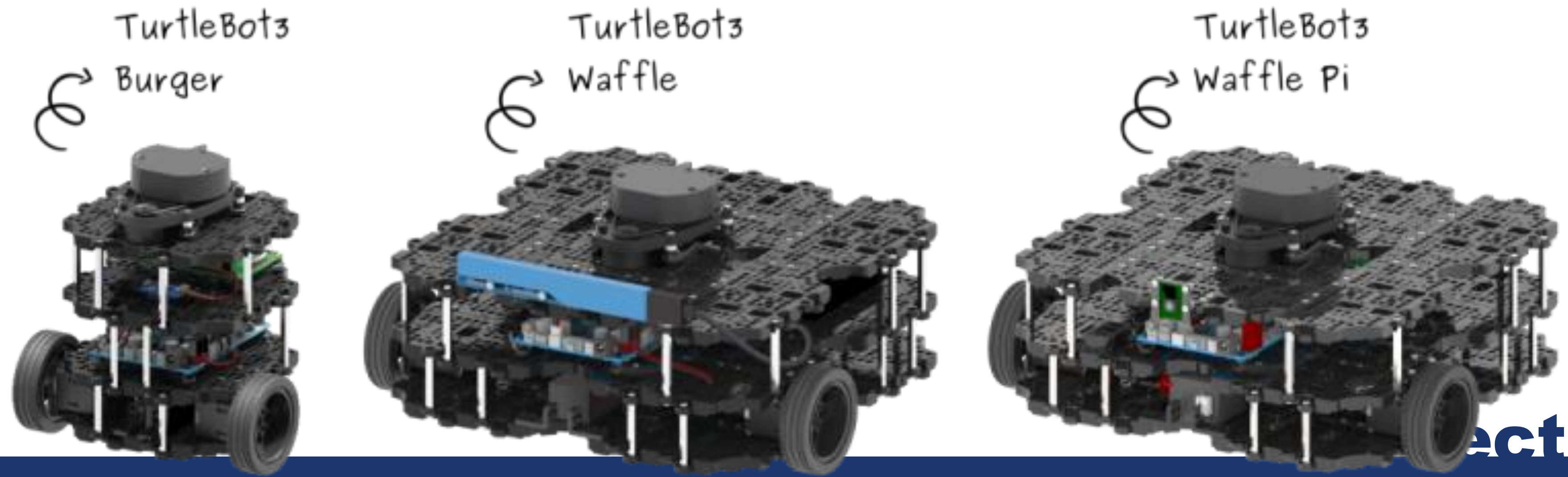

ecture 5

2025

INFO 703

Master Advanced Mechatronics

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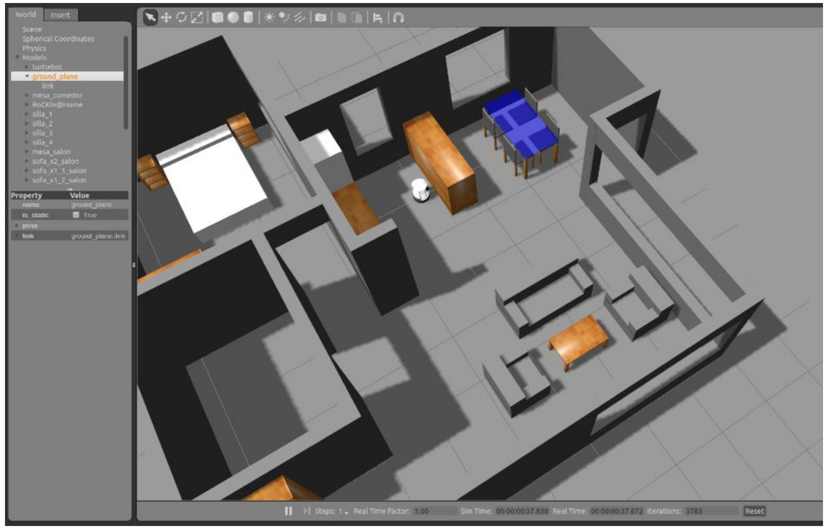
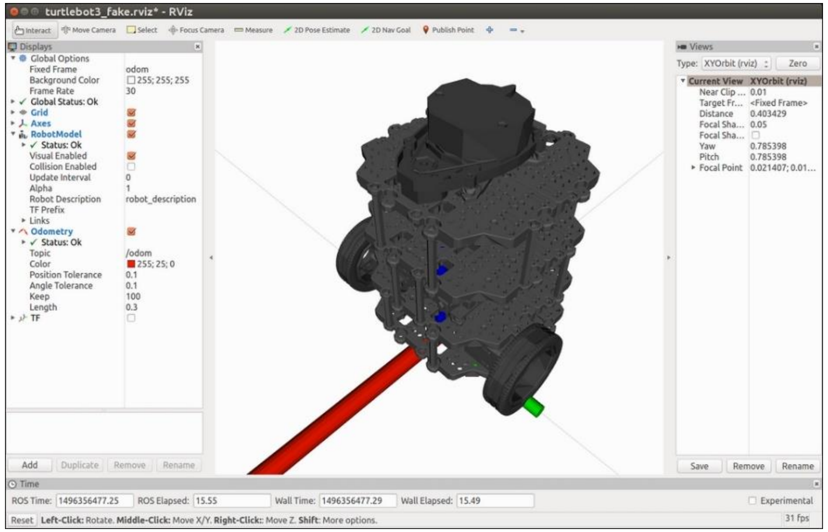
POLYTECH ANNECY-CHAMBÉRY

Gazebo
Turtlebot3

Robotic simulation scenarios





More Info and tutorials
http://gazebosim.org/tutorials
http://wiki.ros.org/rviz/Tutorials

Gazebo – TurtleBot3 Simulation

- A multi-robot simulator
- Capable of simulating a population of robots, sensors and objects, in 3D
- Includes an accurate simulation of rigid-body physics and generates realistic sensor feedback
- Allows code designed to operate a physical robot to be executed in an artificial environment
- Gazebo is under active development at the OSRF (Open Source Robotics Foundation)

GAZEBO

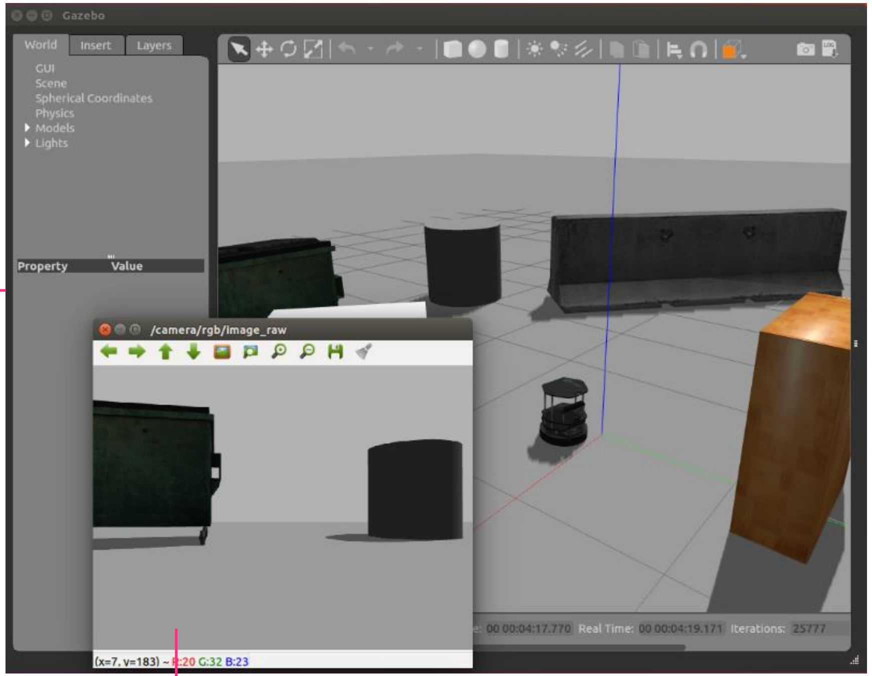
More Info and tutorials
http://gazebosim.org/tutorials

Exercise

Gazebo and TurtleBot3

- Read docs on Gazebo (and Rviz as well if you want to have a larger view of ROS capabilities).
- Launch Gazebo with the `turtlebot_world` environment (the `turtlebot_house` might be too heavy for your computer but you can try) and:
  - the Waffle robot
  - the Burger robot
- What are the differences for these robots?
- Are they using the same topics on Gazebo? Is there any differences?
- Move manually the TurtleBot3 using `teleop_key`
- Show the `rqt graph` to see the topics and nodes

Gazebo – TurtleBot3 Simulation



Launch Gazebo

```
> roslaunch turtlebot3_gazebo turtlebot3_autorace.launch
```

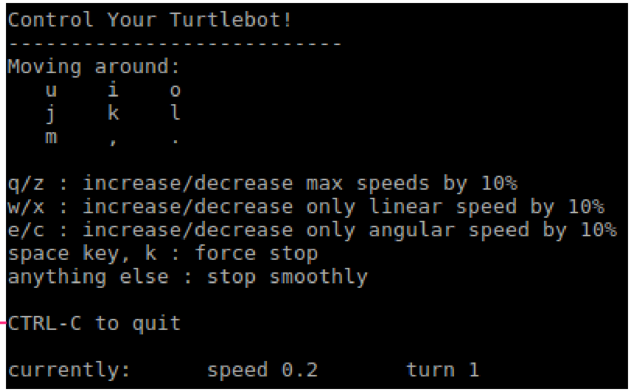
(also try : turtlebot3_house.launch)

Display the image from the robot

```
> rostopic list   # check where the image is published

> rosrun image_view image_view image:=/camera/image
```

Move the robot with keyboard

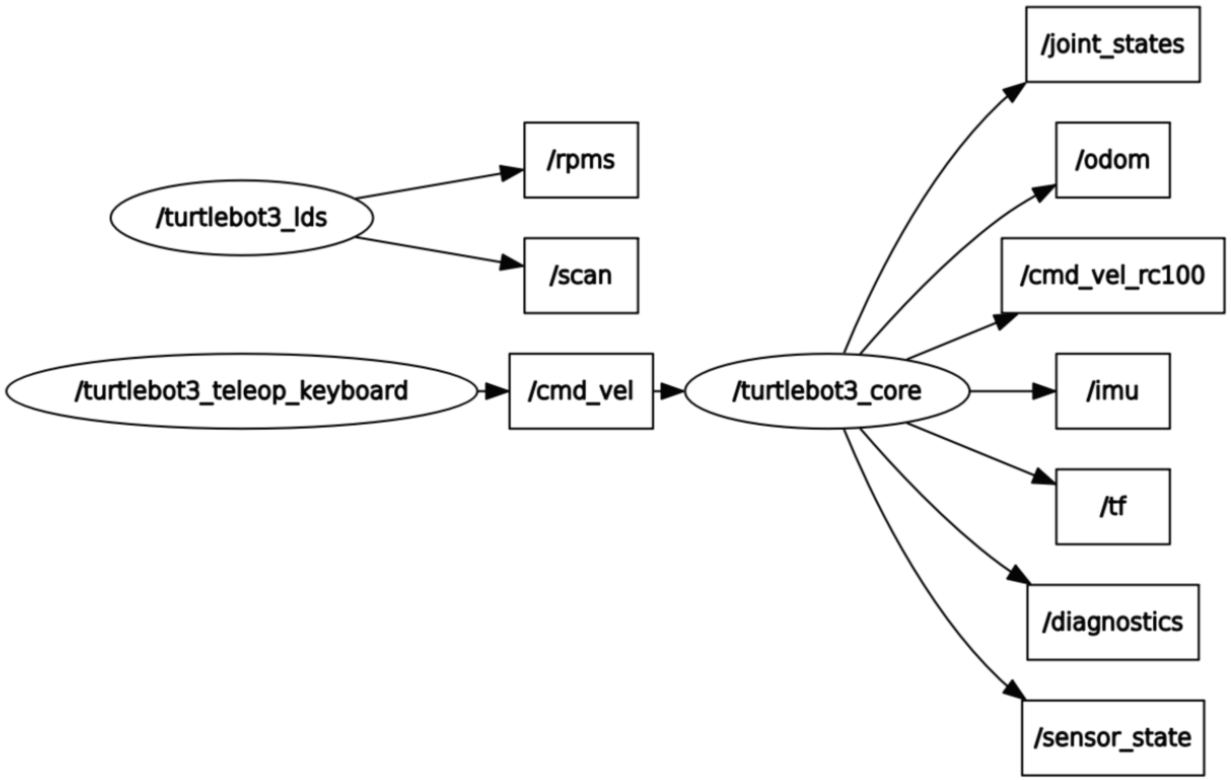
```
> roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch
```



Gazebo – TurtleBot3 Simulation

Node and topic

```
> rqt_graph
```




```
luc@USMB:~$ rostopic list

/camera/camera_info
/camera/image
/camera/image/compressed
/camera/image/compressed/parameter_descriptions
/camera/image/compressed/parameter_updates
/camera/image/compressedDepth
/camera/image/compressedDepth/parameter_descriptions
/camera/image/compressedDepth/parameter_updates
/camera/image/theora
/camera/image/theora/parameter_descriptions
/camera/image/theora/parameter_updates
/camera/parameter_descriptions
/camera/parameter_updates
/clock
/cmd_vel
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/imu
/joint_states
/odom
/rosout
/rosout_agg
/scan
/tf
```

Gazebo – TurtleBot3 Simulation

Odometry

- To make a TurtleBot move in ROS we need to publish:

  Twist messages to the topic ***/cmd_vel***

- To get a TurtleBot position and orientation in ROS we need to subscribe:

  to the topic ***/odom*** and read ***Odometry*** message

- Odometry is part of *nav_msg* message package

  (don't forget to add *import nav_msg.msg* in your code header)

```
> rosmsg show Odometry
```

```
luc@USMB:~$ rosmsg show Odometry
[nav_msgs/Odometry]:
std_msgs/Header header
  uint32 seq
  time stamp
  string frame_id
string child_frame_id
geometry_msgs/PoseWithCovariance pose
  geometry_msgs/Pose pose
    geometry_msgs/Point position
      float64 x
      float64 y
      float64 z
    geometry_msgs/Quaternion orientation
      float64 x
      float64 y
      float64 z
      float64 w
  float64[36] covariance
geometry_msgs/TwistWithCovariance twist
  geometry_msgs/Twist twist
    geometry_msgs/Vector3 linear
      float64 x
      float64 y
      float64 z
    geometry_msgs/Vector3 angular
      float64 x
      float64 y
      float64 z
  float64[36] covariance
```

Exercise

Gazebo and TurtleBot3

- Move TurtleBot3 Waffle using publisher node
    - Create your own package named `Tutorial_TurtleBot`
      (Recall: New packages must be created in the src folder from catkin_ws)
    - Create your own Python script for moving TurtleBot3 with two arguments Linear velocity and Angular Velocity

- Getting laser data of the Waffle using ROS commands and Python script
    - Create a new node to subscribe to the topic scan and get the information from the laser sensor.
    - Named it `get_laser_data.py`
    - We want to get the value of the scanner in front of the robot ----> `msg.range[0]`

LaserScan
https://youtu.be/tEayzulupxE
https://youtu.be/kze3Z8rTkZo

move_turtlebot (Python)

move_turtlebot.py

```python
#! /usr/bin/python3

import rospy
from geometry_msgs.msg import Twist
import sys

def move_turtlebot(lin_vel, ang_vel):
    rospy.init_node('move_turtlebot', anonymous=False)
    pub = rospy.Publisher('/cmd_vel', Twist, queue_size=10)
    rate = rospy.Rate(1) # 1hz
    vel = Twist()

    while not rospy.is_shutdown():
        vel.linear.x = lin_vel
        vel.angular.z = ang_vel
        pub.publish(vel)
        rate.sleep()

if __name__ == '__main__':
    try:
        move_turtlebot(float(sys.argv[1]),float(sys.argv[2]))
    except rospy.ROSInterruptException:
        pass
```

https://github.com/LucMarechal/ROS_Lectures/blob/master/turtlesim_tutorials/move_turtlebot.py

LaserScan Message

Getting laser data

- Laser data is published on the topic *scan.* Therefore, to access this data we have to subscribe to this topic, obtain the required data and use it for our desired application.
- Obtain information about the topic (in a separate window):

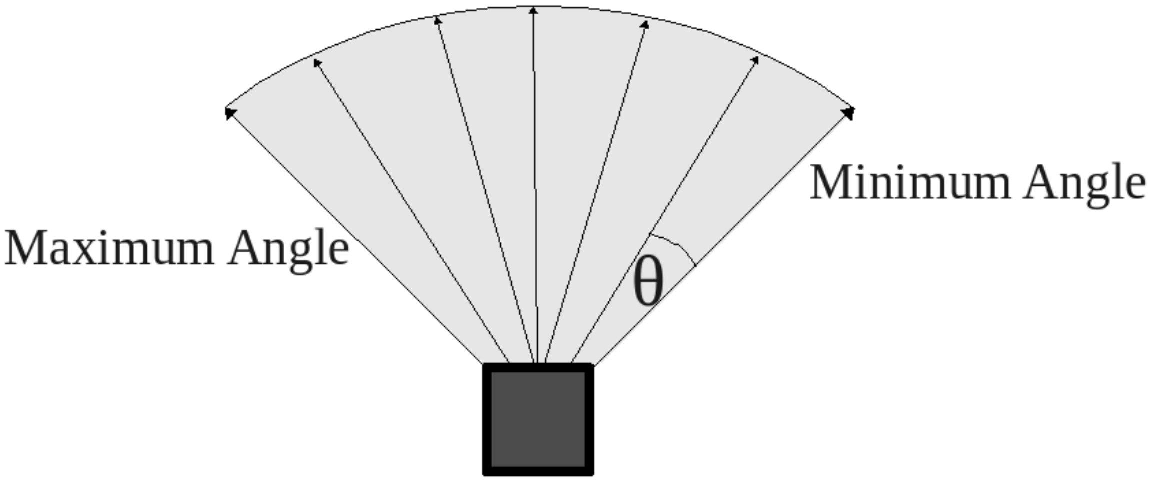
```
$ rostopic list
$ rostopic info scan
$ rosmsg show LaserScan
$ rostopic echo scan
```

LaserScan Message

- http://docs.ros.org/api/sensor_msgs/html/msg/LaserScan.html

Raw Message Definition

```
# Single scan from a planar laser range-finder
#
# If you have another ranging device with different behavior (e.g. a sonar
# array), please find or create a different message, since applications
# will make fairly laser-specific assumptions about this data

Header header            # timestamp in the header is the acquisition time of
                         # the first ray in the scan.
                         #
                         # in frame frame_id, angles are measured around
                         # the positive Z axis (counterclockwise, if Z is up)
                         # with zero angle being forward along the x axis

float32 angle_min        # start angle of the scan [rad]
float32 angle_max        # end angle of the scan [rad]
float32 angle_increment  # angular distance between measurements [rad]

float32 time_increment   # time between measurements [seconds] - if your scanner
                         # is moving, this will be used in interpolating position
                         # of 3d points
float32 scan_time        # time between scans [seconds]

float32 range_min        # minimum range value [m]
float32 range_max        # maximum range value [m]

float32[] ranges         # range data [m] (Note: values < range_min or > range_max should be discarded)
float32[] intensities    # intensity data [device-specific units].  If your
                         # device does not provide intensities, please leave
                         # the array empty.
```

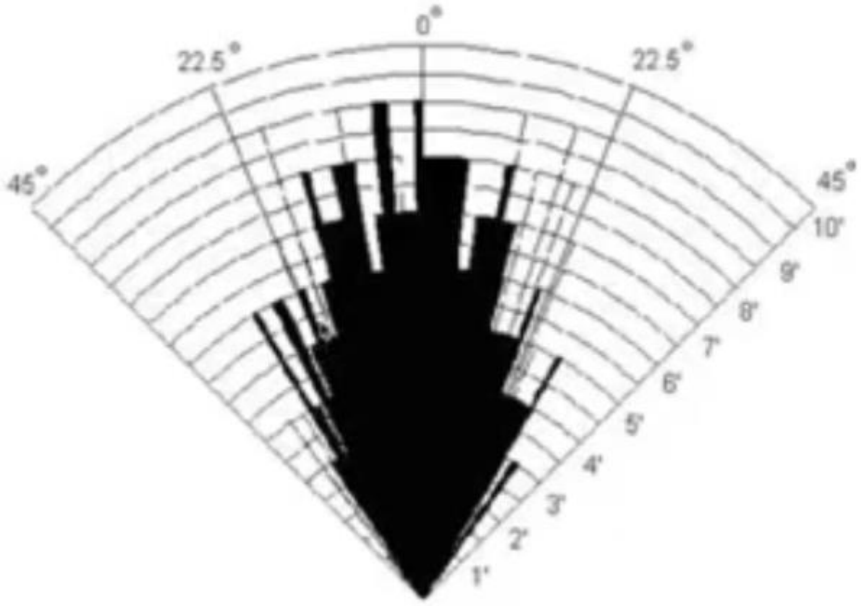


LaserScan Message

```
std_msgs/Header header
float32 angle_min
float32 angle_max
float32 angle_increment
float32 time_increment
float32 scan_time
float32 range_min
float32 range_max
float32[] ranges
float32[] intensities
```

table of float values

(distance in meter to an object)



`ranges = [inf, 50.3, 2.1,…,2.6, 0.4,]`

example : to get the 3rd value of the table In: `ranges[3]`

Out: 2.1

To retrieve the range to the nearest obstacle directly in front of the robot, we will select the middle element of the ranges array:

```
range_ahead = msg.ranges[len(msg.ranges)/2]
```

Or, to return the range of the closest obstacle detected by the scanner:

```
closest_range = min(msg.ranges)
```

Exercise

LaserScan

- Create a new node laser_data.py to subscribe to the topic *scan* and get the information from the Lidar sensor

```
#! /usr/bin/python3
import rospy
from sensor_msgs.msg import LaserScan
import sys

def scan_callback(msg):
    front_distance = int(len(msg.ranges)/2)
    range_ahead = msg.ranges[front_distance]
    rospy.loginfo("range ahead = %0.2f\n",range_ahead)

def read_laser():
    rospy.init_node('Turtlebot3_Read_Laser', anonymous=False)
    rospy.Subscriber('scan', LaserScan, scan_callback)
    rospy.spin()


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

LaserScan Message

Getting laser data

- Create a new node to subscribe to the topic *scan* and get the information from the laser sensor.

```
gedit laser_data.py
```

```
#! /usr/bin/env python

import rospy
from sensor_msgs.msg import LaserScan

def callback(msg):          # Define a function called 'callback' that receives a parameter named 'msg'
    print('==================================================')
    print('s1 [0]')         #value front-direction laser beam
    print msg.ranges[0]     # print the distance to an obstacle in front of the robot. the sensor returns a vector
                            # of 359 values, being the initial value the corresponding to the front of the robot

    print('s2 [90]')
    print msg.ranges[90]

    print('s3 [180]')
    print msg.ranges[180]

    print('s4 [270]')
    print msg.ranges[270]

    print('s5 [359]')
    print msg.ranges[359]


rospy.init_node('laser_data')                         # Initiate a Node called 'laser_data'
sub = rospy.Subscriber('scan', LaserScan, callback)   # Create a Subscriber to the laser/scan topci

rospy.spin()
```

Exercise

Gazebo and TurtleBot3

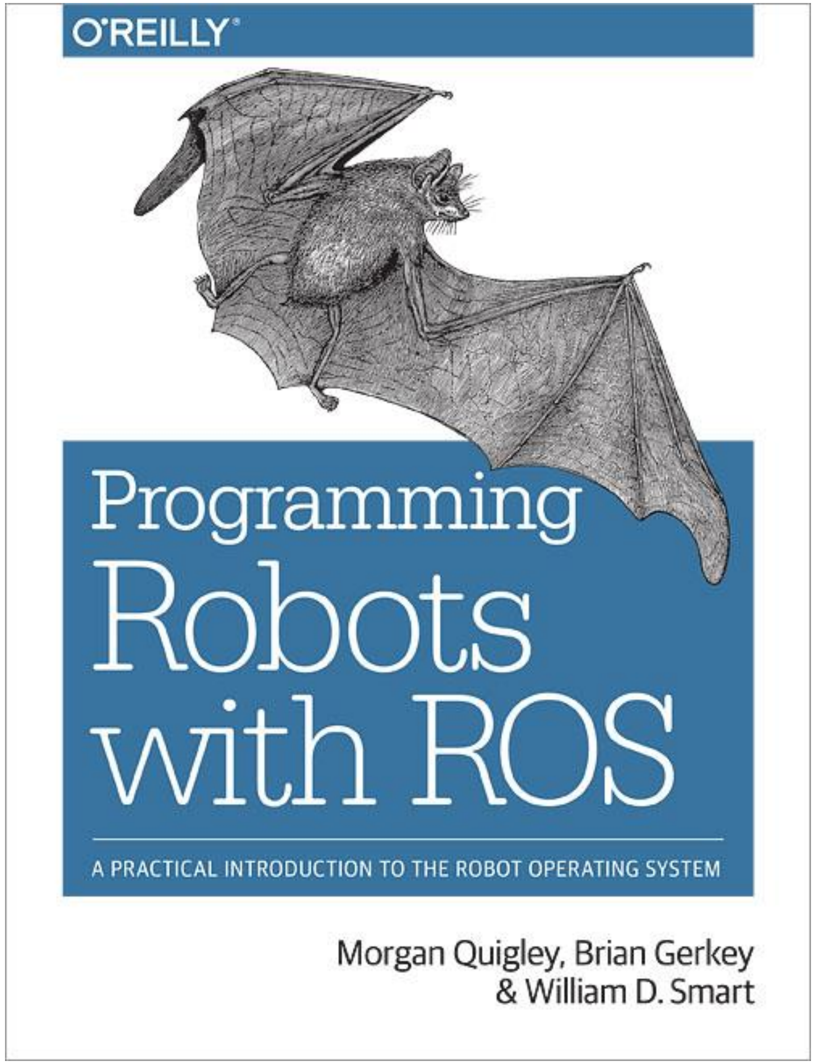
- Make robot avoid obstacles in front of him
  - Make the robot to stop when an obstacle in front of the robot is closer than 0.5 m

- Hints:
  - Create a node which is a publisher and subscriber at the same time.
  - The node should subscribe to the topic scan and publish on the topic cmd_vel
  - Use the code implemented in the previous scripts and put everything together.
  - Use conditionals to make the robot behave as you want

Exercise

Gazebo and TurtleBot3

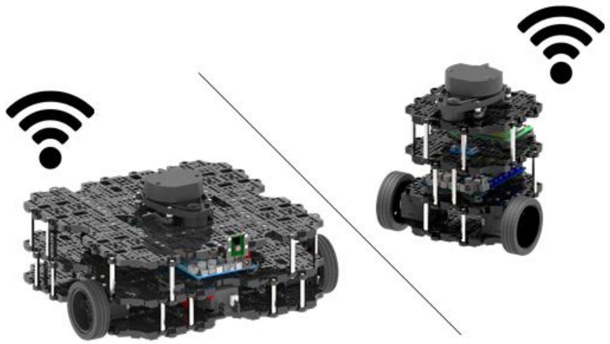
- You will find help in this Book in the Chapter 7 Wander-bot



TurtleBot3

Setup

TurtleBot



Remote PC

On remote PC

On TurtleBot AND on remote PC

```
> sudo apt-get install ros-kinetic-joy ros-kinetic-teleop-twist-joy ros-kinetic-
teleop-twistkeyboard ros-kinetic-laser-proc ros-kinetic-rgbd-launch ros-kinetic-
depthimage-to-laserscan roskinetic-rosserial-arduino ros-kinetic-rosserial-python ros-
kinetic-rosserial-server ros-kinetic-rosserial-client ros-kinetic-rosserial-msgs ros-
kinetic-amcl ros-kinetic-map-server ros-kinetic-move-base ros-kinetic-urdf ros-
kinetic-xacro ros-kinetic-compressed-image-transport ros-kinetic-rqt-image-view ros-
kinetic-gmapping ros-kinetic-navigation
```

TurtleBot3

Setup

On TurtleBot

```
> cd ~/catkin_ws/src
> git clone https://github.com/ROBOTIS-GIT/turtlebot3.git
> git clone https://github.com/ROBOTIS-GIT/turtlebot3_msgs.git
> git clone https://github.com/ROBOTIS-GIT/hls_lfcd_lds_driver.git
> cd ~/catkin_ws && catkin_make
```

On remote PC

```
> cd ~/catkin_ws/src/
> git clone https://github.com/ROBOTIS-GIT/turtlebot3.git
> git clone https://github.com/ROBOTIS-GIT/turtlebot3_msgs.git
> git clone https://github.com/ROBOTIS-GIT/turtlebot3_simulations.git
> cd ~/catkin_ws && catkin_make
```

TurtleBot3

Setup

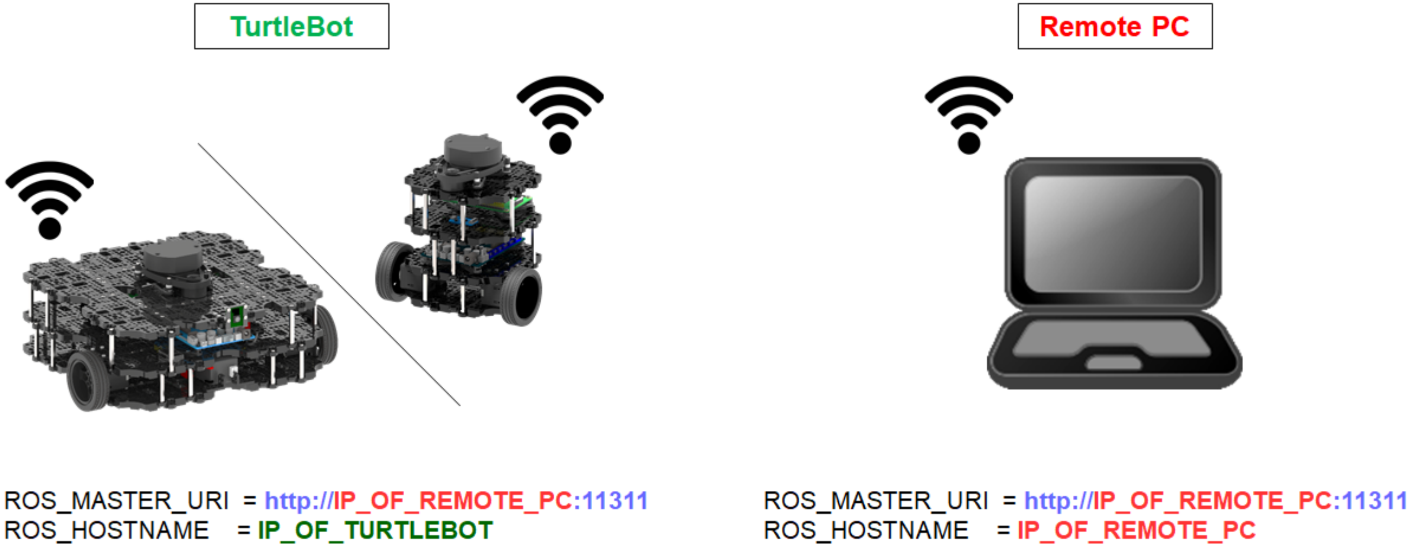
On remote PC

```
> Sudo gedit ~/.bashrc
  export ROS_MASTER_URI =
  export ROS_HOSTNAME =
  export TURTLEBOT_MODEL = burger

> source ~/.bashrc
```

On TurtleBot

```
> Sudo gedit ~/.bashrc
  export ROS_MASTER_URI =
  export ROS_HOSTNAME =

> source ~/.bashrc
```

```
> roslaunch turtlebot3_bringup turtlebot3_robot.launch
```



* Example when ROS Master is running on the Remote PC

More Info
http://emanual.robotis.com/docs/en/platform/turtlebot3/pc_setup/

TurtleBot3

Setup

SSH (Secure Shell)

- cryptographic network protocol that allows to log in to another computer and run command on a remote system

Install SSH

```
> sudo apt-get install ssh
```

Connect to a remote computer

```
> ssh username on the remote PC  @ ip address of the remote PC

  Example: > ssh turtlebot@192.168.1.100
```

Enable and start SSH

```
> sudo systemctl enable ssh
> sudo systemctl start ssh
```

More info
https://www.raspberrypi.org/documentation/remote-access/ssh/

TurtleBot3

TurtleBot3 remote control

Start roscore (Execute on the remote PC only)

```
> roscore
```

Run TurtleBot3 (Execute on the TurtleBot)

```
> roslaunch turtlebot3_bringup turtlebot3_robot.launch --screen
```

Control TurtleBot with keyboard (Execute from the Remote PC)

```
> roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch --screen
```

Control TurtleBot with PS3 joystick (Execute from the Remote PC)

```
> sudo apt-get install ros-kinetic-joy ros-kinetic-joystick-
drivers ros-kinetic-teleop-twist-joy
```

```
> roslaunch teleop_twist_joy teleop.launch --screen
```

TurtleBot3

Node and topic

Visualize

```
> rqt_graph
```