Introduction to Ubuntu, MuJoCo, IsaacGym

2024 Summer GEARS
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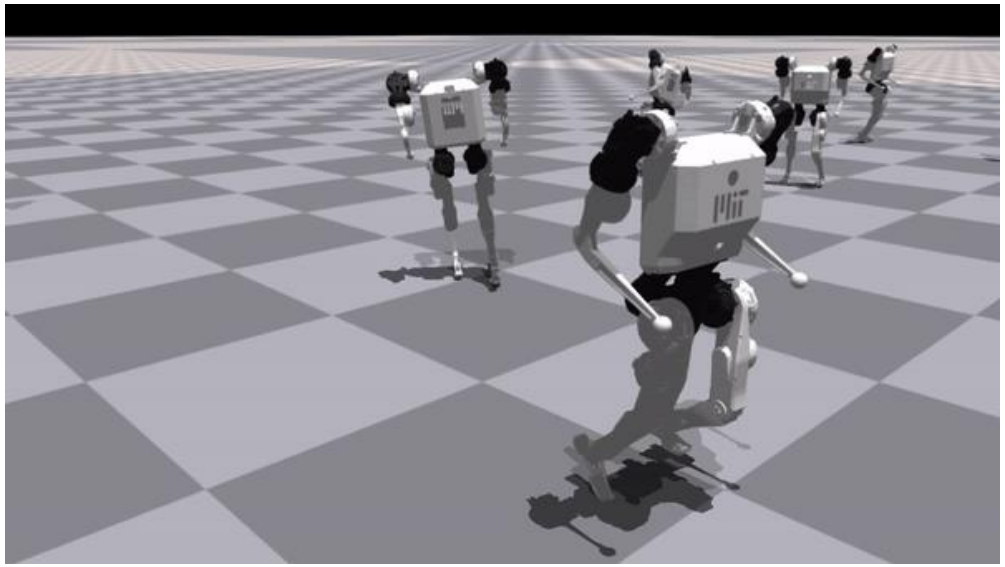
Humanoid Robot Project

- Requires Ubuntu 18.04 and Nvidia GPU with CUDA
- Objective: Learn how to train a robot controller to make the robot walk naturally via reinforcement learning and evaluate the robot walking performance corresponding to different reward function composition
- Link: https://github.com/biomechatronics001/NCSU-GEARS-Reinforcement-Learning-Humanoid-Control?tab=readme-ov-file#humanoid-project



Legged Robot Learns to Walk via Reinforcement Learning

- Tentative Tasks
  - Setup the simulation environment in Ubuntu
  - Given a robot, learn to formulate a good reward function: what terms should be used, and how to assign weights to balance between different terms
  - With the robot and reward function, complete the code to perform the controller training
  - Evaluate the walking performance of the robot using the trained controller
  - Reproduce benchmark figures in the paper regarding different reward formulations
  - Given the CAD model of a new robot, learn to load it into the simulation environment
  - With this new robot, repeat the procedures above and train a good controller

Project Deliverables

- Coding
  - Train the controller and visualize robot running
  - Reproduce benchmark figures in the paper regarding different reward formulations
  - Define your own reward functions
  - Robot virtual competition
- Answering short questions
  - Main challenges in defining effective reward functions
  - Difference between potential-based reward shaping (PBRS) and direct-reward shaping (DRS)
  - Insights from the paper

Requirement

- Linux Ubuntu 18.04:
  - Dual boot with Windows
  - Install Ubuntu onto a USB drive and boot the system from it
- Nvidia GPU with CUDA strongly preferred
  - CPU is maybe usable but training will be very slow
- Code provided by us
- Isaac Gym from Nvidia

Install Ubuntu with Windows (Dual boot)

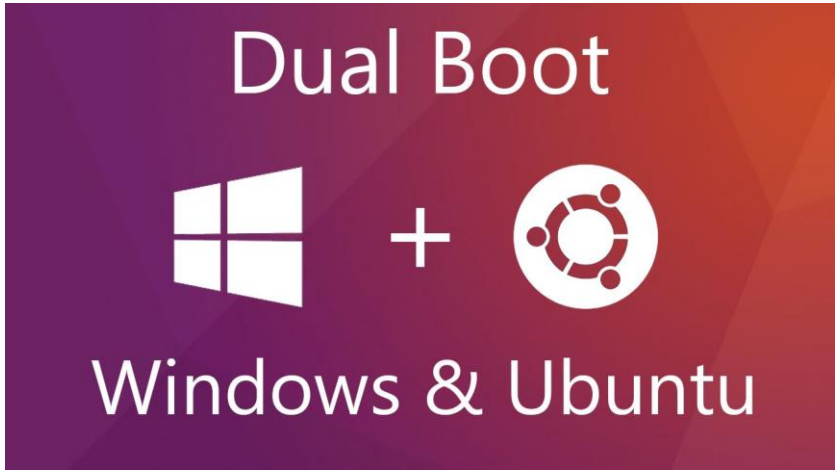
Installing Ubuntu

- Step1: Download **Ubuntu 18.04** from the link below:
  - https://releases.ubuntu.com/18.04/ubuntu-18.04.6-desktop-amd64.iso

- Step 2: Make bootable USB drive
  - Check if your system is BIOS or UEFI
    - Run (Win + R)-> type “msinfo32” -> Check BIOS Mode
  - If BIOS: https://www.pendrivelinux.com/universal-usb-installer-easy-as-1-2-3/
  - If UEFI : https://rufus.ie/en/

- Step 3: Create a new drive
  - Follow Step 2 from the link

- Step 4: Being installation
  - Follow Step 4 and next link



Install Ubuntu from USB drive

Requirements

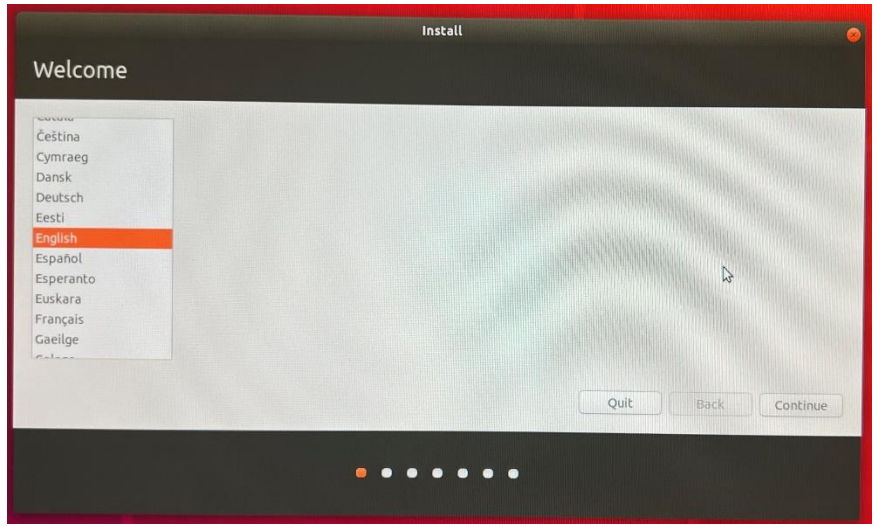
- Bootable drive with Ubuntu 18.04
- High-speed portable drive (at least 64 GB of capacity)

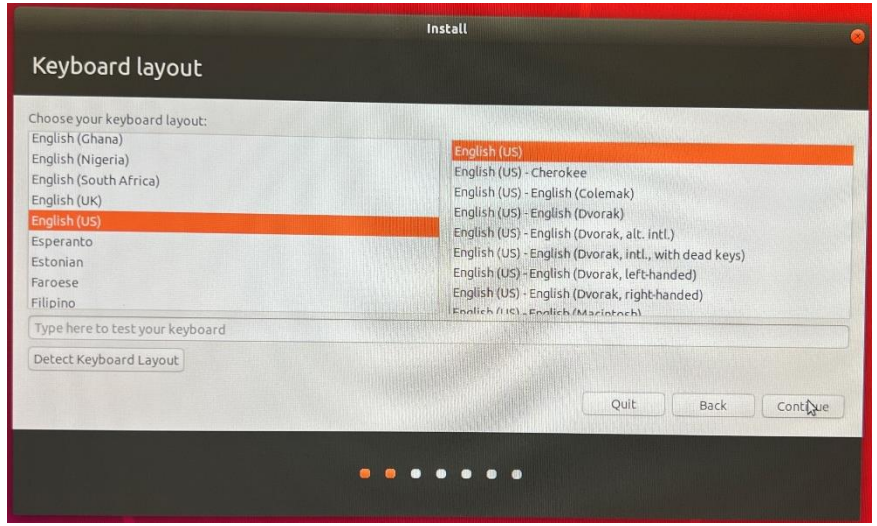
Connection & Start

1. Connect the Bootable drive with Ubuntu 18.04 in the PC
2. Connect the High-speed portable drive (at least 64 GB of capacity)
3. Turn on the PC
4. Get into the BIOS
   (commonly by pressing F1, F11, or F12 during the start up)
5. Select the Bootable drive with Ubuntu 18.04
6. From the available options, select “Install Ubuntu”

Steps

- Select the preferred language
  - For the system
  - For the keyboard
- English recommended

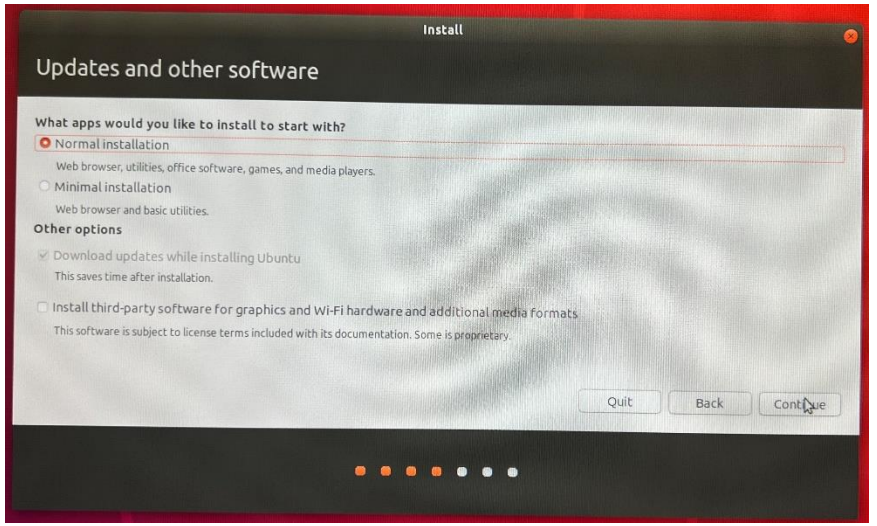




Steps

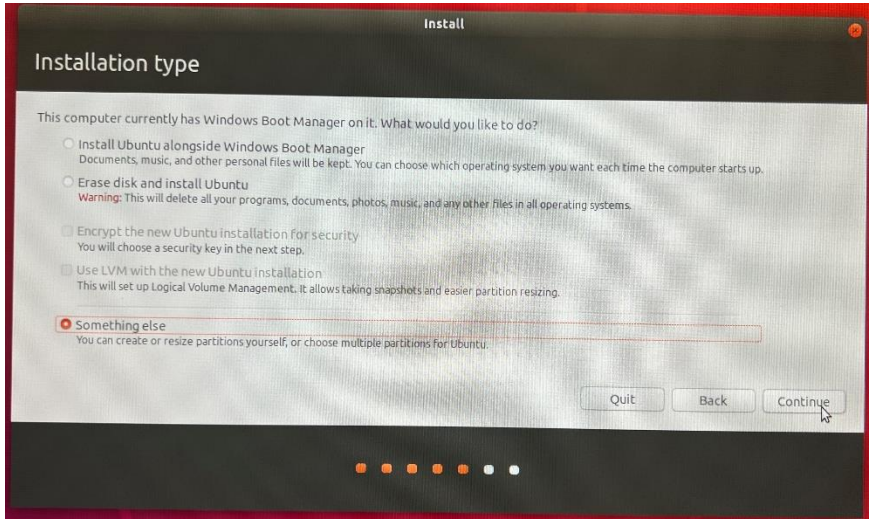
Updates and other software

- Select “Normal installation”
- Click “Continue”



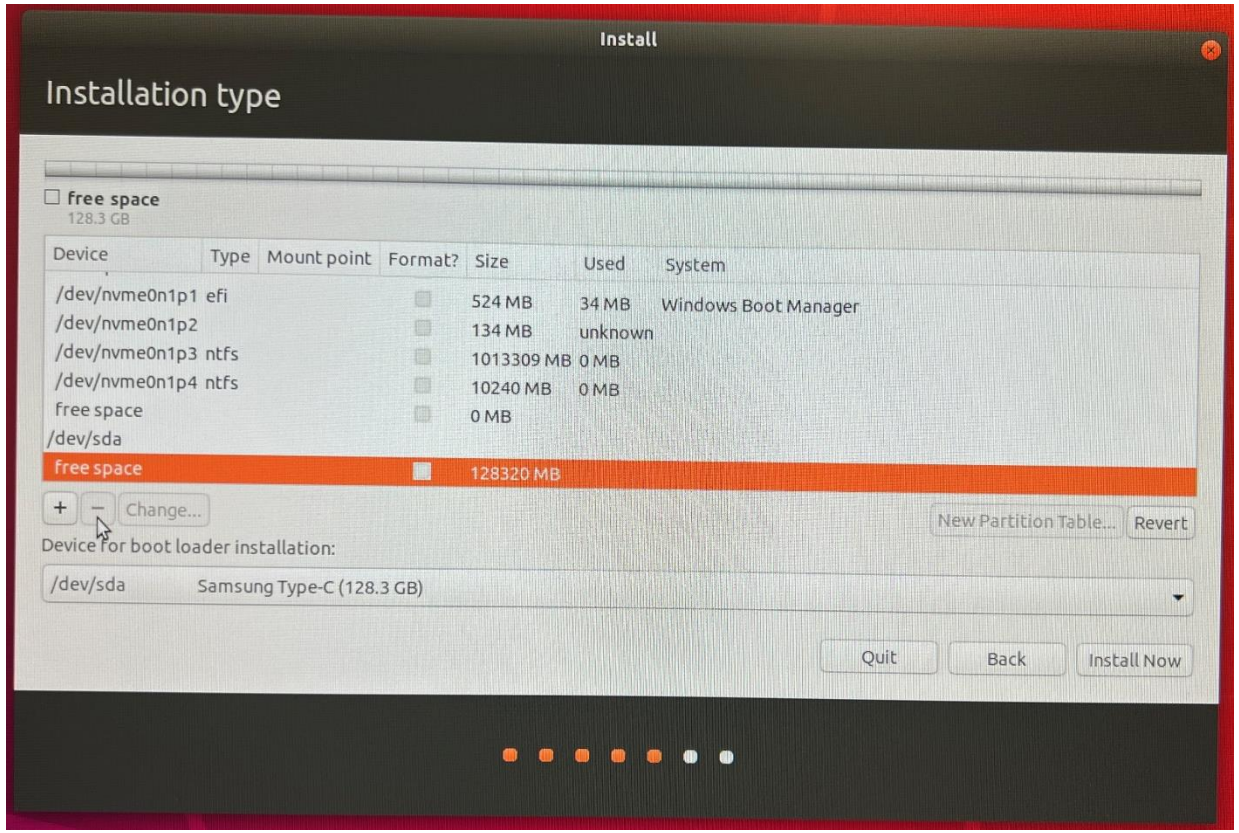
Installation type

- Select “Something else”
- Click “Continue”



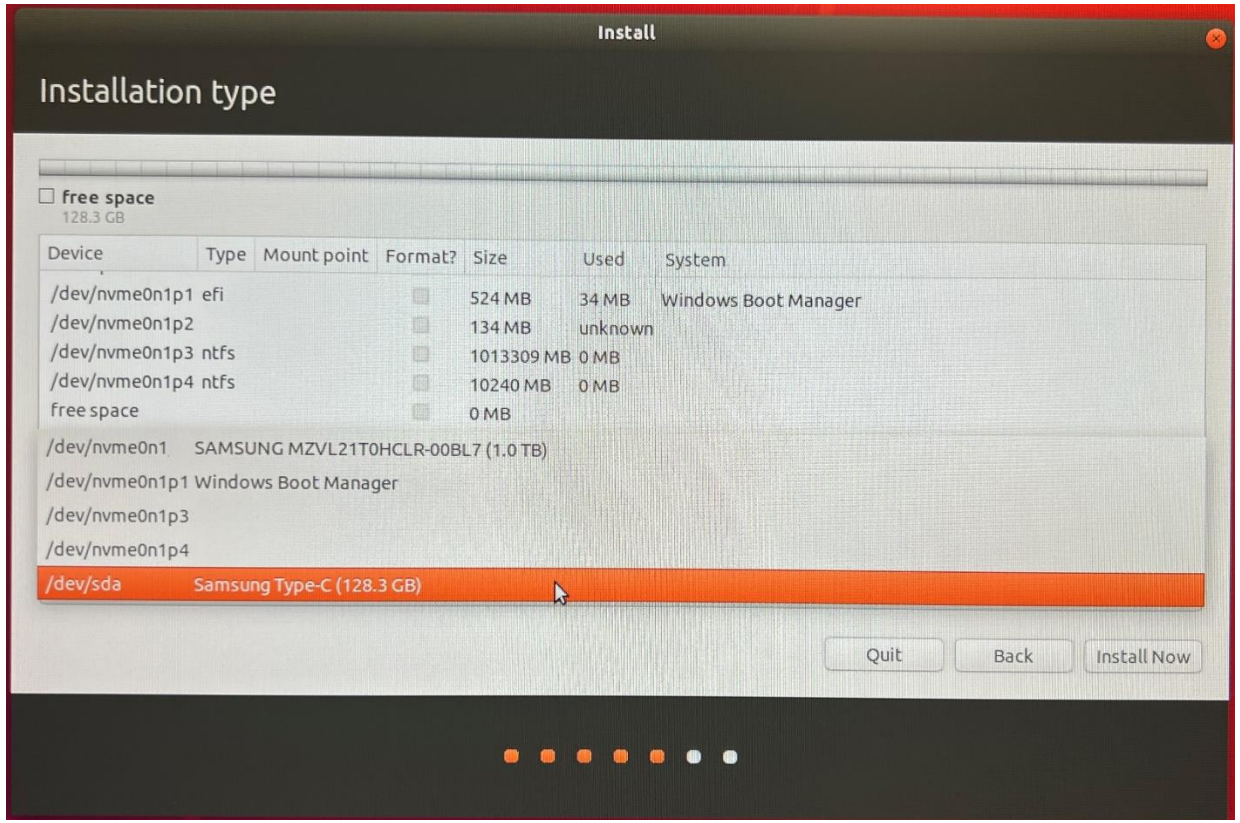
Step

- Go to the bottom and find the device with the same size as the portable drive that you will use to install Ubuntu (in this case, 128 GB).
- Then select it and click on the minus sign button.
- After that, you will see that the device now is displayed as “free space”.



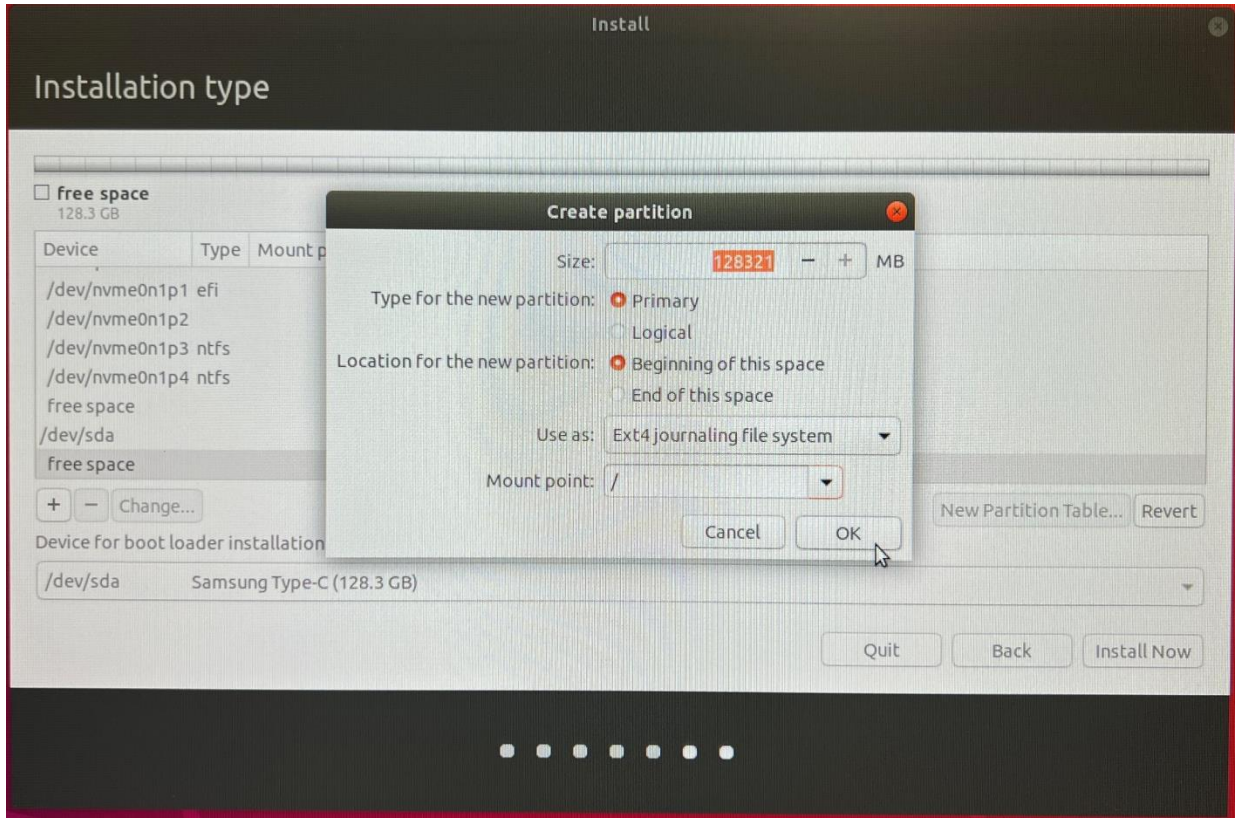
Step

- From the drop-down menu “Device for boot loader installation”, select the portable drive where Ubuntu will be installed (in this case, the 128 GB size)



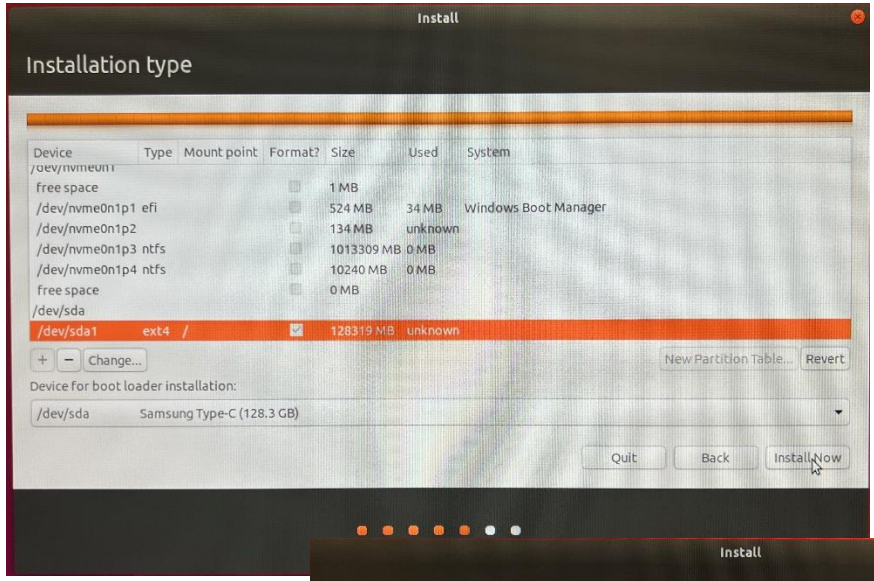
Step

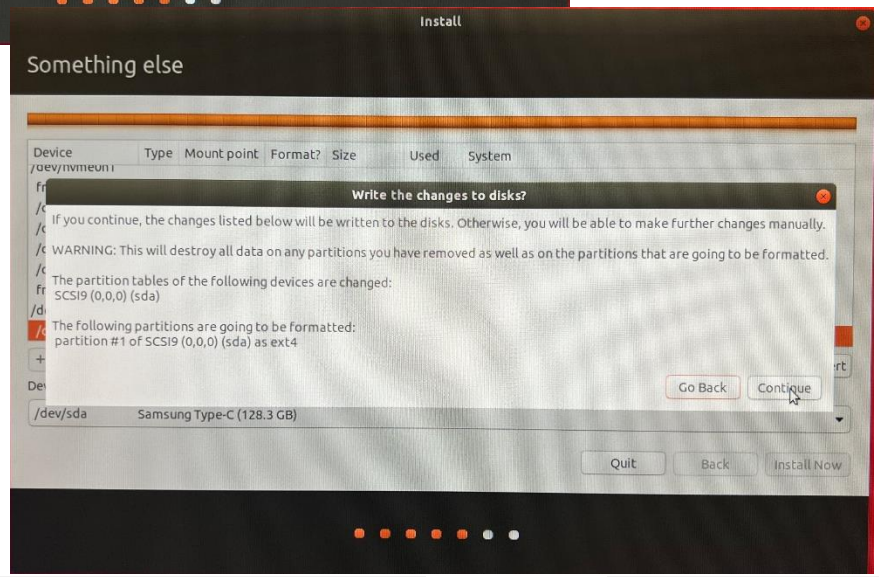
- From the drop-down “Mount point” menu select “/”
- Click “OK”



Step

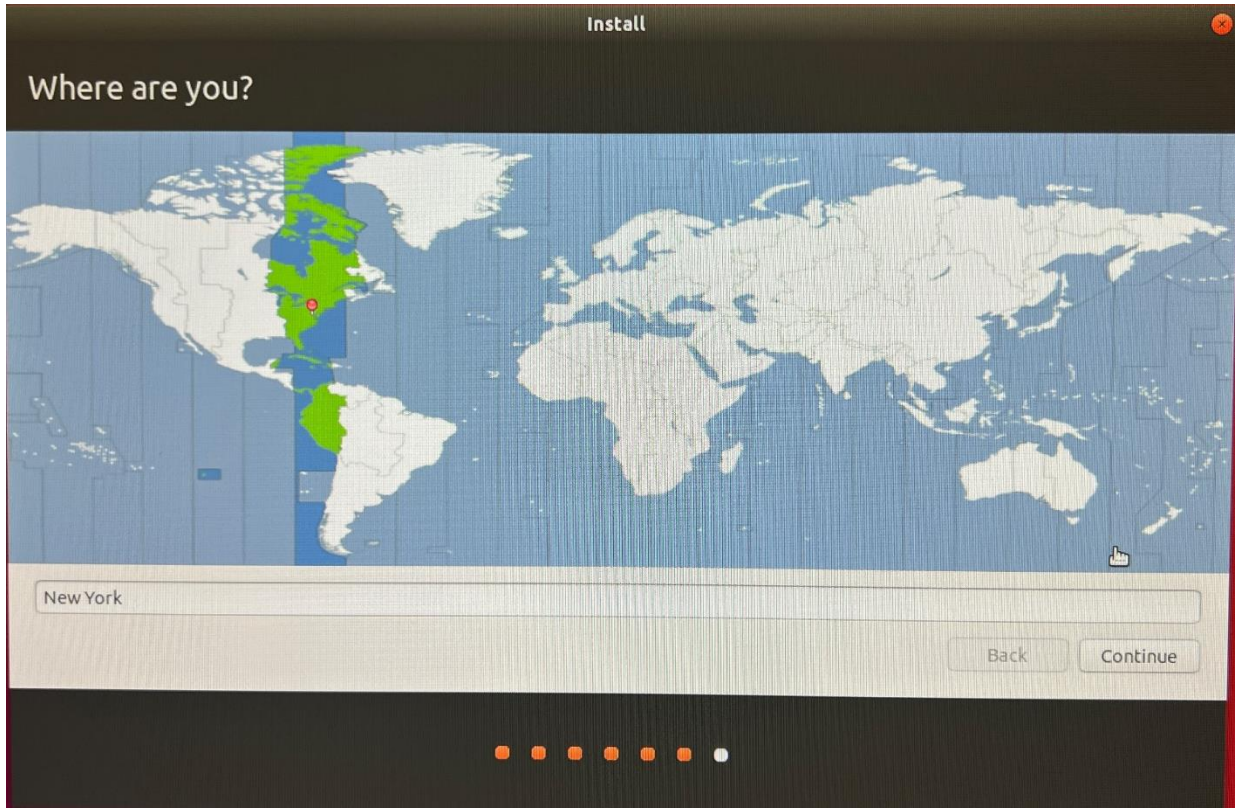
- Select the portable drive and click Install Now.
- Click Continue





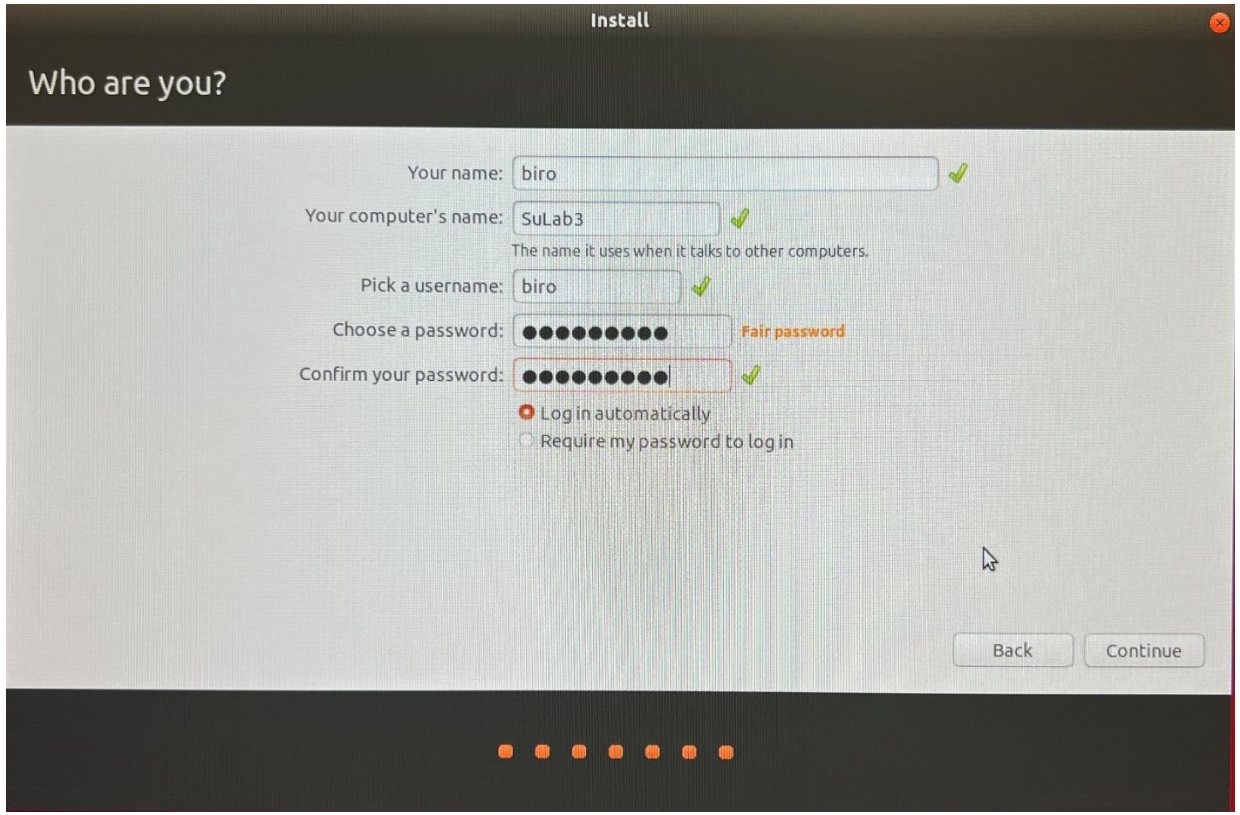
Step

- Select the proper time zone (in this case, New York it fine)



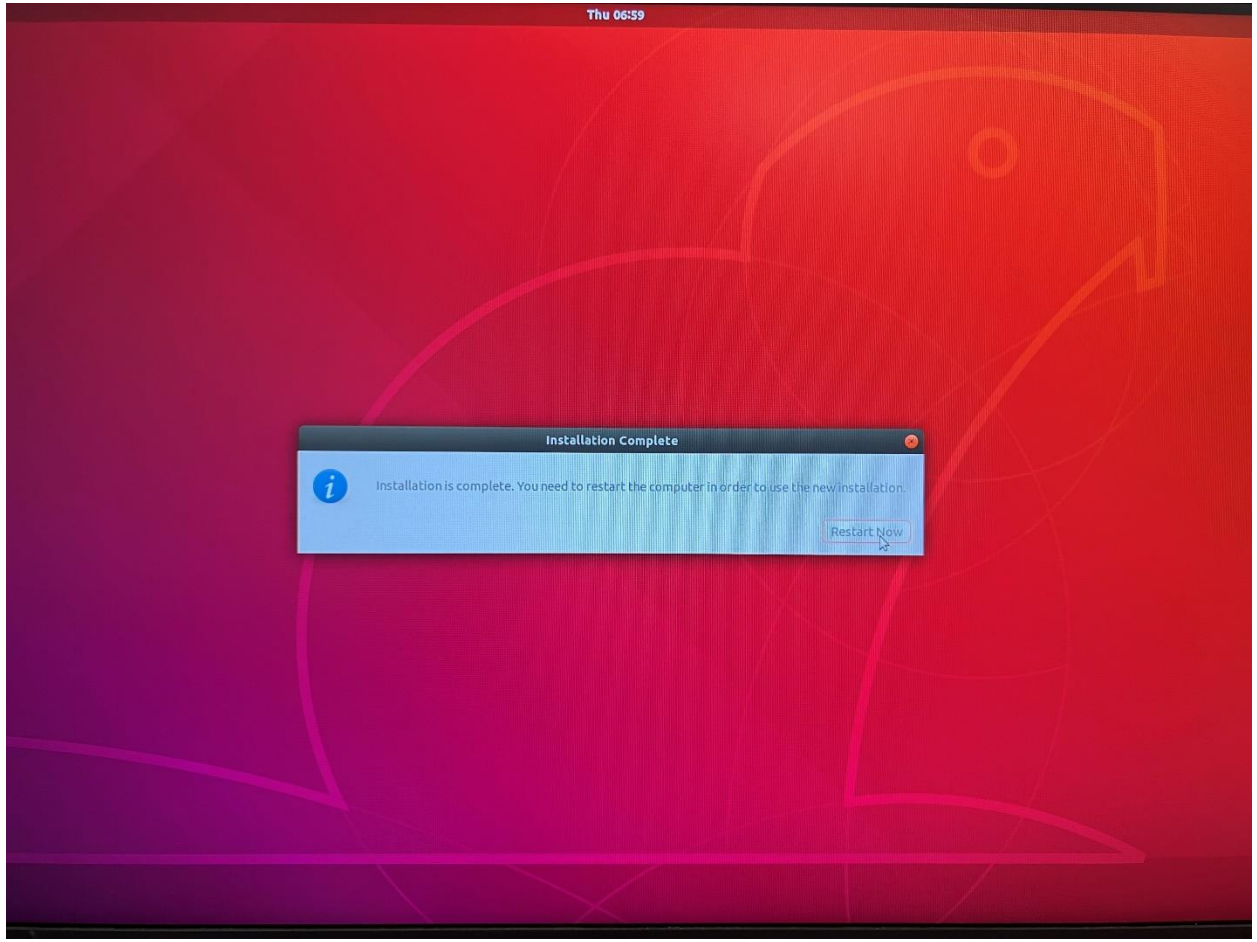
Step

- Enter your desired username
- Enter your computer's desired name (try something short and easy)
- Enter the password
- Click "Continue"
- Wait the installation to finish.



Step

- Remove the installer drive from the PC.
- Keep the portable drive connected to the PC (here is where Ubuntu is).
- Click Restart Now.
- After this, you will be able to run Ubuntu from the portable drive.



Install IsaacGym

Basic Commands

- **Terminal** : Executes your commands in Ubuntu
  - To open terminal press ctrl+alt+T
- **ls** : lists all the directories in the current directory
- **cd ..** : Move one directory back
- **mkdir "name_directory":** Creates a directory with user specified name "name_directory"
- **Rm –rf "name_directory" :** Deletes the directory with user specified name "name_directory"
- For more please refer to : https://ubuntu.com/tutorials/command-line-for-beginners#4-creating-folders-and-files

Environment Installation

1. Create a new python virtual env with python 3.6, 3.7 or 3.8 (3.8 recommended)
2. Install pytorch 1.10 with cuda-11.3:
   - pip install torch==1.10.0+cu113 torchvision==0.11.1+cu113 torchaudio==0.10.0+cu113 -f https://download.pytorch.org/whl/cu113/torch_stable.html

Environment Installation

3. Install Isaac Gym
   - Download and install Isaac Gym Preview 4 from https://developer.nvidia.com/isaac-gym (extract the zip package, copy the isaacgym folder within the package whereever you want it to live - I prefer in the directory with my virtual environment)
   - cd isaacgym_lib/python && pip install -e . to install the requirements
   - Try running an example cd examples && python 1080_balls_of_solitude.py (you need to execute the examples from the examples directory)
   - For troubleshooting check docs isaacgym/docs/index.html)

Environment Installation

4. Download the base code from here
   - go to gpu_gym, then init the submodules:
   - cd gpu_gym && git submodule init && git submodule update
5. Install gpu_rl (PPO implementation)
   - cd gpu_rl && pip install -e .
6. Install gpuGym
   - cd .. && pip install -e .
7. Install WandB for experiment tracking - follow this guide
   - pip install wandb==0.15.11

Loading a Blank Policy (Robot Visualization)

- Link to the project main folder: https://www.dropbox.com/scl/fo/bph6cvb6a0ugr5ljckpvl/AN_0DMHxS92FtmKIu99OZho?rlkey=8fp81ms8g32vvvir8s38lkwua&dl=0
- Copy the provided blank policy folder into *code/logs/2024Summer*
- Using a terminal that is open in *code/scripts*, execute the following command:
  - **python play.py --task=pbrs:humanoid --experiment_name=2024Summer –load_run=<folder name>**
- You should see several robots falling over because the controller is doing nothing.

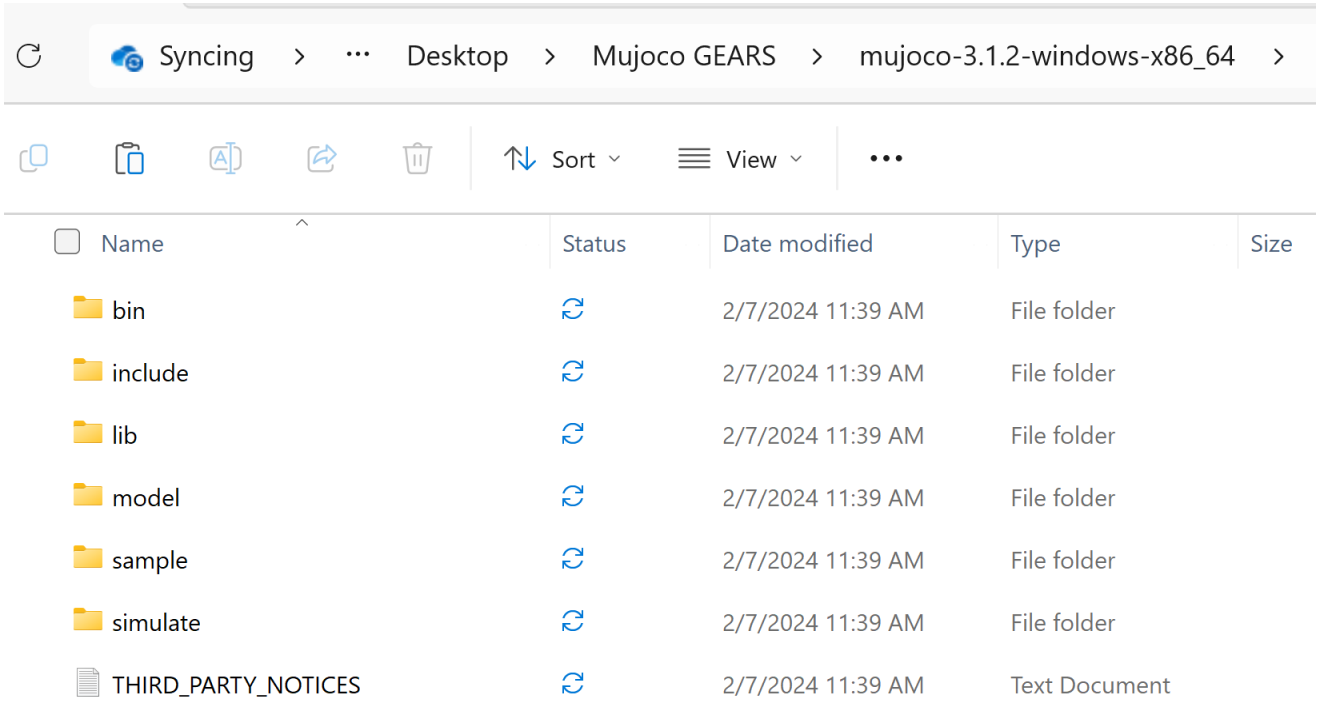
Install Mujuco

Visualizing the Robot Using Mujoco

- You will also use Mujoco, an open-source physics simulation environment to visualize the robot and see how its joints work.
- To do this you will utilize the same .urdf file that describes the robot for the RL simulator (with a small compatibility change for Mujoco)
- Tasks:
  - Download and Setup Mujoco
  - Download .zip file containing the .urdf file and 3d models of the robot components

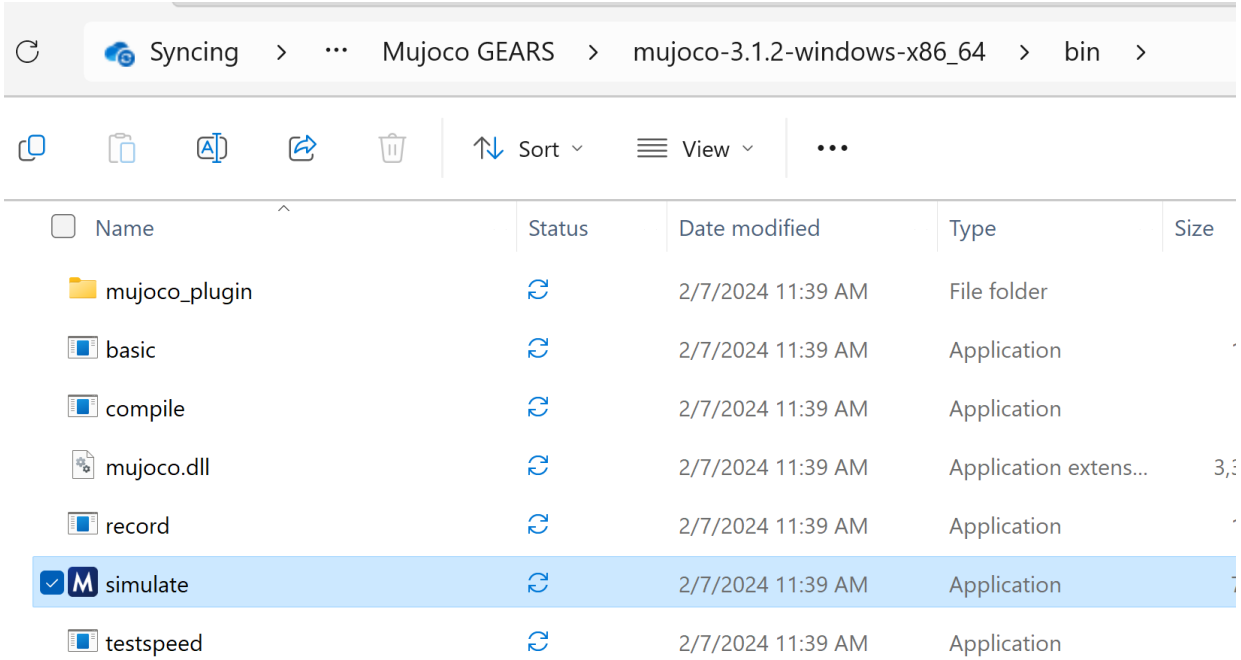
Download and Setup of MuJoCo

- Download the latest release archive for your operating system from this page: https://github.com/google-deepmind/mujoco/releases
- Extract the contents of the archive to a folder of your choice, from here I will assume it is called “Mujoco”
- You should see the following:



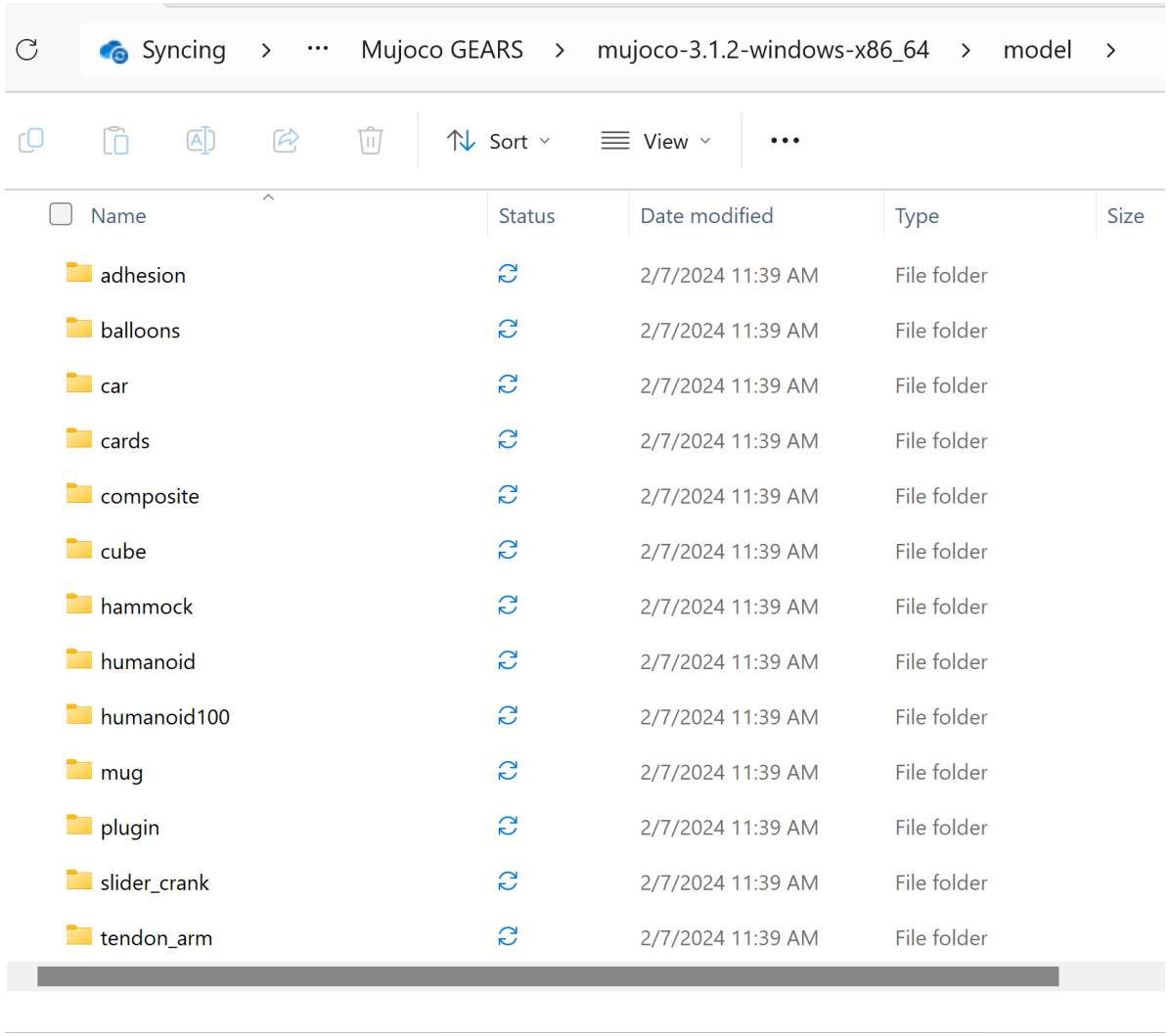
Running MuJoCo

- To run MuJoCo, simply go to Mujoco/bin and double click on the “simulate” application.
  - You may also wish to create a shortcut for simulate and place it on your desktop to make it easier to find later.



Loading a Model into MuJoCo

- To load a model into MuJoCo, simply drag a .urdf or .xml file from your file manager onto the simulate window.
- Please try one of the examples found in Mujoco/model

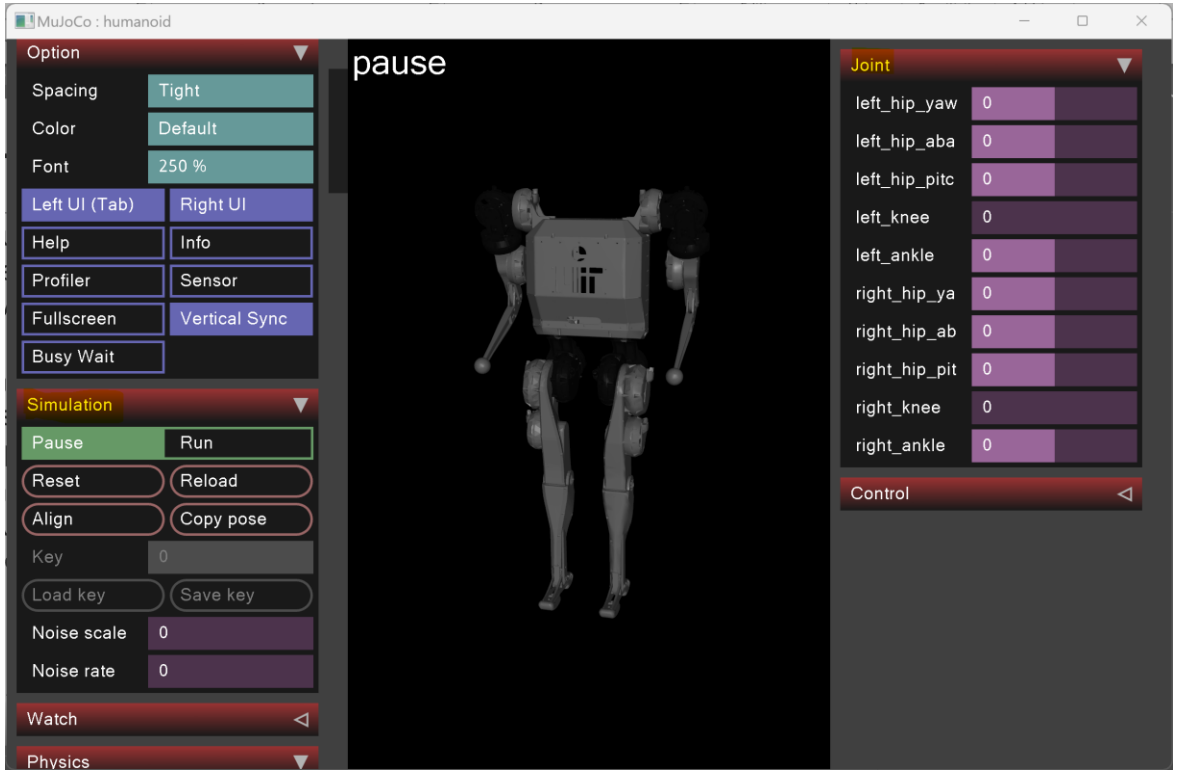


Humanoid Model

- The humanoid model for this project is provided in a separate zip file in the Dropbox. Please download it and extract it to a known location (without having spaces in the path).
  - Link: https://www.dropbox.com/scl/fo/bph6cvb6a0ugr5ljckpvl/AN_0DMHxS92FtmKIu99OZho?rlkey=8fp81ms8g32vvvir8s38lkwua&dl=0
- When you open the folder, you will see a .urdf description file and folder full of .stl 3d models.
- Open the .urdf file and update the ***meshdir*** to be the location of the folder of .stls files on your machine. Remember to include the **entire path** and **avoid having spaces in the path**.

Humanoid Model (Cont.)

- Once you have updated the meshdir, drag the .urdf file into the MuJoCo simulate window.
- On the right panel, you can use the joint sliders to manipulate the robots lower body joints.
- On the left panel, use the run, pause, and reset buttons to see the robot react to gravity. Just explore with these, you will get the hang of it quickly.



Resources on URDF File

- https://mujoco.readthedocs.io/en/stable/XMLreference.html#body-geom
- https://wiki.ros.org/urdf/Tutorials/Building%20a%20Visual%20Robot%20Model%20with%20URDF%20from%20Scratch