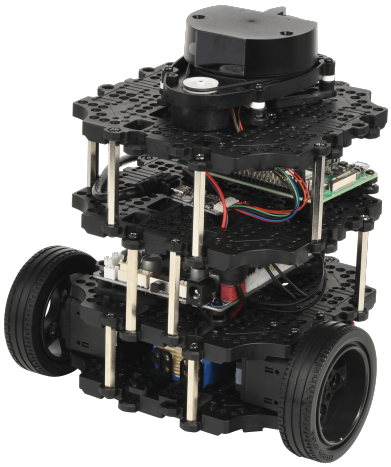
Robot Design Lab
WiSe 2022/2023

Installation Guide

Linux and ROS 2



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1. Introduction

Welcome to the Robot Design Lab course!

In this class you will work with Turtlebot3 Burger robots. In order to connect to the robots, send commands and read data, you have to setup your PC first.

You will need the following:

- **Ubuntu 22.04** operating system.
  - **Option 1:** fresh installation that overwrites your current operating system (OS) or dual boot (see section: Linux Installation). HIGHLY RECOMMENDED![1]
  - **Option 2:** setup a virtual machine in your existing OS where you can install Ubuntu 22.04. After you install the virtual box software (see section: Install Virtual Box), you have again two options:
    - **Option 2.1:** Setup a new virtual box and install Ubuntu 22.04 there (see section: Create a New Virtual Machine).
    - **Option 2.2:** Use the virtual box image that we provide as a .zip file. This comes with Ubuntu 22.04 and ROS 2 Humble installed (see section: Setup Virtual Machine from File).
- **ROS 2 Humble** middleware installed in Ubuntu 22.04 (see section: ROS 2 Humble Installation).

Now we can get started with the installation. Let's go!

[1] During testing we noticed that the VirtualBox sometimes loses the connection to the robot so it should only be used for testing, not for longer tasks like mapping or a competition!

2. Linux Installation

This section is for students who would like to fully boot their system on Ubuntu 22.04. Linux is a widely used operating system so you should consider doing it soon if you would like to work in robotics or computer science.

Note: You can also install Ubuntu 22.04 as a **dual boot** along with your current operating system provided you have enough storage space available on your hard disk. However, this is a more advanced setup, therefore we don't provide a standard installation setup. Please feel free to look up for resources online on dual boot installation for your particular needs.

2.1 Ubuntu 22.04

Please follow the instructions below to make a fresh installation of Ubuntu 22.04 on your computer.
Note: This will format your laptop! If you do not want this, go to the Virtual Machine section.

- Download Ubuntu Image file here: `https://ubuntu.com/download/desktop`.
- Download "balenaEtcher" here: `https://www.balena.io/etcher/`.
- Open balena Etcher, click "Flash from file" and choose the .iso Ubuntu file you downloaded.
- Connect an USB-stick to your PC that is empty or with data that can get deleted.
- Click the "Select target" and choose the USB-Stick.
- Click on "Flash!"
- When balena Etcher is done turn off your system, and insert only the USB.
- Turn on your system and boot from USB (you can do this using BIOS/Boot Menu - check how to access this for your specific laptop).
- When this is done you can try/install Ubuntu.

3. Virtual Machine

In this section you will learn how to set up a virtual machine in your existing operating system. After you install the Virtual Box software, you will have to install Ubuntu 22.04 and ROS 2 Humble in a new virtual box. There are two option to do so:

- Setup a new virtual box where you install Ubuntu 22.04 and ROS 2 Humble.
- Use the virtual box image that we provide as a .zip file. This comes with Ubuntu 22.04 and ROS 2 Humble installed already.

3.1 Install Virtual Box

The virtual machine can be downloaded and installed from the link below:
`https://www.oracle.com/de/virtualization/technologies/vm/downloads/virtualbox-downloads.html`

Note: select the correct operating system for your current installation and make sure to have at least 20 GB of free disk space on your computer before continuing.

3.2 Create a New Virtual Machine

1. Open Virtual Box and click the New button in the toolbar.
2. Type in a descriptive name for the operating system and select the operating system that you want to install later (i.e Ubuntu (64-bit)). Click on next to proceed.
3. Increase the memory size of RAM to 6470 MB min and click Next.
4. Select "Create a virtual hard disk now" and click Create.
5. Select "VirtualBox Disk Image (VDI)" and click Next.
6. Choose a Fixed size virtual hard disk to have better performance, and click Next.
7. Select 20 GB min for the hard disk space. Then click Create.

It might take several minutes to create the virtual hard disk.

3.2.1 Install Ubuntu in Virtual Machine

As a prerequisite, you will first have to download the Ubuntu Desktop image file.

Link for download: `https://ubuntu.com/download/desktop`.
Version: Ubuntu 22.04.1 LTS

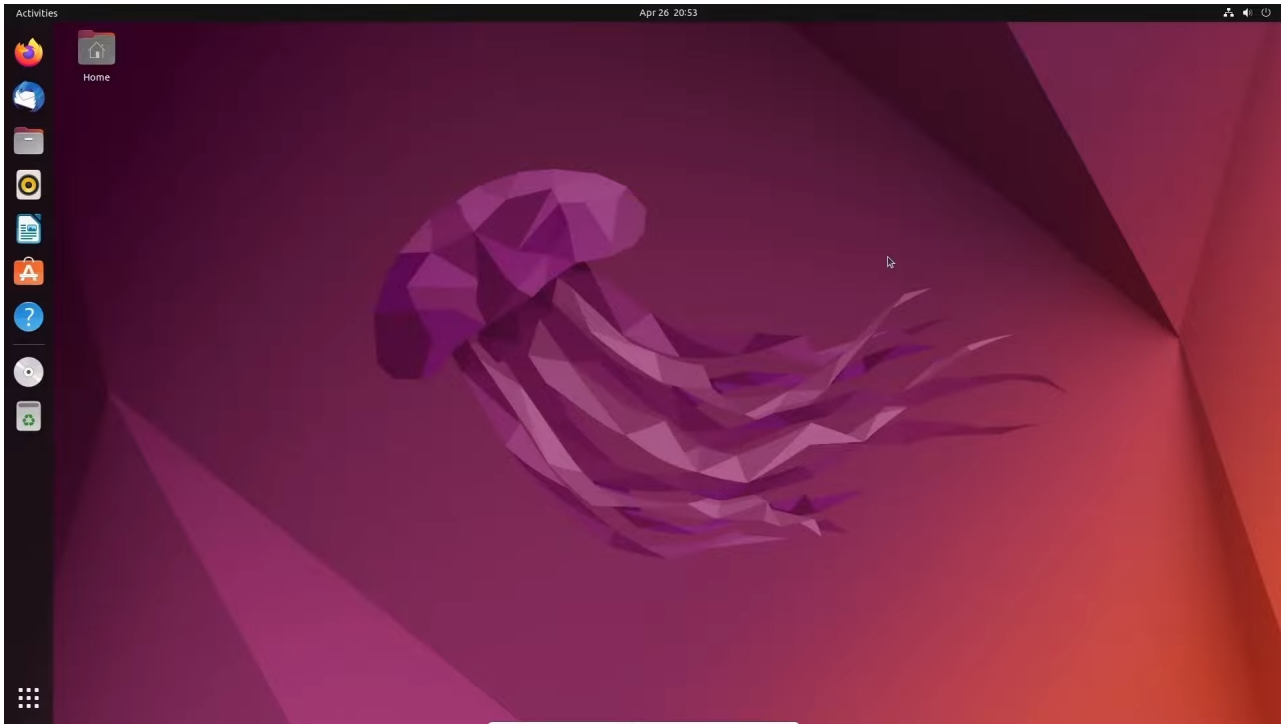
Steps:

1. Double click on the left panel for the created Virtual machine.
2. A startup window will appear. Click the Folder icon next to Empty. A popup box will appear that is titled "Optical Disk Selector." Click Add.
3. Find the downloaded Ubuntu image of extension .iso file. Select it. Click Start to proceed with that Ubuntu image. Ubuntu should start launching.
4. In the new screen, Click on "Install Ubuntu" to install Ubuntu and follow the steps as asked for easy installation.

Note: Install the VirtualBox Guest Addons so the screen resolution automatically changes to the size of the virtualbox image (see 3.4.2). For now you can just set the screen resolution to something that fits inside your screen.

More infos: `https://www.youtube.com/watch?v=zHwFtyxJsog`.

Finally you should be able to see a screen like this:



Continue with setting up your network (section *3.4 Settings*)

3.3 Setup Virtual Machine from File

We provide you a virtual machine image that already comes with Ubuntu 22.04 and ROS 2 installed.
Please download the virtual box image from this link:
`https://seafile.zfn.uni-bremen.de/d/52efbde1ee3048c7bdbd/`

The two .zip files are one larger archive split in half. Please download both of them and extract the file `robot_design_lab_ros2_humble.z01` using 7-Zip or any other compatible file archiver.

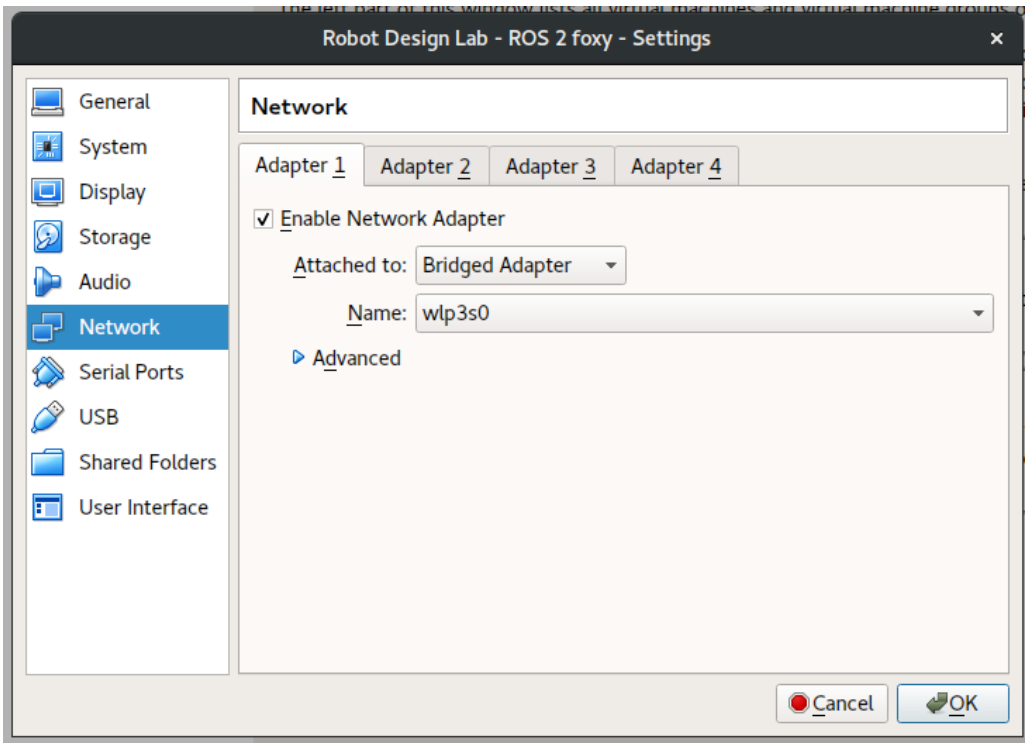
You should be able to see a file called *Robot Design Lab - ROS 2 humble.vbox*. If you double click on it, it should open in the Virtual Box software that you installed in the section Install Virtual Box.

Note: the sudo password for the Ubuntu 22.04 ros user **"ubuntu"** is **"robotics"**.

3.4 Settings

3.4.1 Network Setup

In order to be able to connect to the Turtlebots, you will have to configure the virtual machine so that it uses your Wifi device as bridge and not NAT as in the figure below:



3.4.2 Enable Copy-Paste from Host

If you want to copy text from your host machine to Ubuntu 22.04 in the virtual machine, you might have to install the **virtualbox-guest-x11** package.

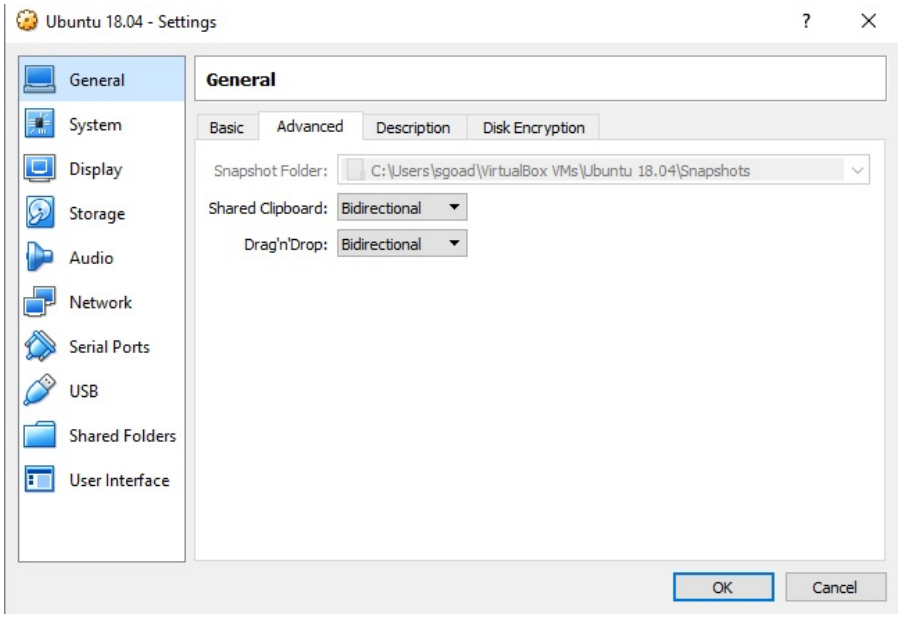
For this, execute the commands below in the virtual machine:

```
sudo apt-get update
sudo apt-get install virtualbox-guest-x11
```

If it asks you about keeping a file or installing the new one, select the new one.

```
sudo VBoxClient --clipboard
```

This should enable clipboard sharing. Make sure that Clipboard Sharing is set to Bidirectional under VM Settings in VirtualBox as shown in the figure below:



Note: this might not work all the time, so we recommend you to open the PDF file and/or any additional information in your virtual box directly.

Source: `https://superuser.com/questions/1318231/why-doesnt-clipboard-sharing-work-with-ubuntu-18-04-lts-inside-virtualbox-5-1-2`

4. ROS 2 Humble Installation

You will need ROS 2 Humble installed in your Ubuntu 22.04 system. If you used the virtual box image file that we provided, ROS 2 Humble is installed already. Otherwise please proceed with the ROS 2 installation bellow.

If you don't want to type the commands but copy them do not use this PDF but copy them from:
`https://foxglove.dev/blog/installing-ros2-humble-on-ubuntu`

4.1 Prerequisites

Everything in bold is code to run in your terminal.

Check for locale UTF-8:
`locale`

If that does not show `LANG=en_US.UTF8` there then run these commands.

```
sudo apt update && sudo apt install locales
sudo locale-gen en_US en_US.UTF-8
sudo update-locale LC_ALL=en_US.UTF-8 LANG=en_US.UTF-8
export LANG=en_US.UTF-8
```

Add the ROS 2 keyring to your system (there should not be a line break after -o):

```
sudo apt update && sudo apt install curl gnupg lsb-release
sudo curl -sSL https://raw.githubusercontent.com/ros/rosdistro/master/ros.key -o
/usr/share/keyrings/ros-archive-keyring.gpg
```

And then add the ROS repository to your sources list (without line breaks!):

```
echo "deb [arch=$(dpkg --print-architecture) signed-by=/usr/share/keyrings/ros-archive-keyring.gpg]
http://packages.ros.org/ros2/ubuntu $(source /etc/os-release && echo $UBUNTU_CODENAME) main" | sudo tee /
ros2.list > /dev/null
```

4.2 Installation

Update repositories.

```
sudo apt update
```

Install ROS2 full version.

```
sudo apt install ros-humble-desktop
```

(Note that this will take a while!)
Now you can setup the environment by sourcing the .bash file.

```
source /opt/ros/humble/setup.bash
```

Now everything should be set-up well such that you can run some examples.
To quickly test if everything was done well you can follow the steps below.

Open a command terminal tab_1 and run:

```
source /opt/ros/humble/setup.bash
ros2 run demo_nodes_cpp talker
```

This will launch a node which will publish a message to any other nodes that want to listen to it.
Now open a new command terminal tab_2 and run:

```
source /opt/ros/humble/setup.bash
ros2 run demo_nodes_py listener
```

The second node (listener) should print the messages it is receiving from the first node (talker).

Congratulations! You went through your first ROS2 tutorial!

For more information, check the official documentation and tutorials here:
`https://docs.ros.org/en/humble/Tutorials.html`.

5. Appendix

5.1 Introduction to Python

5.1.1 Prerequisites

1. Code Indentation: this is one of the most important rules of python programming. In programming language like Java, C or C++, generally curly brackets are used to define a code block, but python doesn't use brackets. Then how does python knows where a particular code block ends? Well, Python used indentation instead.
2. Python is case sensitive. Hence a variable with name robot is NOT same as Robot.
3. In python there is no command terminator, which means no semicolon ; or anything. So if you want to print something as output, all you have to do is:
   `print("Hello,World")`
4. Only a single executable statement should be written in one line and the line change acts as a command terminator in python.
5. You can write comments in your program using a # at the beginning of the line. Comments are ignored when the python script is executed.
6. Line continuation: in order to write a code expression over multiple lines you can use a backslash \ at the end of each line to explicitly denote line continuation. Blank lines in between a program are ignored.

5.1.2 First Python Program

First program is just one single line. To print "Hello, World!" on screen, all you need is the command:
`print("Hello, World!")`

Save this command in a text file and name it test.py (you can actually name it as you wish, just keep the extension of the file as .py).

To run the test.py python script, open a terminal window in Ubuntu, go to the directory where you saved this file using the *cd* command, and then type the following in command prompt or your terminal:
`python3 test.py`

This will execute the python script and will show you the output in the same terminal.

For more information, feel free to visit the Python3 tutorials here:
`https://www.tutorialspoint.com/python3/index.htm`.