Lecture 4

2021

INFO 802
Master Advanced Mechatronics

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POLYTECH ANNECY-CHAMBÉRY

ROS

Robot control
Turtlesim

Course 4 : Robot control

Outline

- Turtlesim topic, messages and commands
- Move Turtle
- Gazebo TurtleBot simulation
- TurtleBot3 real robot
- Assignement

Course 4 : Robot control

Objectives

- Know which topics are at stake in a node
- Know what type of message is at stake and what is the source package
- Know how to use Twist, Pose, Odometry messages
- Write a publisher function
- Write a subscriber function and understand its callback

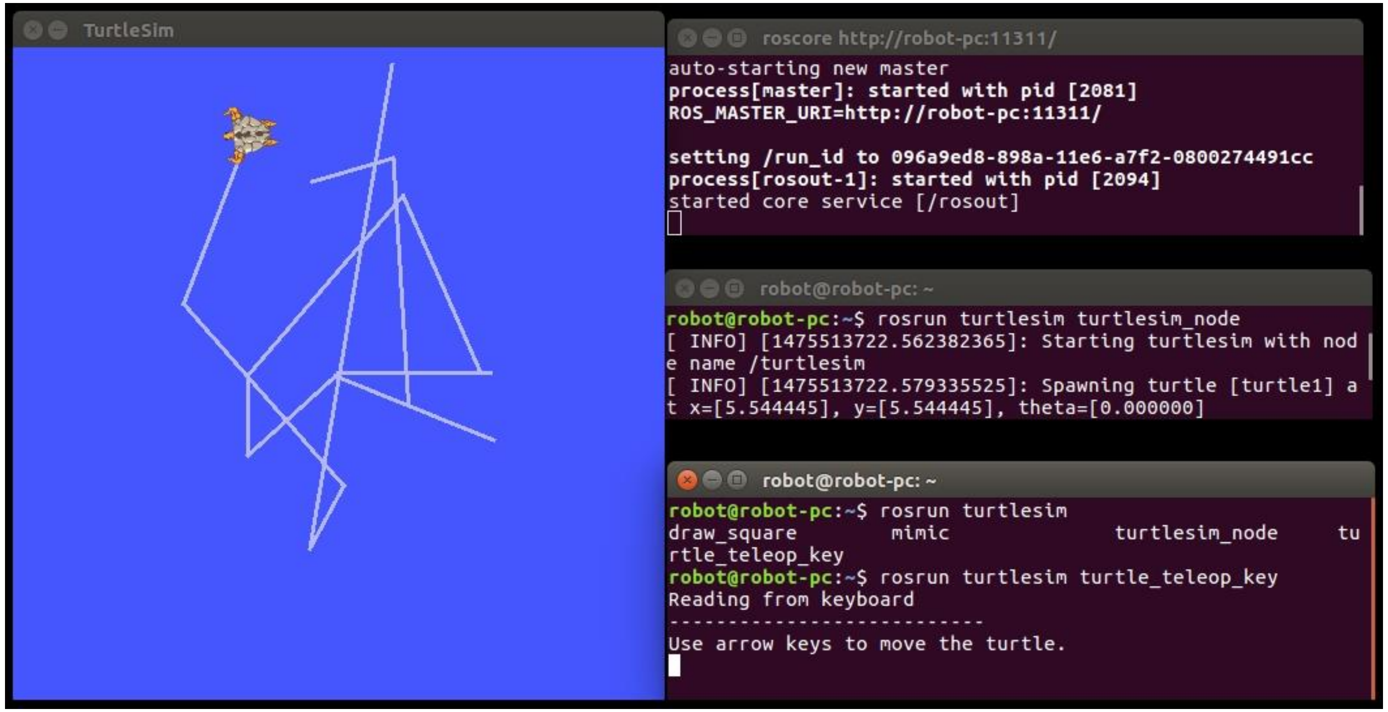
Turtlesim

Recall: Open a terminal for each command

```
> roscore
```

```
> rosrun turtlesim turtlesim_node
```

```
> rosrun turtlesim turtle_teleop_key
```



Turtlesim

- Questions to answer:

Which topic is the velocity command published to?

Which topic is the position information available from?

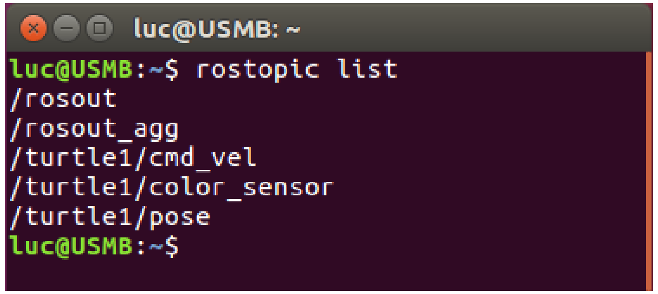
What kind of messages are used?

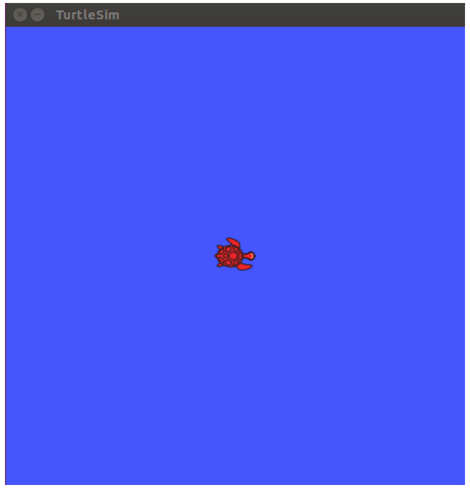
Which message packages are they from?

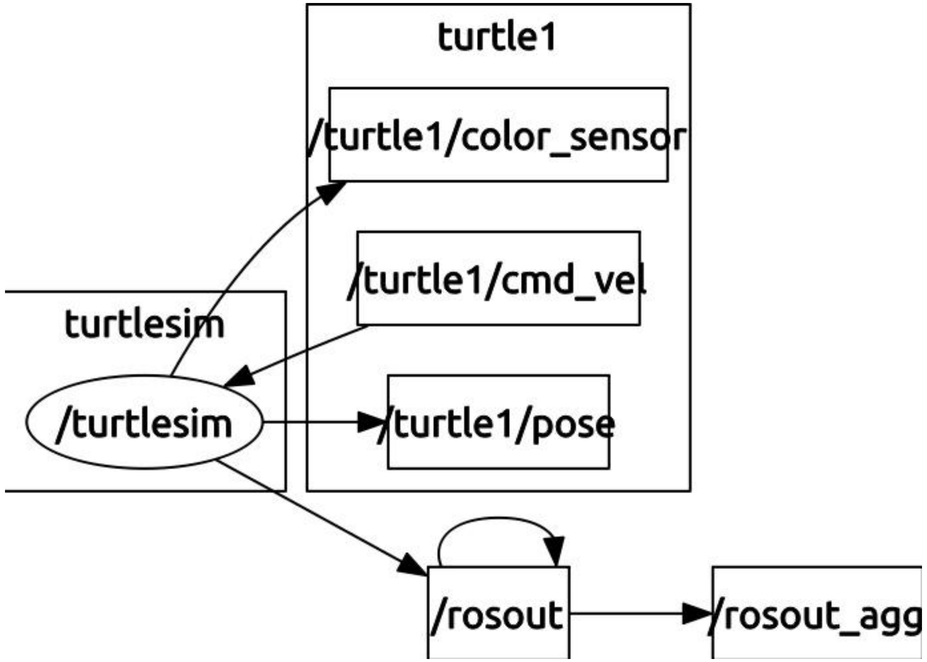
```
> rosrun turtlesim turtlesim_node
> rostopic list
> rostopic type [topic]
> rosnode info turtlesim_node
```

Visualize node and topic

```
> rqt_graph
```

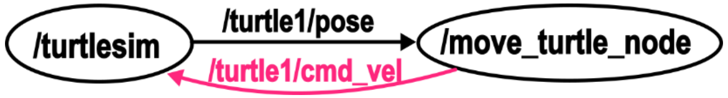






Turtlesim

Twist




```
> rostopic type /turtle1/cmd_vel
> rosmsg show Twist
```

```
luc@USMB:~$ rosmsg show Twist
[geometry_msgs/Twist]:
geometry_msgs/Vector3 linear
  float64 x
  float64 y
  float64 z
geometry_msgs/Vector3 angular
  float64 x
  float64 y
  float64 z
```

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

  `Twist` messages to the topic *`/turtle1/cmd_vel`*

- This message has:

  - a linear component for the (x,y,z) velocities,

  - an angular component for the angular rate about the (x,y,z) axes

- Twist is part of *`geometry_msgs`* message package

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

Example of use

create a *Twist* object
set the linear velocity along x
set the angular rate about z

```
vel = Twist()
vel.linear.x = 1.0
vel.angular.z = 0.4
```

Turtlesim

Pose

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

  to the topic ***/turtle1/Pose*** and read ***Pose*** message

```
> rostopic type /turtle1/Pose
> rosmsg show Pose
```

```
luc@USMB:~$ rosmsg show Pose
[turtlesim/Pose]:
  float64 x
  float64 y
  float64 theta
  float64 linear_velocity
  float64 angular_velocity
```

- This message has:

  - a linear component for the (x,y) 2D coordinates,

  - an angular component theta about the z axes

- Pose is among others part of *turtlesim* message package

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

Example of use

create a *Pose* object — `pose = Pose()`
get the x position of turtle — `robot_x = pose.x`
get the y position of turtle — `robot_y = pose.y`

```
pose = Pose()
robot_x = pose.x
robot_y = pose.y
```

Turtlesim

Twist / Pose

Test moving the turtle
(command from the Terminal)

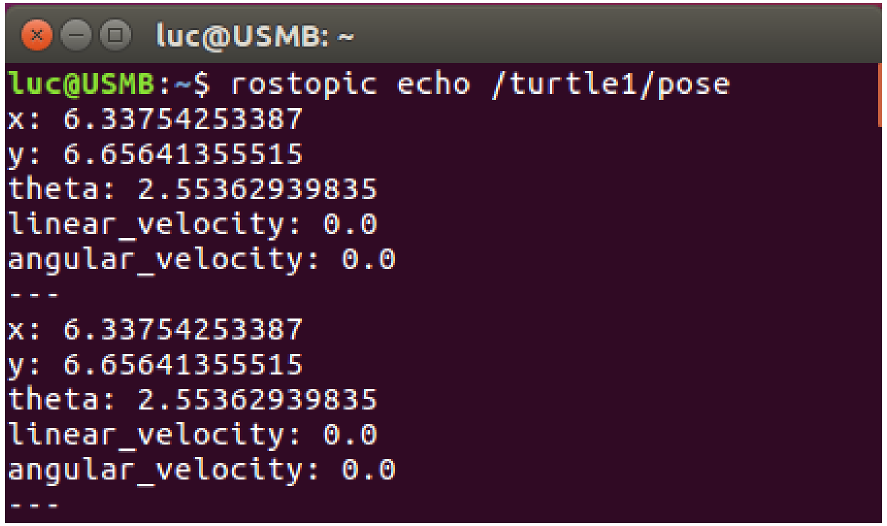
linear.x linear.y linear.z angular.x angular.y angular.z

```
> rostopic pub -1 /turtle1/cmd_vel geometry_msgs/Twist -- '[2.0, 0.0, 0.0]' '[0.0, 0.0, 1.8]'
```

topic message

Test printing out the turtle position
(command from the Terminal)

```
> rostopic echo /turtle1/pose
```



move_turtle_linear_node (Python)

Writing the Node

Create package

```
> cd ~/catkin_ws/src/
> catkin_create_pkg turtlesim_tutorials rospy
```

Edit script

```
> cd ~/catkin_ws/src/turtlesim_tutorials
> mkdir scripts
> subl move_turtle_linear_node.py
```

Make script executable

```
> cd ~/catkin_ws/src/turtlesim_tutorials/scripts
> sudo chmod +x move_turtle_linear_node.py
```

Make package and source environment

```
> cd ~/catkin_ws
> catkin_make
> source ~/catkin_ws/devel/setup.bash
```

move_turtle_linear_node.py

```
#! /usr/bin/env python3

import rospy
XXXXXXXXXXXX  # import Twist message

def move_turtle():
   # Initialize node
    XXXXXXXXXXXX

    # Create a publisher to "talk" to Turtlesim
    pub = XXXXXXXXXXXX

    # Create a Twist message and add linear x values
    vel = Twist()
    vel.linear.x = 1.0  # Move along the x axis only

    # Save current time and set publish rate at 10 Hz
    tStart = rospy.Time.now()
    rate = rospy.Rate(10)

    # For the next 6 seconds publish vel move commands to Turtlesim
    while rospy.Time.now() < tStart + rospy.Duration.from_sec(6):
        XXXXXXXXXXXX # publish velocity command to Turtlesim
        rate.sleep()

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

https://https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_linear_node.py

move_turtle_linear_node (Python)

Writing the Node

Create package

```
> cd ~/catkin_ws/src/
> catkin_create_pkg turtlesim_tutorials rospy
```

Edit script

```
> cd ~/catkin_ws/src/turtlesim_tutorials
> mkdir scripts
> subl move_turtle_linear_node.py
```

Make script executable

```
> cd ~/catkin_ws/src/turtlesim_tutorials/scripts
> sudo chmod +x move_turtle_linear_node.py
```

Make package and source environment

```
> cd ~/catkin_ws
> catkin_make
> source ~/catkin_ws/devel/setup.bash
```

move_turtle_linear_node.py

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

import rospy
from geometry_msgs.msg import Twist  # import Twist message

def move_turtle():
    # Initialize node
    rospy.init_node('move_turtle_linear_node', anonymous=False)

    # Create a publisher to "talk" to Turtlesim
    pub = rospy.Publisher('turtle1/cmd_vel', Twist, queue_size=1)

    # Create a Twist message and add linear x values
    vel = Twist() # Creates a Twist object
    vel.linear.x = 1.0  # Move along the x axis only

    # Save current time and set publish rate at 10 Hz
    tStart = rospy.Time.now()
    rate = rospy.Rate(10)

    # For the next 6 seconds publish vel move commands to Turtlesim
    while rospy.Time.now() < tStart + rospy.Duration.from_sec(6):
        pub.publish(vel) # publish velocity command to Turtlesim
        rate.sleep()

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

https://https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_linear_node.py

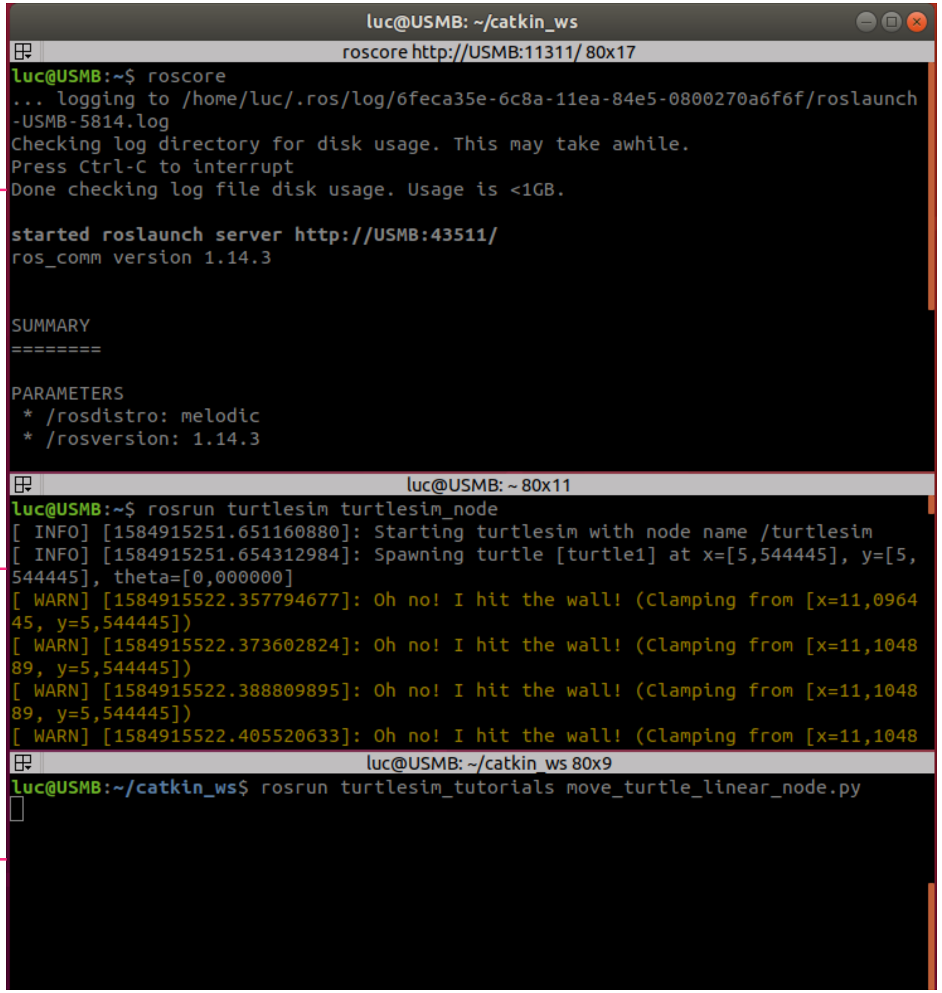
move_turtle_linear_node (Python)

Run the Node

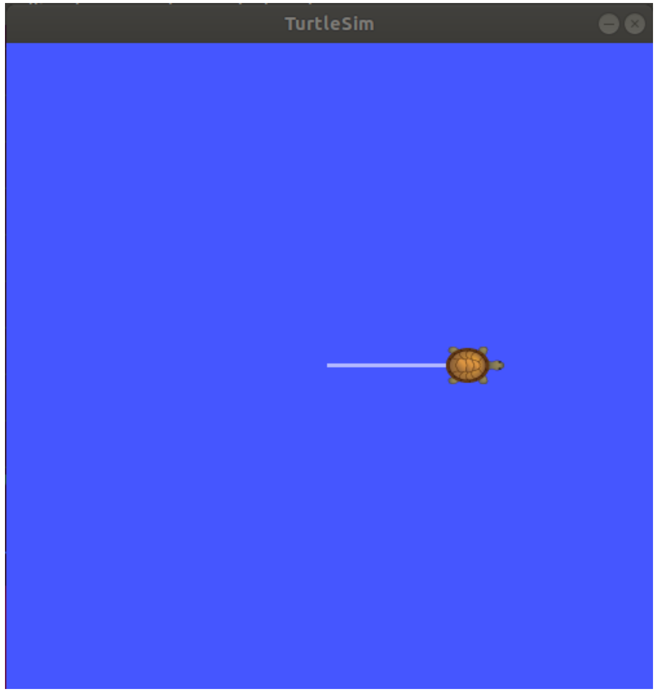
start roscore

run the turtlesim_node

run your node !



move_turtle_linear_node.py



https://https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_linear_node.py

move_turtle_command_node (Python)

Adding command line arguments

move_turtle_command_node.py

```
#! /usr/bin/env python3

import rospy
from geometry_msgs.msg import Twist

# Handling command line arguments
import sys # Python sys module to get the command-line arguments
           # inside our code

def move_turtle(lin_vel, ang_vel):
    rospy.init_node('move_turtle_command', anonymous=False)

    pub = rospy.Publisher('/turtle1/cmd_vel', Twist, queue_size=10)
    rate = rospy.Rate(10) # 10hz

    vel = Twist()  # creates a Twist object

    while not rospy.is_shutdown():

       # Adding linear and angular velocity to the message
       vel.linear.x = lin_vel
       vel.linear.y = 0
       vel.linear.z = 0

       vel.angular.x = 0
       vel.angular.y = 0
       vel.angular.z = ang_vel
```

Display information in the Console

```
       rospy.loginfo("Linear Vel = %f: Angular Vel =%f",lin_vel,ang_vel)

       #Publishing Twist message
       pub.publish(vel)

       rate.sleep()


if __name__ == '__main__':
    #Providing linear and angular velocity through command line
    move_turtle(float(sys.argv[1]),float(sys.argv[2]))
```

Run the node

```
> rosrun turtlesim_tutorials move_turtle_command_node.py 0.5 0.2
```

arguments
linear.x angular.z

https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_command_node.py

move_turtle_printout_node (Python)

Adding the turtle position print out

move_turtle_printout_node.py

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

import rospy
XXXXXXXXXXXX  # import Twist message
XXXXXXXXXXXX  # import Pose message

import sys

# callback for topic /turtle1/Pose
def pose_callback(XXXXX):
    XXXXXXXXXX # printout in the console the pose of turtle1

def move_turtle(lin_vel,ang_vel):
    rospy.init_node('move_turtle', anonymous=False)

    pub = rospy.Publisher('/turtle1/cmd_vel', Twist, queue_size=10)

    # Creating new subscriber. Topic name: /turtle1/pose
    #                          Callback name: pose_callback
    XXXXXXXXXXXXXXXXXXX

    rate = rospy.Rate(10) # 10hz

    vel = Twist()
```

```python
    while not rospy.is_shutdown():
        vel.linear.x = lin_vel
        vel.linear.y = 0
        vel.linear.z = 0

        vel.angular.x = 0
        vel.angular.y = 0
        vel.angular.z = ang_vel

        rospy.loginfo("Linear Vel = %f: Angular Vel
=%f",lin_vel,ang_vel)

        pub.publish(vel)

        rate.sleep()

if __name__ == '__main__':
    # Providing linear and angular velocity through command line
    move_turtle(float(sys.argv[1]),float(sys.argv[2]))
```

https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_printout_node.py

move_turtle_printout_node (Python)

Adding the turtle position print out

move_turtle_printout_node.py

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

import rospy
from geometry_msgs.msg import Twist    # import Twist message
from turtlesim.msg import Pose         # import Pose message

import sys

# callback for topic /turtle1/Pose
def pose_callback(pose):
    rospy.loginfo("Robot X = %f : Y=%f : Z=%f\n",pose.x,pose.y,pose.theta)

def move_turtle(lin_vel,ang_vel):
    rospy.init_node('move_turtle', anonymous=False)

    pub = rospy.Publisher('/turtle1/cmd_vel', Twist, queue_size=10)

    # Creating new subscriber. Topic name: /turtle1/pose
    #                          Callback name: pose_callback
    rospy.Subscriber('/turtle1/pose', Pose, pose_callback)

    rate = rospy.Rate(10) # 10hz

    vel = Twist()
```

```python
    while not rospy.is_shutdown():
        vel.linear.x = lin_vel
        vel.linear.y = 0
        vel.linear.z = 0

        vel.angular.x = 0
        vel.angular.y = 0
        vel.angular.z = ang_vel

        rospy.loginfo("Linear Vel = %f: Angular Vel
=%f",lin_vel,ang_vel)

        pub.publish(vel)

        rate.sleep()

if __name__ == '__main__':
 # Providing linear and angular velocity through command line
    move_turtle(float(sys.argv[1]),float(sys.argv[2]))
```

https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_printout_node.py

move_turtle_feedback_node (Python)

Adding the position feedback

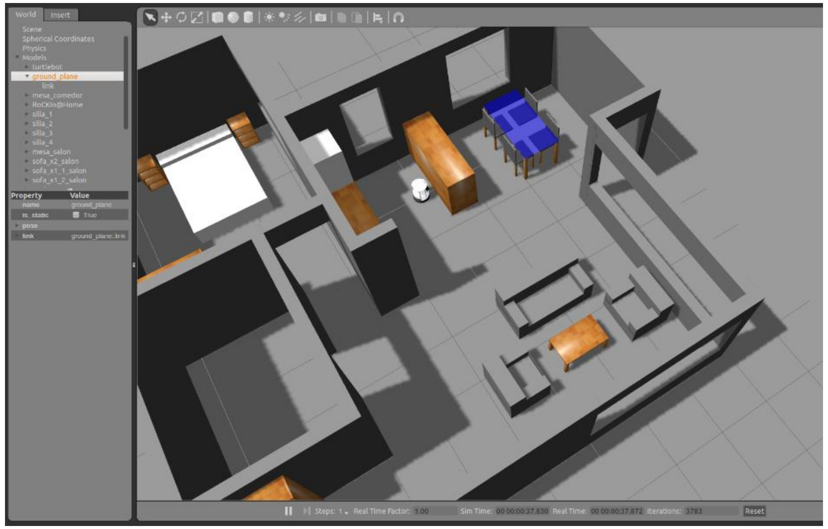
move_turtle_feedback_node.py

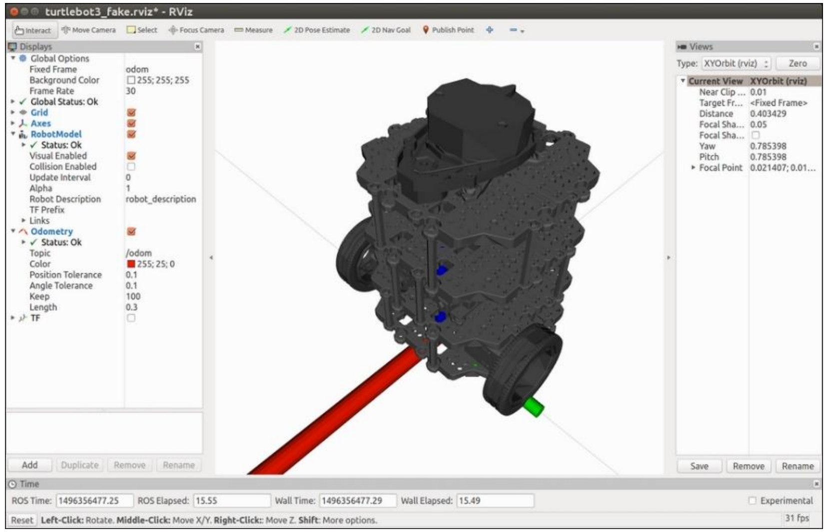
```python
#! /usr/bin/env python3

import rospy
from geometry_msgs.msg import Twist
from turtlesim.msg import Pose

import sys

robot_x = 0

# callback for topic /turtle1/Pose
def pose_callback(pose):
    global robot_x
    rospy.loginfo("Robot X = %f\n", pose.x)
    robot_x = pose.x

def move_turtle(lin_vel,ang_vel,distance):

    global robot_x

    rospy.init_node('move_turtle', anonymous=False)
    pub = rospy.Publisher('/turtle1/cmd_vel', Twist, queue_size=10)
    rospy.Subscriber('/turtle1/pose',Pose, pose_callback)
    rate = rospy.Rate(10) # 10hz
    vel = Twist()
```

```python
    while not rospy.is_shutdown():

        vel.linear.x = lin_vel
        vel.linear.y = 0
        vel.linear.z = 0
        vel.angular.x = 0
        vel.angular.y = 0
        vel.angular.z = ang_vel

# Checking the robot distance is greater than the commanded distance
# If it is greater, stop the node
        if(robot_x >= distance):
            rospy.loginfo("Robot Reached destination")
            rospy.logwarn("Stopping robot")

            break

        pub.publish(vel)
        rate.sleep()

if __name__ == '__main__':
    #Providing linear and angular velocity through command line
    move_turtle(float(sys.argv[1]),float(sys.argv[2]),
float(sys.argv[3]))
```

https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_feedback_node.py

Robotic simulation scenarios





GAZEBO

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

Gazebo – TurtleBot3 Simulation

Installing TurtleBot3 simulation packages

Installing Gazebo

```
> sudo apt-get install ros-noetic-gazebo-ros-pkgs ros-noetic-gazebo-ros-control
```

Installing TurtleBot3 simulation packages

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

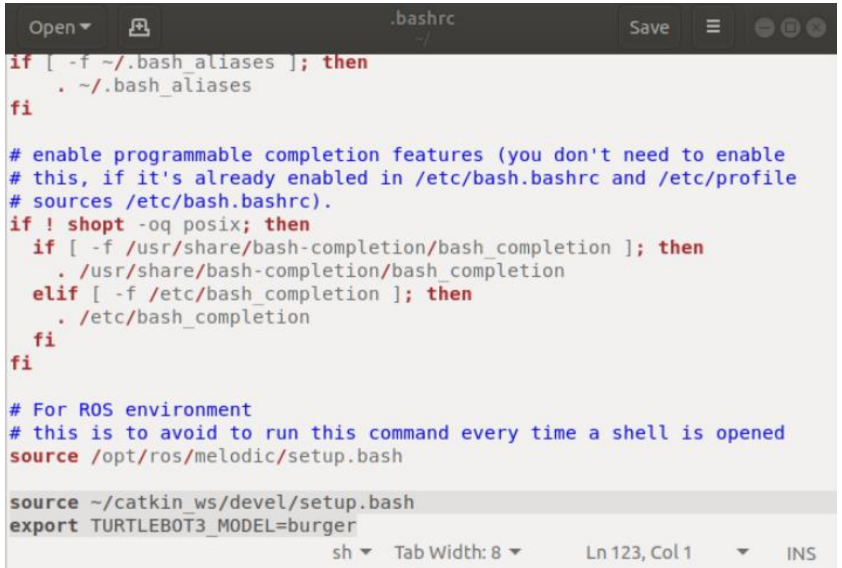
Modify bashrc file

```
> gedit ~/.bashrc
```

to add this 2 settings

```
source ~/catkin_ws/devel/setup.bash
export TURTLEBOT3_MODEL=waffle  # setting the model
```

TurtleBot3 has three models, Burger, Waffle, and Waffle Pi, so you have to set which model you want to use



Gazebo – TurtleBot3 Simulation

Installing TurtleBot3 simulation packages

Reload .bashrc

```
> source ~/.bashrc
```

Download the TurtleBot3 simulation files

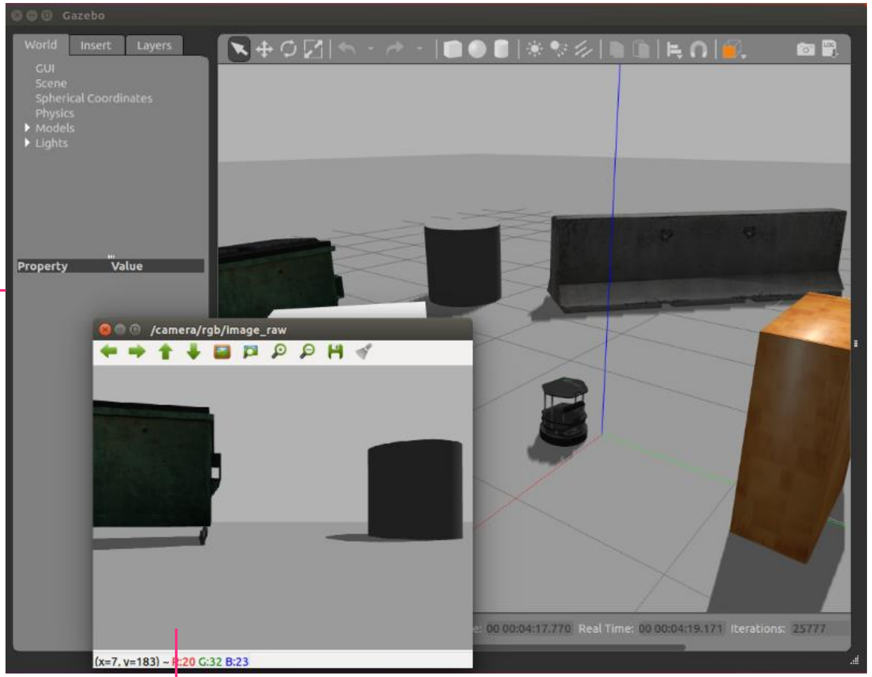
```
> cd ~/catkin_ws/src/
> git clone https://github.com/ROBOTIS-GIT/turtlebot3_simulations.git
> cd ~/catkin_ws && catkin_make
```

Gazebo – TurtleBot3 Simulation

Launch Gazebo

```
> roslaunch turtlebot3_gazebo turtlebot3_world.launch
```

(also try : turtlebot3_house.launch)

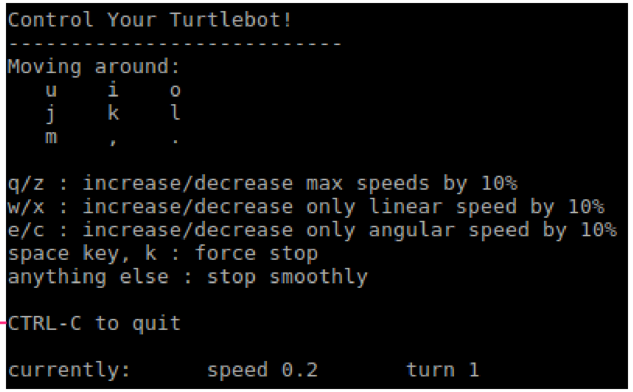


Display the image from the robot

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

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

Move the robot with keyboard

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



Gazebo – TurtleBot3 Simulation

```
luc@USMB:~$ rostopic list
/camera/depth/camera_info
/camera/depth/image_raw
/camera/depth/points
/camera/parameter_descriptions
/camera/parameter_updates
/camera/rgb/camera_info
/camera/rgb/image_raw
/camera/rgb/image_raw/compressed
/camera/rgb/image_raw/compressed/parameter_descriptions
/camera/rgb/image_raw/compressed/parameter_updates
/camera/rgb/image_raw/compressedDepth
/camera/rgb/image_raw/compressedDepth/parameter_descriptions
/camera/rgb/image_raw/compressedDepth/parameter_updates
/camera/rgb/image_raw/theora
/camera/rgb/image_raw/theora/parameter_descriptions
/camera/rgb/image_raw/theora/parameter_updates
/clock
/cmd_vel_mux/active
/cmd_vel_mux/input/navi
/cmd_vel_mux/input/safety_controller
/cmd_vel_mux/input/switch
/cmd_vel_mux/input/teleop
/cmd_vel_mux/parameter_descriptions
/cmd_vel_mux/parameter_updates
/depthimage_to_laserscan/parameter_descriptions
/depthimage_to_laserscan/parameter_updates
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
```

```
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
/gazebo_gui/parameter_descriptions
/gazebo_gui/parameter_updates
/joint_states
/laserscan_nodelet_manager/bond
/mobile_base/commands/motor_power
/mobile_base/commands/reset_odometry
/mobile_base/commands/velocity
/mobile_base/events/bumper
/mobile_base/events/cliff
/mobile_base/sensors/bumper_pointcloud
/mobile_base/sensors/core
/mobile_base/sensors/imu_data
/mobile_base_nodelet_manager/bond
/odom
/rosout
/rosout_agg
/scan
/tf
/tf_static
```

Gazebo – TurtleBot3 Simulation

Odometry

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

  `Twist` messages to the topic *`/cmd_vel_mux/input/teleop`*

- 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
```

move_turtlebot (Python)

move_turtlebot.py

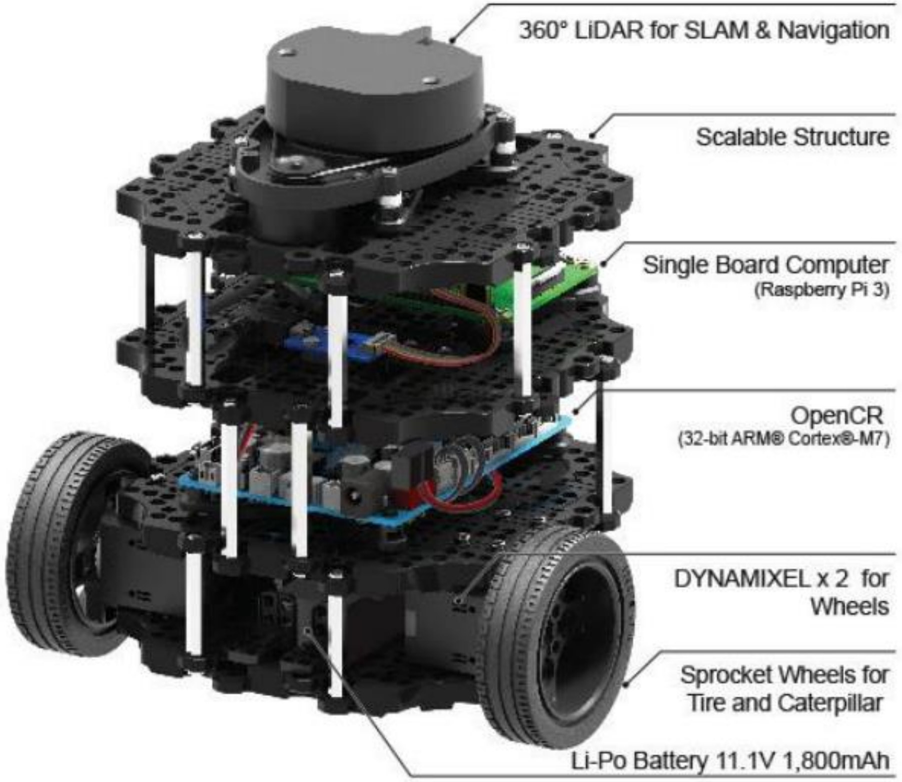
```
#! /usr/bin/python3

import rospy
from geometry_msgs.msg import Twist
import sys

def move_turtlebot():

    rospy.init_node('move_turtlebot', anonymous=False)
    pub = rospy.Publisher('/cmd_vel_mux/input/teleop', 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__':
    move_turtlebot(float(sys.argv[1]),float(sys.argv[2]))
```

Add distance

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

TurtleBot3

- **Features**
  - Low-cost, personal robot kit with open-source software and hardware. Two models available: burger / waffle.
  - Modular, compact and customizable.
  - World's most popular ROS platform
- **Components (Burger model)**
  - Single Board Computer (SBC)
  - Sensors
    - Laser Sensor
    - Depth Camera
    - Video Camera
  - Control Board
  - Actuators – Dynamixel Series



Laser Sensor

360 LASER DISTANCE SENSOR LDS-01 (LIDAR

- 2D laser scanner that collects a set of data around the robot to use for SLAM
- Light source: Semiconductor Laser Diode (λ=785nm)
- Distance Range: 120 ~ 3,500mm
- Angular Range: 360
- Angular Resolution: 1

https://www.youtube.com/watch?v=kze3Z8rTkZo&t=278s

Laser Sensor

LaserScan Message

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

```
# Single scan from a planar laser range-finder

Header header
# stamp: The acquisition time of the first ray in the scan.
# frame_id: The laser is assumed to spin around the positive Z axis
# (counterclockwise, if Z is up) with the zero angle 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.
```

Moving TurtleBot3 (Python)

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

import rospy                                   # Import the Python library for ROS
from geometry_msgs.msg import Twist            # Import the Twist message from the std_msgs package

def talker():
        rospy.init_node('vel_publisher')                # Initiate a Node named 'vel_publisher'
        pub = rospy.Publisher('cmd_vel', Twist, queue_size=10)  # Create a Publisher object
        move = Twist()                       # Create a var named move of type Twist
        rate = rospy.Rate(1)                 # Set a publish rate of 0.5 Hz
        while not rospy.is_shutdown():
                move.linear.x = 1
                move.angular.z = 1
                pub.publish(move)
                rate.sleep()

if __name__ == '__main__':
    try:
        talker()
    except rospy.ROSInterruptException:
        pass
```

Getting laser data (Python)

```python
#! /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()
```

Turtlebot3 - Obstacle avoidance

- Now it's time to put everything together: Subscriber, Publisher, Messages. You will need to use all of this concepts in order to succeed!
- Goal: Make robot avoid obstacles in front of him.
- Baby step: 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.

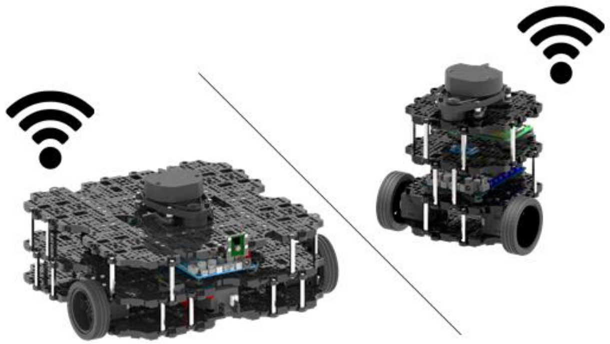
Turtlebot3 - Obstacle avoidance

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

import rospy
from sensor_msgs.msg import LaserScan
from geometry_msgs.msg import Twist

def callback(msg):          # Define a function called 'callback' that receives a parameter named 'msg'
    print('=================================================')
    print('s1 [270]')       #value right-direction laser beam
    print msg.ranges[270]
    print('s2 [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('s3 [90]')        #value left-direction laser beam
    print msg.ranges[90]


    #If the distance to an obstacle in front of the robot is bigger than 1 meter, the robot will move forward
    if msg.ranges[0] > 0.5:
      move.linear.x = 0.5
      move.angular.z = 0.0
    else:
      move.linear.x = 0.0
      move.angular.z = 0.0

    pub.publish(move)

rospy.init_node('obstacle_avoidance')                   # Initiate a Node called 'obstacle_avoidance'
sub = rospy.Subscriber('/scan', LaserScan, callback)    # Create a Subscriber to the /scan topic
pub = rospy.Publisher('/cmd_vel', Twist)                #Create a publisher on the /cmd_vel topic
move = Twist()

rospy.spin()
```

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

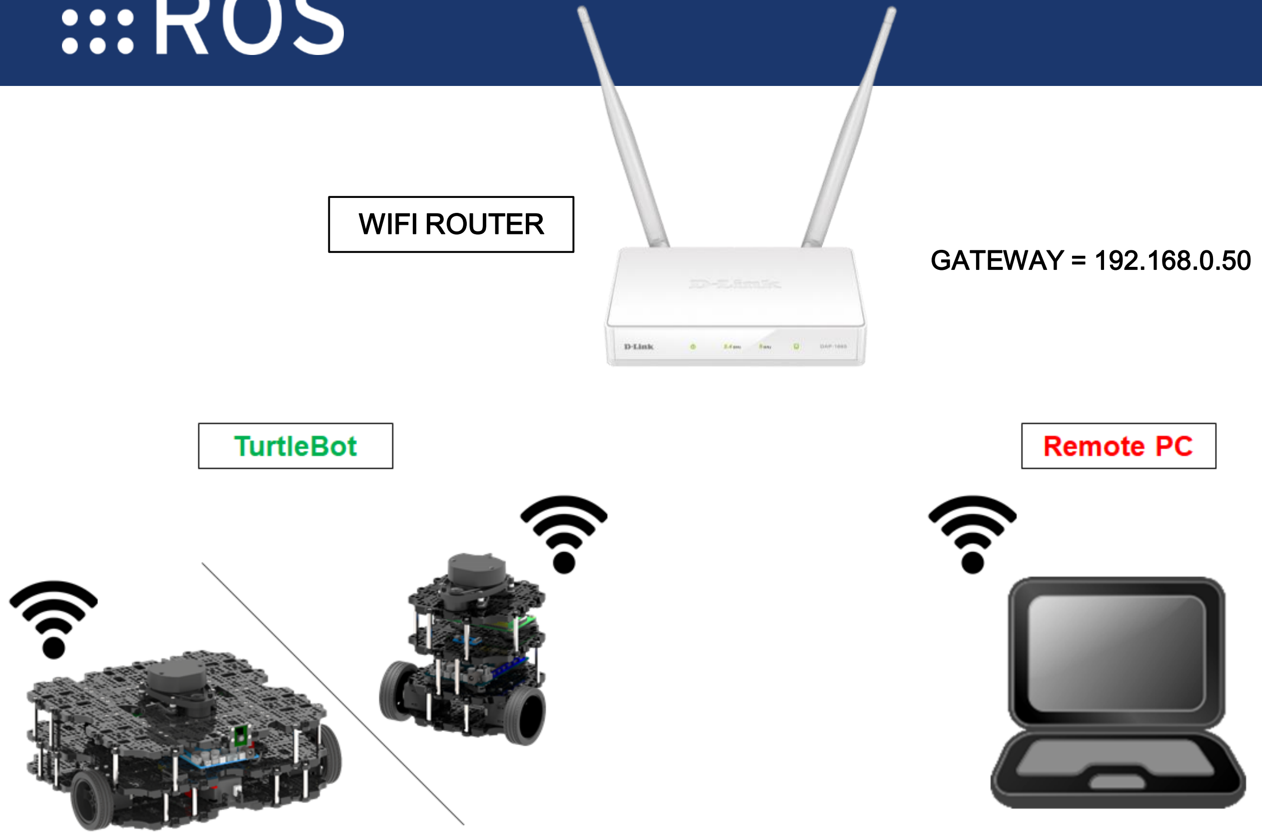
On remote PC

```
> sudo nano ~/.bashrc
  export ROS_MASTER_URI =
  export ROS_HOSTNAME =
  export TURTLEBOT_MODEL = burger

> source ~/.bashrc
```

On TurtleBot

```
> sudo nano ~/.bashrc
  export ROS_MASTER_URI =
  export ROS_HOSTNAME =

> source ~/.bashrc
```

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



ROS_MASTER_URI = http://IP_OF_REMOTE_PC:11311
ROS_HOSTNAME = IP_OF_TURTLEBOT

ROS_MASTER_URI = http://IP_OF_REMOTE_PC:11311
ROS_HOSTNAME = IP_OF_REMOTE_PC

* 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/

roslaunch turtlebot3_teleop turtlebot3_teleop_key.launch

TurtleBot3

Setup

WIFI ROUTER

GATEWAY = 192.168.0.50

Angry IP Scanner

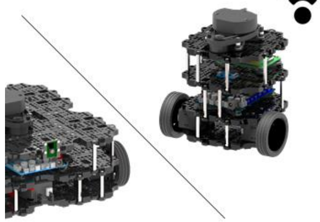
Remote PC

```
> nano ~/.bashrc
```

export ROS_MASTER_URI=http://192.168.0.42:11311 #IP adress of hostname (here masterpc since ros@masterpc)
export ROS_HOSTNAME=192.168.0.42
export TURTLEBOT3_MODEL=burger

```
> source ~/.bashrc
> roscore
```

TurtleBot



```
> ssh ubuntu@192.168.0.229
> nano ~/.bashrc
```

export ROS_MASTER_URI=http://192.168.0.42:11311
export ROS_HOSTNAME=192.168.0.229

```
> source ~/.bashrc
> roslaunch turtlebot3_bringup turtlebot3_robot.launch
```

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

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
```

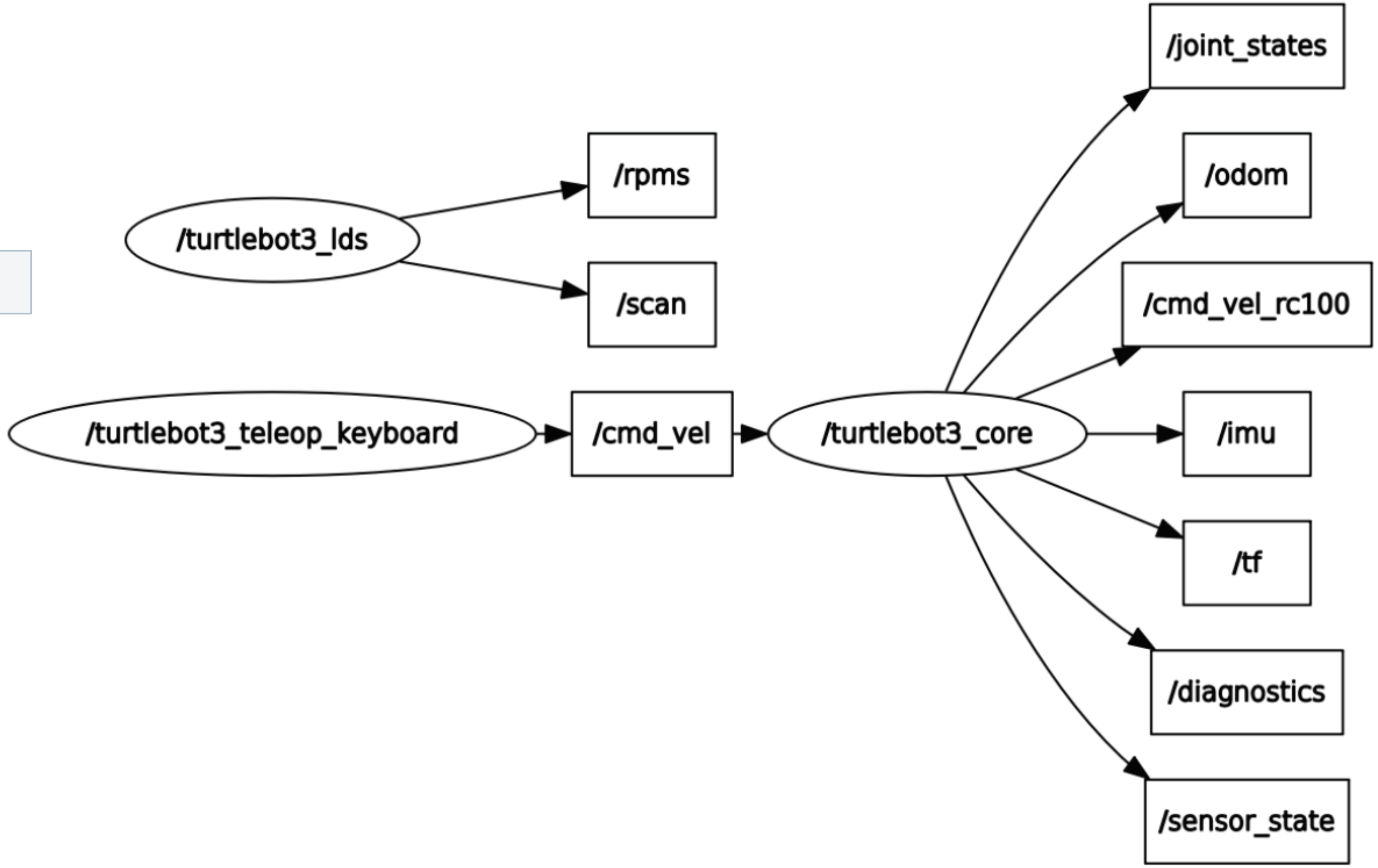
```
> roslaunch teleop_twist_joy teleop.launch --screen
```

TurtleBot3

Node and topic

Visualize

```
> rqt_graph
```



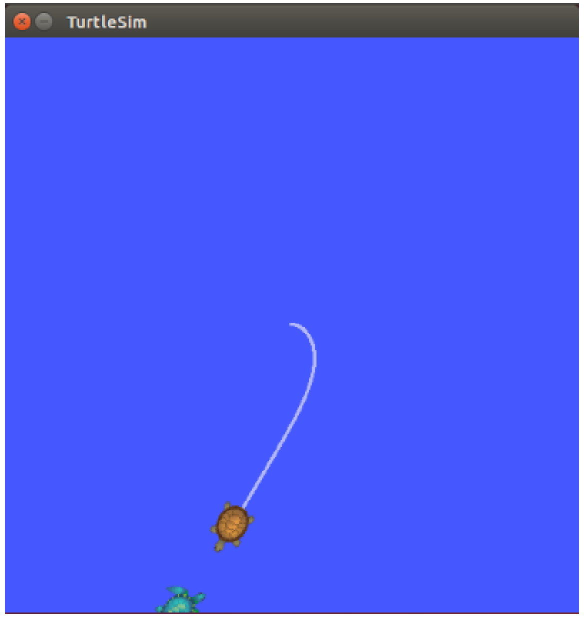
SUMMARY

- Twist
- Pose
- Odometry

Assignement

turtle_to_target (Python)

- Due to Wednesday April 8, 2020. (6pm max. deadline)
- Send me by email the answers to questions in the further slides
- Attach your *turtle_to_target.py* code and launch file
- luc.marechal@univ-smb.fr



Assignement

turtle_to_target (Python)

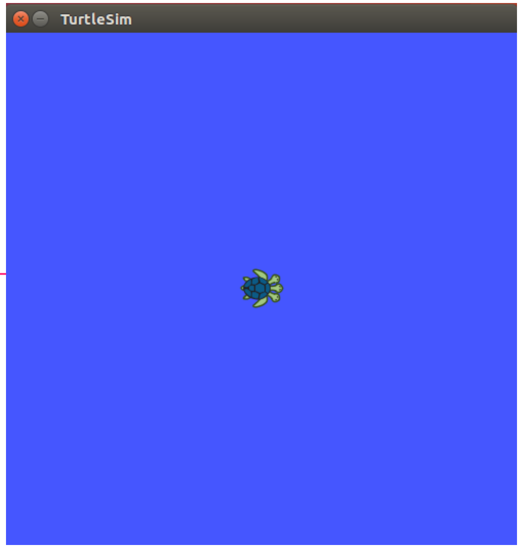
Run the **turtlesim_node** and the **spawn_turtle** node

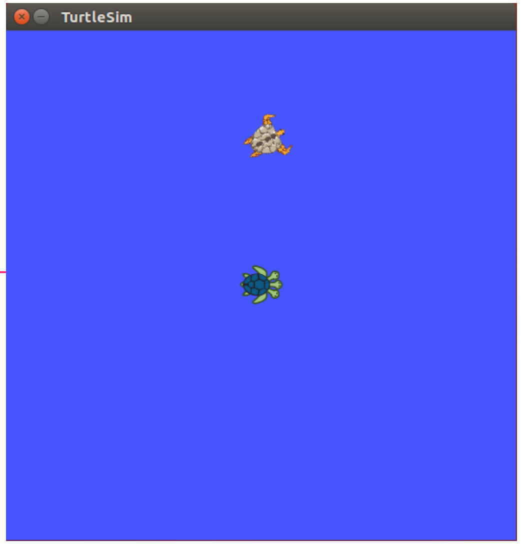
Find which topics are running on the ROS system

```
luc@USMB:~$ roscore
```

```
luc@USMB:~$ rosrun turtlesim turtlesim_node
```

```
luc@USMB:~$ rosrun turtlesim_tutorials spawn_turtle.py
```





Assignement

turtle_to_target (Python)

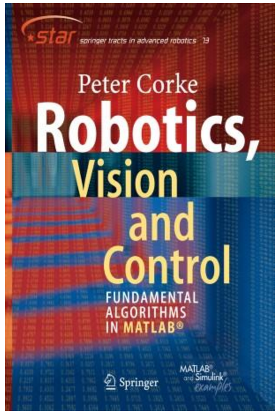
- Create a node called *turtle_to_target* that automatically move the turtle1 to the turtle2. For that you will use linear velocity and angular velocity to control the turtle1.

- The forward velocity is defined as a constant gain of multiplied by the distance between the target turtle2 and the turtle1. This means that the forward velocity is higher the further you are away from the target, and goes to zero as you approach the target.

- The angular velocity is calculated similarly with a gain multiplied by the difference in angle between the line that is directly connecting the turtle and the goal position, and the angular pose of the robot itself (check the meaning of the atan2 in the steering angle computation). This causes the robot to adjust its own theta to eventually move in a straight line to the target.

Assignement

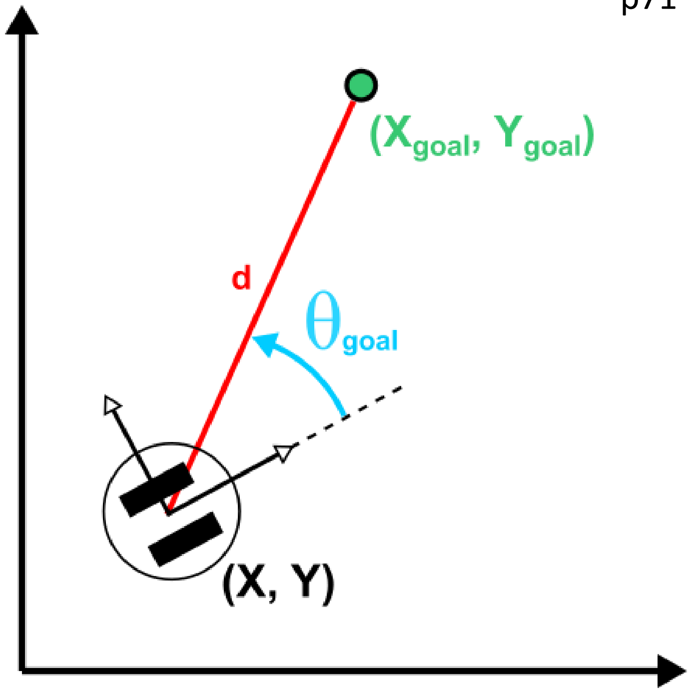
Moving to a Point (x,y) in the 2D plane



p71

- Euclidean distance: $distance = \sqrt{(x_{goal} - x)^2 + (y_{goal} - y)^2}$
- Orientation: $\theta_{goal} = \text{atan2}\frac{(y_{goal} - y)}{(x_{goal} - x)}$
- Proportional Controller: Velocity $v = K_v \times distance$

  Steering angle $\gamma = K_h \times \theta_{goal}$



The robot's velocity is proportional to its distance to the goal

Assignement

turtle_to_target (Python)

At least, answer the following questions:

- What are the turtlesim Pose and Twist message like?
- What should we import in the python header file to use Pose and Twist objects?

- How can we get the Pose of the turtle?
- How can we get the Pose of the target?

- How can we send velocity command to the turtle?
- What should we then import in the python header file ?

- Explain what the *spawn_turtle* node is doing

Assignement

turtle_to_target (Python)

Download the files: *turtlesim_target.launch*

spawn_turtle.py

turtle_to_target.py

https://github.com/LucMarechal/ROS_Lectures/tree/master/Assignement_Lecture4

Place them in the right folders inside the *turtlesim_tutorials* package (give the locations)

Don't forget to source your catkin workspace !

Edit the *turtle_to_target.py* and fill the XXXX in the code

Edit the *turtlesim_target.launch* file so it launches :

- *turtlesim_node.py*
- *spawn_turtle.py*
- *turtlesim_target.py*

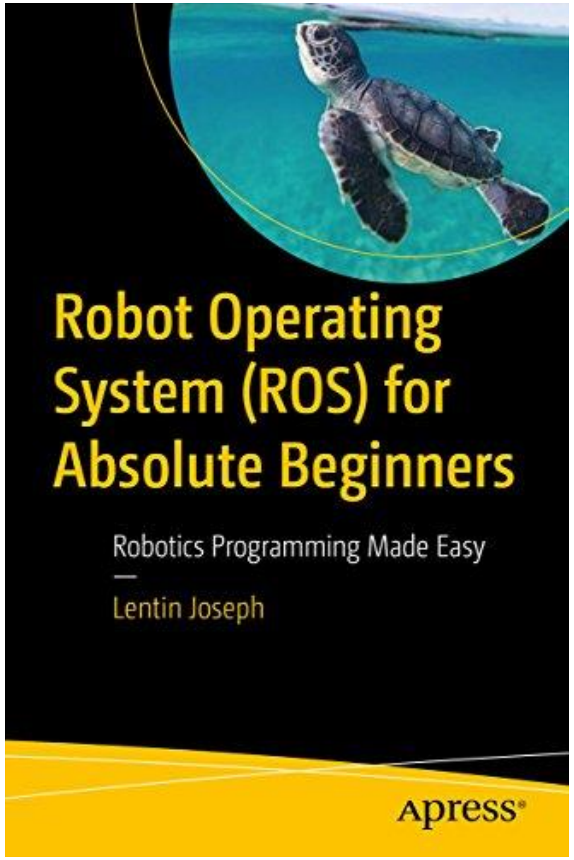
- *spawn_turtle.py* : node that randomly spawn the target (i.e turtle2) in the turtlesim window
- *turtle_to_target.py* : the node that makes the turtle1 move to the turtle2

Further References

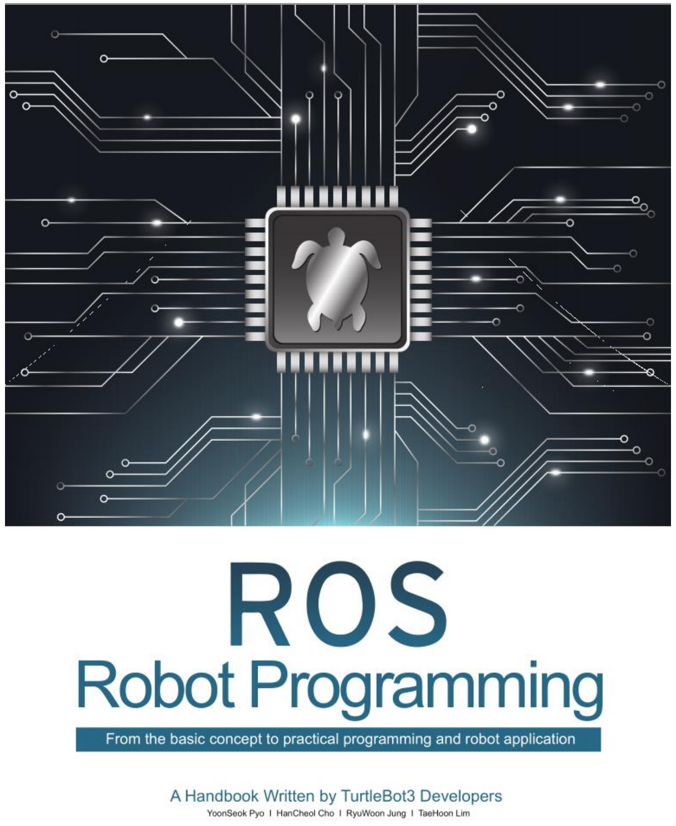
- ROS Turtlesim tutorials
  - wiki.ros.org/turtlesim/Tutorials/

- ROS Cheat Sheet
  - https://www.clearpathrobotics.com/ros-robot-operating-system-cheat-sheet/
  - https://kapeli.com/cheat_sheets/ROS.docset/

Relevant books and sources



Chapter 5



Chapter 10

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SYMME Lab (Systems and Materials for Mechatronics)

move_turtle_to_target_node (Python)

move_turtle_to_target_node.py

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

import rospy
from geometry_msgs.msg import Twist
from turtlesim.msg import Pose
from math import atan2, sqrt
import sys

target_x = 0
target_y = 0
x = 0
y = 0
yaw = 0

# callback for topic /turtle1/Pose
def pose_callback(pose):
    global robot_x
    rospy.loginfo("Robot X = %f\n", pose.x)
    robot_x = pose.x

def move_turtle(lin_vel,ang_vel,distance):

    global robot_x

    rospy.init_node('move_turtle', anonymous=False)
    pub = rospy.Publisher('/turtle1/cmd_vel', Twist, queue_size=10)
    rospy.Subscriber('/turtle1/pose',Pose, pose_callback)
    rate = rospy.Rate(10) # 10hz
    vel = Twist()
```

```python
    while not rospy.is_shutdown():

        vel.linear.x = lin_vel
        vel.linear.y = 0
        vel.linear.z = 0
        vel.angular.x = 0
        vel.angular.y = 0
        vel.angular.z = ang_vel

# Checking the robot distance is greater than the commanded distance
# If it is greater, stop the node
        if(robot_x >= distance):
            rospy.loginfo("Robot Reached destination")
            rospy.logwarn("Stopping robot")

            break

        pub.publish(vel)
        rate.sleep()

if __name__ == '__main__':
    #Providing linear and angular velocity through command line
    move_turtle(float(sys.argv[1]),float(sys.argv[2]),
float(sys.argv[3]))
```

https://raw.githubusercontent.com/LucMarechal/USMB_INFO802_ROS_Lectures/master/turtlesim_tutorials/move_turtle_feedback_node.py