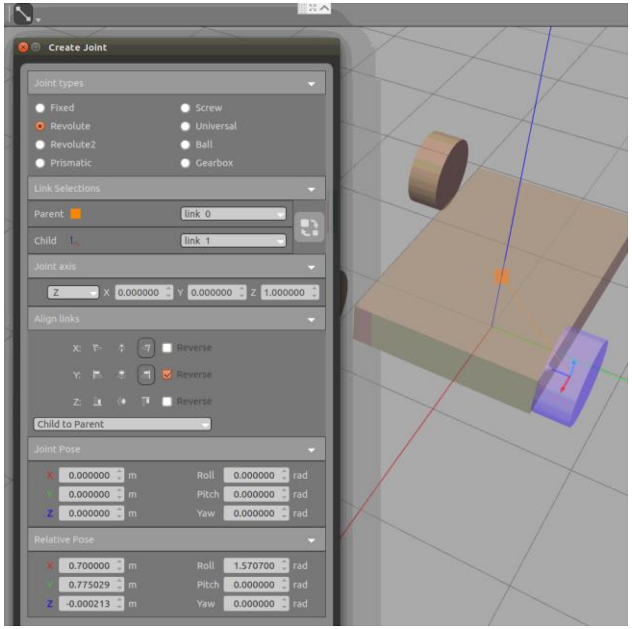
- Insert Box
- Use Scale mode to modify the size of the box (x = 2m, y = 1.3m z =0.3m)
- Open Link inspector -> set Pose z : 0.5m
- You can set the size of the box using Link inspector
  - modify the values in both Visual tab, and Collision tab

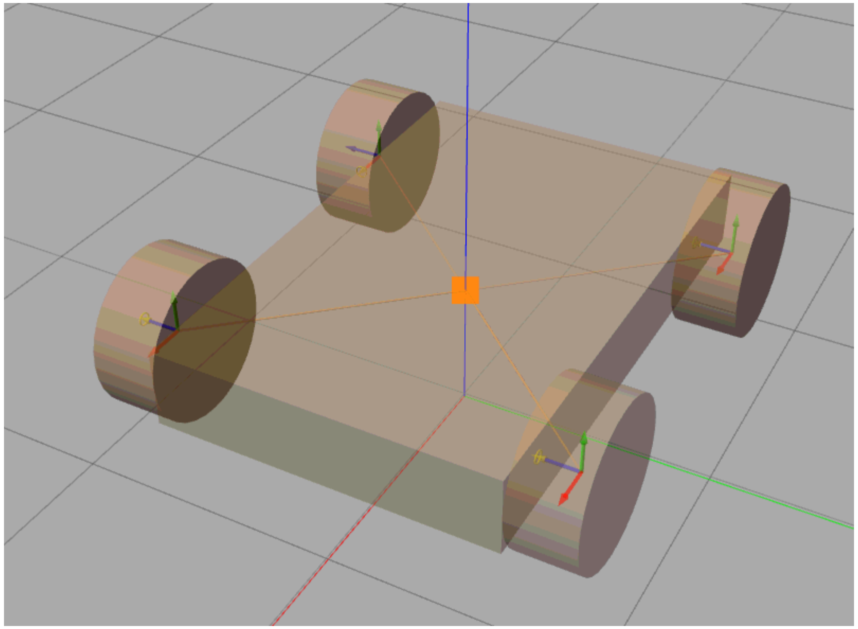


Build a simple machine by Gazebo GUI

Creating a vehicle

- Insert Cylinder
- Open Link inspector -> set Link-Pose : Roll = 1.5707 rad
- set Visual, Collision - Geometry : r = 0.3m, length = 0.25m
- Copy and paste
- Create Joint
  -Revolute, Parent : link 0 (box), Child link 1(wheel), Joint axis : -Z, Align

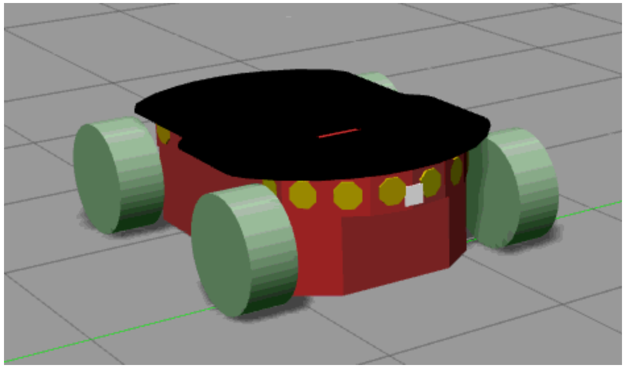


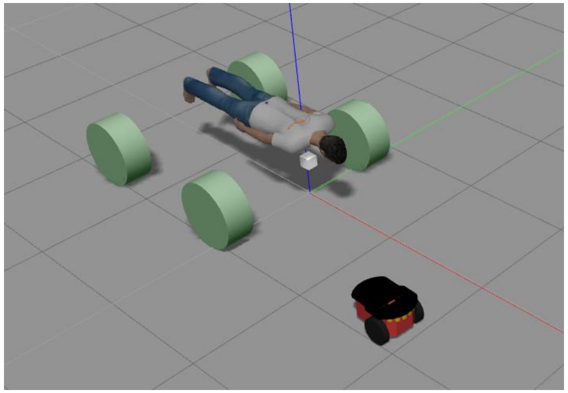


Build a simple machine by Gazebo GUI

Insert mesh

- We have to edit the Gazebo SDF file.
- Find the visual tag of main link (body link) of the vehicle
- Comment out the original visual code using <!-- … -->
- Instead, write :
-
```
<pose>0 0 0.3 0 0 0</pose>
<geometry>
        <mesh>
                <uri>model://pioneer2dx/meshes/chassis.dae</uri>
                <scale>4 4 4></scale>
        </mesh>
</geometry>
```





ROS control

Controlling the vehicle

- We will use Skid steering Drive plugin (http://gazebosim.org/tutorials?tut=ros_gzplugins)

```
<plugin name='skid_steer_drive_controller'
filename='libgazebo_ros_skid_steer_drive.so'>
  <updateRate>5.0</updateRate>
  <robotNamespace>/</robotNamespace>
  <leftFrontJoint>front_left_wheel_joint</leftFrontJoint>
  <rightFrontJoint>front_right_wheel_joint</rightFrontJoint>
  <leftRearJoint>back_left_wheel_joint</leftRearJoint>
  <rightRearJoint>back_right_wheel_joint</rightRearJoint>
  <wheelSeparation>1.5</wheelSeparation>
  <wheelDiameter>0.6</wheelDiameter>
  <robotBaseFrame>base_link</robotBaseFrame>
  <torque>20</torque>
  <topicName>cmd_vel</topicName>
  <broadcastTF>false</broadcastTF>
</plugin>
```

Add sensors

Add a ray sensor

- Edit model my_vehicle
- Insert cylinder Link-pose : x= 0.8m, z = 0.4m
  Visual, Collision : R = 0.04m, Length = 0.1m
- Crate joint – fixed (Parent : Link 0)
- Save model as ‘my_vehicle’ and exit the ‘model editor’
- Go to model.sdf, find the ray sensor link

Add sensors

Just after </collision> and before </sensor>

```
<sensor type='ray' name='lidar'>
  <pose>0 0 0 1.5707  0 0 </pose>
  <visualize>true</visualize>
  <update_rate>30</update_rate>
  <ray>
    <scan>
      <horizontal>
        <samples>32</samples>
        <resolution>1</resolution>
        <min_angle>-0.53529248</min_angle>
        <max_angle>0.18622663></max_angle>
      </horizontal>
     </scan>
    <range>
      <min>0.05</min>
      <max>70></max>
      <resolution>0.02</resolution>
    </range>
  </ray>
</sensor>
```

Horizontal becomes vertical
Enable visualization in GUI

Horizontal beam
Number of beams

http://gazebosim.org/tutorials?cat=guided_i&tut=guided_i1

Connect to ROS

Just after </ray>

- <plugin name=‘gazebo_ros_head_hokuyo_controller’ filename=‘libgazebo_ros_laser.so’>
- <topicName>/my_vehicle/laser/scan</topicName>
- <frameName>hokuyo_link</frameName>
- </plugin>

- You can see the pointcloud form through RViz
  - Add by either display type or topic
  - Change the fixed frame to hokuyo_link

Build a simple machine

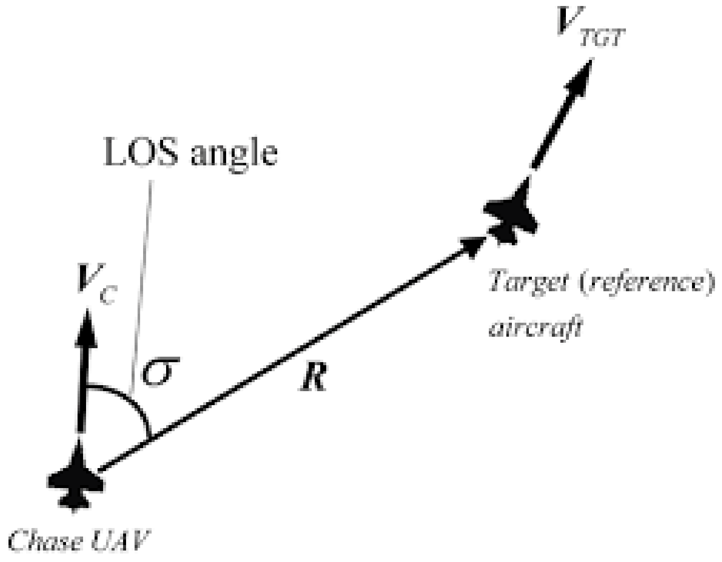
Difference between URDF and using Gazebo gui

- The file created is in sdf format instead of xacro
- Xacro / Universal Robotic Description Format (URDF)
  - Established format for describing robot structure in ROS
  - In Gazebo, URDF is converted to and read as SDF
  - Lacks friction and other properties
  - Cannot specify things that are not robot such as lights
- Simulation Description Format (SDF)
  - Devised by Gazebo to meet simulation needs
  - Can specify the pose of the robot within a world
  - Solves the shortcomings of URDF/xacro
- Later, you can combine the mobile robot(sdf) and the actuator(xacro) by converting the sdf file into xacro format and transferring the robot model code to the actuator model code
- This is necessary because ROS Control requires transmission tag that is not available in SDF

Practice using Turtlebot

Pursuit guidance (Waypoint tracking)

- Probably the simplest form of guidance
- The interceptor remains pointed at the target at all times.
- The pursuit paths are often highly curved near the end of flight.
- Typically employed for stationary or slow-moving targets
- Relatively poor performance against maneuvering targets

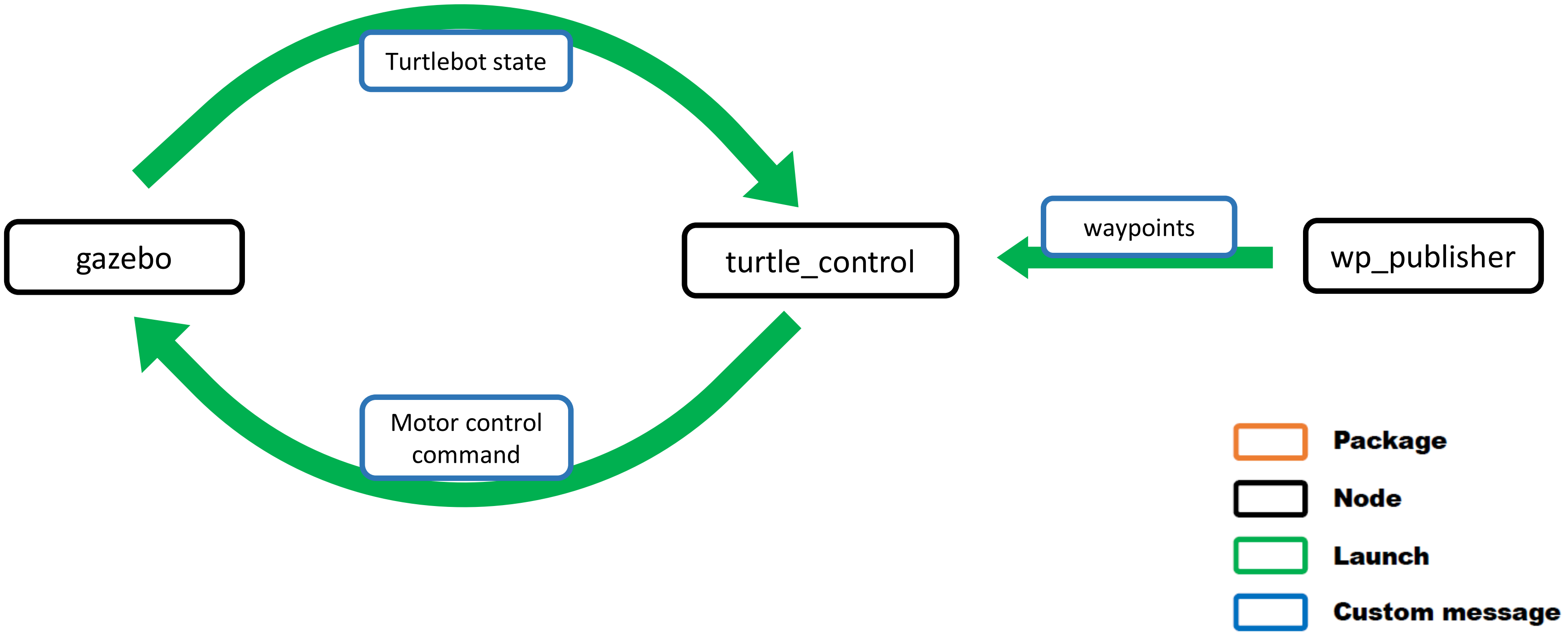


$$u = \pm k \times \sigma$$

K : control gain
σ : Line of sight angle

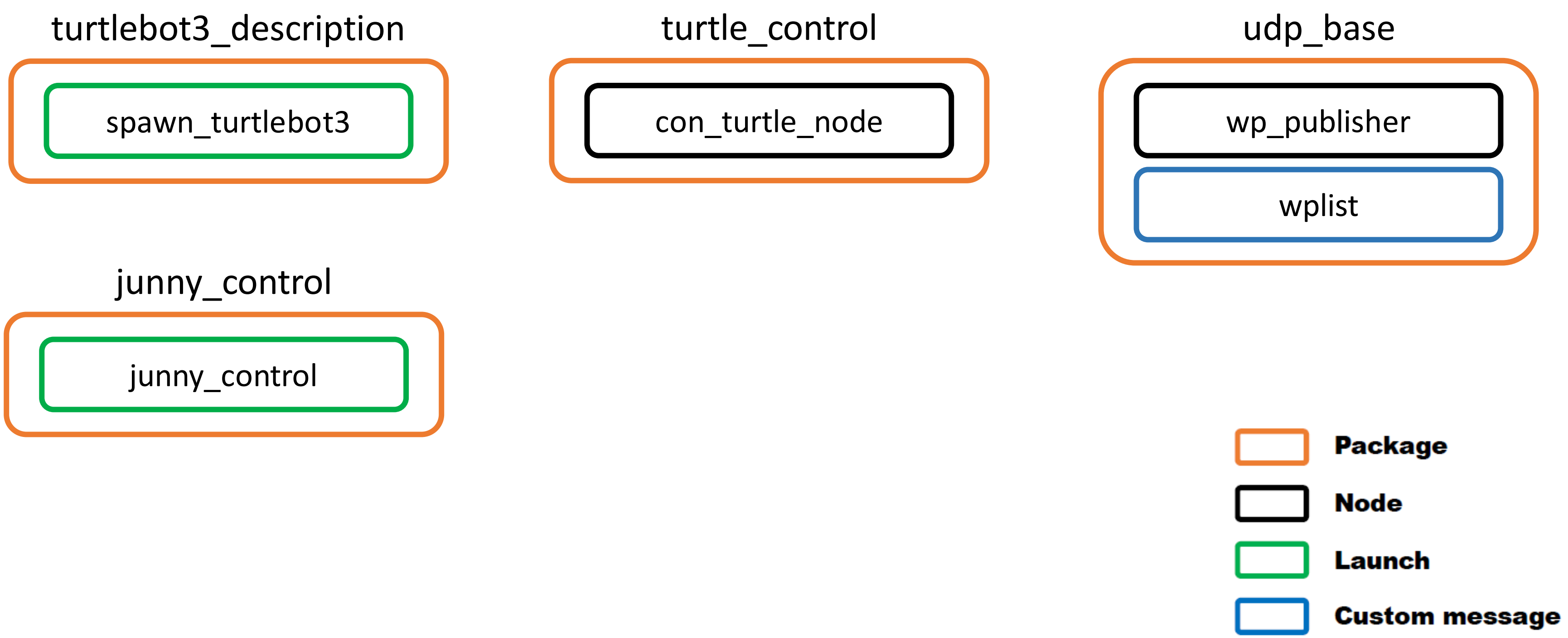
Practice using Turtlebot

Simple Flow chart



Practice using Turtlebot

ROS packages



Thank you!