COMP3431

Robot Software Architectures

Week 1 – Introduction to ROS

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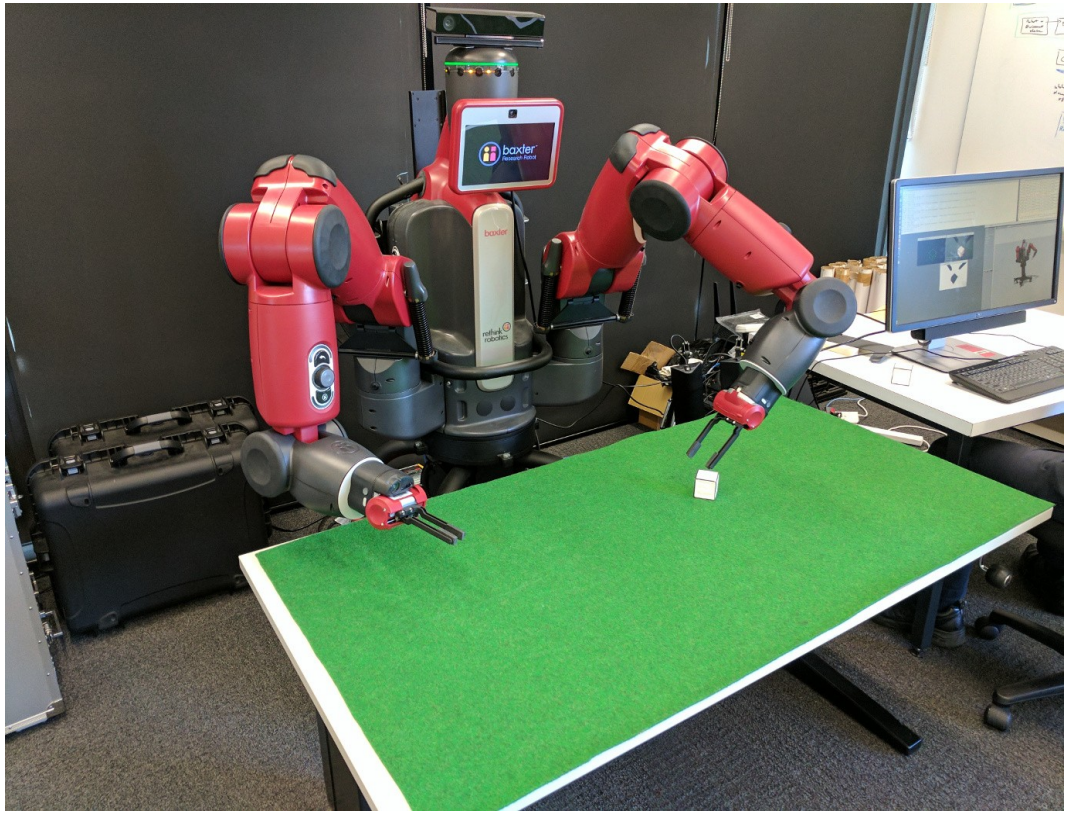
Robots in the Wild

- RoboCup
  - Fast Goal
  - Goalie Save
  - Goal!
  - We All Fall Down
  - 2014 SPL Final rUNSWift v HTWK
- Rescue
  - Negotiator Mobility Chalenge
  - 2011 Rescue Reel
  - 2010 Rescue News Cast
- At Home
  - 2014 Brown Bears Qualification Video
  - Nimbro 2013 Winners
- Other Robots
  - BigDog Overview
  - BigDog Beta
  - Darpa Robotics Challenge

My Research in Robotics

- Cognitive Robotics.
- Make robots behave intelligently.
- Connect high level cognition with low-level sensing/actuators.
- Working with Baxter.
- Blocksworld video...



Course Timetable

- Lectures
  - Monday 12:00-14:00. Civil Engineering (H20) G6.
- Tutorials / Labs
  - Monday 14:00 – 15:00. Mech Eng (J17) level 5 robotics lab.
  - Wednesday 10:00 – 12:00. Mech Eng (J17) level 5.

Expectation

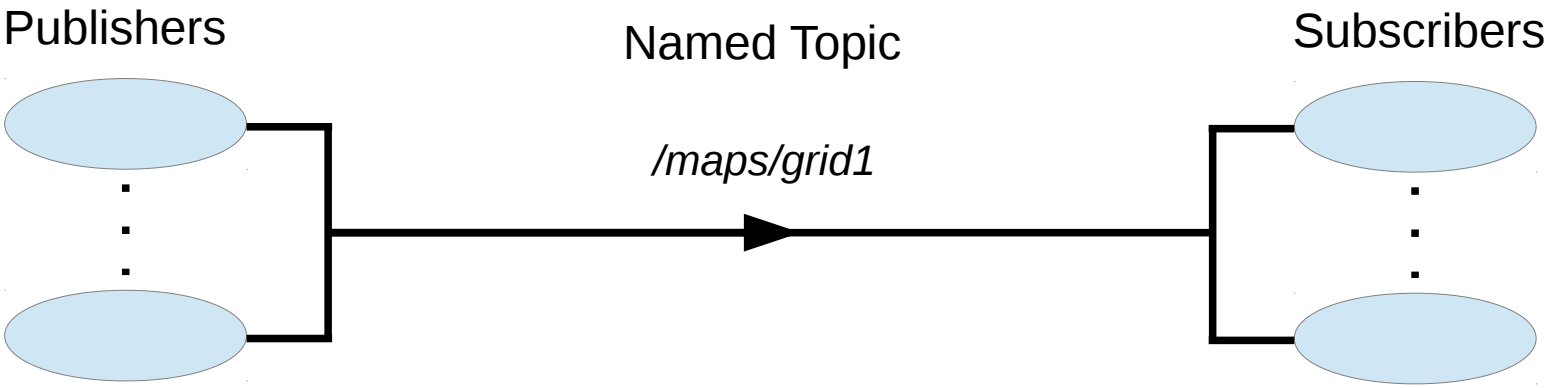
- C++ / Python.
- Version Control (git).
- Patience – expect things to go wrong.
- Consideration – some team work required.

Overview of ROS

- ROS (Robot Operating System) - open-source platform.
- NOT an operating system.
- Peer-to-peer comms for distributed processes (*nodes*).
- Library of drivers, filters (e.g., mapping), behaviours (e.g., navigation).
- Not real-time.
- OS agnostic (in theory).
- Language agnostic:
  - Rich APIs for Python and C++, but also other languages.

ROS Basics

- ROS Nodes - registration at process startup.
- Two models of comms between nodes:
  - ROS Topics: Publisher-subscriber (many-to-many).



*Commonly: one publisher and many subscribers

ROS Basics

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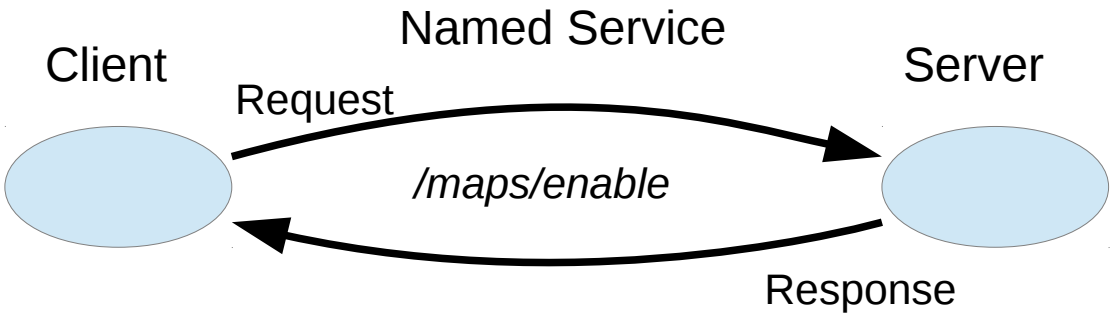
  - ROS Services: remote procedure call (one-to-one).



ROS Basics

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- Two models of comms between nodes:
  - ROS Topics: Publisher-subscriber (many-to-many).
  - ROS Services: remote procedure call (one-to-one).
- ROS *ActionLib*
  - Services with incremental feedback.
  - built using ROS topics.

Messages

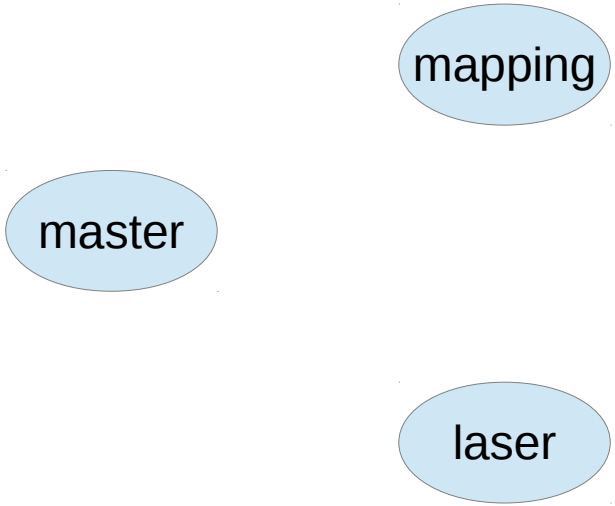
- Topics and services use a well-defined message format:
  - Primitive types (e.g., int8, bool, string, etc).
  - User-defined types (e.g., geometry_msgs/Point, sensor_msgs/LaserScan).
  - ROS takes care of generating language bindings (e.g., C++, Python).

geometry_msgs/Point

float64 x
float64 y
float64 z

Topic Setup

- TCP/IP model - nodes can run on same or different computers.
- ROS *master* provides directory services.
- Scenario: *laser* node publishes and *mapping* node subscribes.



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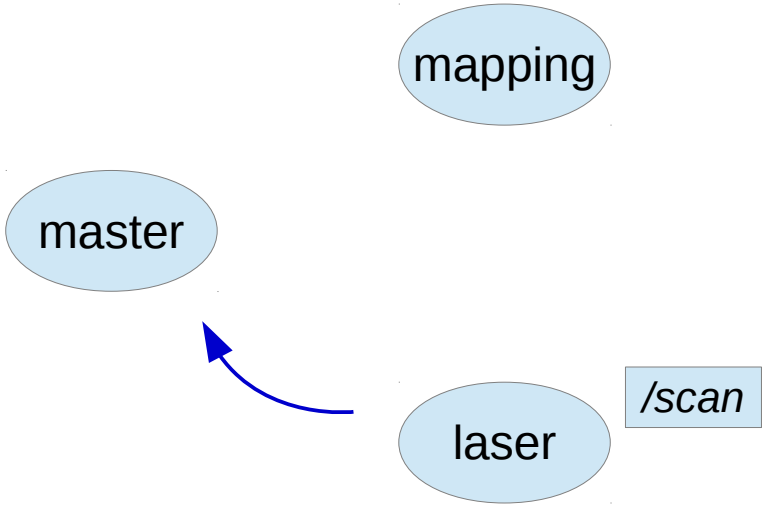
Laser node registers with master that it is publishing laser scans on a topic (with some name).



Topic Setup

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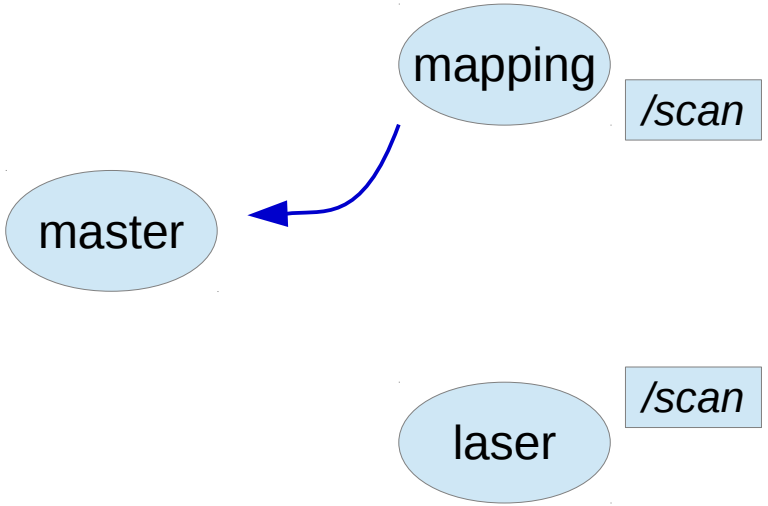
Mapping node registers with master that it is subscribing to the topic name.



Topic Setup

- TCP/IP model - nodes can run on same or different computers.
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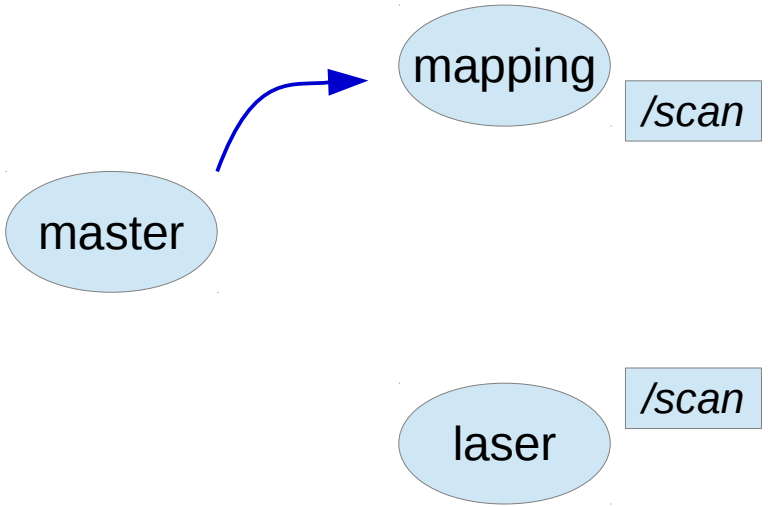
- Scenario: *laser* node publishes and *mapping* node subscribes.

Master tells mapping node that the laser node is publishing the topic.



Topic Setup

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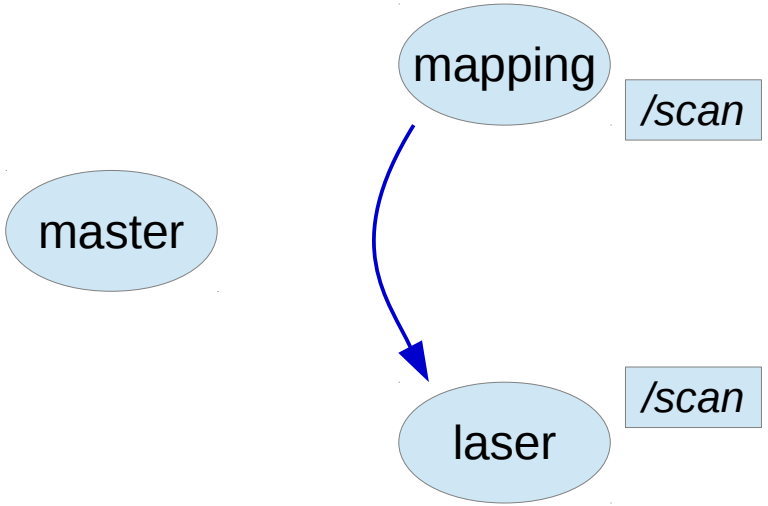
Mapping node initiates direct connection with laser node.



Topic Setup

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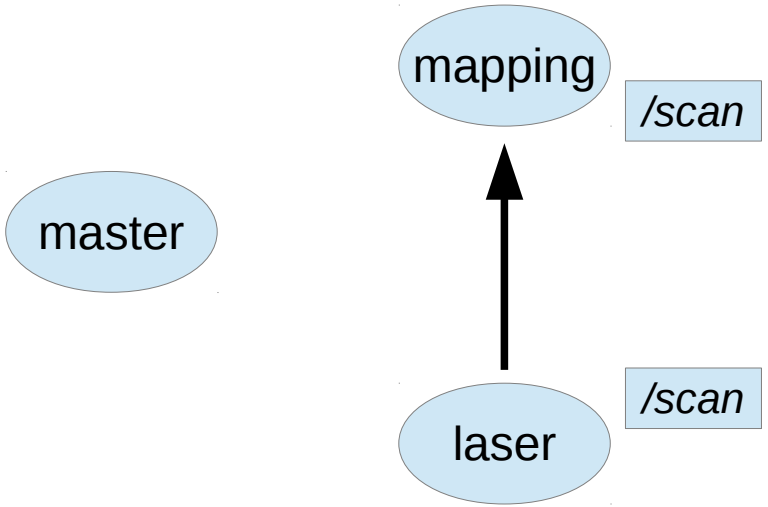
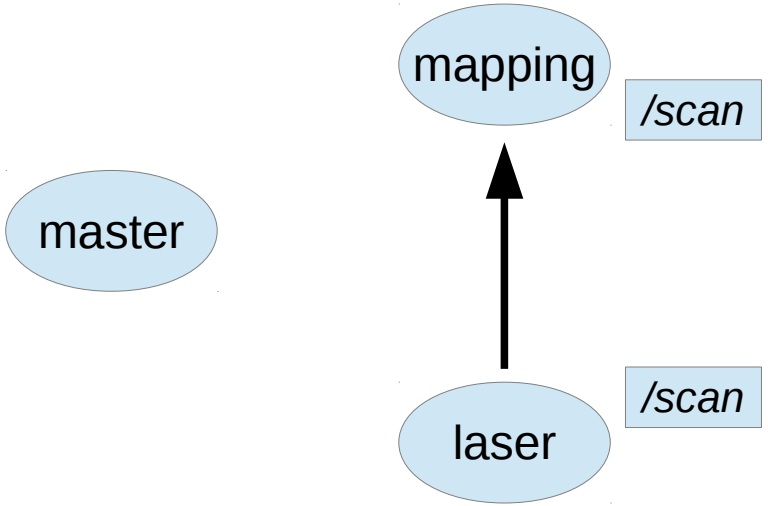
Laser node publishes and mapping node receives laser scan messages.



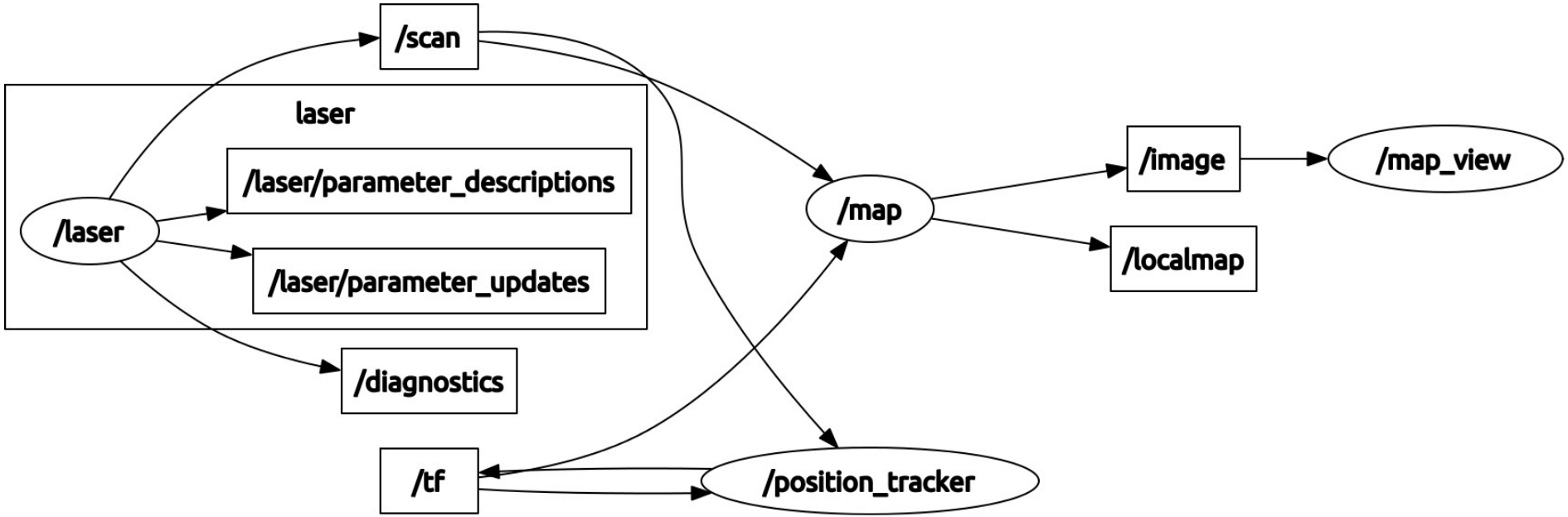
Topic Setup

- TCP/IP model - nodes can run on same or different computers.
- ROS *master* provides directory services.
- Scenario: *laser* node publishes and *mapping* node subscribes.

- NOTE: In reality a bit more complicated:
  - Laser node does not have to register first
  - Multiple publishers and multiple subscribers
  - But same outcome - **peer-to-peer data transfer**



Node/Topic Example



Nodes in a Distributed System

- Nodes can be on different computers.
- Requires some care:
  - Turn off local firewalls
  - Evironment variables to specify addresses of nodes and master:
    - ROS_MASTER_URI - location of the master.
    - ROS_IP - node will register with master using this value.
  - Safest to use IP addresses (not hostnames).

```
export ROS_MASTER_URI=http://192.168.1.2:11311
export ROS_IP=192.168.1.5
```

Catkin Packages

- *Catkin* – the ROS build system:
  - Combines *CMake* (popular C++ build tool) and some Python components.
- User-built components are organised in *packages*.
- A typical package:

```
mypackage/
    CMakeLists.txt    - CMake building
    package.xml       - dependencies between packages
    src/              - source directory: C++/Python/Java/etc
    include/          - typical for C++ headers
    scripts/          - typical for Python
    setup.py          - python installation file
```

- Use the Catkin tools: `catkin_create_pkg my_package depend1 ...`

Packages – Flexible Structure

- Dependencies to other packages.
- Custom *messages* and *service* definitions.
- Specify nodes - 0 or more.
- Libraries – export for use by other packages.

Catkin Workspaces

- Used for compiling and running a catkin system.
- Workspace layout:

```
catkin_ws/
    src/                  - individual packages placed here
      my_package/
    build/                - install location for development files
    devel/
```

- Catkin tools are run within workspace directory.
- To compile your workspace:

```
$ cd catkin_ws
$ catkin_make
```

Names and Namespaces - Warning

- ROS uses namespaces in different contexts.
- Positive: easy to avoid name clashes.
- Negative: can create confusion.
- Do not confuse namespace usage in:
  - Node names.
  - Topic names.
  - Frames of reference – to be discussed later.
- Node name "/mynode/laser" is different from frame "/mynode/laser".

In-Class Examples

- Let's create a simple publisher and subscriber (both in Python and C++).
- Simple example - track location of a robot. (ignoring orientation):
  - Publisher - publish a geometry_msgs/Point.
  - Subscriber can then use data (eg., to locate robot on map).

Laboratories

- Work through the ROS tutorials.
  - http://wiki.ros.org/ROS/Tutorials.
  - Note: we use ROS Indigo for compatibility with various robots.
- First assignment:
  - due week 4 – 5.
  - Turtlebot navigation and recognition task.
  - Get started now!