Software Lecture 2:

Getting Started With ROS

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Contents

In this lecture, we shall cover:

- How ROS works (nodes, publishers, subscribers, etc.)
- Installing ROS
- ROSCORE, and running a simple ROS Program
- Creating a workspace to hold our custom packages
- Creating a package to hold our programs and code

Before We Begin

- I strongly suggest bookmarking the following link: https://github.com/OxRAMSociety/RobotArm
- This is the GitHub repository for the robot arm project
- These lectures and all example scripts can be found in: Tutorials/Software Tutorials (2022)
- Have this accessible while you follow along
- If you download these lecture pdfs, you can copy+paste links and Terminal commands

How ROS Works - Overview

- A ROS network is comprised of many individual programs
- These programs work together to achieve a desired function, for example getting a robot arm to move
- To do this, the programs need to be able to communicate and send all sorts of data between each other
- This behaviour is characterised by some key terminology...

Nodes, Publishers, Subscribers, Topics

- Each program is run as a node in the ROS network
- Nodes communicate by sending messages to each other
  - Messages are simple data structures, comprising typed fields (e.g. int32)
- Messages are communicated across topics
  - Topics act like communication lines, or data buses, between nodes
- Publisher nodes send out messages onto a topic
- Subscriber nodes listen to messages on a topic

Really important to be familiar with this terminology! But don't worry, here's an analogy...

Analogy – Sushi Conveyor Belt

Credit to Sneha Ramshaker!

- Sushi chefs put new plates of sushi on conveyor belts
- Customers at a conveyor belt then take sushi from it

Analogy – Sushi Conveyor Belt

Credit to Sneha Ramshaker!

- Chefs and customers are nodes
- Chefs act as publishers
- Customers act as subscribers
- Conveyer belts are the topics
- Sushi itself is the message

Some Further Notes

- A node can be both a publisher and/or a subscriber to multiple topics, and you can also easily set up new topics
- One-way, Many-to-many communication network
  - When any publisher publishes a message to a topic, ALL subscribers to that topic receive the message
    ALL customers at the same conveyor belt get a piece of sushi from the new plate!
- Nodes can also interact with each other in more direct ways using ROS actions and services, but we will cover these in later lectures

Time to Install ROS!

http://wiki.ros.org/noetic/Installation/Ubuntu

- **Load Terminal and follow steps 1.1-1.6 from the linked tutorial to install ROS Noetic, noting the following:**

1. **In step 1.4, choose the Desktop-Full Install**

2. **In step 1.5, run the commands listed for Bash**

This modifies your bashrc file so that the command that sets up ROS-specific Bash commands is automatically called every time you open a new terminal – this will save you from a lot of tedium in the future!

Testing the Installation

- **Open a new Terminal and run roscore**

- You should see something very similar to the following:

```
jacques@JC-Workstation:~$ roscore
... logging to /home/jacques/.ros/log/dbbf55aa-ce4d-11ec-b088-314771286010/rosla
unch-JC-Workstation-8725.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://JC-Workstation:37707/
ros_comm version 1.15.14


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.14

NODES

auto-starting new master
process[master]: started with pid [8735]
ROS_MASTER_URI=http://JC-Workstation:11311/

setting /run_id to dbbf55aa-ce4d-11ec-b088-314771286010
process[rosout-1]: started with pid [8745]
started core service [/rosout]
```

What is ROSCORE?

- ROSCORE is a collection of core nodes and programs that form the foundations of a ROS-based system
- ROSCORE MUST be running in order for your ROS nodes to communicate with each other
- Think of it as the underlying web that automatically connects all of your nodes together

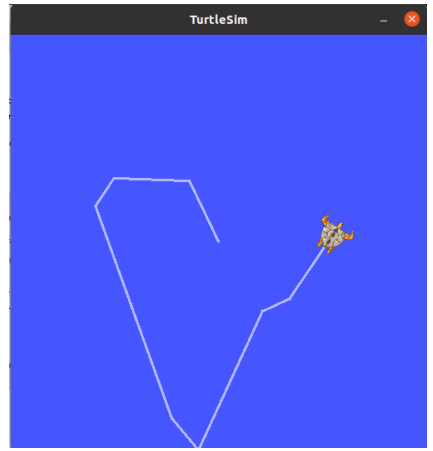
Running Your First ROS Program

- **Open two more terminals and run the following:**

Terminal 2: rosrun turtlesim turtlesim_node

Terminal 3: rosrun turtlesim turtle_teleop_key

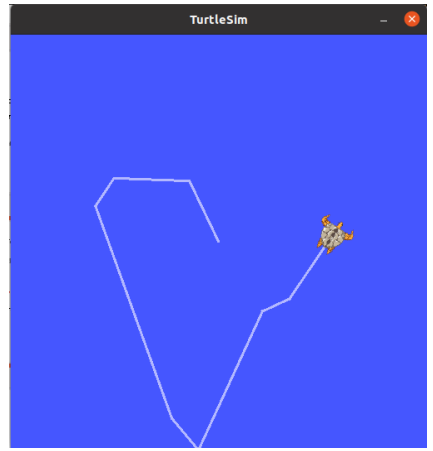
- You should see a turtle that can be controlled by your keyboard – try driving it around



Publishers and Subscribers in Action

- The commands you ran set up two nodes

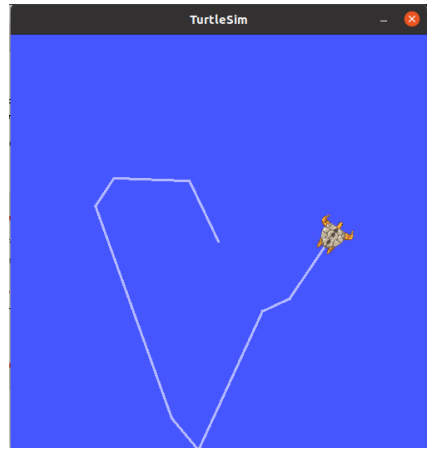
- turtlesim_node generates the turtlesim environment which acts as both a subscriber and a publisher – it listens to incoming velocity messages for the turtle, and sends out messages about the turtle's pose (i.e. position and orientation)



- turtle_teleop_key acts as a publisher – it sends out velocity messages for the turtle according to your inputs into the keyboard

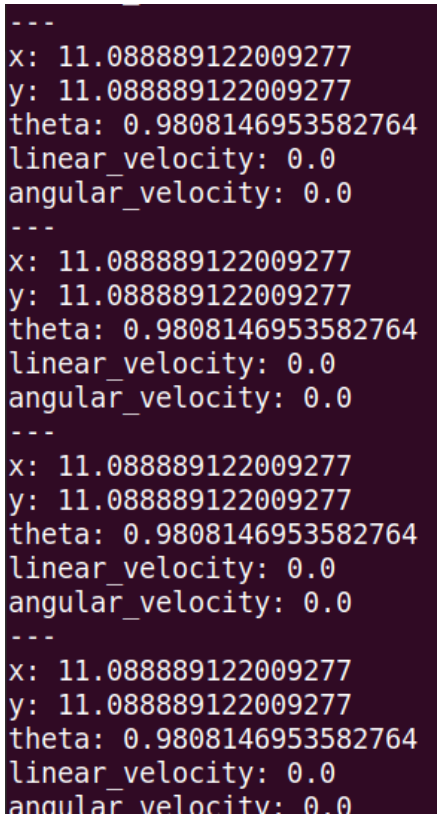
Publishers and Subscribers in Action

- **Open a fourth terminal and run rostopic list**
- This (very helpful) command shows you the names of all topics that are currently active
- In this case, the /turtle1/cmd_vel topic is used to exchange velocity command messages
- Meanwhile, the /turtle1/pose topic is used to exchange messages describing the turtle's pose



Topics and Messages in Action

- We can directly read the contents of messages
- **Now run rostopic echo /turtle1/pose and observe the output**
- You will see a stream of messages describing the turtle's live pose, continually being published by the node running the turtlesim
- Click on the Terminal running turtle_teleop_key and make the turtle move – see how the messages published change as it moves



Killing a Program

- To kill a program that is running in Terminal, **press Ctrl+C while that Terminal is selected**
- **Try doing this now for all terminals currently open**
- It is good practice to always do this before closing any Terminal with a program running inside it

Packages and the Workspace

- Programs and software in ROS are neatly organised and bundled together into directories called packages
- A (catkin) workspace is a folder where you can modify, build, and install these packages
- When you want to use some ROS software, you install the package for it into your workspace

Creating a Workspace

Exit all Terminals and load up a new one;

- **Install catkin:** sudo apt install ros-noetic-catkin python3-catkin-tools python3-osrf-pycommon **(all one line!)**
- **Also install wstool:** sudo apt install python3-wstool
- **Now create a directory to host the workspace:**
  mkdir -p ~/tutorial_ws/src
- **Navigate to the source folder:** cd ~/tutorial_ws/src

Creating a Workspace

- **Run the following command to add missing dependencies:**
  rosdep install -y --from-paths . --ignore-src --rosdistro noetic
- **Navigate to the main workspace directory: cd ~/tutorial_ws**
- **Run the following: source /opt/ros/noetic/setup.bash**
- **Configure the properties for the workspace:**
  catkin config --extend /opt/ros/noetic
- **Build the workspace: catkin build**

Sourcing the Workspace

- **We must also source the workspace; to do this, run this line:**
  source ~/tutorial_ws/devel/setup.bash
- **Add the above command to your bashrc to automate it:**
  echo 'source ~/tutorial_ws/devel/setup.bash' >> ~/.bashrc

The Workspace

- The workspace is made up of four main directories
- Source space contains the source code for all your installed and custom packages – this is where we will create new packages
- The other three directories are important for the functionality of the workspace but not covered here

An Aside – Building the Workspace

- Why did we have to build the workspace?
- Building is the process of compiling source code into stuff like executable programs
- In our case, each ROS package needs to be built before we can use the stuff they provide
- The catkin build command automatically builds every package in the workspace whilst handling the interactions and dependencies between packages when building!

Creating a Package

- To properly start making use of ROS, we will write our own programs and code – we will do this in custom packages
- **Navigate into the Source folder: cd ~/tutorial_ws/src**
- **Create a new package:**
  catkin_create_pkg tutorial_scripts std_msgs rospy
- The first argument is the package name, and all following arguments are the dependencies, i.e. the other packages required for use by the new package

Creating a Package

- **Now return to the main workspace directory (cd ..) and rebuild the workspace: catkin build**
- Now we have a custom package ready to house our own programs and code!
- Note that every time you add a new package to the workspace, you will need to rebuild the workspace to incorporate that new package

Downloading & Installing Packages

- There are many packages freely available for you to install, providing all sorts of useful functionality
- Before installing a package, always update your Debian package index: **sudo apt update**
- To find available packages: **apt search ros-noetic**
- To install a package: **sudo apt install name-of-package**

Final Note: The ROS Wiki

- http://wiki.ros.org/Documentation
- Incredibly useful source of knowledge for all things ROS
  - Plenty of documentation on core ROS functionality
  - Info on many useful packages
  - Tutorials and example code to help you learn

Summary

We covered:

- How ROS works (nodes, publishers, subscribers, etc.)
- Installing ROS
- ROSCORE, and running a simple ROS Program
- Creating a workspace to hold our custom packages
- Creating a package to hold our programs and code

Homework: Familiarise yourself with ROS terminology (p.5), finish setting up workspace

Next time, we will code up our first ROS program!

Thank You!

Any Questions? Contact jacques.cloete@trinity.ox.ac.uk