Industrial Robotics | Fundamentals of Robotics and Bionics 2025/2026
Mechanical Engineering | Biomedical Engineering
Faculty of Sciences and Technology - University of Coimbra
Software Installation Guidelines

Software requirements, for this course:

- MatLab (2021b or later) [~7GB of disk space].
- Virtual Machine 'Player' software (VMware Workstation / Fusion Pro).
- Virtual machine image file w/ everything pre-installed [file w/ ~25GB of disk space]
  - Includes Gazebo 9, the robot simulator and and the Robot Operating System (ROS Melodic)
- 'TurtleBot3-vxx.zip' package [ROS interface between MatLab and the TurtleBot3 robot], available at course repository.

1. MatLab Installation (2021b or later)

Go to the Mathworks website, login with your student account, download and install the latest version.
https://www.mathworks.com/products/get-matlab.html?s_tid=gn_getml

The following toolboxes are required:
- Image Processing Toolbox.
- Robotics System Toolbox.
- ROS ToolBox.
- Computer Vision ToolBox.
- Image Acquisition Toolbox.
- Statistics and Machine Learning Toolbox.

2. Virtual Machine (VM) image

2.1. Download VM image

Download the virtual machine image with the robot simulador already installed (on a guest OS: Ubuntu 18 Bionic).

- VMware compressed image (7.8GB) [Mega]:
https://mega.nz/folder/yIFHFbBJ#WIA1Ohc4neIRhMg5KriP4w

- Alternative link [OneDrive]:
https://universidadedecoimbra154-my.sharepoint.com/:f:/g/personal/uc44454_uc_pt/EqO_zHLVXJdOmSiriJ61iVYBVk4BaUsWThiHYPqGGIYY0A?e=eqj3sg

This file needs to be uncompressed, which results in a folder with 25GB.

2.2. Virtual Machine 'Player' (software to run the VM image)

- Windows users could use VMware Workstation Pro software (free for personal use).
- MacOS (Intel) users have the equivalent VMware Fusion Pro (free for personal use)).
- MacOS (Apple Silicon) only have a limited solution (see notes at the end of document).

- VMware Workstation Pro 17.0 (windows) [version installed in classroom]:
https://mega.nz/folder/aAUQxAZT#p4fO-MxDeOHUJHPQ2XEmMA

- VMware Fusion Pro 13.6 (macOS):
https://mega.nz/folder/ud9TnLjS#bffPUQ2fhwbDs3n-NpvJzg

• (Newer VMware versions are available but it requires creating a free Broadcom account) Download and install VMware Workstation/Fusion Pro software (official Broadcom link): https://support.broadcom.com/.../Workstation176 (windows 64-bits or macOS).

2.3 Initial Setup

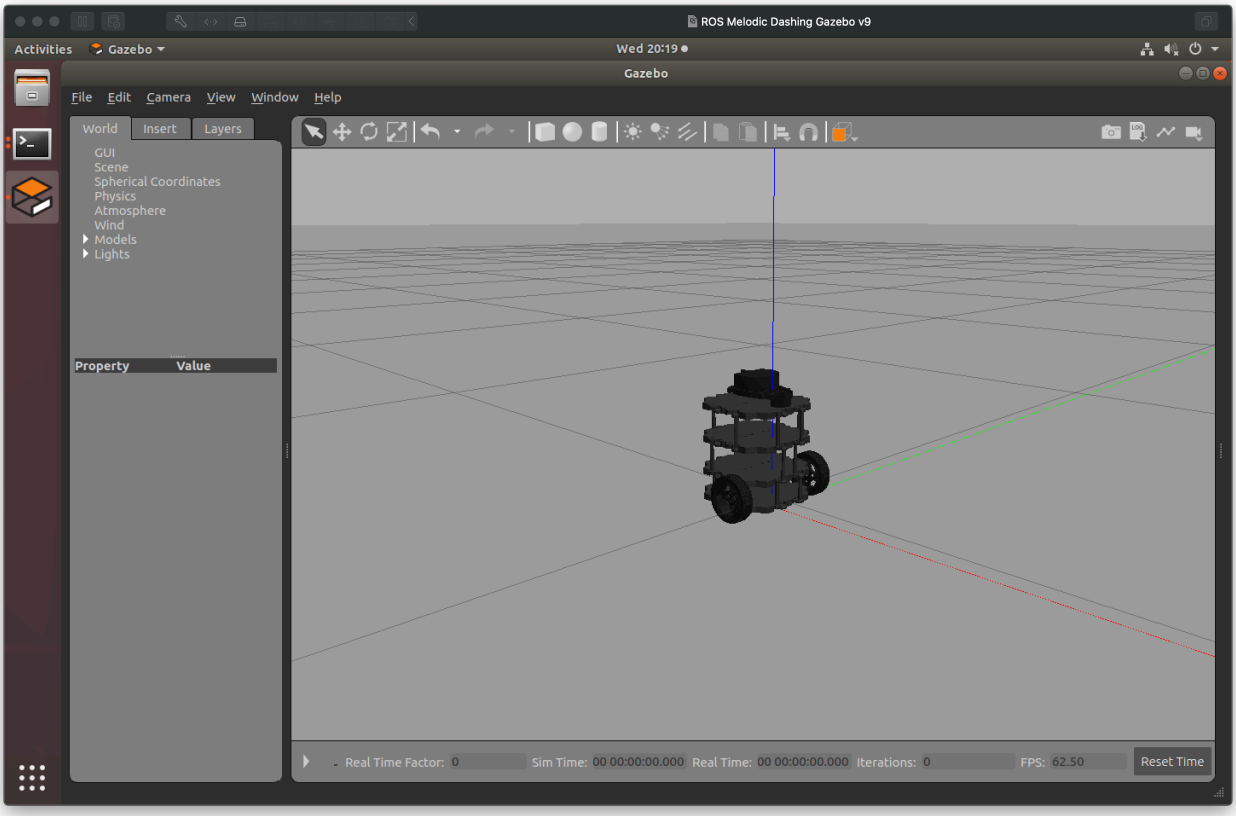
- Decompress the VM image archive to a location on your hard drive.
- Start VMware Workstation (or VMware Fusion if you are using an macOS device).
- Press Open a Virtual Machine.
- Browse to the location of the Ubuntu image, select the ros_melodic_dashing_gazebov9.vmx file.
- Start the virtual machine.
- (Press "I copied it", if a window opens that asks if you copied or moved the virtual machine)

2.4. Run Virtual Machine

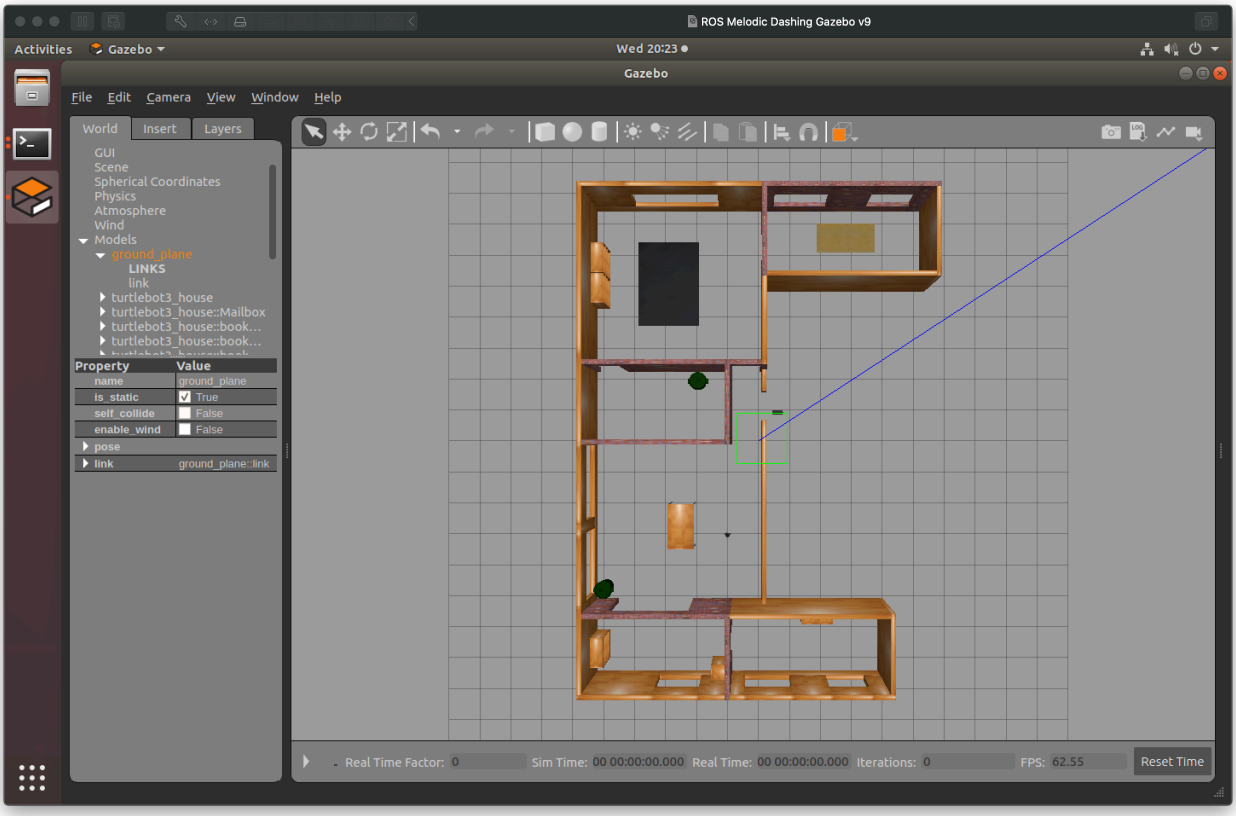
Check VM settings before running the first time.
- 2 processors w/ 4GB RAM is enough (in older machines select just 1 CPU and 2GB RAM).
- [Optional] Choose Bridged Network (autodetect) in the network adapter section.
  Bridged network allows the VM IP address to be in the same range that the host machine.

- Launch the virtual machine.
- Check the username, password and IP address (shown at the wallpaper's top right)
- **Update the keyboard layout**, in Settings App (language and region - input sources).
- The display resolution could be adjusted in the Settings App > Devices > Screen Display.

- Open terminal, and run the start-up (empty) Gazebo world:
  `user@ubuntu:~$ ./start-gazebo-empty.sh`



Gazebo simulation, in an empty world, with the TurtleBot3 robot.



House world simulation with TurtleBot3.

- For TurtleBot3 examples, use the previous Gazebo Empty or Gazebo House scripts (`start-gazebo-house.sh`)

3. Download 'TurtleBot3-vxx.zip' MatLab package

The 'TurtleBot3-vxx.zip' includes:
- MatLab class (`TurtleBot3.m`) file. Main class that allows to interface between MatLab and the TurtleBot robot (real/simulated).
- Multiple 2D & 3D maps (maps folder).
- Tools folder (utility functions).
- Code demo examples.

3.1 Download package

The 'TurtleBot3-vxx.zip' is available at course repository webpage (https://ucteacher.uc.pt/).
Download it, uncompress all files and copy them to the MatLab working folder.

3.2 Install 3D maps

3.2.1. Copy the entire "maps" folder to the virtual machine (to any location):

- Some virtual machines also support simple drag-and-drop functionality.
- Windows users can use WinSCP (https://winscp.net/) to copy data between you computer and the virtual machine (use a sftp connection).
- MacOs users can use the free Cyberduck App.
- Linux users just need to write in the location path: sftp://user@192.168.10.xxx (replace with the IP of virtual machine).
- Some virtual machines also support simple drag-and-drop functionality.

3.2.2. Open terminal, navigate to the directory location of the maps folder, and run the install script as:
>> user@ubuntu:~$ sh install_maps.sh
The message "---done---" should appear upon a successful installation.
The home folder (/home/user) should hold ten new scripts (start-gazebo-"map".sh).

[3.2.2. Uninstall 3D maps]
Similarly, all maps and respective configuration files can be removed by running the uninstall script.
>> user@ubuntu:~$ sh uninstall_maps.sh

3.3 [Optional] Compile* Auxiliary ROS Messages (access to low level encoders data in real TurtleBot robot)

* Only supported in linux64 and mac64 systems. Requires python** and cmake.
(** Matlab 2021b requires python 2.7. Matlab 2022b, or later, requires python 3.9).

3.3.1. Check which python and cmake versions are installed (and detected by MatLab):
`TurtleBot3('check-versions');`
If all packages are installed but not detected, go to the `setupPath()` function (in `TurtleBot3.m`) and modify the PATH settings according to your system.
After that run: `TurtleBot3('setup-path');`

3.3.2. Compile auxiliar sensors-state ROS message:
`TurtleBot3('setup-sensors-msg');`

3.3.3. Check if new ROS message is available:
`TurtleBot3('check-sensors-msg');`

4. Run MatLab demos:

In the provided demos, the TurtleBot is initially controlled under a MatLab environment, that issues commands (thought ROS) to the Gazebo simulator. Later on, this procedure is extended to the real robot.

- Edit each `demoXXX.m` file and update the local host and virtual machine IP addresses (i.e. modify the `IP_OF_TURTLEBOT` and `IP_OF_HOST_COMPUTER` string variables).
- The IP address of you machine can be found using the `ifconfig` terminal command (linux and Mac) or `ipconfig` (Windows).
- **Note** (Windows users): Accept firewall rules for `libmwros1server` service in both private and public network profiles, when asked for the first time.

4.1. Read robot location (pose)

- Launch the virtual machine.
- Open terminal, and start the empty Gazebo world (`./start-gazebo-empty.sh`).

- Launch MatLab (host machine)
- Run the `demoPose.m`

4.2. Read Lidar data

- Launch the virtual machine.
- Open terminal, and start the house Gazebo world (`./start-gazebo-house.sh`).

- Launch MatLab (host machine)
- Run the `demoLidar.m`

4.3. Teleoperation with keyboard

- Launch the virtual machine.
- Open terminal, and start the house Gazebo world (`./start-gazebo-empty.sh`).

- Launch MatLab (host machine)
- Run the `demoKeyboardOperation.m`

4.4. Add 3D virtual obstacles

- Launch the virtual machine.
- Open terminal, and start the empty Gazebo world (`./start-gazebo-empty.sh`).

- Launch MatLab (host machine)
- Run the `demoGazeboObjects.m`

5. Operate with real TurtleBot3 mobile robot

The available TurtleBot3 robot is configured to connect via the `TurtleNet` WIFI network. It has the following (static) IP address:

```
IP: 192.168.10.200
```

5.1. Connect to TurtleNet WIFI network

Use the following network information:

```
SSID: TurtleNet
password: turtleRI23
```

Upon connection, your machine should have an IP in range of 192.168.10.xxx.
This is you `IP_HOST_COMPUTER` value.

5.2. Connect to a robot via secure-shell protocol (ssh)

In Windows, an external ssh client is required. Use Putty (https://www.putty.org/).
Fill the Host name / IP Address text box with `192.168.10.200` when using TurtleBot3 and then click Open. The username is `pi` and the password is `turtlebot3`

In Linux and MacOs, simply open a terminal session and write:

```
>> ssh pi@192.168.10.200
>> password = turtlebot3
```

5.2.1. Startup ROS server

Upon connection by ssh, start the ROS server by typing in the following command:

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

Wait for startup, while a set of log messages are being shown. Proceed after receiving `'[INFO] [xxx]: Calibration End'` status. The ROS server is now running.
The shell session should remain open during the entire operation with the robot.

For terminate ROS server, press: **`[ctrl + c]`**

5.3. Connect using MatLab

Update your code with updated connection settings:

```
IP_TURTLEBOT = "192.168.10.200";                    % TurtleBot IP
IP_HOST_COMPUTER = "192.168.10.xxx";                % local machine IP
tbot = TurtleBot3(IP_TURTLEBOT, IP_HOST_COMPUTER); % init connection
```

Run as standard.

5.4 Shutdown TurtleBot

Termine the ROS server (by pressing **`[ctrl + c]`** in the previous shell session).

Shutdown the robot Operation System:

```
>> sudo shutdown now
```

Power down OpenCR (robot's controller):

```
Turn off power switch.
```

6. References (and useful links):

• TurtleBot3 resources:
https://emanual.robotis.com/docs/en/platform/turtlebot3/features/#features
https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation/

• VMware compressed original Ubuntu18+ROS+Gazebo image file (7.8GB) [MathWorks server]:
https://ssd.mathworks.com/supportfiles/ros/virtual_machines/v2/ros_melodic_dashing_gazebov9_linux_win_v4.zip

• Disable IPv6 on Ubuntu:
https://itsfoss.com/disable-ipv6-ubuntu-linux/

• Manually Install ROS (Melodic) + TurtleBot3 Simulation Package (in Ubuntu 18 LTS):
http://wiki.ros.org/melodic/Installation/Ubuntu
https://emanual.robotis.com/docs/en/platform/turtlebot3/quick-start/
https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation/#gazebo-simulation

• Virtualization software for Apple Silicon Macs:
The current virtualization software solutions compatible with Apple Silicon are the VMmare Fusion (v13+) and Parallels Desktop (v18 or higher). However, the available ROS + Ubuntu 18 image file is only compatible with Parallels Desktop.

Parallels Desktop (free limited amount of time)
https://www.parallels.com/eu/products/desktop/

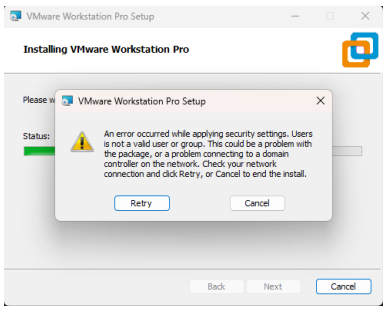
Download ARM specific ROS + Ubuntu image (compress 3.64GB zip) [only for Parallels Desktop]
https://mega.nz/folder/bU1XXAKD#xBpKH3l7LxcLlORgknwiSw

Uncompress (~10.3GB) and import using Parallels Desktop.
The default username and password is “user”/“password”, respectively.

• Direct link for VMware Workstation Pro 17.6 (windows)
https://mega.nz/folder/6UkH2aST#S89wKZVsJWVJrxlblW2xNQ

• VMware Workstation Pro 17.6 - “security settings” installation error (Windows)
Open window terminal: Start menu -> search for ‘cmd’, then execute the following commands:

```
net localgroup /add "Authenticated Users"
net localgroup /add “Users”
```



(source: https://community.broadcom.com/vmware-cloud-foundation/discussion/vmware-workstation-176-does-not-install)

• Alternative Virtualization Software - Virtual Box
Official website: https://www.virtualbox.org/wiki/Downloads

• Ubuntu+ROS+Gazebo image file for Virtual Box
ROS-VM-VirtualBox