Introductory Session

Who are we, and what do you need to get ready to work with ROS

Session 1: Introductory session.

I. Introduction (45 min approx.) *Live*
   - Who we are? Manchester Robotics Introduction
   - Why are we here? Explain the course structure, goals and aims.

II. Getting Started with ROS (2 hours approx.) *Live*
   - What do we need? A general overview of Ubuntu and ROS.
   - Installing Ubuntu: Quick guide, tricks and troubleshooting
   - General walk-through in Ubuntu (Video)
   - Quick guide on how to install ROS

Requirements: Laptop or PC.

Introduction

Who are we?

Who are we?

Manchester Robotics Limited is University of Manchester spin-out company.

How we became a company?

- Faculty of Science & Engineering
- Faculty of Biology, Medicine & Health
- Faculty of Humanities (including MBS Worldwide)

The University of Manchester

Robotics and Autonomous Systems Research Theme

- Theme leaders
  Dr Alexandru Stancu
  Dr Mario Martinez
- More than 40 Academics, Research Associates and PhD students
- Collaboration with industry

Manchester Robotics Limited

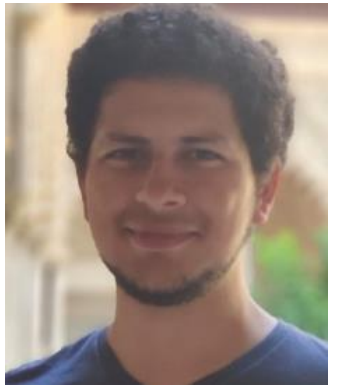
- Spin-out company of the University of Manchester
- We create open software and hardware platforms for robotics. We use those platforms to solve real problems from industry and we help others to do the same.
- Robotic democratization

Manchester Robotics Executive Team

Prof Costas Soutis
Co-founder, Director &
Scientific Advisor

Phil Kemp
Business Strategy
(ex-Nokia VP)

Dr Alexandru Stancu
Co-founder, Director & CEO



Dr Mario Martinez
Co-founder & CTO

Manchester Robotics Core Team

The problems in Industry 4.0

- Primary & secondary sectors of the global economy are rapidly adopting robotics (The World Economic Forum).
- Education systems are failing to meet the demand for robotics-related STEM (Science, Technology, Engineering, and Math) skills.
- Just in Europe, 10 million plant, machine operator & assembler position are forecast to remain vacant over the next 10 years due to a lack of qualified labour (International Federation of Robotics).

MARKET SECTOR	% OF COMPANIES ADOPTING ROBOTICS IN 2021
Mining & Metals	90%
Advanced Manufacturing	85%
Manufacturing	79%
Oil & Gas	79%
Transportation & Storage	69%
Automotive	60%
Agriculture, Food & Bev	54%

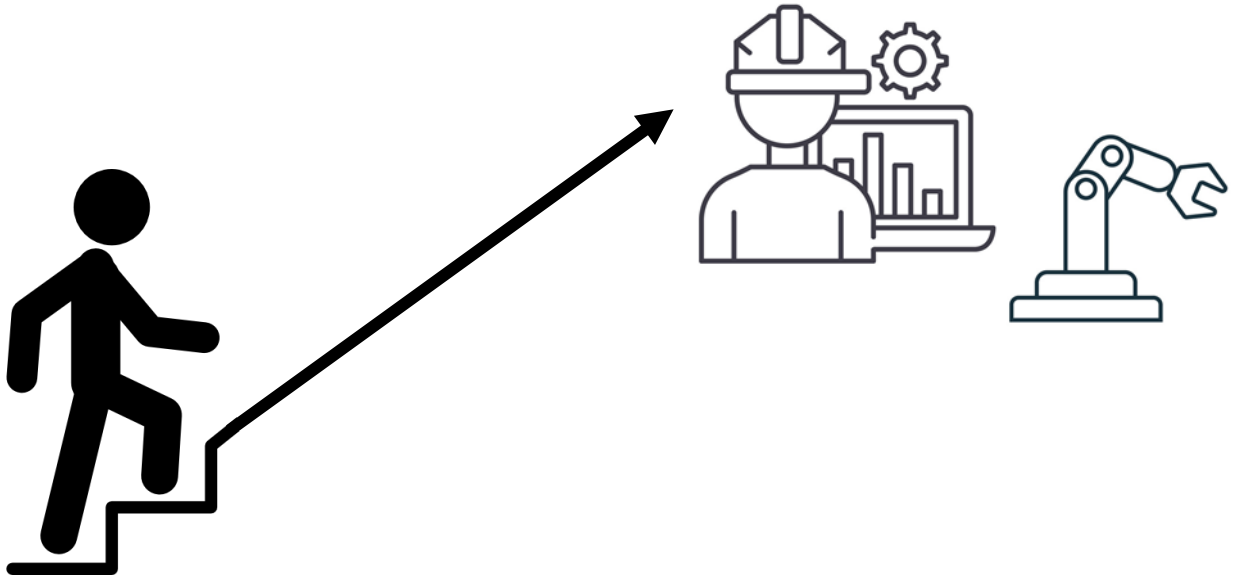
Our mission:

- **Solve real problems from industry** – To help primary & secondary sectors of the global economy to rapidly adopting robotics.
- **Robotic democratization** – Provide to engineering heroes accessible robotic platforms and help them to reach their potential.
- **Making robotics a net job-creator** – guiding learners to exciting careers & providing employers a pipeline of skilled labour.

Manchester Robotics and teaching

We create globally-accessible educational tools & curricula for Robotics & Automation

.. & providing employers a pipeline of skilled labour



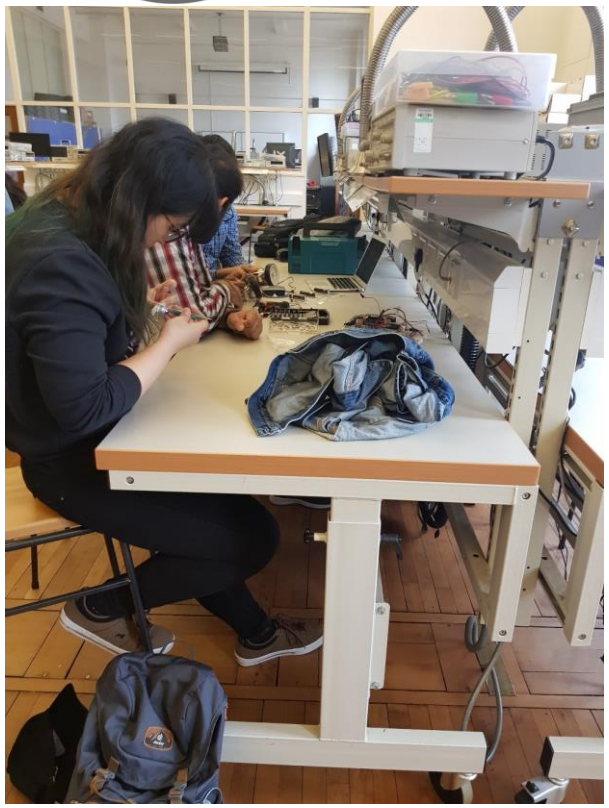
… guiding learners to exciting careers …

Manchester Robotics & strategic partners

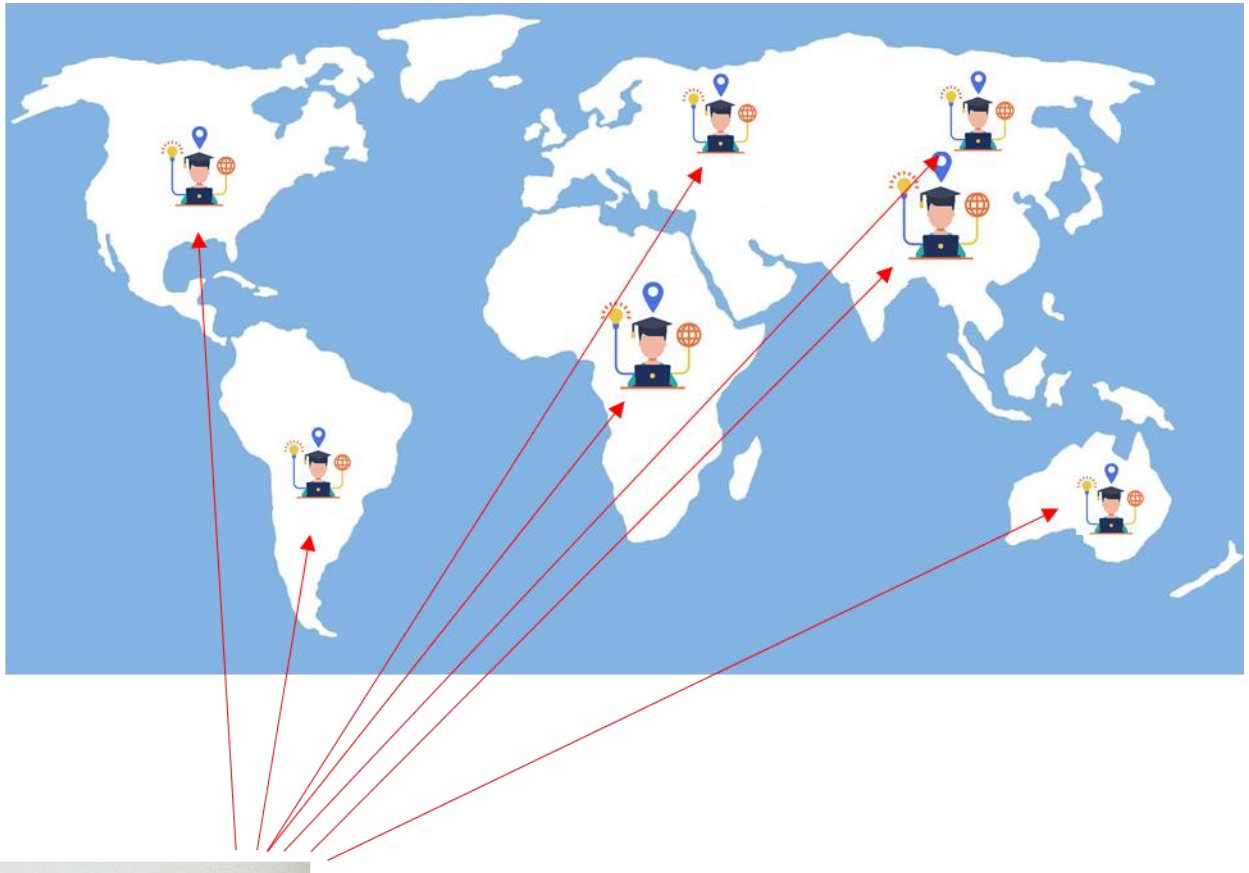
Large scale projects

- Nuclear Industry
- Defense Industry
- Textile Industry

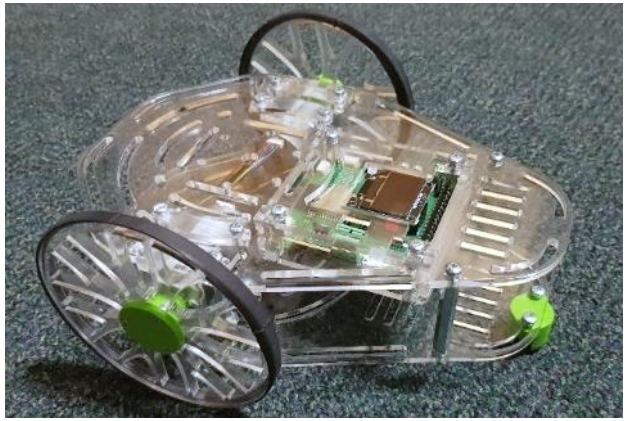
Competitions & Challenges



Solution for lockdown



- A lab in a portable robot.
- Accessible, independent learning tools for key skills in Robotics & Automation.
- Accessible price – Robotic democratization.
- AAA (Anyone, Anytime, Anywhere) Teaching.



Manchester Robotics & NVIDIA

Closed collaboration with NVIDIA for developing robotic platforms and curricula to teach robot vision and AI. We participated as NVIDIA partner at GTC Conference (NVIDIA **G**PU **T**echnology **C**onference) in November 2021.

In the academic year 2021-2022 we participated as “Socio Formador” for 2 courses at TEC Monterrey (7 Campuses): “Fundamentos de Robotica” and “Robotica Inteligente”.

What is a robot???

Is the avalanche a robot???

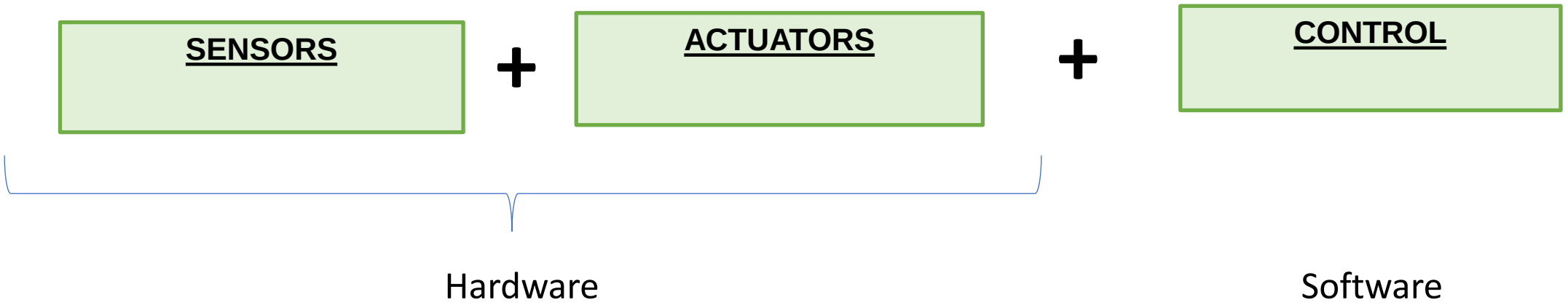
Is the avalanche a robot???

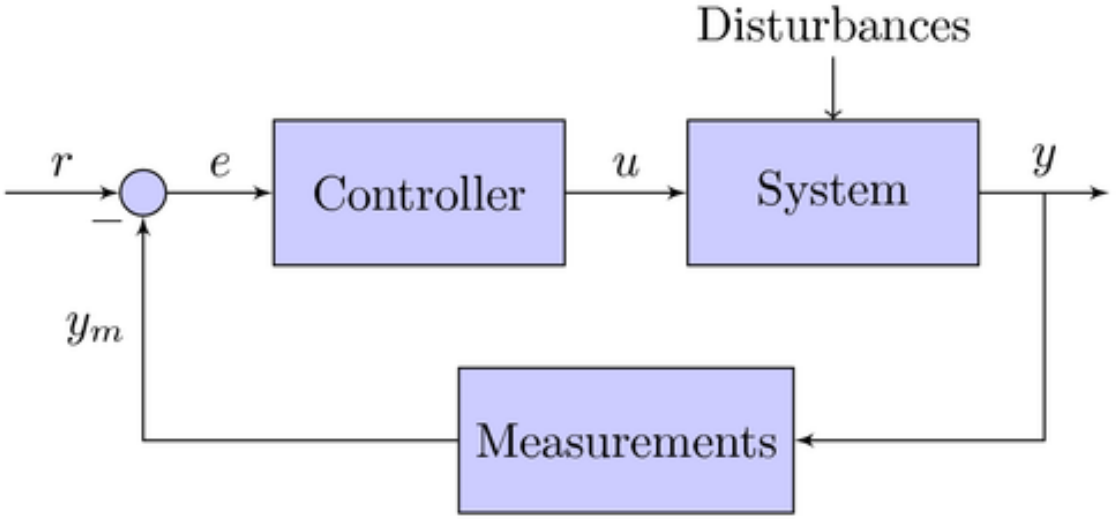
No, the avalanche is just a dynamic system which can be described by an ODE $\dot{x} = f(x)$

What else we need for a dynamic system to become a robot???

$$\dot{x} = f(x, u)$$

$$u = g(x)$$





Home heating system is a robot.

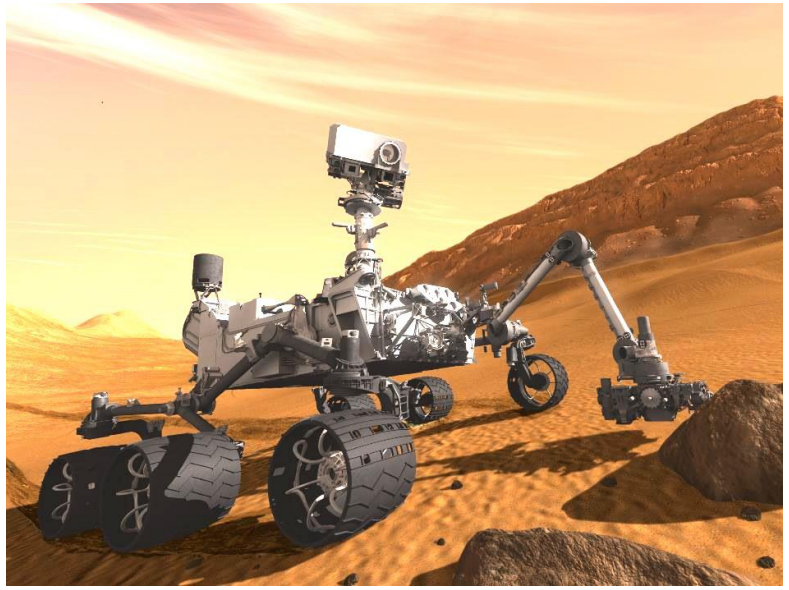
A Robot is a dynamic system that is guided by a computer program (an algorithm, or an agent) to perform some specific tasks. This is also known as a Control System.

If the dynamic system is a **mechanical system** which act on the environment, then we have **Industrial Robots** and **Autonomous Systems** (**Mobile Robots)**.

Industrial Robots and Mobile Robots

The robots can be categorized based on their environment into: *Industrial Robots* and *Mobile Robots*.

(a) Industrial robotic arm for welding © KUKA Inc.



(b) Mobile robot: Curiosity Mars Rover 2012 © NASA/JPL

Mobile Robots

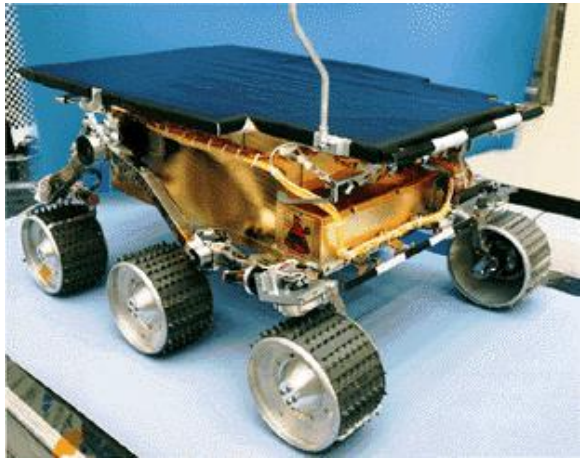
Mobile robots can traverse anywhere in the environment without being bolted to a reference point in the environment.

Ground Mobile robots are categorized based on *locomotion* mechanism into:

(a) Legged Robots

© AIBO Sony Corp.

(b) Wheeled Robots



© NASA/JPL.

Wheeled Mobile Robots

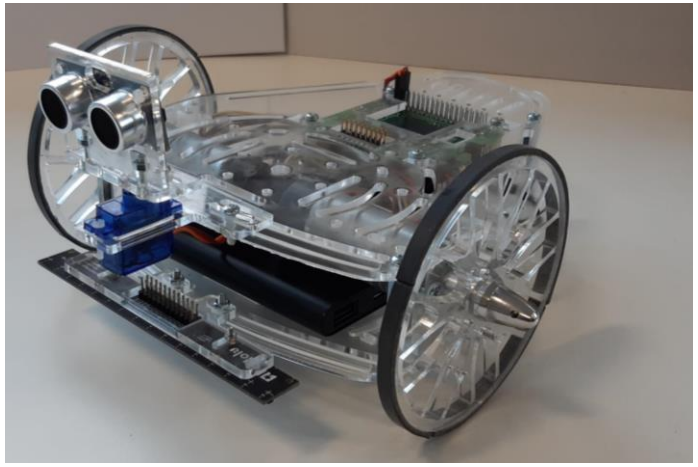
There are many types of wheeled mobile robots:

Differential-Drive robots

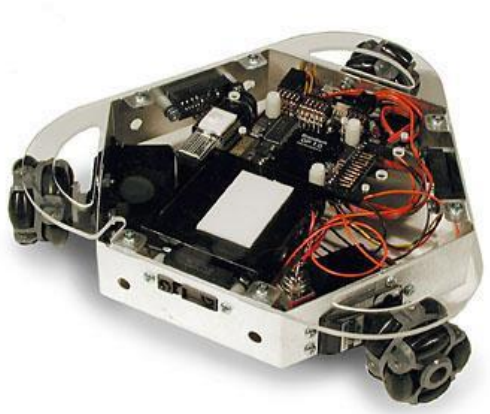
Holonomic robots

Ackermann-steering robots

and many others...



Differential-drive
© PuzzleBot.



Holonomic Robot
© Acroname.

Autonomy in Mobile Robots

Fundamental question: How much information and support must be provided by human to ensure that the robot is able to achieve its goals.

Remote Control

Semi-autonomous

Fully Autonomous

© I-Robot Movie

Telerobotics vs. Semi-autonomous

Telerobotics

Kraft TeleRobotics, Inc.

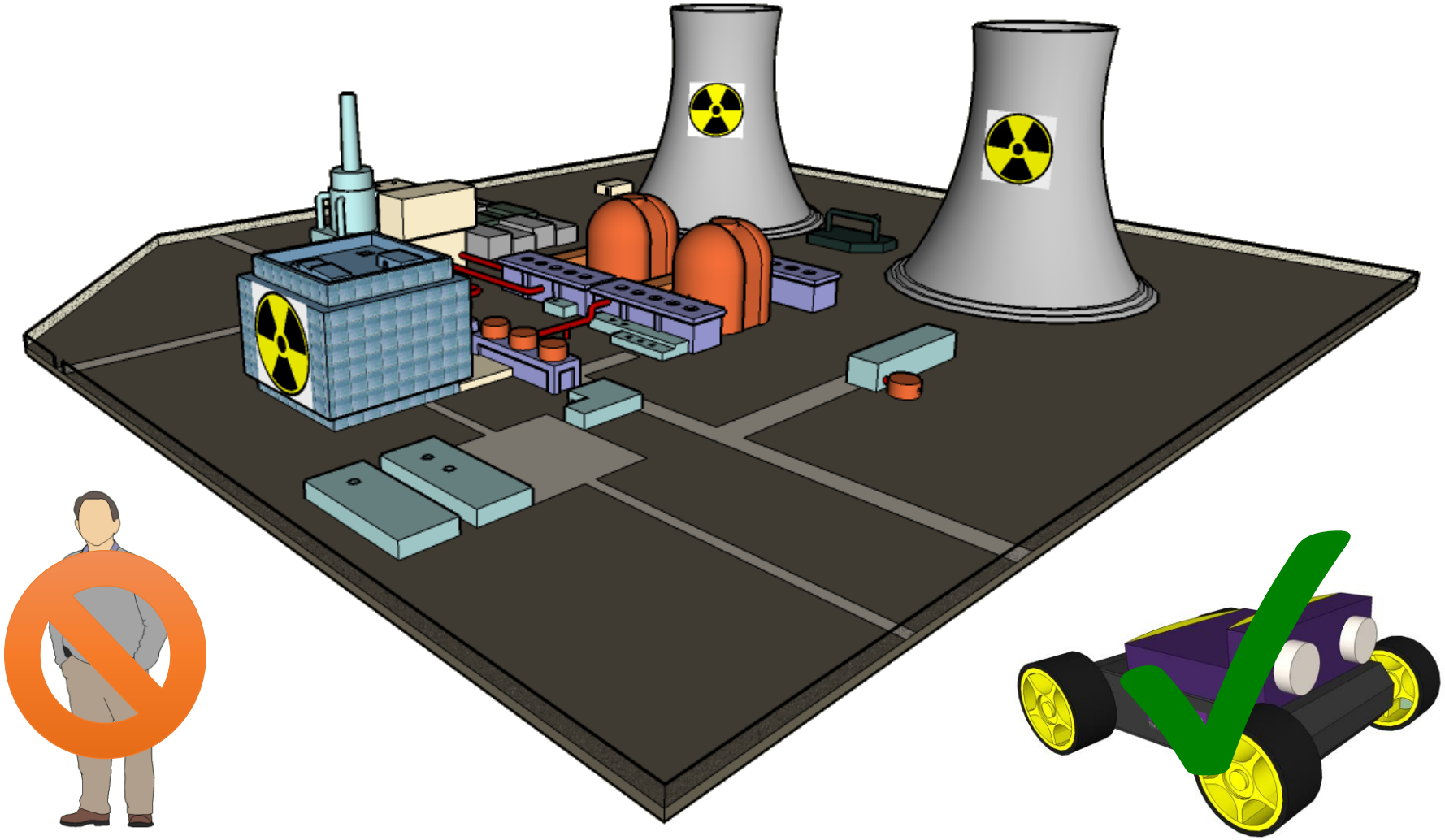
- Human operator has full control.
- Requires a long period of training.

Semi-autonomous

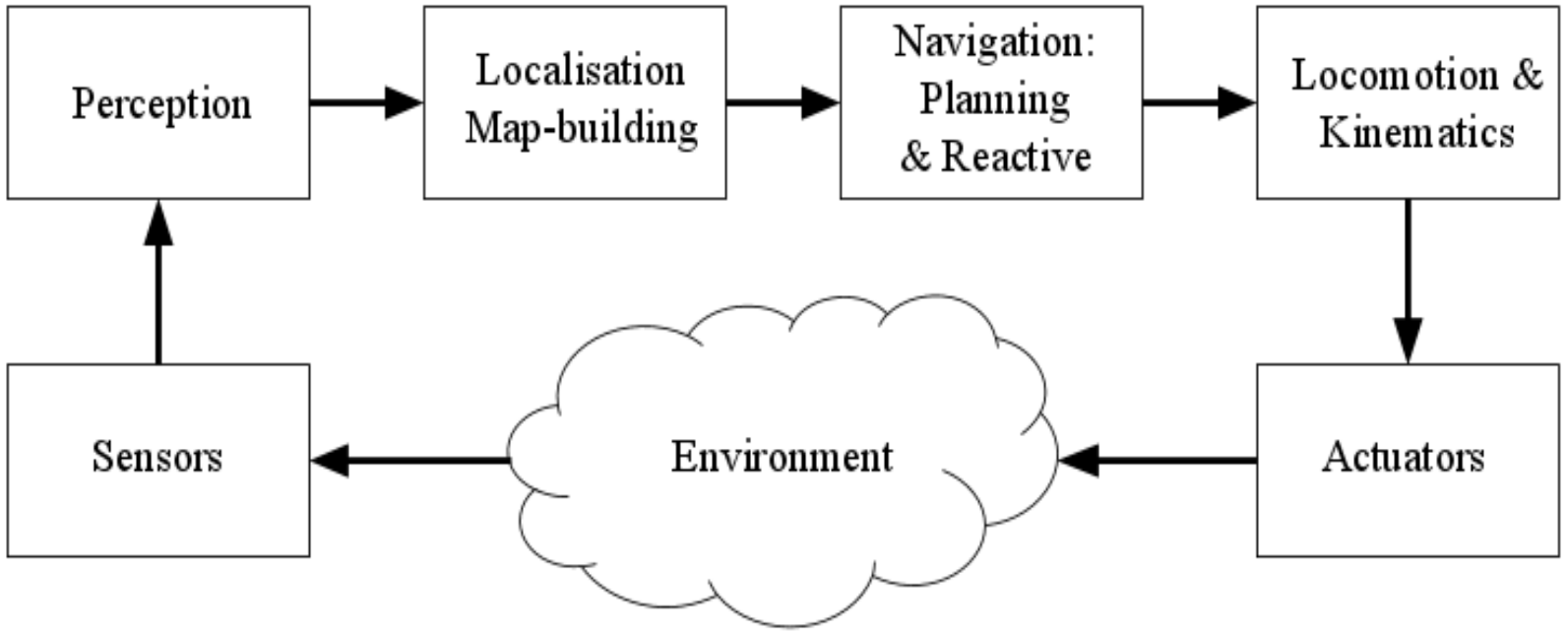
Curiosity Rover, JPL, NASA

- Human provides high-level goals.
- Robot makes reactive decisions.

Why autonomous mobile robots

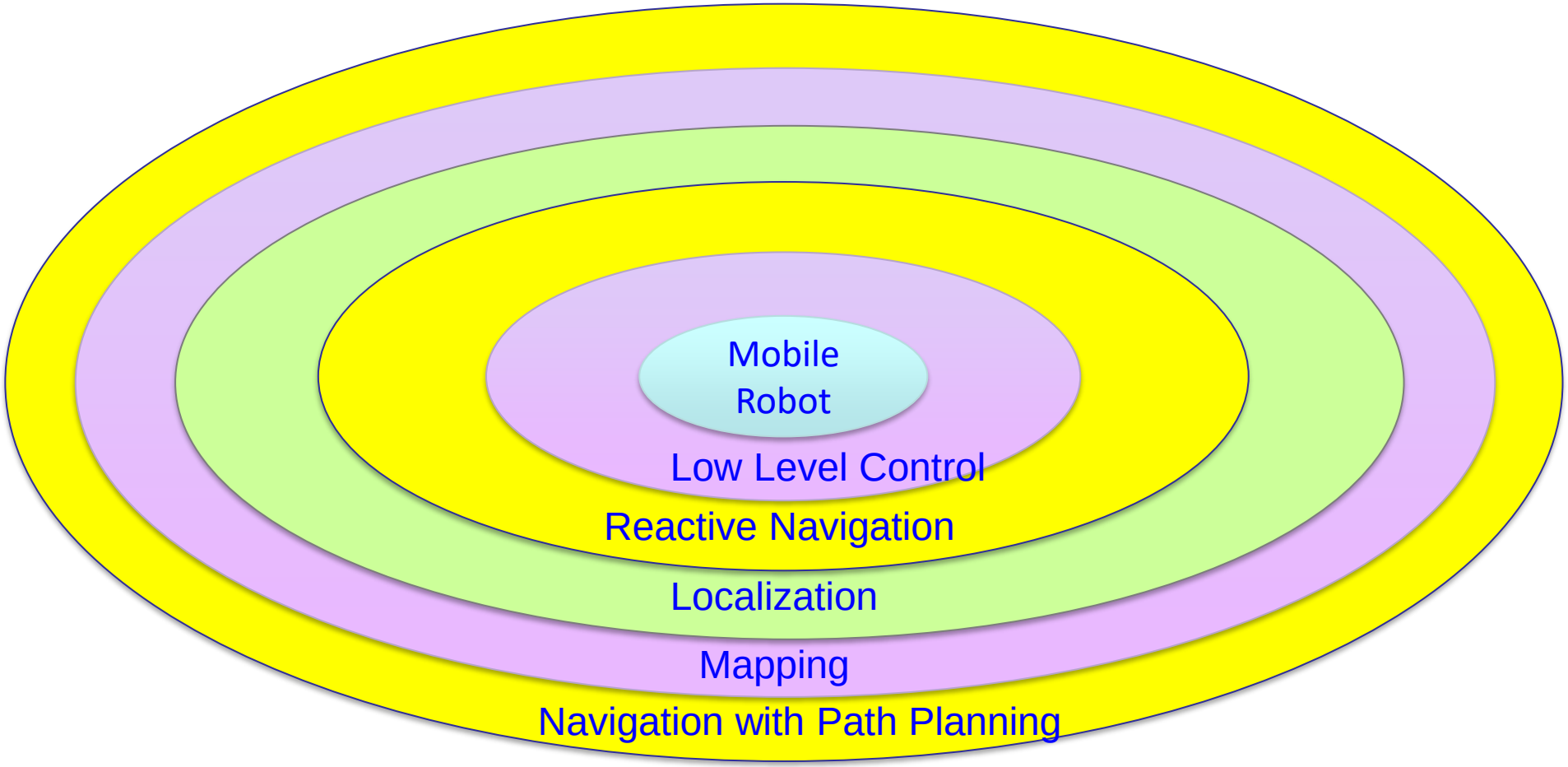


Autonomous mobile robots in unknown environment



Examples of mobile autonomous systems

The hierarchy of autonomy



Course Structure
Aims

The student will:

- Learn the requirements for working with ROS: Ubuntu and ROS installation.
- Learn basics of robotics and control necessary to understand and use a Differential drive (Puzzlebot).
- Learn the Basics of ROS and write basic nodes.
- Learn how to use a Puzzlebot simulation model (Gazebo)

Course Structure
Goal

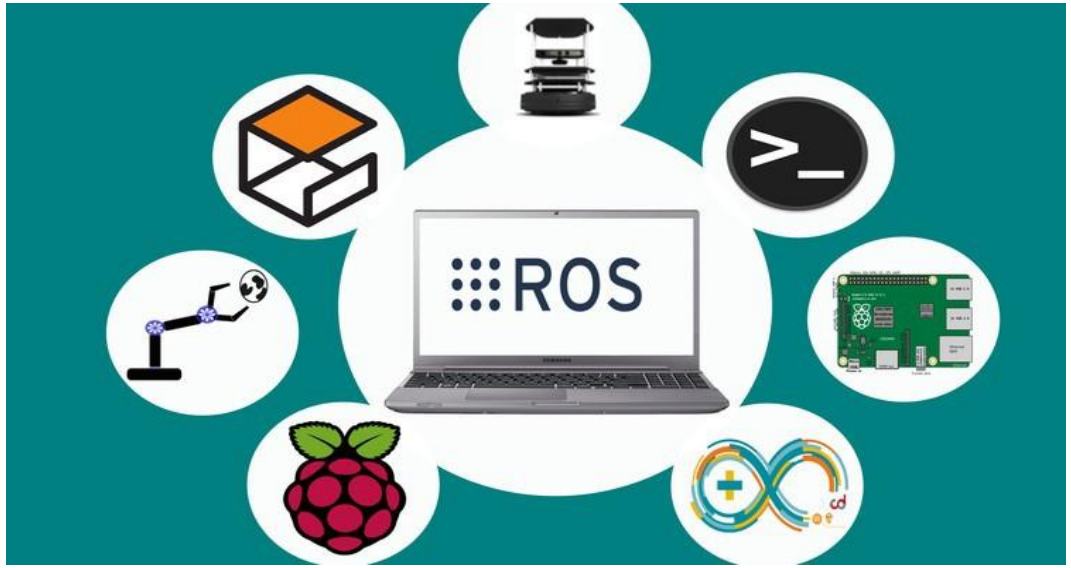
At the end of the course, the student would be able to put together the acquired knowledge to applied basic controllers into a PuzzleBot robot simulated in Gazebo.

Getting Started with ROS

What is ROS? Why do we need it?

Getting Started with ROS

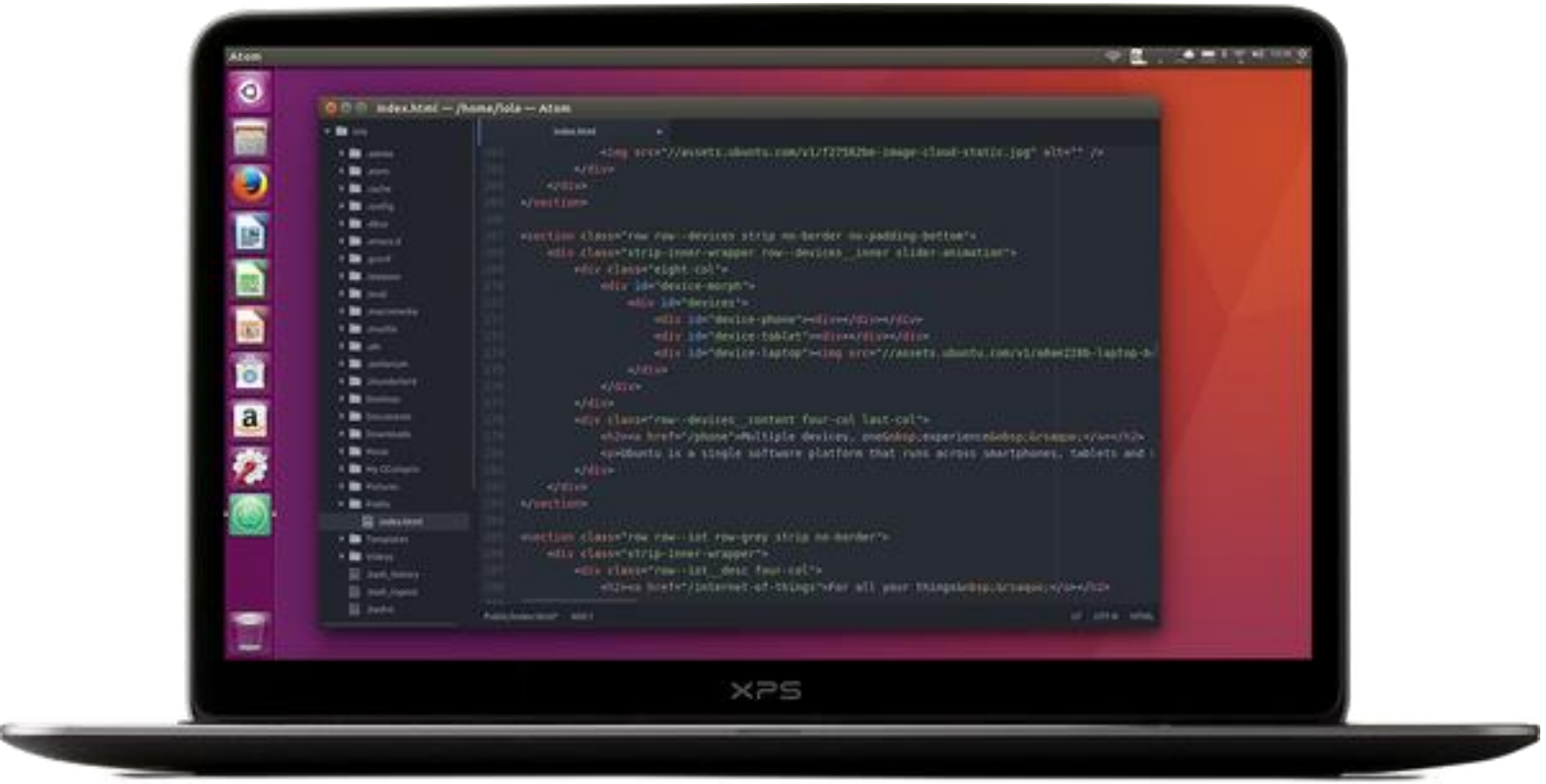
What is ROS and why do we need it ?



“The ROS is a set of software libraries and tools that help you build robot applications. From drivers to state-of-the-art algorithms, and with powerful developer tools, ROS has what you need for your next robotics project. And it's all open source.”

Getting Started with ROS

What do we need to start working?



Minimum Requirements*:

- Processor: i5 or higher
- RAM: 8 GB or higher
- Storage: 20 GB
- Graphics: Dedicated GPU

*This requirements are the minimum for the activities designed.

Getting Started with ROS
ROS versions and installation

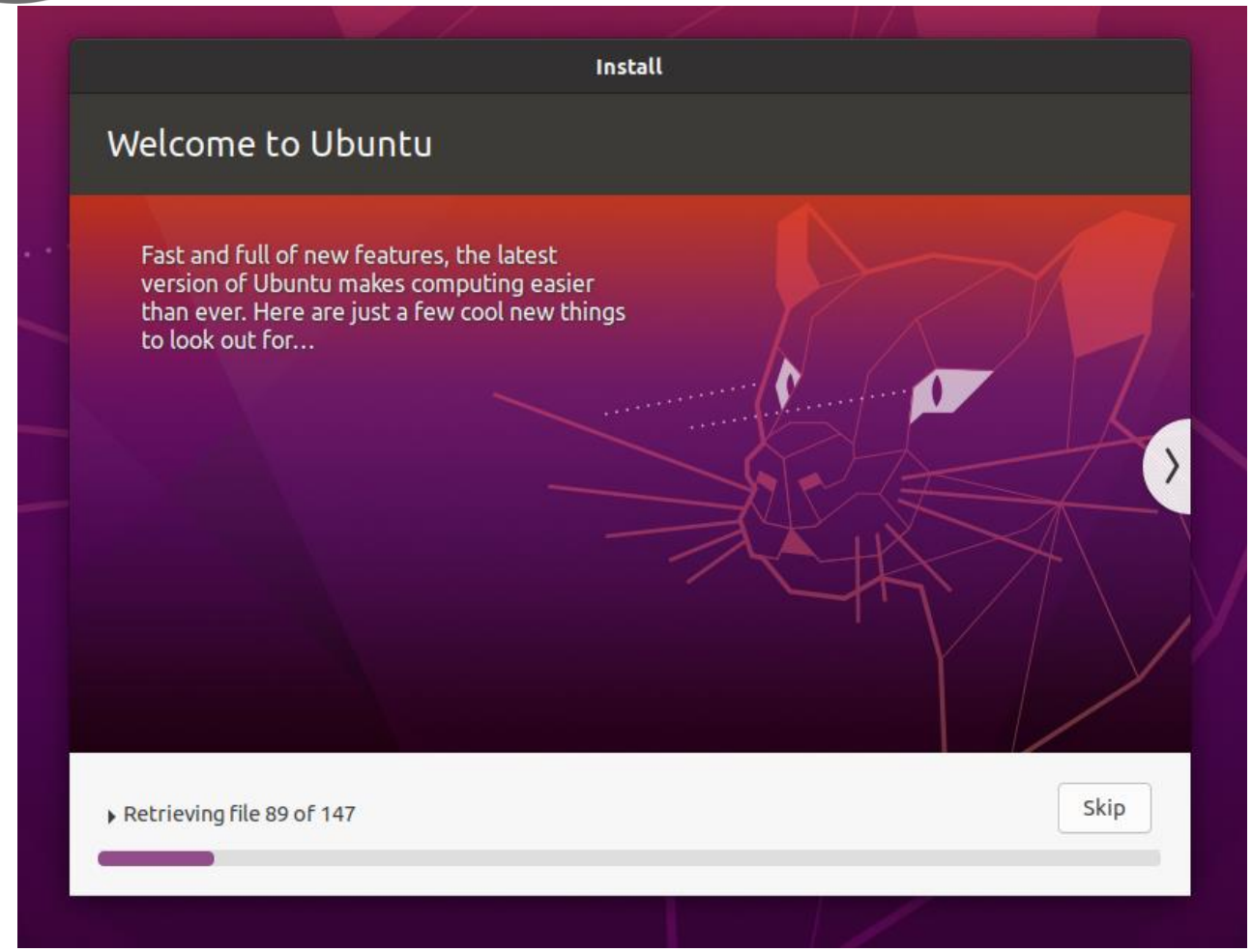
- A new version of ROS is released with each Linux distribution. **We will use ROS Noetic in this course** (released with **Ubuntu 20.04**).
- Currently, another version of ROS is available, Ubuntu 22.04, and a revision of the ROS structure, known as ROS2, that aims to increase the robustness of the framework for industrial applications and distributed systems. Furthermore, ROS2 allows real-time applications.

ROS Melodic Morenia
Released May, 2018
LTS, supported until May, 2023
Recommended for Ubuntu 18.04

ROS Noetic Ninjemys
Released May, 2020
Latest LTS, supported until May, 2025
Recommended for Ubuntu 20.04

Getting Started with ROS

Ways of installing Ubuntu

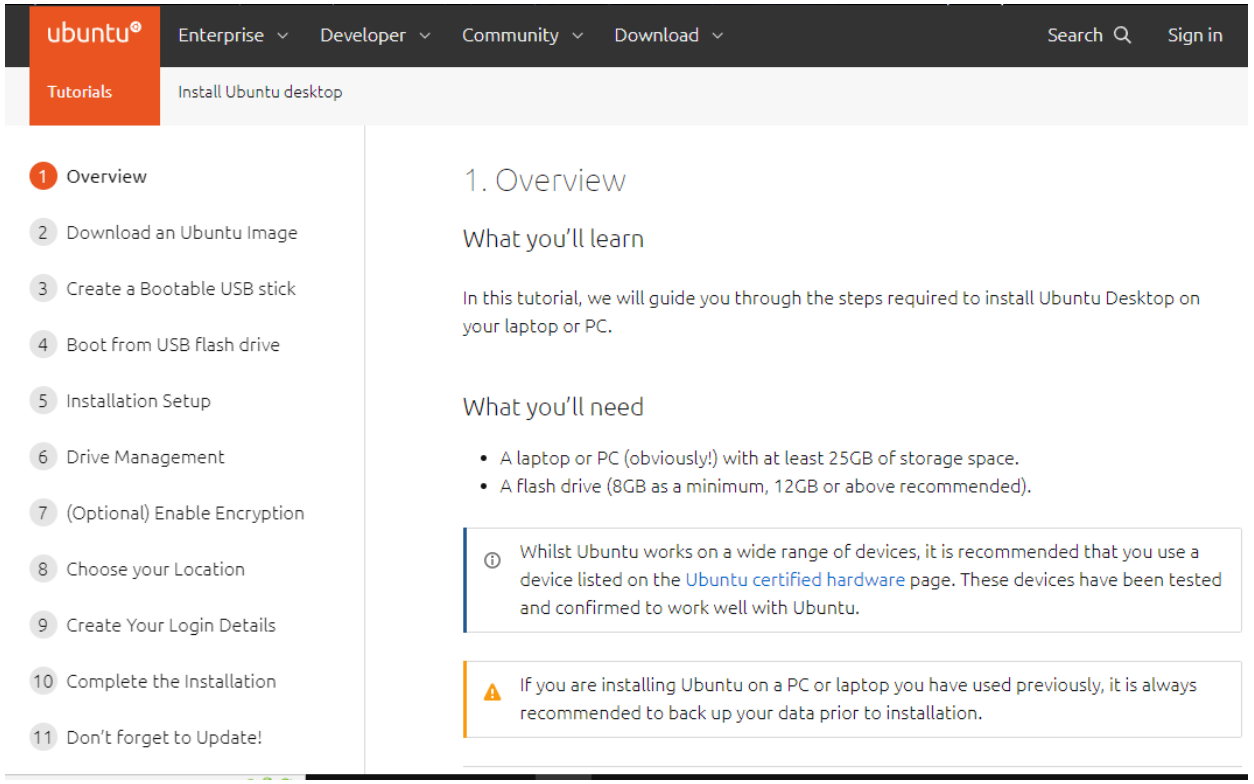


The Recommended way of installing Ubuntu for Robotics is as the **main operating system** or as **Dual booting**.

As a last resort, it can also run on a **Virtual machine**, but this will limit features, and the performance speed could be affected.

Installing Ubuntu

Quick Installation Guide for main OS



Follow the tutorial on the official ubuntu website. Download the ubuntu 20.02 image here.

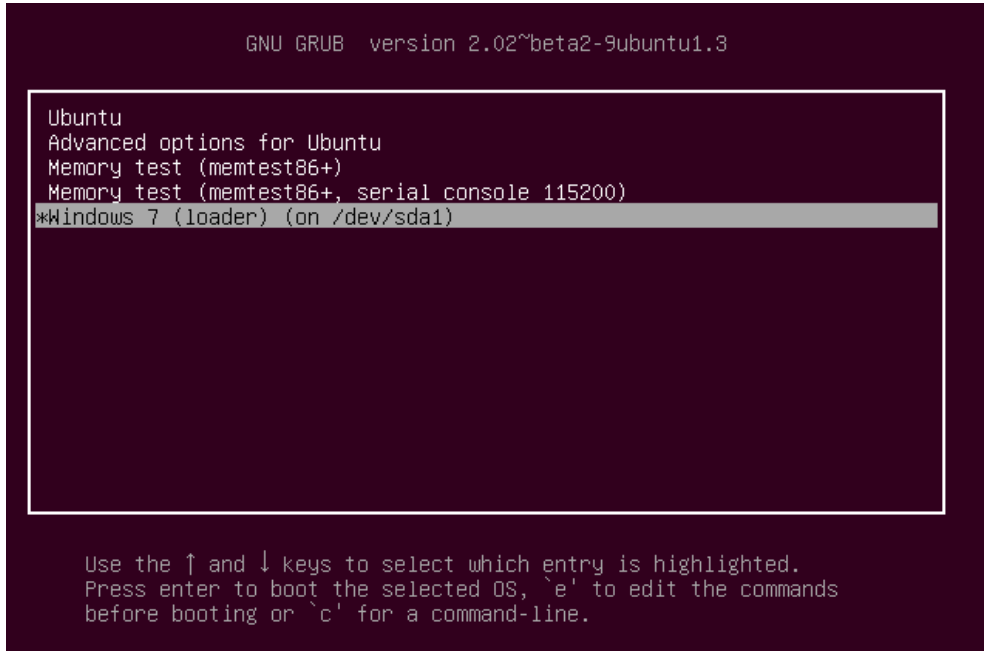
On the left side of the webpage, all the steps for the installation are detailed.

Once you click on each step, the installation details are described in the right panel.

PROS: Easy installation, access in full to hardware.
"CONS": if you need windows installed on the same machine.

Installing Ubuntu
Dual booting installation

This installation requires preparing the computer first. This may vary depending on the computer brand, but the main steps are:



- Prepare the USB as the website indicates. (Step 1-4)
- You may need to modify some parameters from the BIOS configuration. Check here for info.
- Depending on how many partitions or how full the disc is, you may want to defrag and partition your hard drive using Windows. More info here.
- Change the booting option from the computer and keep following the steps on the website.

Windows + Ubuntu

PROS: Relatively easy install, access in full to hardware
CONS: a problem if you have to use windows and don't have another machine

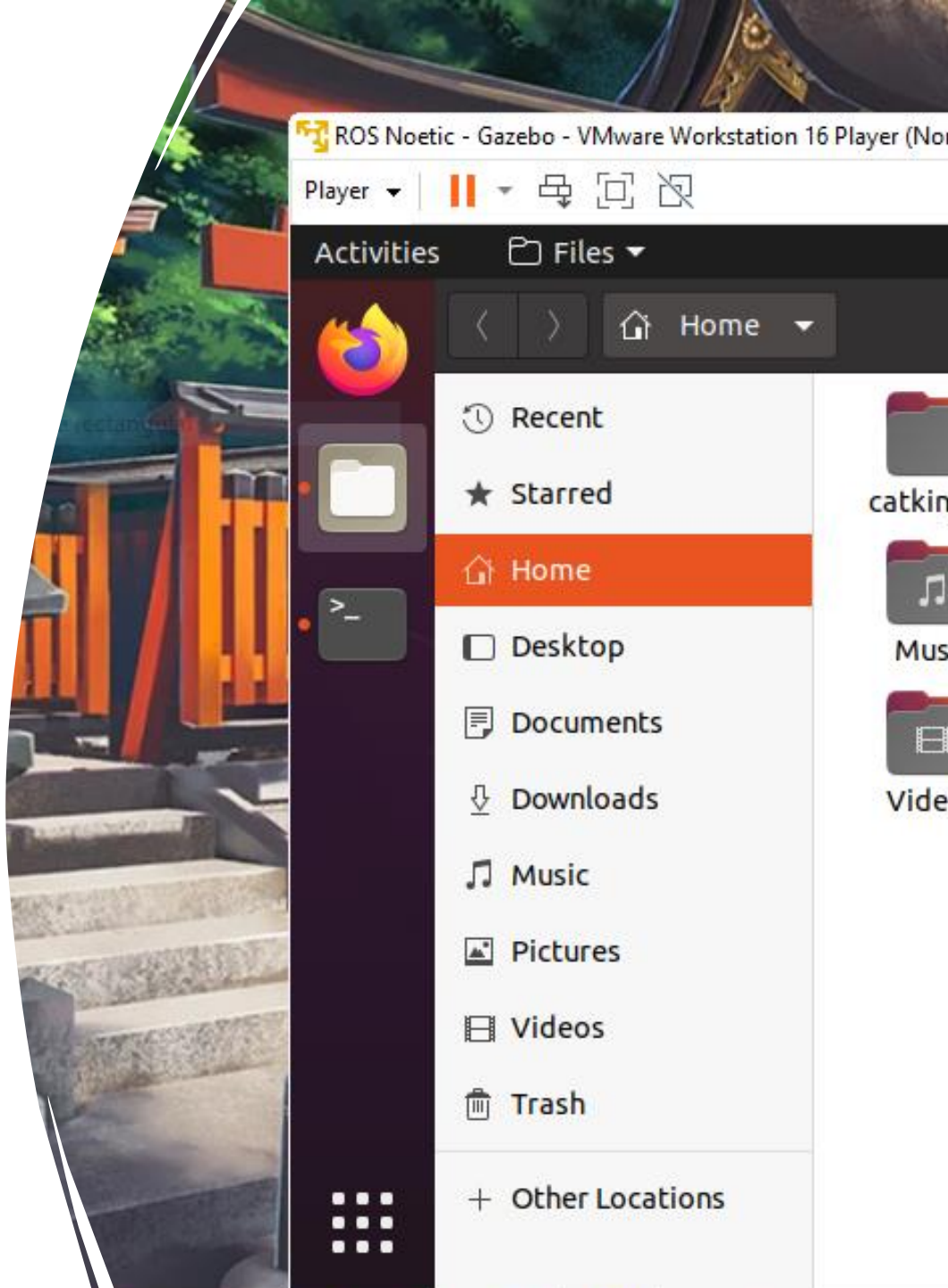
Installing Ubuntu

Virtual Machine vs Standard installation

A Virtual Machine (VM or guest OS) is an emulated Operated System done by software (Virtual Box and VMware most popular) installed in the main OS (host OS).

This could be helpful as a starting point (or a last resort), but it has some cons:

- The host OS and guest OS **share the same resources**, affecting both operations (especially for heavy simulations).
- Also, a VM requires drivers to **access the peripherical** (USB, Serial), which **could be not supported** or not fully working.
- The VM cannot have the same network as the host (main operative system), which would be a **problem for ROS projects requiring multiple devices communicating** with each other.



Virtual Machine Installation

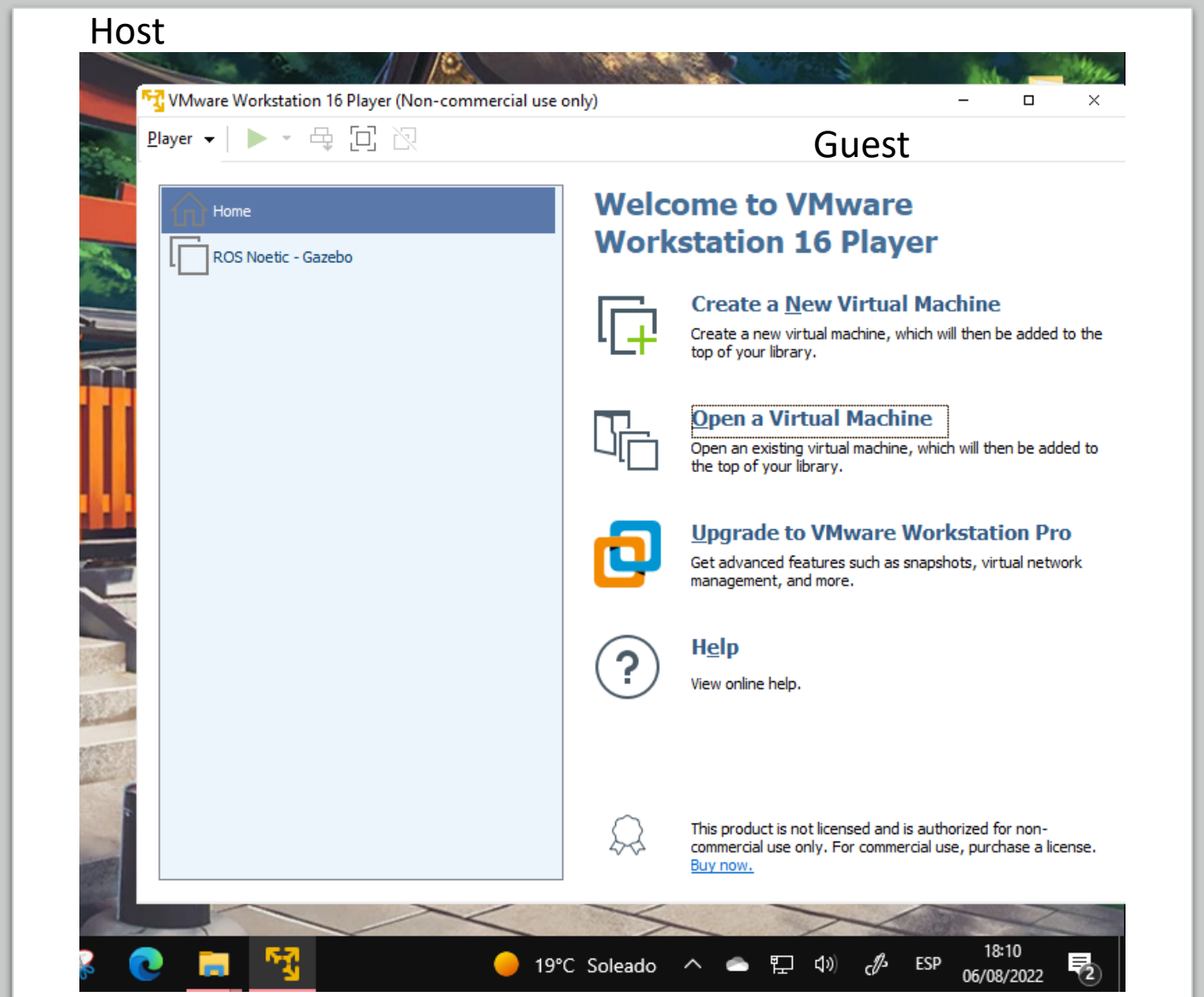
- Download the files:
  - VMware software executable
- Install the VMware software
- Open software to finish the installation

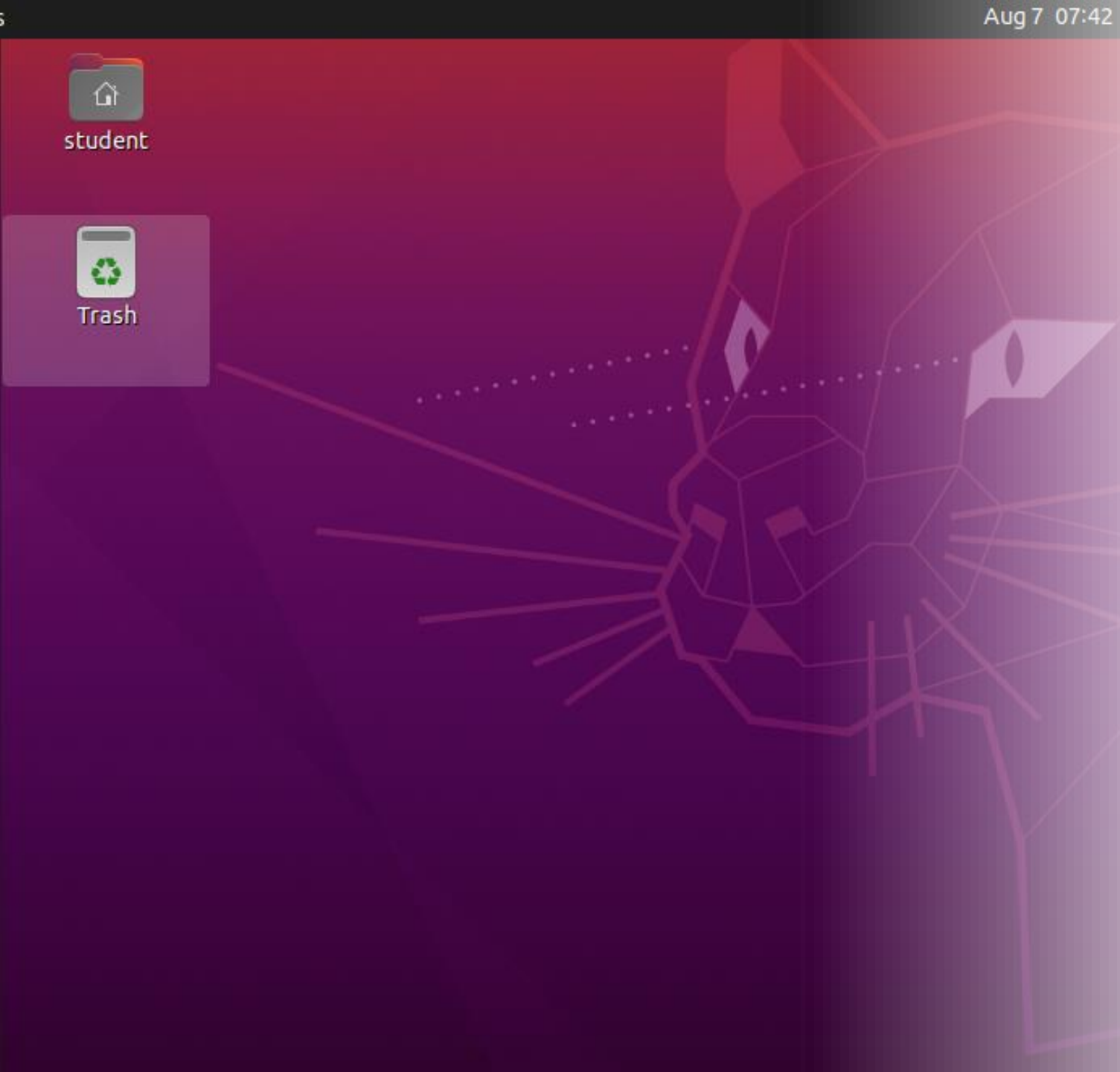
NOTE: Select personal "non-commercial" use

- Click on "create a virtual machine".
- Select the OS iso file and installation folder, and the installation will start.

Note: The disk space and ram could be modified in this step. We recommend 20 GB and at least 4 GB (half the ram of the host)

- Once ubuntu starts, you need to choose the user and password to continue the installation. After a restart, the VM should be working.



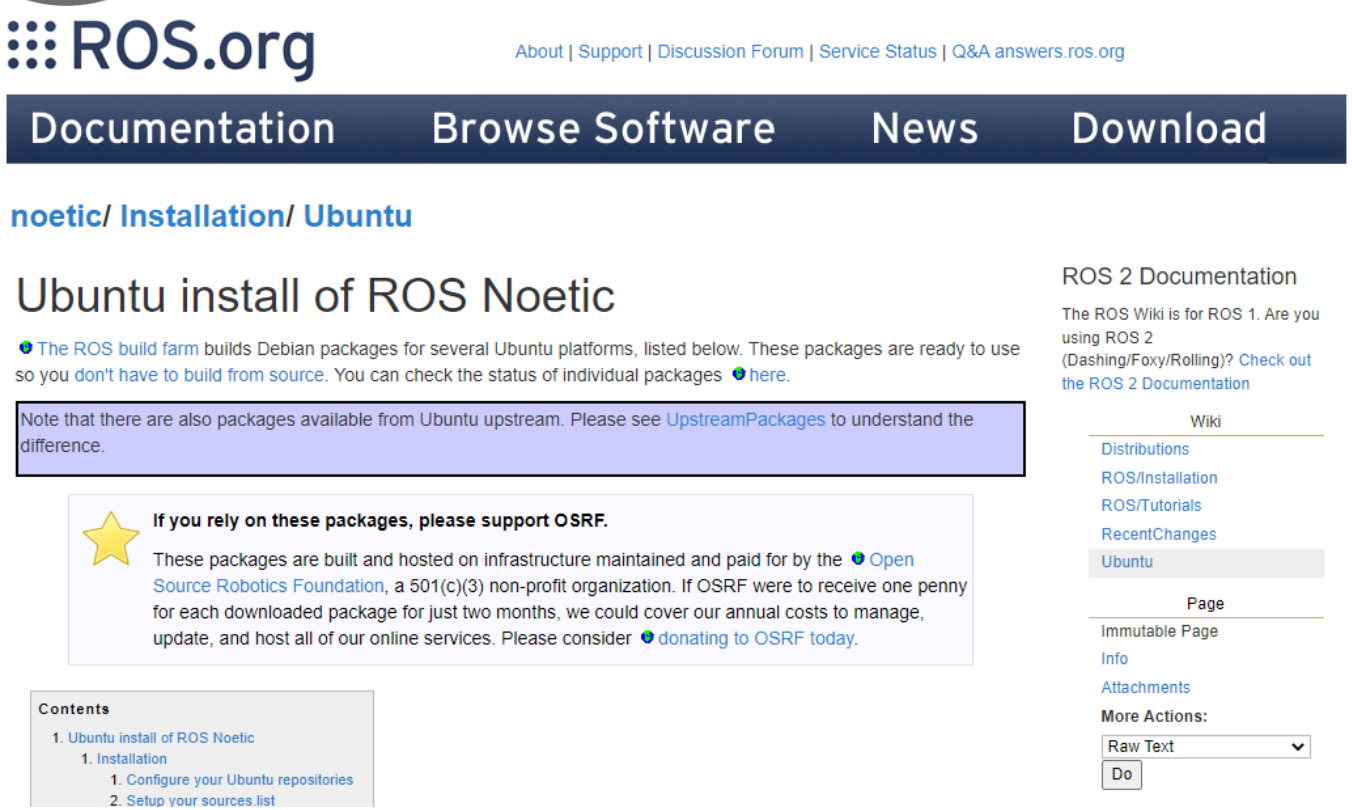


Ubuntu Walkthrough

If you are new to ubuntu, you may need to know a few things:

- Interface
- Wi-Fi Setup
- Folder and Analogies to Windows
- How to use the Terminal
- Basic Ubuntu Commands

Quick installation guide for ROS



Follow the tutorial on the official ROS website.

The ROS installation is done using the terminal.

In section 1.4, use the command for installing **Desktop-Full Install**. This will install Gazebo too.

Additionally, the following package is needed for this unit: sudo apt-get install ros-noetic-ros-control ros-noetic-ros-controllers

ROS is installed.

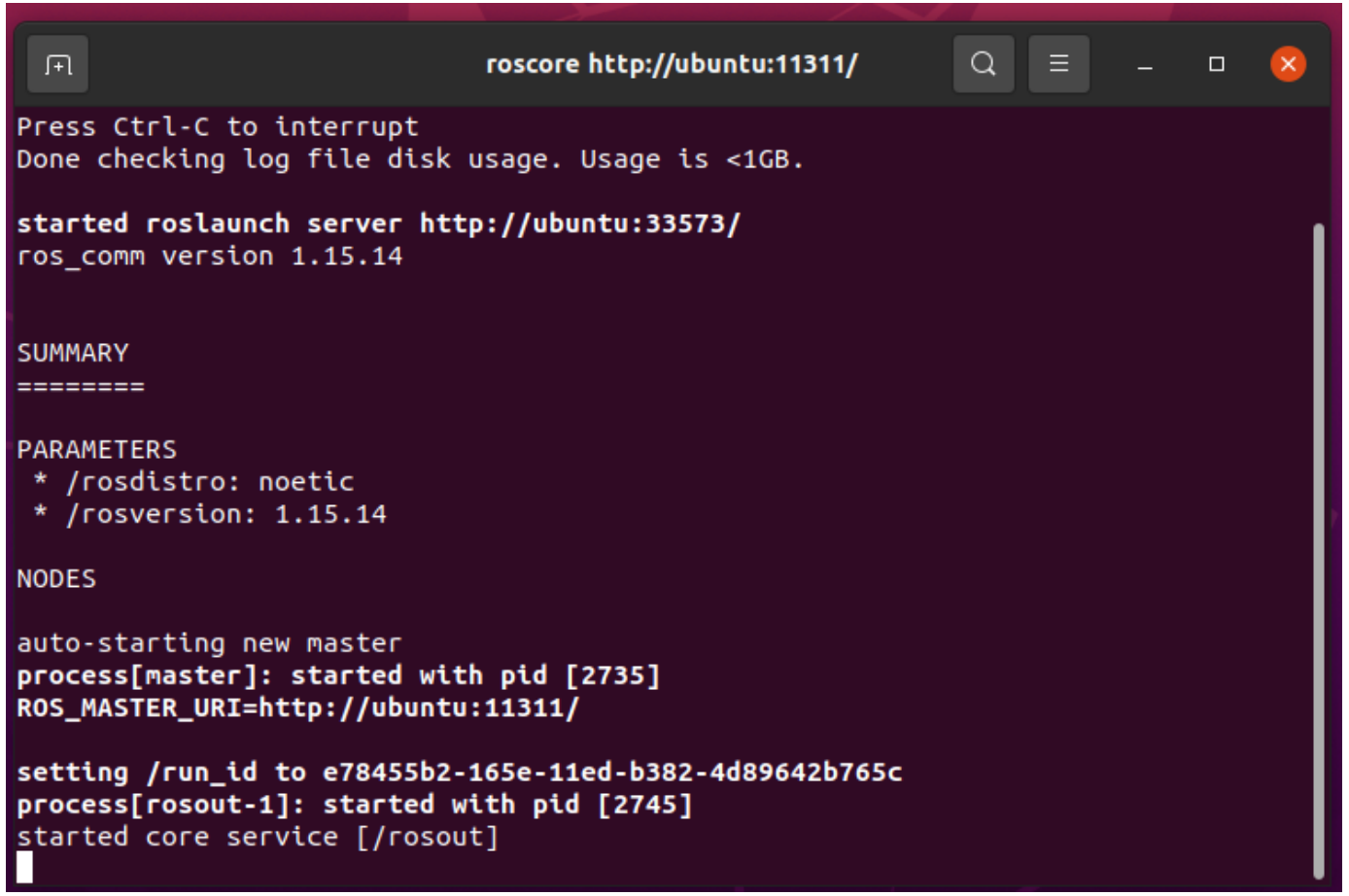
How do I know it is working correctly?

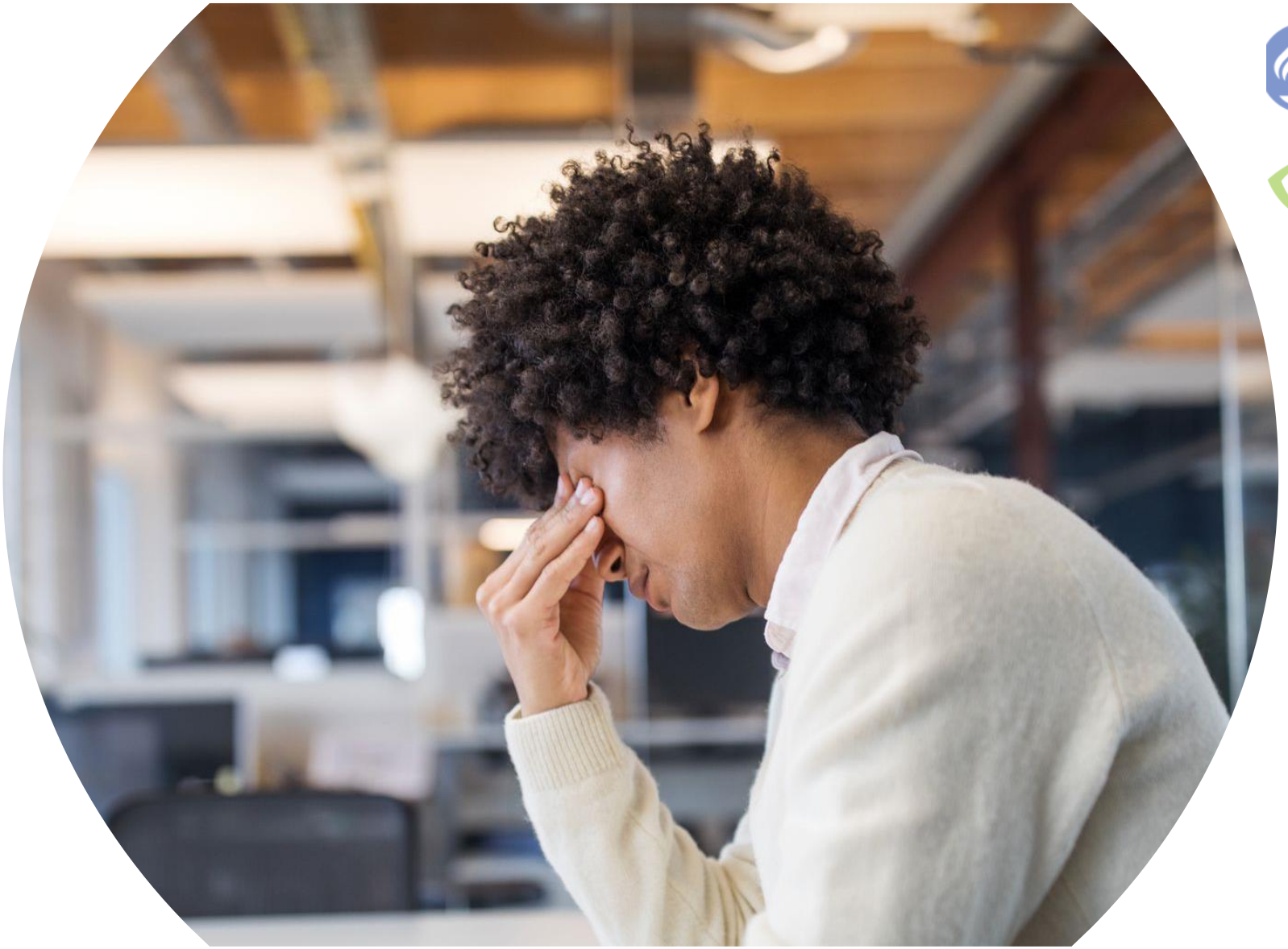
If you finished the installation and everything went smoothly.

Then, try the following command to start ROS:

roscore

If the terminal displays a similar output to this image in the slide: Congrats, you have Ubuntu and ROS running!





Having trouble? Or Too daunting?

Super Easy Virtual Machine Installation

- Download and unzip the files:
  - VMware software executable
  - Preinstalled VM zip file

NOTE: This is a long file (~ 6GB).

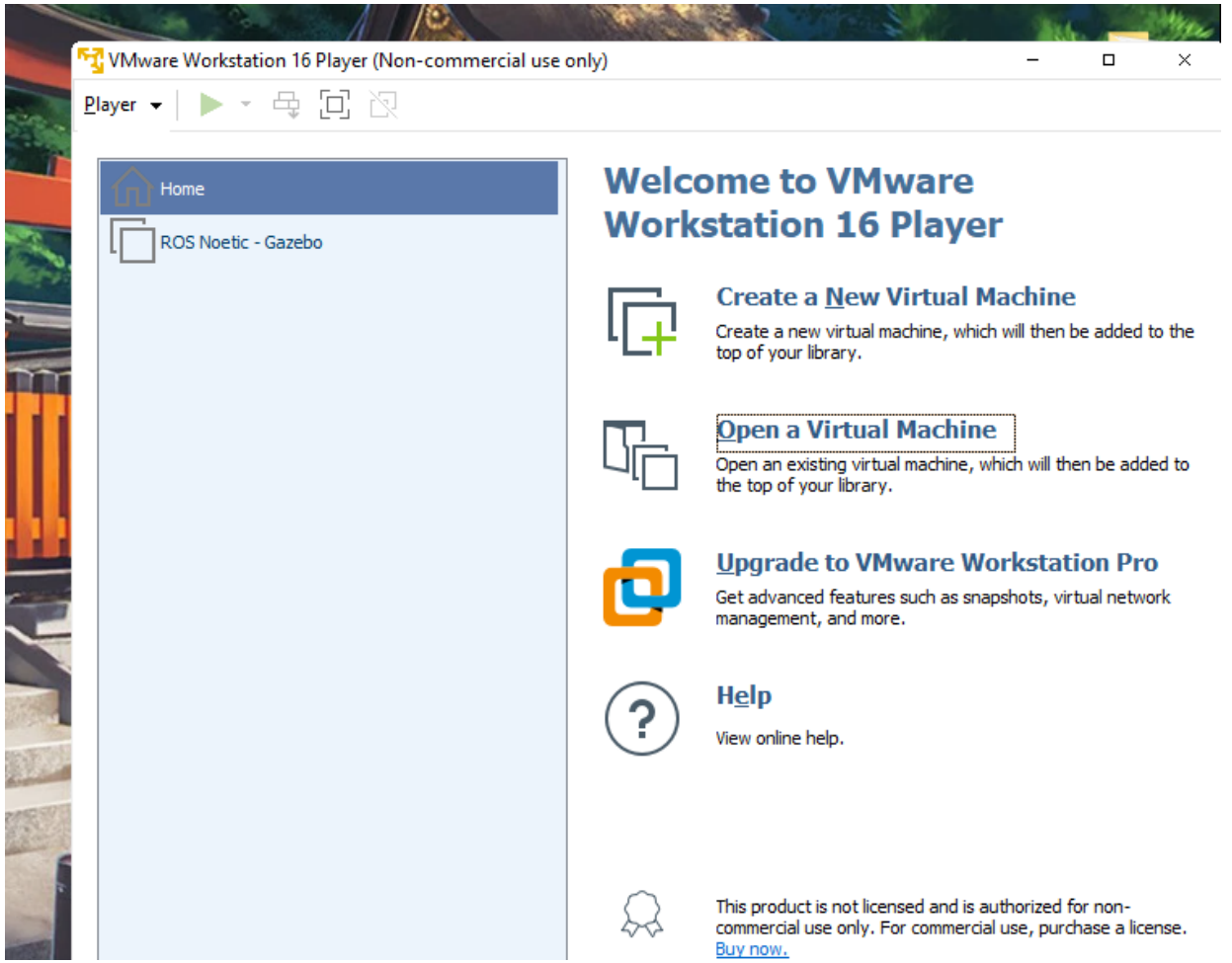
- Install the VMware software.
- Open the software, finish the setup, and license.

NOTE: Select personal “non-commercial” use

- Click on “open virtual machine”: (you only must do this once). The virtual machine will start to be set up.

NOTE: Choose the option “I copied it”

- The virtual machine should start up with Ubuntu and ROS installed!



USER: Student
PASSWORD: admin