Lab Session 4.3:
Yolov8 Object Detection and Counting on Nvidia Jetson AGX Orin GPU

Overview:

In this lab, students will set up the Nvidia Jetson AGX Orin and familiarize themselves with it. We will set up the environment for AI applications. Furthermore, we will do object detection and counting using the popular Yolov8 model. Please note that the boards have been already flashed with the Jetpack 6 SDK. Some useful wheel files for installing the torch 2.3 and torchvision 1.8 were also downloaded. Follow the steps outlined and ask the TAs and the instructors if you have any difficulty.

Required Software:

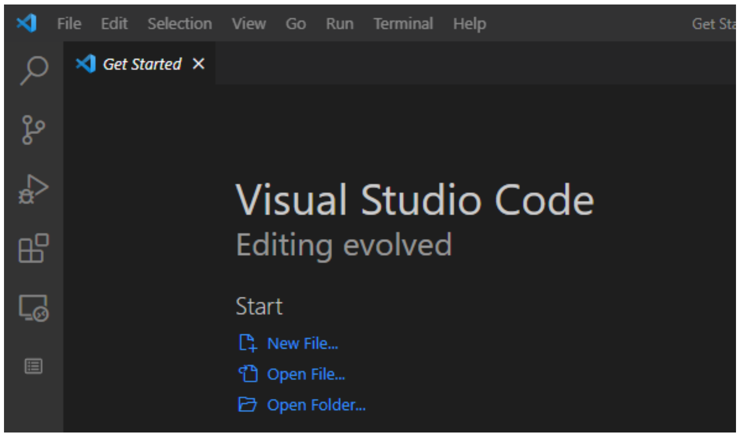
1. Windows/Linux/MAC Host PC
2. Visual Studio Code:
3. Putty
4. X11 Server for X11 forwarding

Steps for the Lab Session:

1. Download and install the required software
2. Connect and access the Jetson AGX Orin board
3. Setup the AI environment
4. Performing the Yolov8 object detection Inference
5. Setting Up X11 forwarding in VS Code for having GUI with remote SSH
6. Object counting with Yolov8
7. Home Exercise: Face recognition

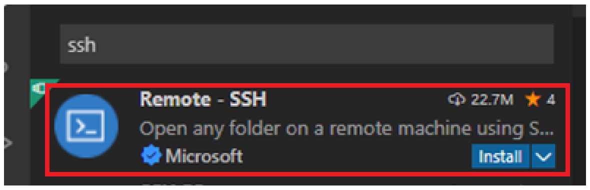
1.0 Download and Installed the Required Software:

1. **Visual Studio Code:**
    - Download and install VS Code: https://code.visualstudio.com/
    - Open VS code from the start menu or by searching



In the VS Code Environment, add the following extensions

1. Remote SSH



2. Putty:

Download and install Putty: https://www.putty.org/

2.0 Connect and access the Jetson AGX Orin board

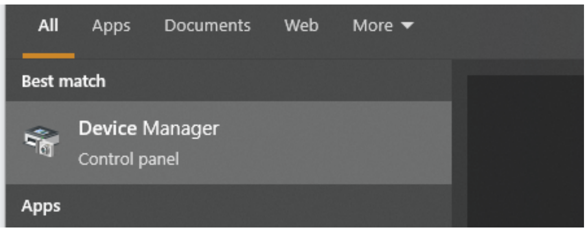
To connect and access the board there are various ways as follows:

1. Using serial port (Use Putty or other serial communication tools)
2. SSH using Putty
3. SSH using command prompt
4. SSH in VS Code

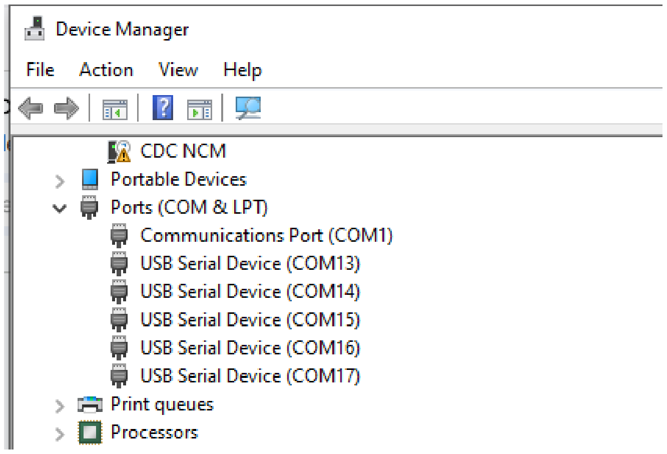
We recommend the **SSH in VS Code**, however, it is useful to learn using the serial port, could be useful for debugging or finding the IP address before establishing the SSH at the beginning.

2.1 Remote Access to the Board Using Serial Port with Putty

- Open Device Manager



- Check the Port Number of the board under **PORTS.** The board has 4 serial ports, use the first one.Choose the first Port that comes with the board. Here COM14

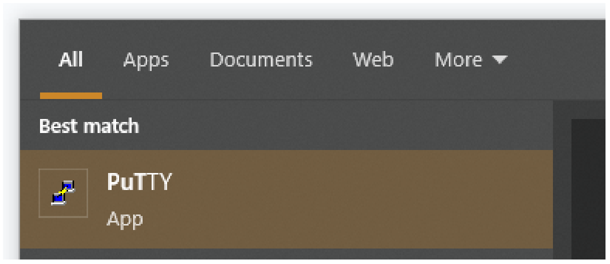


Device Manager

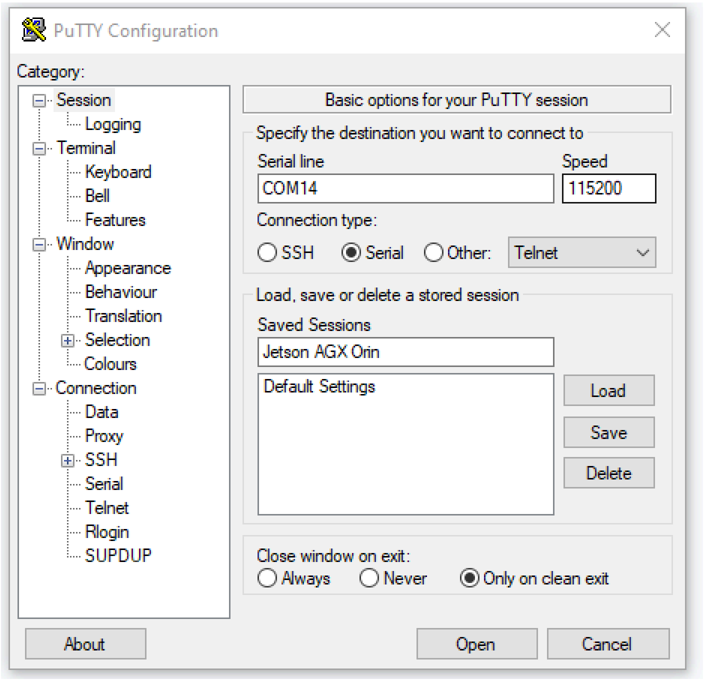
File Action View Help

- CDC NCM
- Portable Devices
- Ports (COM & LPT)
  - Communications Port (COM1)
  - USB Serial Device (COM13)
  - USB Serial Device (COM14)
  - USB Serial Device (COM15)
  - USB Serial Device (COM16)
  - USB Serial Device (COM17)
- Print queues
- Processors

- Open Putty



- Select the **Serial** option and enter the port number and the Baud rate (**115200**). Set **Flow Control** to None in the serial setting.



PuTTY Configuration

Basic options for your PuTTY session

Specify the destination you want to connect to

Serial line: COM14

Speed: 115200

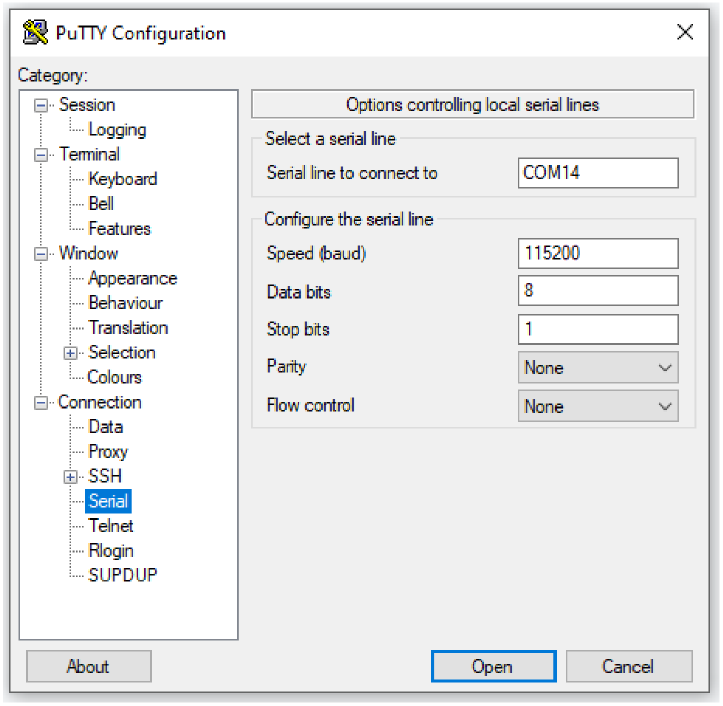
Connection type: SSH [✓ Serial] Other: Telnet

Load, save or delete a stored session

Saved Sessions: Jetson AGX Orin

Default Settings

Close window on exit: Always Never [✓ Only on clean exit]


PuTTY Configuration

Options controlling local serial lines

Select a serial line

Serial line to connect to: COM14

Configure the serial line

Speed (baud): 115200

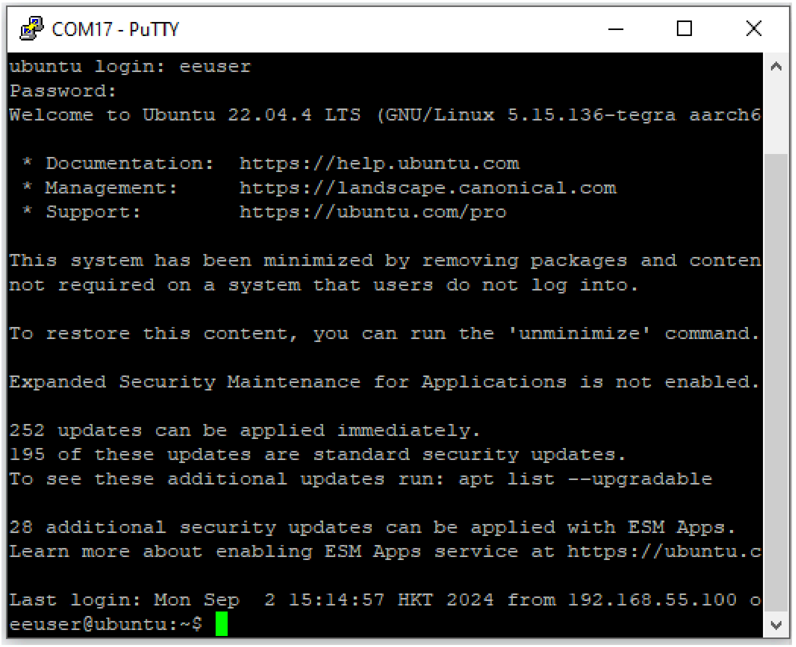
Data bits: 8

Stop bits: 1

Parity: None

Flow control: None

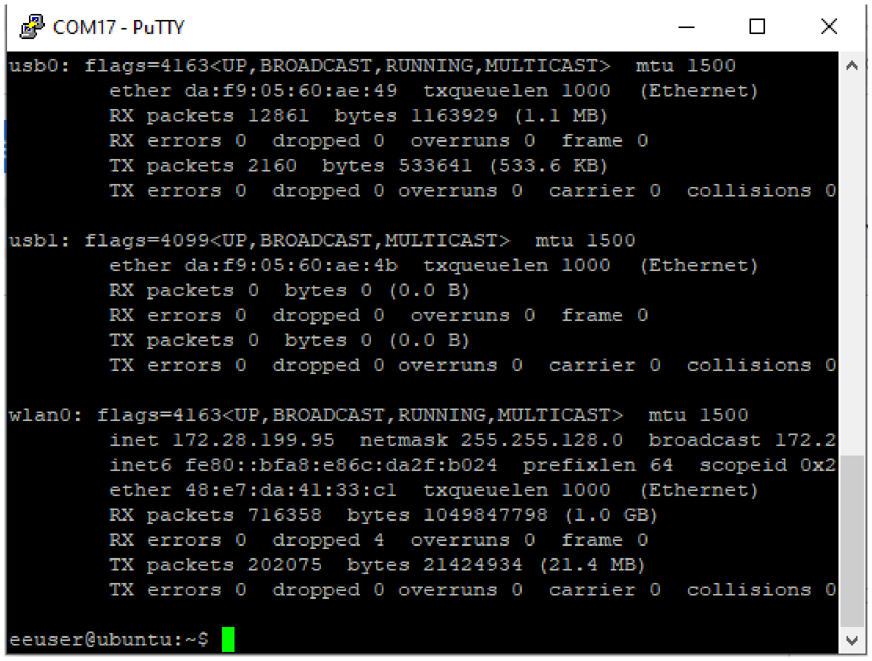
- Click Open. Press Enter if the board has already started.
- Enter username: **eeuser**, and password: **eeuser**


COM17 - PuTTY

```
ubuntu login: eeuser
Password:
Welcome to Ubuntu 22.04.4 LTS (GNU/Linux 5.15.136-tegra aarch6

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

This system has been minimized by removing packages and conten
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize' command.

Expanded Security Maintenance for Applications is not enabled.

252 updates can be applied immediately.
195 of these updates are standard security updates.
To see these additional updates run: apt list --upgradable

28 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.c

Last login: Mon Sep  2 15:14:57 HKT 2024 from 192.168.55.100 o
eeuser@ubuntu:~$
```

- Check the ip address:

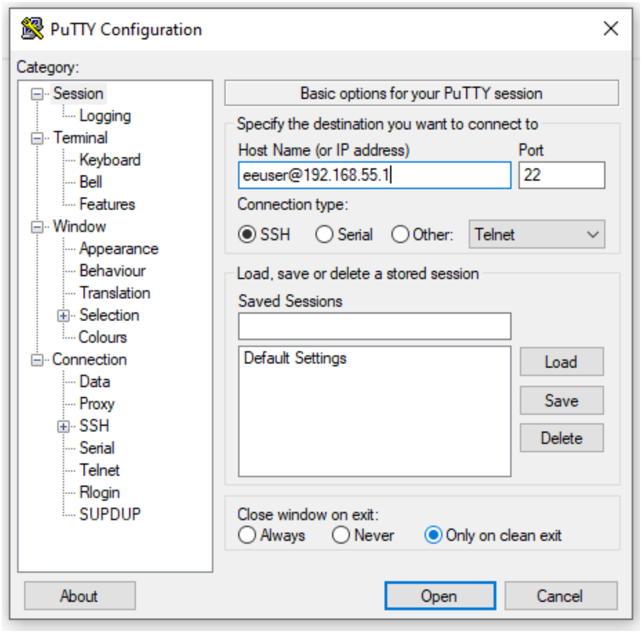
  >> ifconfig



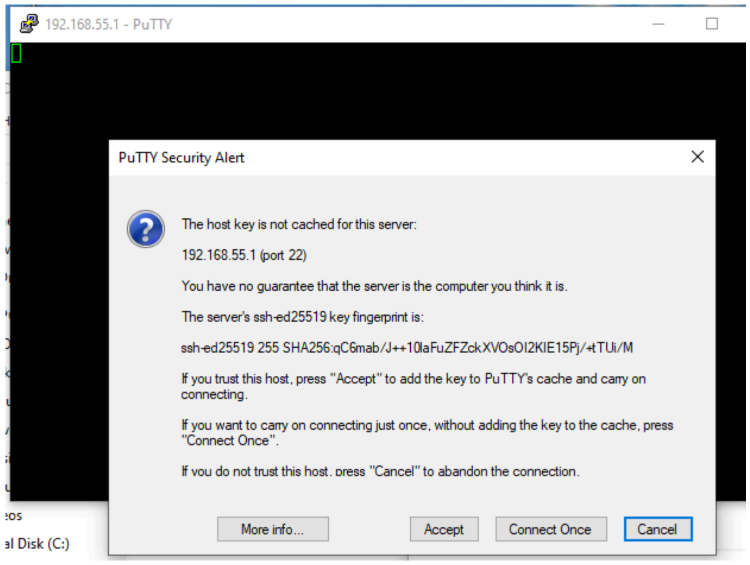
```
usb0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        ether da:f9:05:60:ae:49  txqueuelen 1000  (Ethernet)
        RX packets 12861  bytes 1163929 (1.1 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 2160  bytes 533641 (533.6 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

usb1: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
        ether da:f9:05:60:ae:4b  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 172.28.199.95  netmask 255.255.128.0  broadcast 172.2
        inet6 fe80::bfa8:e86c:da2f:b024  prefixlen 64  scopeid 0x2
        ether 48:e7:da:41:33:c1  txqueuelen 1000  (Ethernet)
        RX packets 716358  bytes 1049847798 (1.0 GB)
        RX errors 0  dropped 4  overruns 0  frame 0
        TX packets 202075  bytes 21424934 (21.4 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

eeuser@ubuntu:~$
```

2.2 SSH using Putty:

- You can alternatively choose SSH in Putty
- Connect the USB cable to the board and the PC
- Enter the hostname@ip_address e.g. eeuser@192.168.55.1
- Accept the key connection request and click **Open**



Specify the destination you want to connect to
Host Name (or IP address): eeuser@192.168.55.1
Port: 22
Connection type: [✓ SSH] Serial Other: Telnet
Close window on exit: Always Never [✓ Only on clean exit]


192.168.55.1 - PuTTY

PuTTY Security Alert

The host key is not cached for this server:

192.168.55.1 (port 22)

You have no guarantee that the server is the computer you think it is.

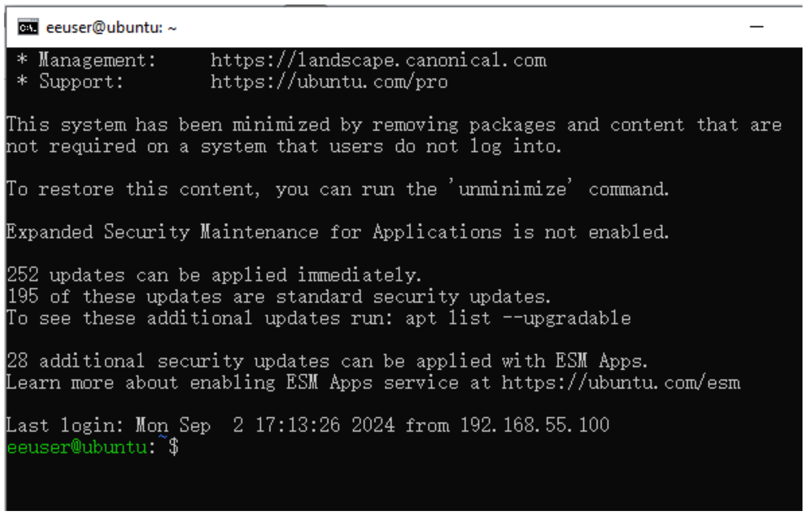
The server's ssh-ed25519 key fingerprint is:

ssh-ed25519 255 SHA256:qC6mab/J++10laFuZFZckXVOsOI2KIE15Pj/+tTUi/M

If you trust this host, press "Accept" to add the key to PuTTY's cache and carry on connecting.

If you want to carry on connecting just once, without adding the key to the cache, press "Connect Once".

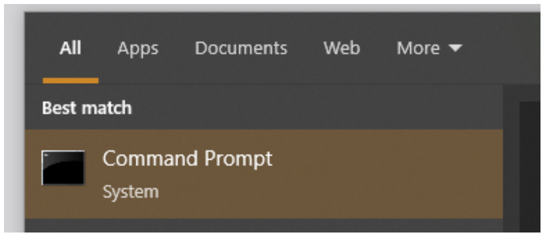
If you do not trust this host, press "Cancel" to abandon the connection.


eeuser@ubuntu: ~

```
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

This system has been minimized by removing packages and content that are
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize' command.

Expanded Security Maintenance for Applications is not enabled.

252 updates can be applied immediately.
195 of these updates are standard security updates.
To see these additional updates run: apt list --upgradable

28 additional security updates can be applied with ESM Apps.
Learn more about enabling ESM Apps service at https://ubuntu.com/esm

Last login: Mon Sep  2 17:13:26 2024 from 192.168.55.100
eeuser@ubuntu:~$
```

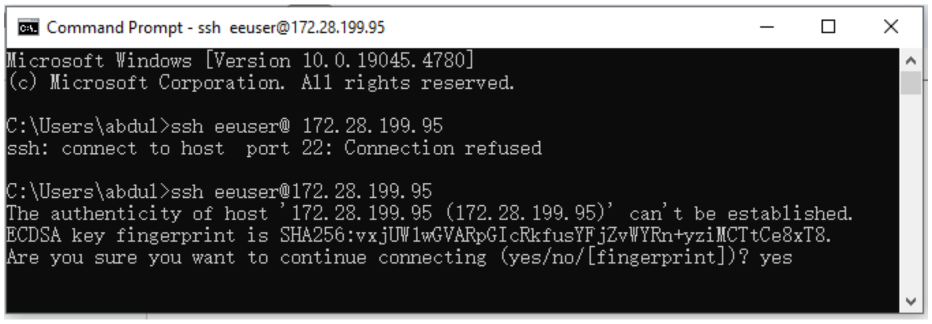
2.3 SSH using command prompt

- If you want to use the command prompt, type cmd in the search area and open the command prompt.



- SSH to the board by typing the command:

    >> ssh eeuser@192.168.55.1

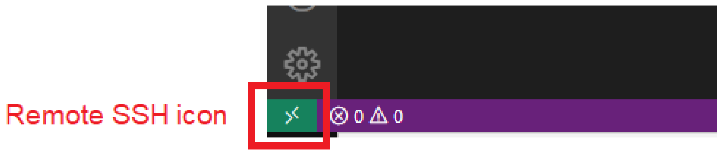


```
Command Prompt - ssh  eeuser@172.28.199.95
Microsoft Windows [Version 10.0.19045.4780]
(c) Microsoft Corporation. All rights reserved.

C:\Users\abdul>ssh eeuser@ 172.28.199.95
ssh: connect to host  port 22: Connection refused

C:\Users\abdul>ssh eeuser@172.28.199.95
The authenticity of host '172.28.199.95 (172.28.199.95)' can't be established.
ECDSA key fingerprint is SHA256:vxjUW1wGVARpGIcRkfusYFjZvWYRn+yziMCTtCe8xT8.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
```

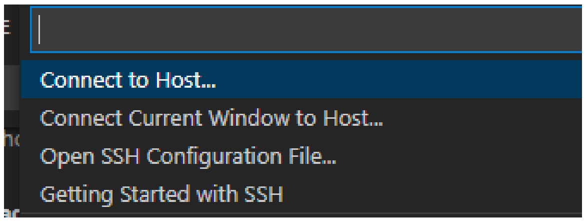
- Accept the connect request and press enter

2.3 SSH using Visual Studio Code (Recommended in this lab)

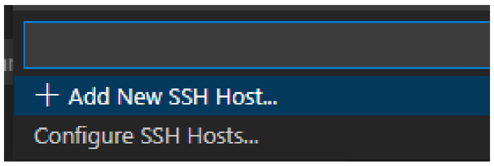
- Open VS Code
- Click at the Remote SSH icon at the left bottom of the VS Code window



- Select **Connect to Host** from the window that open at the top

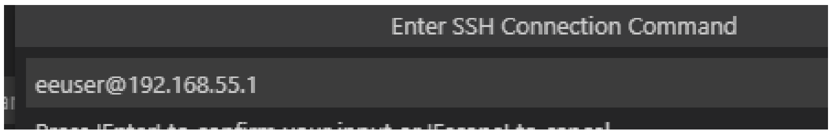

Connect to Host...
Connect Current Window to Host...
Open SSH Configuration File...
Getting Started with SSH

- Choose the **+ Add New SSH Host**

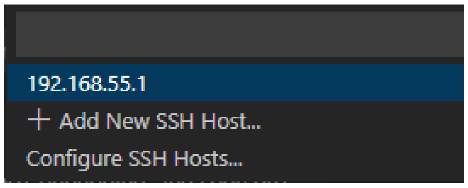


- Enter the ssh connection command

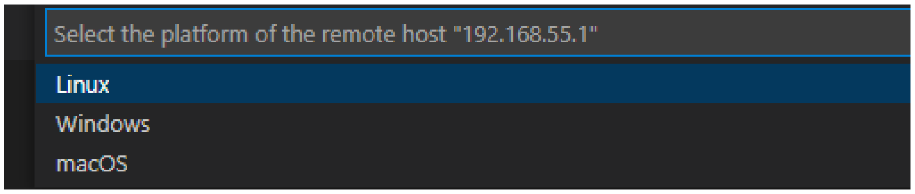
>> eeuser@192.168.55.1



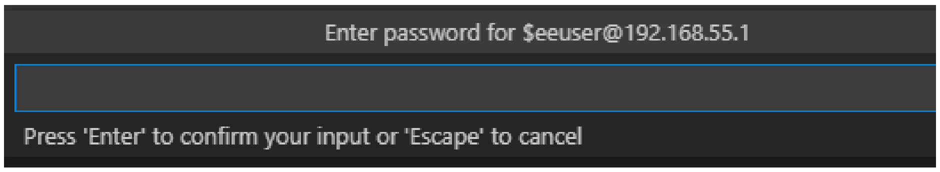
- Click the SSH icon again, now select the saved ip address of the board (192.168.55.1)



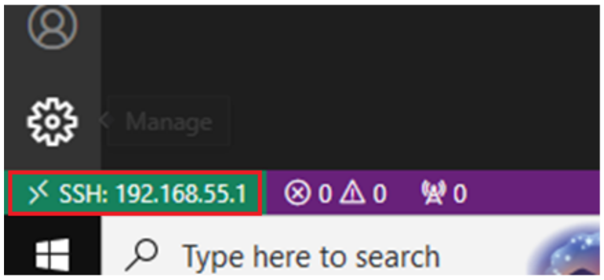
- Select Linux and Continue



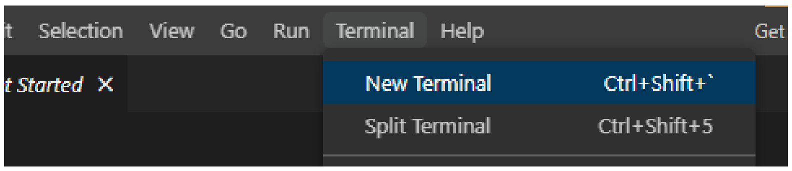
- Enter the Password

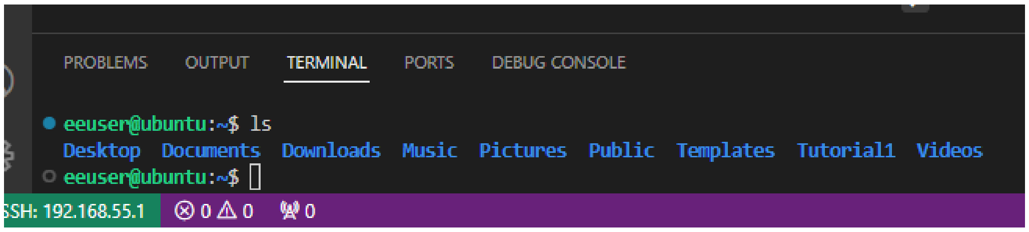

Enter password for $eeuser@192.168.55.1
Press 'Enter' to confirm your input or 'Escape' to cancel

- SSH will now be ready. You confirm by seeing “**SSH:192.168.55.1**”



- Open a terminal or a folder on the board





```
eeuser@ubuntu:~$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Tutorial1  Videos
eeuser@ubuntu:~$
```

3.0 Setting up the AI environment

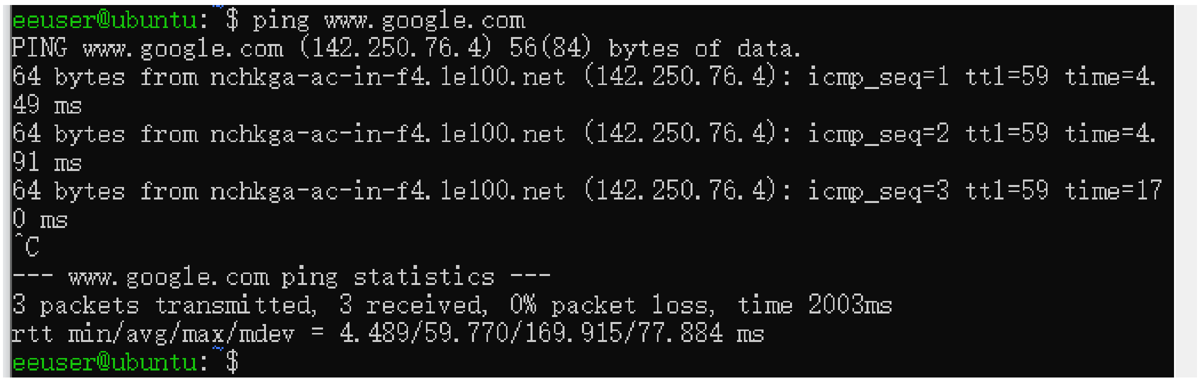
Here, we set up the environment for the AI inference. We can alternatively use Ultralytics' docker. However, in this tutorial we will use the native installation using python environment.

Steps involved:

1. Establish and check network connection
2. Check Python, virtual environment, and JeckPack 6 availability
3. Check Tensorrt availability
4. Create a virtual environment
5. Copy tensorrt to the virtual environment package folder
6. Install Ultralytics
7. Install Torch 2.3 and Torchvision 1.8
8. Install Onnxruntime
9. Test the environment

3.1 Establish and check network connection

- Connect the board to either WiFi or share Ethernet from your PC. You can use nmtui to setup WiFi connect if warranted. Run in Terminal >> nmtui
- Ping Google to ensure internet connection
  >> ping www.google.com
- Press ctrl+C to stop



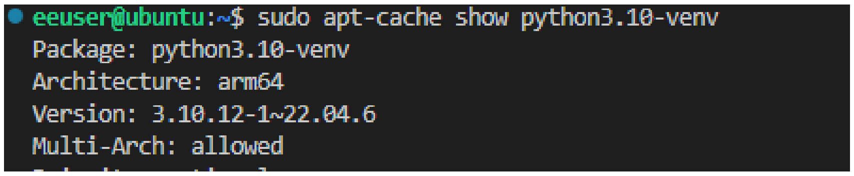
```
eeuser@ubuntu:~$ ping www.google.com
PING www.google.com (142.250.76.4) 56(84) bytes of data.
64 bytes from nchkga-ac-in-f4.1e100.net (142.250.76.4): icmp_seq=1 ttl=59 time=4.
49 ms
64 bytes from nchkga-ac-in-f4.1e100.net (142.250.76.4): icmp_seq=2 ttl=59 time=4.
91 ms
64 bytes from nchkga-ac-in-f4.1e100.net (142.250.76.4): icmp_seq=3 ttl=59 time=17
0 ms
^C
--- www.google.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 4.489/59.770/169.915/77.884 ms
eeuser@ubuntu:~$
```

3.2 Check Python, virtual environment, and JeckPack 6 availability

- Check if python has been installed
  >> python --version
- If Python is not installed, you will need to install it or download and install it from the official Python website.
  >> sudo apt-get update
  >> sudo apt install python3.10

- Check if the virtual environment has been installed

  >> sudo apt-cache show python3.10-venv

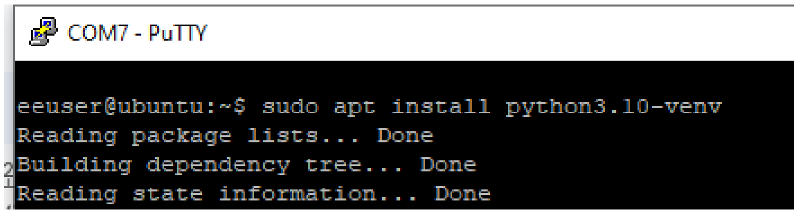


```
eeuser@ubuntu:~$ sudo apt-cache show python3.10-venv
Package: python3.10-venv
Architecture: arm64
Version: 3.10.12-1~22.04.6
Multi-Arch: allowed
```

- If Python environment is not installed, you will need to install it

  >> sudo apt-get update

  >> sudo apt install python3.10-venv

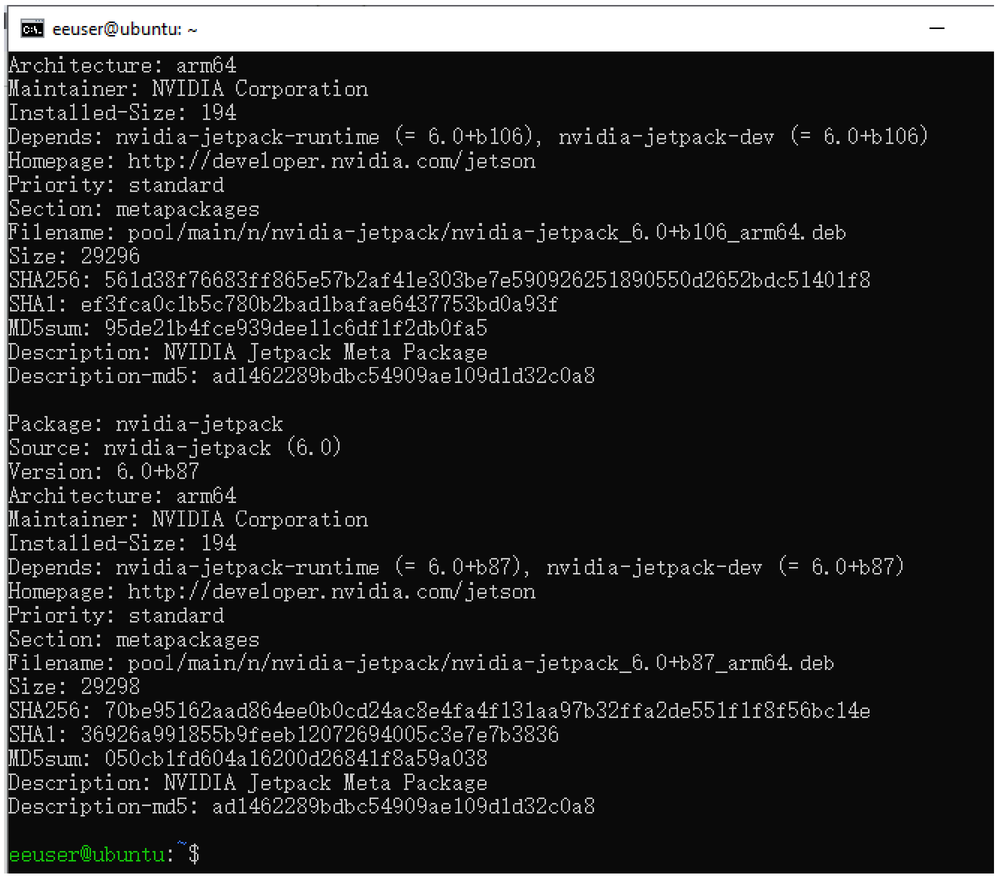


COM7 - PuTTY

```
eeuser@ubuntu:~$ sudo apt install python3.10-venv
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
```

- Check if Jetpack 6 has be successfully installed
- Check the Jetpack version

  >> sudo apt-cache show nvidia-jetpack



eeuser@ubuntu: ~

```
Architecture: arm64
Maintainer: NVIDIA Corporation
Installed-Size: 194
Depends: nvidia-jetpack-runtime (= 6.0+b106), nvidia-jetpack-dev (= 6.0+b106)
Homepage: http://developer.nvidia.com/jetson
Priority: standard
Section: metapackages
Filename: pool/main/n/nvidia-jetpack/nvidia-jetpack_6.0+b106_arm64.deb
Size: 29296
SHA256: 561d38f76683ff865e57b2af41e303be7e590926251890550d2652bdc51401f8
SHA1: ef3fca0c1b5c780b2bad1bafae6437753bd0a93f
MD5sum: 95de21b4fce939dee11c6df1f2db0fa5
Description: NVIDIA Jetpack Meta Package
Description-md5: ad1462289bdbc54909ae109d1d32c0a8

Package: nvidia-jetpack
Source: nvidia-jetpack (6.0)
Version: 6.0+b87
Architecture: arm64
Maintainer: NVIDIA Corporation
Installed-Size: 194
Depends: nvidia-jetpack-runtime (= 6.0+b87), nvidia-jetpack-dev (= 6.0+b87)
Homepage: http://developer.nvidia.com/jetson
Priority: standard
Section: metapackages
Filename: pool/main/n/nvidia-jetpack/nvidia-jetpack_6.0+b87_arm64.deb
Size: 29298
SHA256: 70be95162aad864ee0b0cd24ac8e4fa4f131aa97b32ffa2de551f1f8f56bc14e
SHA1: 36926a991855b9feeb12072694005c3e7e7b3836
MD5sum: 050cb1fd604a16200d26841f8a59a038
Description: NVIDIA Jetpack Meta Package
Description-md5: ad1462289bdbc54909ae109d1d32c0a8

eeuser@ubuntu:~$
```

3.3 Check Tensorrt availability

- Check Tensorrt installation directory
  >> pip show tensorrt
- Check Tensorrt version
  >> python3.10
  import tensorrt as trt
  print(trt.__version__)

If Tensorrt is not found, you may need to call the attention of our TA. The TA will either install the Tensorrt dependency or reinstall the jetpack again by running these commands:

Install tensorrt dependency
>> sudo apt install python3-libnvinfer
Re-install Jetpack 6
>> sudo apt-get update
>> sudo apt install jetpack

3.4 Create a virtual environment

- Open a terminal and navigate to the directory where you want to create your virtual environment. Run the following command to create a new virtual environment named ultralytics-env:

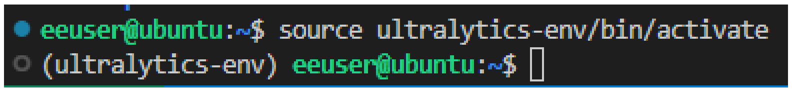
>> python3 -m venv ultralytics-env

3.4.1 Activate the Virtual Environment

- Activate the virtual environment using the following command:

>> source ultralytics-env/bin/activate

- After activation, your terminal prompt should change to indicate that you are now working within the virtual environment.



```
eeuser@ubuntu:~$ source ultralytics-env/bin/activate
(ultralytics-env) eeuser@ubuntu:~$ 
```

3.4.2 Deactivate the Virtual Environment

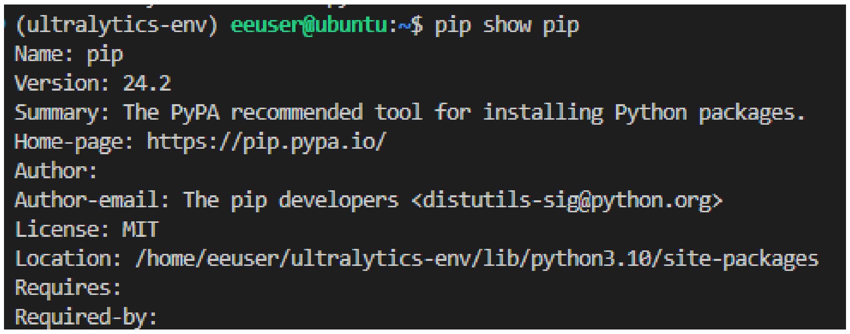
- Once you are done working in the virtual environment at the end of the lab or if you want to troubleshoot, you can deactivate it by running:

>> deactivate

3.5 Copy tensorrt to the virtual environment package directory

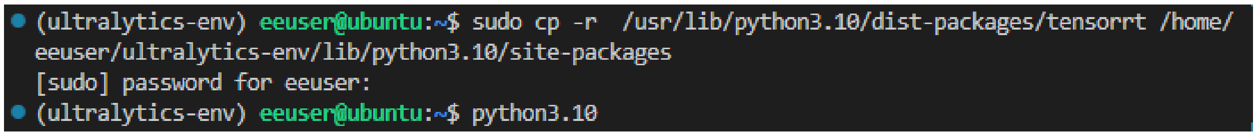
Since you want to use tensorrt and the tensorrt is not installed in the virtual environment, you need to copy the tensorrt installation directory to your Python environment's packages directory.

- To find the tensorrt installation directory, run this command outside the environment:
  >> pip which tensorrt
- Usually, the tensorrt will be installed in /usr/bin/python3.10/dist-packages
- To find the Python environment's packages directory, run this command inside the environment:
  >> pip show pip



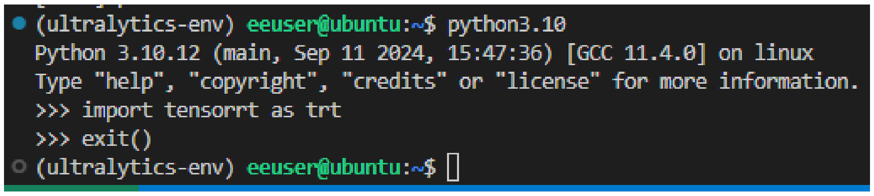
```
(ultralytics-env) eeuser@ubuntu:~$ pip show pip
Name: pip
Version: 24.2
Summary: The PyPA recommended tool for installing Python packages.
Home-page: https://pip.pypa.io/
Author:
Author-email: The pip developers <distutils-sig@python.org>
License: MIT
Location: /home/eeuser/ultralytics-env/lib/python3.10/site-packages
Requires:
Required-by:
```

- Copy the tensorrt from its global installation directory to the environment's packages directory.
  >> sudo cp -r /usr/lib/python3.10/dist-packages/tensorrt /home/eeuser/ultralytics-env/lib/python3.10/site-packages



```
(ultralytics-env) eeuser@ubuntu:~$ sudo cp -r  /usr/lib/python3.10/dist-packages/tensorrt /home/
eeuser/ultralytics-env/lib/python3.10/site-packages
[sudo] password for eeuser:
(ultralytics-env) eeuser@ubuntu:~$ python3.10
```

- **Check the tensorrt version in the environment to verify its availability.**
  >> python3.10
  import tensorrt as trt
  print(trt.__version__)



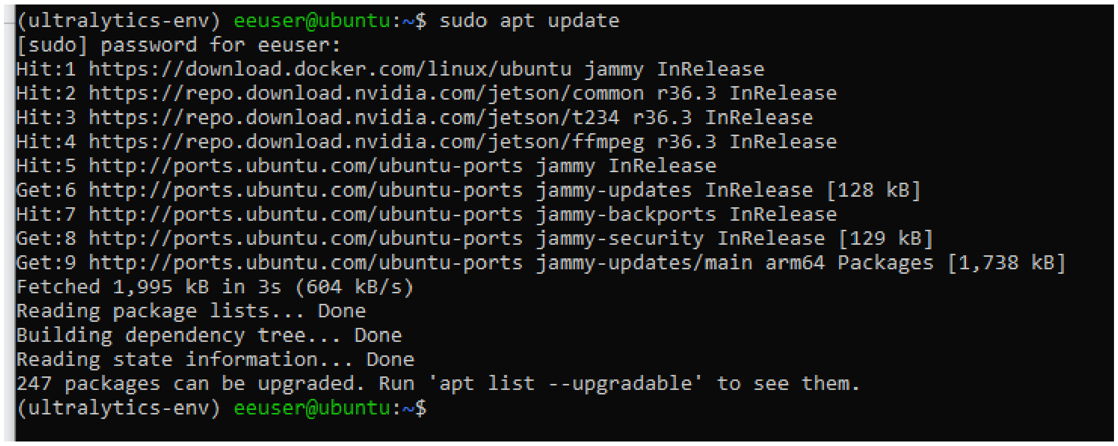
```
(ultralytics-env) eeuser@ubuntu:~$ python3.10
Python 3.10.12 (main, Sep 11 2024, 15:47:36) [GCC 11.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import tensorrt as trt
>>> exit()
(ultralytics-env) eeuser@ubuntu:~$
```

3.6 Install Ultralytics Package

Now we will install Ultralytics package on the Jetson with optional dependencies so that we can export the PyTorch models to other different formats. We will mainly focus on NVIDIA TensorRT exports because TensorRT will make sure we can get the maximum performance out of the Jetson devices.

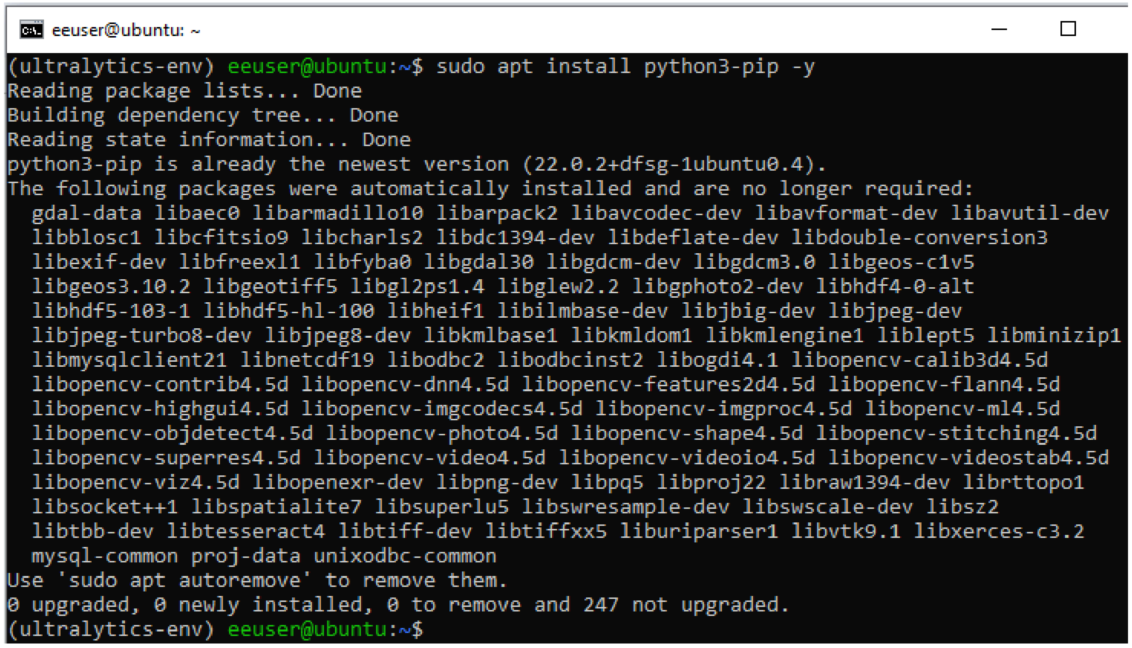
- Update packages list, install pip and upgrade to latest

  >> sudo apt update



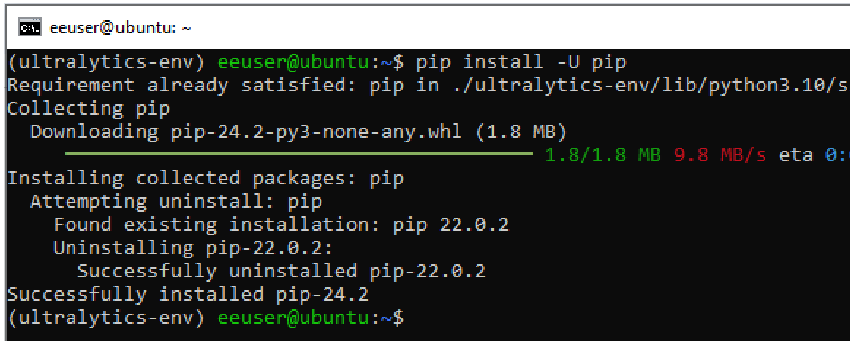
```
(ultralytics-env) eeuser@ubuntu:~$ sudo apt update
[sudo] password for eeuser:
Hit:1 https://download.docker.com/linux/ubuntu jammy InRelease
Hit:2 https://repo.download.nvidia.com/jetson/common r36.3 InRelease
Hit:3 https://repo.download.nvidia.com/jetson/t234 r36.3 InRelease
Hit:4 https://repo.download.nvidia.com/jetson/ffmpeg r36.3 InRelease
Hit:5 http://ports.ubuntu.com/ubuntu-ports jammy InRelease
Get:6 http://ports.ubuntu.com/ubuntu-ports jammy-updates InRelease [128 kB]
Hit:7 http://ports.ubuntu.com/ubuntu-ports jammy-backports InRelease
Get:8 http://ports.ubuntu.com/ubuntu-ports jammy-security InRelease [129 kB]
Get:9 http://ports.ubuntu.com/ubuntu-ports jammy-updates/main arm64 Packages [1,738 kB]
Fetched 1,995 kB in 3s (604 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
247 packages can be upgraded. Run 'apt list --upgradable' to see them.
(ultralytics-env) eeuser@ubuntu:~$
```

  >> sudo apt install python3-pip -y



```
(ultralytics-env) eeuser@ubuntu:~$ sudo apt install python3-pip -y
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
python3-pip is already the newest version (22.0.2+dfsg-1ubuntu0.4).
The following packages were automatically installed and are no longer required:
  gdal-data libaec0 libarmadillo10 libarpack2 libavcodec-dev libavformat-dev libavutil-dev
  libblosc1 libcfitsio9 libcharls2 libdc1394-dev libdeflate-dev libdouble-conversion3
  libexif-dev libfreexl1 libfyba0 libgdal30 libgdcm-dev libgdcm3.0 libgeos-c1v5
  libgeos3.10.2 libgeotiff5 libgl2ps1.4 libglew2.2 libgphoto2-dev libhdf4-0-alt
  libhdf5-103-1 libhdf5-hl-100 libheif1 libilmbase-dev libjbig-dev libjpeg-dev
  libjpeg-turbo8-dev libjpeg8-dev libkmlbase1 libkmldom1 libkmlengine1 liblept5 libminizip1
  libmysqlclient21 libnetcdf19 libodbc2 libodbcinst2 libogdi4.1 libopencv-calib3d4.5d
  libopencv-contrib4.5d libopencv-dnn4.5d libopencv-features2d4.5d libopencv-flann4.5d
  libopencv-highgui4.5d libopencv-imgcodecs4.5d libopencv-imgproc4.5d libopencv-ml4.5d
  libopencv-objdetect4.5d libopencv-photo4.5d libopencv-shape4.5d libopencv-stitching4.5d
  libopencv-superres4.5d libopencv-video4.5d libopencv-videoio4.5d libopencv-videostab4.5d
  libopencv-viz4.5d libopenexr-dev libpng-dev libpq5 libproj22 libraw1394-dev librttopo1
  libsocket++1 libspatialite7 libsuperlu5 libswresample-dev libswscale-dev libsz2
  libtbb-dev libtesseract4 libtiff-dev libtiffxx5 liburiparser1 libvtk9.1 libxerces-c3.2
  mysql-common proj-data unixodbc-common
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 247 not upgraded.
(ultralytics-env) eeuser@ubuntu:~$
```

  >> pip install -U pip



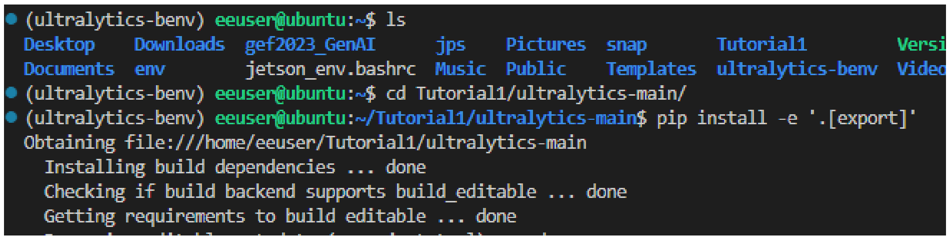
```
eeuser@ubuntu: ~
(ultralytics-env) eeuser@ubuntu:~$ pip install -U pip
Requirement already satisfied: pip in ./ultralytics-env/lib/python3.10/s
Collecting pip
  Downloading pip-24.2-py3-none-any.whl (1.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.8/1.8 MB 9.8 MB/s eta 0:
Installing collected packages: pip
  Attempting uninstall: pip
    Found existing installation: pip 22.0.2
    Uninstalling pip-22.0.2:
      Successfully uninstalled pip-22.0.2
Successfully installed pip-24.2
(ultralytics-env) eeuser@ubuntu:~$
```

- Install `ultralytics` pip package with optional dependencies (Takes around 5 mins)

Recommended in this lab:

To save time, we already cloned the ultralytics github in the **Tutorial1** folder. Change to the ultralytics-main folder and install ultralytics.

>> cd ~/Tutorial1/ultralytics-main
>> pip install -e '.[export]'

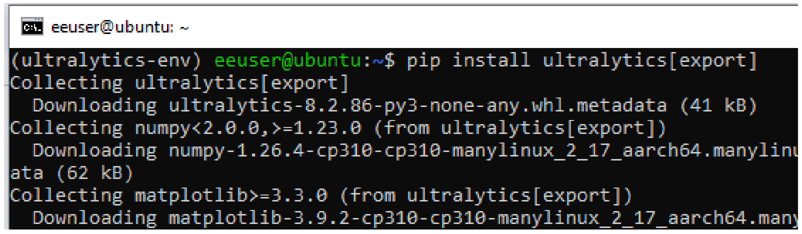


```
● (ultralytics-benv) eeuser@ubuntu:~$ ls
 Desktop    Downloads  gef2023_GenAI      jps    Pictures  snap       Tutorial1          Versi
 Documents  env        jetson_env.bashrc  Music  Public    Templates  ultralytics-benv   Video
● (ultralytics-benv) eeuser@ubuntu:~$ cd Tutorial1/ultralytics-main/
● (ultralytics-benv) eeuser@ubuntu:~/Tutorial1/ultralytics-main$ pip install -e '.[export]'
 Obtaining file:///home/eeuser/Tutorial1/ultralytics-main
   Installing build dependencies ... done
   Checking if build backend supports build_editable ... done
   Getting requirements to build editable ... done
```

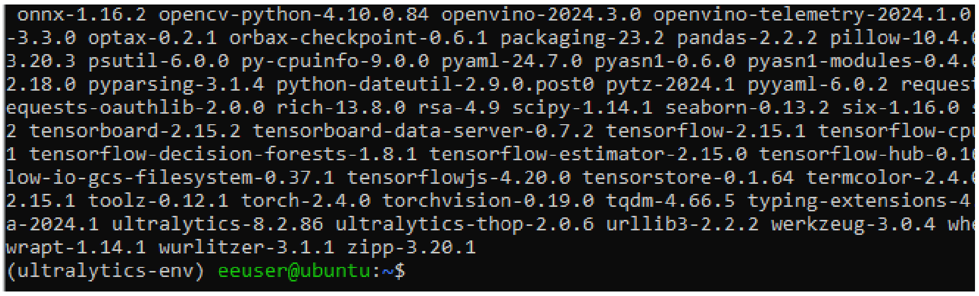
Alternatively:

If you prefer to directly install ultralytics online, use the command

>> pip install ultralytics[export]



```
eeuser@ubuntu: ~
(ultralytics-env) eeuser@ubuntu:~$ pip install ultralytics[export]
Collecting ultralytics[export]
  Downloading ultralytics-8.2.86-py3-none-any.whl.metadata (41 kB)
Collecting numpy<2.0.0,>=1.23.0 (from ultralytics[export])
  Downloading numpy-1.26.4-cp310-cp310-manylinux_2_17_aarch64.manylinu
ata (62 kB)
Collecting matplotlib>=3.3.0 (from ultralytics[export])
  Downloading matplotlib-3.9.2-cp310-cp310-manylinux_2_17_aarch64.many
```



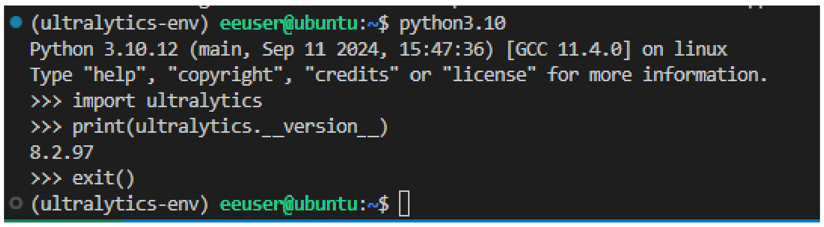
```
 onnx-1.16.2 opencv-python-4.10.0.84 openvino-2024.3.0 openvino-telemetry-2024.1.0
-3.3.0 optax-0.2.1 orbax-checkpoint-0.6.1 packaging-23.2 pandas-2.2.2 pillow-10.4.
3.20.3 psutil-6.0.0 py-cpuinfo-9.0.0 pyaml-24.7.0 pyasn1-0.6.0 pyasn1-modules-0.4.
2.18.0 pyparsing-3.1.4 python-dateutil-2.9.0.post0 pytz-2024.1 pyyaml-6.0.2 reques
equests-oauthlib-2.0.0 rich-13.8.0 rsa-4.9 scipy-1.14.1 seaborn-0.13.2 six-1.16.0 s
2 tensorboard-2.15.2 tensorboard-data-server-0.7.2 tensorflow-2.15.1 tensorflow-cpu
1 tensorflow-decision-forests-1.8.1 tensorflow-estimator-2.15.0 tensorflow-hub-0.16
low-io-gcs-filesystem-0.37.1 tensorflowjs-4.20.0 tensorstore-0.1.64 termcolor-2.4.
2.15.1 toolz-0.12.1 torch-2.4.0 torchvision-0.19.0 tqdm-4.66.5 typing-extensions-4
a-2024.1 ultralytics-8.2.86 ultralytics-thop-2.0.6 urllib3-2.2.2 werkzeug-3.0.4 whe
wrapt-1.14.1 wurlitzer-3.1.1 zipp-3.20.1
(ultralytics-env) eeuser@ubuntu:~$
```

- **Verify Ultralytics Installation**

  To verify that Ultralytics has been installed correctly, you can run the following command in the Python interpreter:

```
>> python3.10
        import ultralytics
        print(ultralytics.__version__)
```

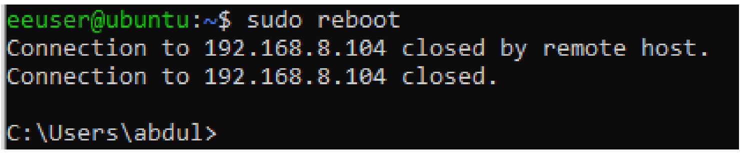
If there are no errors and the version prints successfully, the installation was successful.



```
(ultralytics-env) eeuser@ubuntu:~$ python3.10
Python 3.10.12 (main, Sep 11 2024, 15:47:36) [GCC 11.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import ultralytics
>>> print(ultralytics.__version__)
8.2.97
>>> exit()
(ultralytics-env) eeuser@ubuntu:~$
```

- Reboot the device

```
>> sudo reboot
```



```
eeuser@ubuntu:~$ sudo reboot
Connection to 192.168.8.104 closed by remote host.
Connection to 192.168.8.104 closed.

C:\Users\abdul>
```

3.7 Install PyTorch 2.3.0 and Torchvision 0.18

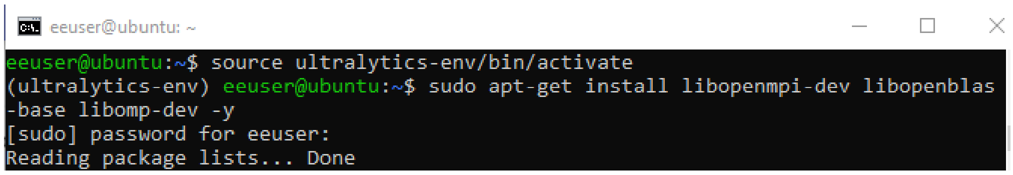
The above ultralytics installation will install Torch and Torchvision. However, these 2 packages installed via pip are not compatible to run on Jetson platform which is based on ARM64 architecture. Therefore, we need to manually install a pre-built PyTorch pip wheel and compile/ install Torchvision from source.

- Activate the virtual environment using the following command:

```
>> source ultralytics-env/bin/activate
```

- Install dependencies

```
>> sudo apt-get install libopenmpi-dev libopenblas-base libomp-dev -y
```



```
eeuser@ubuntu:~$ source ultralytics-env/bin/activate
(ultralytics-env) eeuser@ubuntu:~$ sudo apt-get install libopenmpi-dev libopenblas
-base libomp-dev -y
[sudo] password for eeuser:
Reading package lists... Done
```

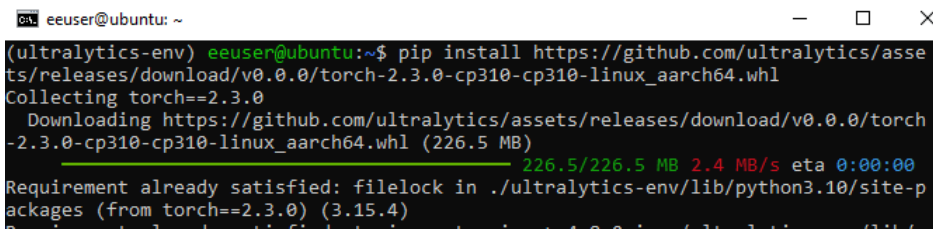
Note: The wheel files have already been downloaded and placed in the **~/Tutorial1** folder.

– Install Torch 2.3.0

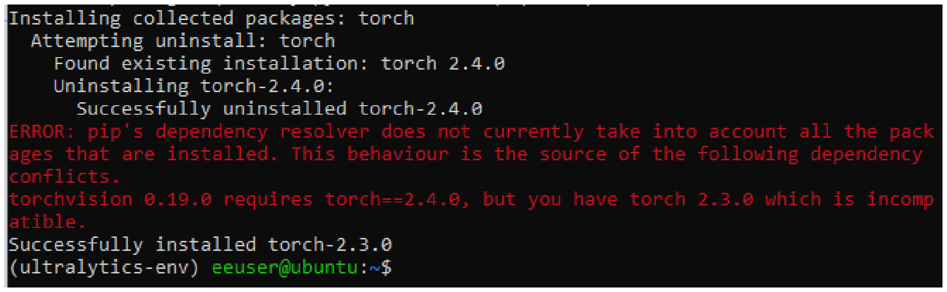
>> pip install ~/Tutorial1/torch-2.3.0-cp310-cp310-linux_aarch64.whl

- **Alternatively:** If you would like to install the torch directly from its repo, use the below command instead of the above. If you already have run the above, please skip this

  >> pip install https://github.com/ultralytics/assets/releases/download/v0.0.0/torch-2.3.0-cp310-cp310-linux_aarch64.whl



```
(ultralytics-env) eeuser@ubuntu:~$ pip install https://github.com/ultralytics/asse
ts/releases/download/v0.0.0/torch-2.3.0-cp310-cp310-linux_aarch64.whl
Collecting torch==2.3.0
  Downloading https://github.com/ultralytics/assets/releases/download/v0.0.0/torch
-2.3.0-cp310-cp310-linux_aarch64.whl (226.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 226.5/226.5 MB 2.4 MB/s eta 0:00:00
Requirement already satisfied: filelock in ./ultralytics-env/lib/python3.10/site-p
ackages (from torch==2.3.0) (3.15.4)
```



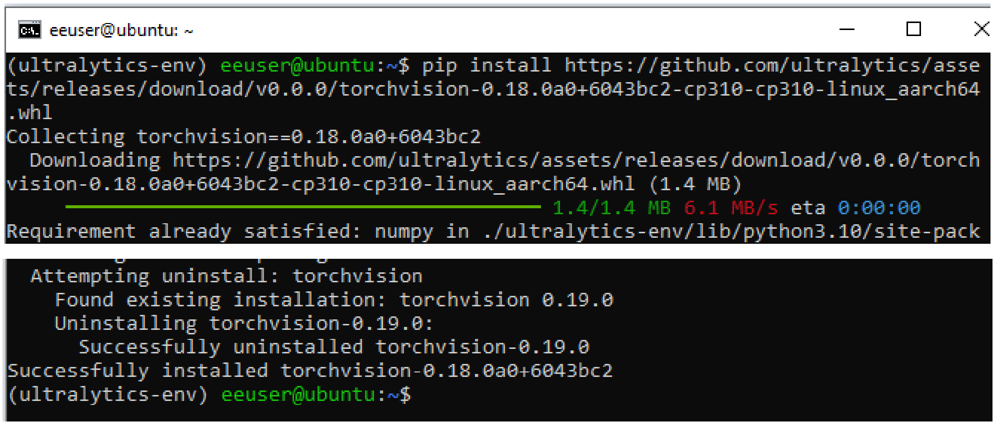
```
Installing collected packages: torch
  Attempting uninstall: torch
    Found existing installation: torch 2.4.0
    Uninstalling torch-2.4.0:
      Successfully uninstalled torch-2.4.0
ERROR: pip's dependency resolver does not currently take into account all the pack
ages that are installed. This behaviour is the source of the following dependency
conflicts.
torchvision 0.19.0 requires torch==2.4.0, but you have torch 2.3.0 which is incomp
atible.
Successfully installed torch-2.3.0
(ultralytics-env) eeuser@ubuntu:~$
```

– Install Torchvision 0.18

>> pip install ~/Tutorial1/torchvision-0.18.0a0+6043bc2-cp310-cp310-linux_aarch64.whl

- **Alternatively:** If you would like to install the torch directly from its repo, use the below command instead of the above. If you already have run the above, please skip this.

  >> pip install https://github.com/ultralytics/assets/releases/download/v0.0.0/torchvision-0.18.0a0+6043bc2-cp310-cp310-linux_aarch64.whl



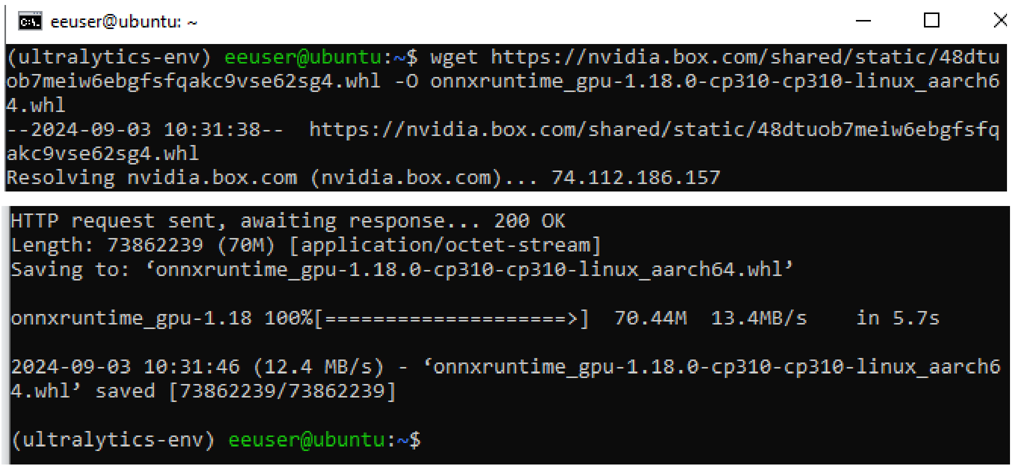
```
eeuser@ubuntu: ~
(ultralytics-env) eeuser@ubuntu:~$ pip install https://github.com/ultralytics/asse
ts/releases/download/v0.0.0/torchvision-0.18.0a0+6043bc2-cp310-cp310-linux_aarch64
.whl
Collecting torchvision==0.18.0a0+6043bc2
  Downloading https://github.com/ultralytics/assets/releases/download/v0.0.0/torch
vision-0.18.0a0+6043bc2-cp310-cp310-linux_aarch64.whl (1.4 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.4/1.4 MB 6.1 MB/s eta 0:00:00
Requirement already satisfied: numpy in ./ultralytics-env/lib/python3.10/site-pack
  Attempting uninstall: torchvision
    Found existing installation: torchvision 0.19.0
    Uninstalling torchvision-0.19.0:
      Successfully uninstalled torchvision-0.19.0
Successfully installed torchvision-0.18.0a0+6043bc2
(ultralytics-env) eeuser@ubuntu:~$
```

3.8 Install onnxruntime-gpu

The onnxruntime-gpu package hosted in PyPI does not have `aarch64` binaries for the Jetson. So we need to manually install this package. This package is needed for some of the exports. All different `onnxruntime-gpu` packages corresponding to different JetPack and Python versions are listed here. However, here we will download and install `onnxruntime-gpu 1.18.0` with `Python3.10` support.

Note: The onnxruntime-gpu wheel file has already been downloaded and placed in the **~/Tutorial1** folder. Hence the below command is not needed. However if you prefer to download it directly online use the below command:

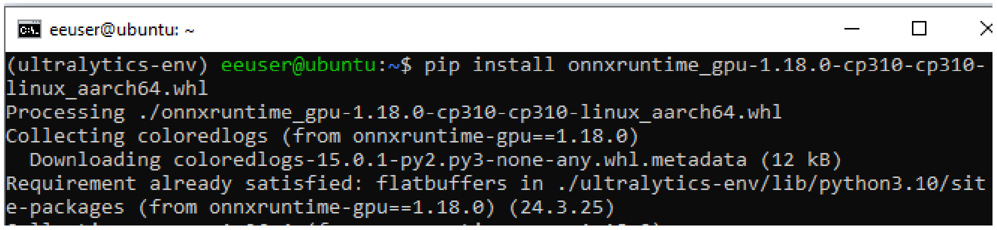
>> wget https://nvidia.box.com/shared/static/48dtuob7meiw6ebgfsfqakc9vse62sg4.whl -O onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch64.whl



```
eeuser@ubuntu: ~
(ultralytics-env) eeuser@ubuntu:~$ wget https://nvidia.box.com/shared/static/48dtu
ob7meiw6ebgfsfqakc9vse62sg4.whl -O onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch6
4.whl
--2024-09-03 10:31:38--  https://nvidia.box.com/shared/static/48dtuob7meiw6ebgfsfq
akc9vse62sg4.whl
Resolving nvidia.box.com (nvidia.box.com)... 74.112.186.157
HTTP request sent, awaiting response... 200 OK
Length: 73862239 (70M) [application/octet-stream]
Saving to: ‘onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch64.whl’

onnxruntime_gpu-1.18 100%[===================>]  70.44M  13.4MB/s    in 5.7s

2024-09-03 10:31:46 (12.4 MB/s) - ‘onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch6
4.whl’ saved [73862239/73862239]

(ultralytics-env) eeuser@ubuntu:~$
```

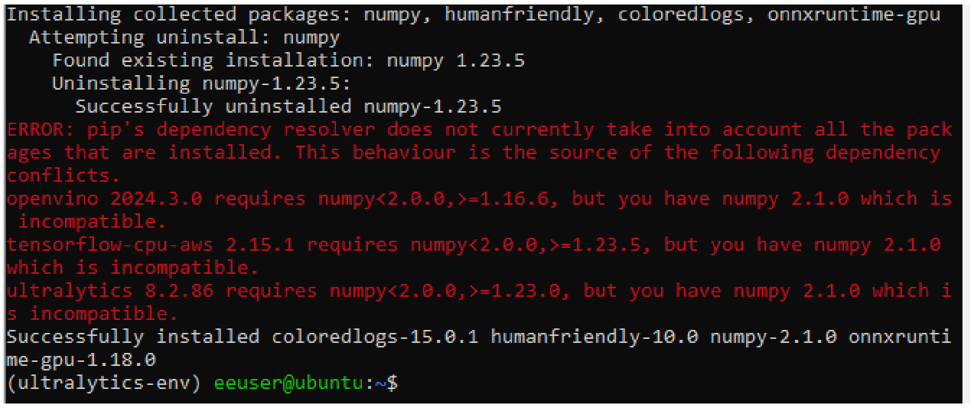
– Install the downloaded onnxruntime_gpu

>> pip install ~/Tutorial1/onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch64.whl



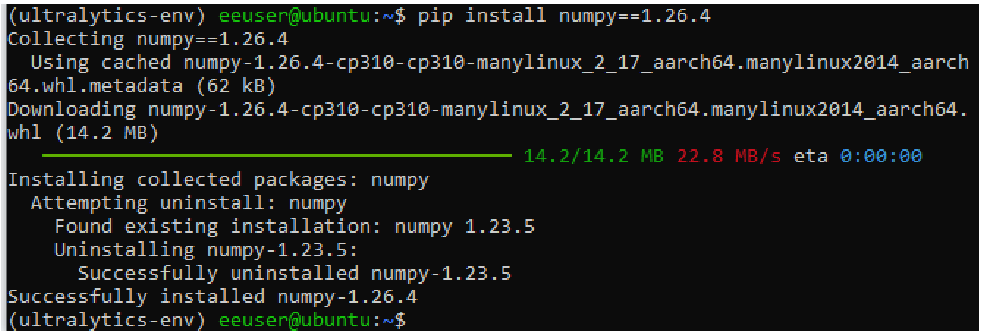
```
(ultralytics-env) eeuser@ubuntu:~$ pip install onnxruntime_gpu-1.18.0-cp310-cp310-
linux_aarch64.whl
Processing ./onnxruntime_gpu-1.18.0-cp310-cp310-linux_aarch64.whl
Collecting coloredlogs (from onnxruntime-gpu==1.18.0)
  Downloading coloredlogs-15.0.1-py2.py3-none-any.whl.metadata (12 kB)
Requirement already satisfied: flatbuffers in ./ultralytics-env/lib/python3.10/sit
e-packages (from onnxruntime-gpu==1.18.0) (24.3.25)
```

Note: `onnxruntime-gpu` will automatically revert back the numpy version to latest. So we need to reinstall numpy to `1.26.4` to fix an issue by executing:



```
Installing collected packages: numpy, humanfriendly, coloredlogs, onnxruntime-gpu
  Attempting uninstall: numpy
    Found existing installation: numpy 1.23.5
    Uninstalling numpy-1.23.5:
      Successfully uninstalled numpy-1.23.5
ERROR: pip's dependency resolver does not currently take into account all the pack
ages that are installed. This behaviour is the source of the following dependency
conflicts.
openvino 2024.3.0 requires numpy<2.0.0,>=1.16.6, but you have numpy 2.1.0 which is
 incompatible.
tensorflow-cpu-aws 2.15.1 requires numpy<2.0.0,>=1.23.5, but you have numpy 2.1.0
which is incompatible.
ultralytics 8.2.86 requires numpy<2.0.0,>=1.23.0, but you have numpy 2.1.0 which i
s incompatible.
Successfully installed coloredlogs-15.0.1 humanfriendly-10.0 numpy-2.1.0 onnxrunti
me-gpu-1.18.0
(ultralytics-env) eeuser@ubuntu:~$
```

```
>> pip install numpy==1.26.4
```



```
(ultralytics-env) eeuser@ubuntu:~$ pip install numpy==1.26.4
Collecting numpy==1.26.4
  Using cached numpy-1.26.4-cp310-cp310-manylinux_2_17_aarch64.manylinux2014_aarch
64.whl.metadata (62 kB)
Downloading numpy-1.26.4-cp310-cp310-manylinux_2_17_aarch64.manylinux2014_aarch64.
whl (14.2 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 14.2/14.2 MB 22.8 MB/s eta 0:00:00
Installing collected packages: numpy
  Attempting uninstall: numpy
    Found existing installation: numpy 1.23.5
    Uninstalling numpy-1.23.5:
      Successfully uninstalled numpy-1.23.5
Successfully installed numpy-1.26.4
(ultralytics-env) eeuser@ubuntu:~$
```

4.0 Performing the Yolov8 object detection Inference

Out of all the model export formats supported by Ultralytics, TensorRT delivers the best inference performance when working with NVIDIA Jetson devices and our recommendation is to use TensorRT with Jetson.

4.1 Convert model to TensorRT and run inference

The YOLOv8n model in PyTorch format is converted to TensorRT to run inference with the exported model. The code is provided as below for the export and the inference.

- **Using Python:**

```
from ultralytics import YOLO
import matplotlib.pyplot as plt
import cv2

# Load a YOLOv8n PyTorch model
model = YOLO("yolov8n.pt")

# Export the model to tensorrt format
model.export(format="engine", device=0)   # creates 'yolov8n.engine'

# Load the exported TensorRT model
trt_model = YOLO("yolov8n.engine")

# Run inference
results = trt_model("https://ultralytics.com/images/bus.jpg")

# Annotate results
annotated_frame = results[0].plot()  # Draw bounding boxes on the frame

# Display the resulting frame
plt.imshow(annotated_frame)
```

- **Using Cli (Terminal):**

```
# Export a YOLOv8n PyTorch model to TensorRT format
yolo export model=yolov8n.pt format=engine  # creates 'yolov8n.engine'

# Run inference with the exported model
yolo predict model=yolov8n.engine source='https://ultralytics.com/images/bus.jpg'
```

4.2 How to run the python code?

We recommend using Jupyter and VS code to efficiently do inference using Python code.

Option 1: Create and run a python script using vi as shown below:

- Create a new directory for the python scripts

  ```
  >> mkdir My-Yolo
  ```

- Create a new Python script

  ```
  >>  touch my_yolov8.py
  ```

- Copy and paste the python code

  ```
  >> vi my_yolov8  ( save the file. Press esc and type :w to save; :wq to quit)
  ```

- Execute the code

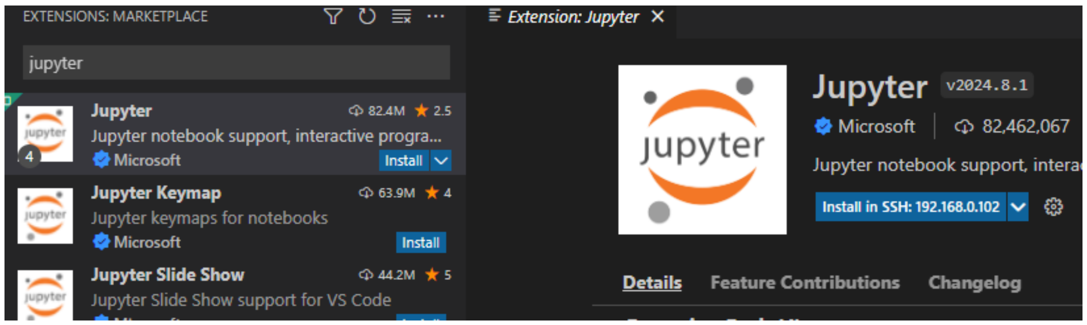
  ```
  >> python ./my_yolov8
  ```

Option 2: Using the Jupyter and VS code with Remote SSH

To use Jupyter notebook with VScode remote SSH, you need to install the following on the target

1. **Python VS Code extension**
2. **Jupyter VS Code extension**
3. **ipykernel**

- From VS Code, remote SSH to the board
- Search Jupyter from the extension tab
- To install Jupyter on the the board, click **Install in SSH**


EXTENSIONS: MARKETPLACE
jupyter
Jupyter 82.4M 2.5
Jupyter notebook support, interactive progra...
Microsoft
Install
Jupyter Keymap 63.9M 4
Jupyter keymaps for notebooks
Microsoft
Install
Jupyter Slide Show 44.2M 5
Jupyter Slide Show support for VS Code
Extension: Jupyter
Jupyter v2024.8.1
Microsoft 82,462,067
Jupyter notebook support, intera
Install in SSH: 192.168.0.102
Details
Feature Contributions
Changelog

- Search Python from the extension tab also
- To install the Python extension on the the board, click **Install in SSH**
- Open a Terminal and install the ipykernel manually

>> pip install ipykernel

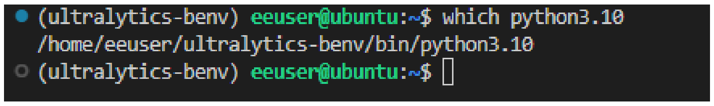
- **Select the Python Interpreter of the remote virtual environment in VS Code**

    - Activate the virtual environment if not activated

        >> source ultralytics-venv/bin/activate

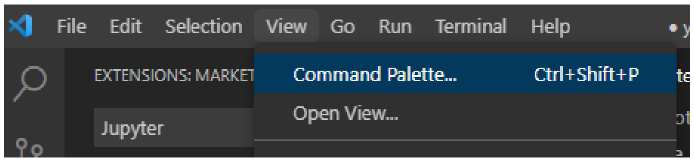
    - Check the Python Interpreter directory

        >> which Python3.10

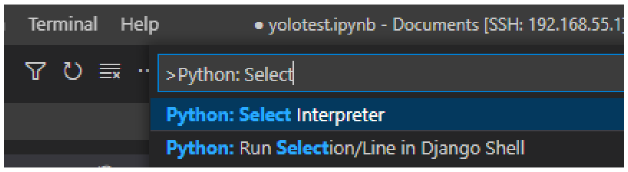


```
(ultralytics-benv) eeuser@ubuntu:~$ which python3.10
/home/eeuser/ultralytics-benv/bin/python3.10
(ultralytics-benv) eeuser@ubuntu:~$
```

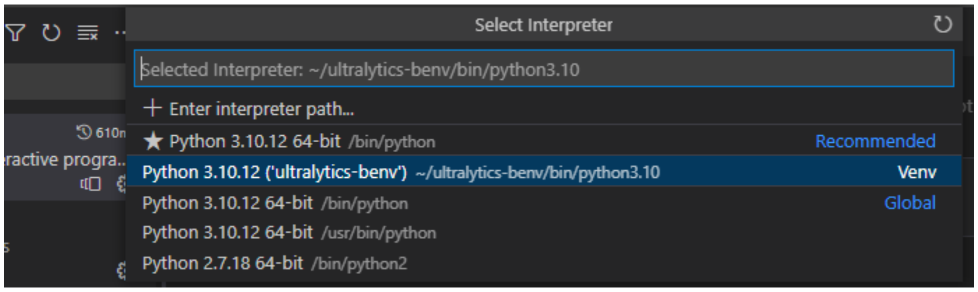
- In VS code goto View -> Command Palette



- Type and select Python: Select Interpreter


Terminal
Help
● yolotest.ipynb - Documents [SSH: 192.168.55.1
>Python: Select
Python: Select Interpreter
Python: Run Selection/Line in Django Shell

- Select the environment interpreter if it appears, if not, select the "Enter interpreter path". Click Enter

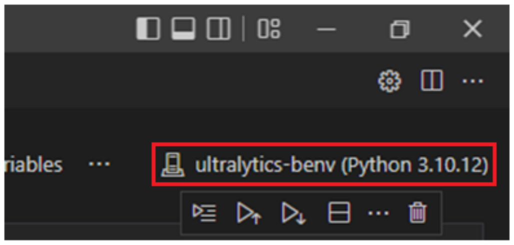


Select Interpreter

Selected Interpreter: ~/ultralytics-benv/bin/python3.10

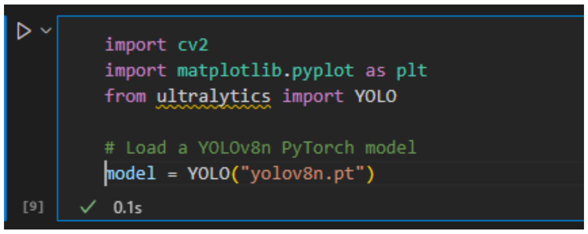
+ Enter interpreter path...		
★ Python 3.10.12 64-bit	/bin/python	Recommended
Python 3.10.12 ('ultralytics-benv')	~/ultralytics-benv/bin/python3.10	Venv
Python 3.10.12 64-bit	/bin/python	Global
Python 3.10.12 64-bit	/usr/bin/python	
Python 2.7.18 64-bit	/bin/python2	

- You can now select the environment Python Interpreter



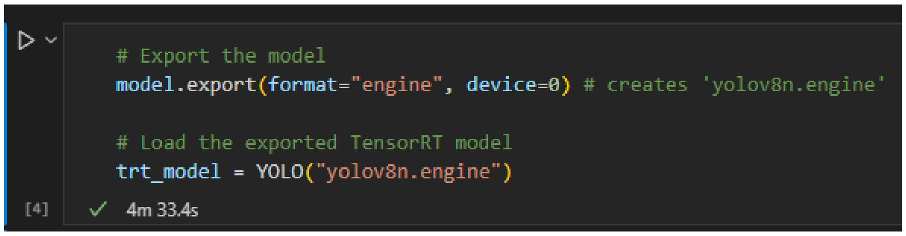
- **Create a Jupyter notebook and do the inference**

- Using the VS Code or Terminal, create and open a folder **my-notebooks**
  >> mkdir my-notebooks
- Create a new empty notebook yolov8.ipynb
  >> touch yolov8-test.ipynb
- Open the file in VS Code
- Copy and paste the Yolov8 object detection code provide
- Run the Jupyter notebook for the inference



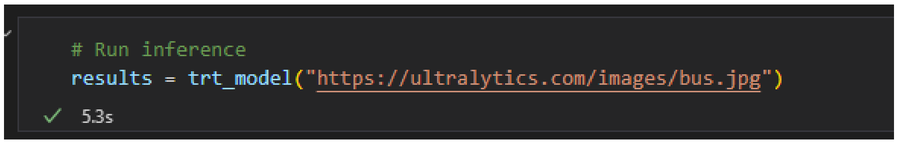
```
import cv2
import matplotlib.pyplot as plt
from ultralytics import YOLO

# Load a YOLOv8n PyTorch model
model = YOLO("yolov8n.pt")
```

```
[9]  ✓ 0.1s
```



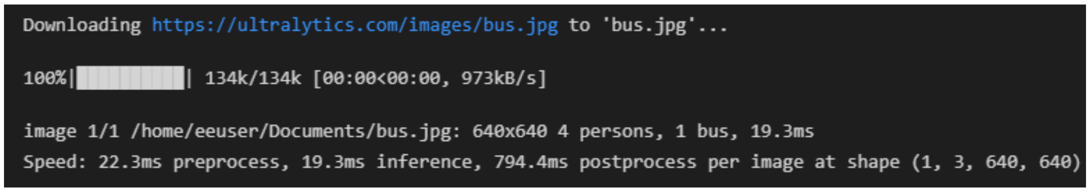
```
# Export the model
model.export(format="engine", device=0) # creates 'yolov8n.engine'

# Load the exported TensorRT model
trt_model = YOLO("yolov8n.engine")
```

```
[4]  ✓ 4m 33.4s
```

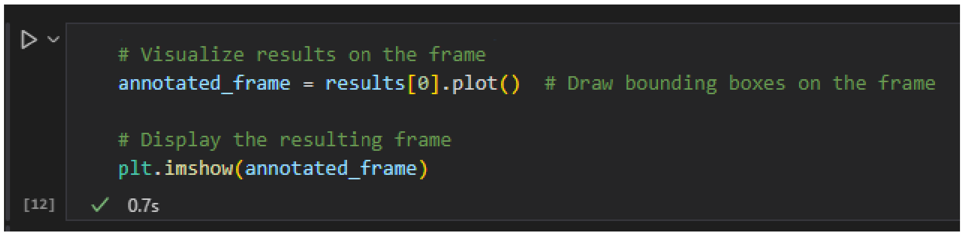


```
# Run inference
results = trt_model("https://ultralytics.com/images/bus.jpg")
```

```
✓ 5.3s
```

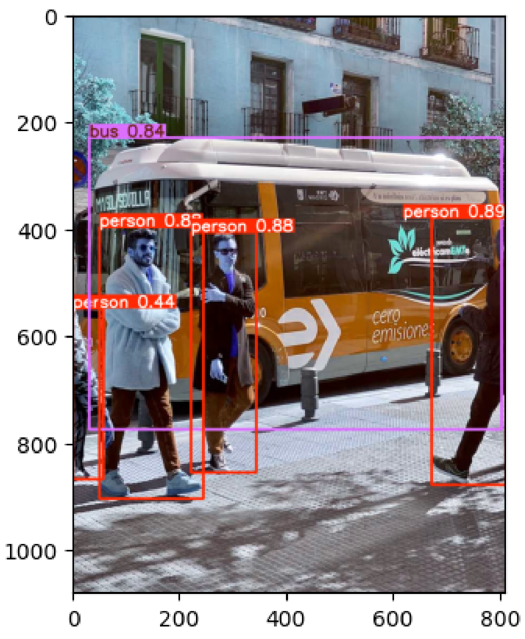


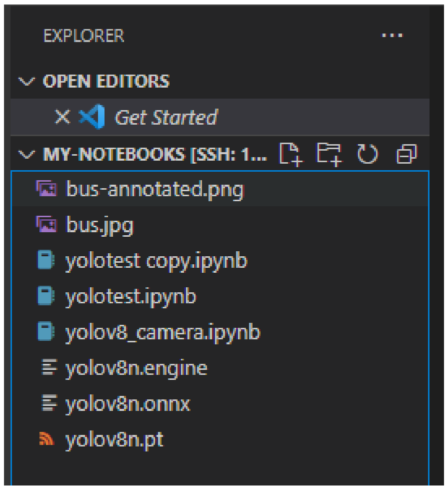
```
Downloading https://ultralytics.com/images/bus.jpg to 'bus.jpg'...

100%|██████████| 134k/134k [00:00<00:00, 973kB/s]

image 1/1 /home/eeuser/Documents/bus.jpg: 640x640 4 persons, 1 bus, 19.3ms
Speed: 22.3ms preprocess, 19.3ms inference, 794.4ms postprocess per image at shape (1, 3, 640, 640)
```



```
# Visualize results on the frame
annotated_frame = results[0].plot()  # Draw bounding boxes on the frame

# Display the resulting frame
plt.imshow(annotated_frame)
```

```
[12]  ✓ 0.7s
```





bus-annotated.png
bus.jpg
yolotest copy.ipynb
yolotest.ipynb
yolov8_camera.ipynb
yolov8n.engine
yolov8n.onnx
yolov8n.pt

4.3 Yolo Benchmarking

If you would like to benchmark the tensorrt, cpu, and onnx yolov8 formats performances, run the following:

Python:

```
from ultralytics import YOLO
# Load a YOLOv8n PyTorch model
model = YOLO("yolov8n.pt")
# Benchmark YOLOv8n speed and accuracy on the COCO8 dataset for all all export formats
results = model.benchmarks(data="coco8.yaml", imgsz=640)
```

Cli:

# Benchmark YOLOv8n speed and accuracy on the COCO8 dataset for all all export formats

> *>> yolo benchmark model=yolov8n.pt data=coco8.yaml imgsz=640*

5.0 Setting up X11 Forwarding for remote GUI

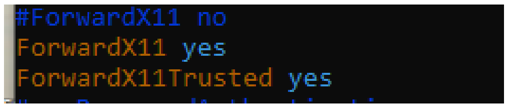
Before the counting, we should setup the X11 forwarding so that we can stream video remote and use GUI on the Jetson board remotely.

1. **On the Jetson board**

- Edit the /etc/ssh/ssh_config and /etc/ssh/sshd_config files to enable the X11 Forwarding

```
>> sudo vi /etc/ssh/ssh_config
```

- Press **"s, or i"** on the keyboard to enter insert mode
- Change ForwardX11 to yes and leave it uncommented
- Change ForwardX11Trusted to yes and also leave it uncommented
- Press **esc**, then type **:wq** and press **enter**

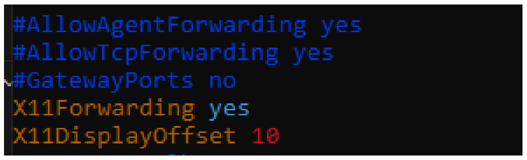


```
#ForwardX11 no
ForwardX11 yes
ForwardX11Trusted yes
```

- Edit the /etc/ssh/sshd_config and /etc/ssh/sshd_config files to enable the X11 Forwarding also.

```
>> sudo vi /etc/ssh/sshd_config
```

- Press **"s, or i"** on the keyboard to enter insert mode
- Uncomment **ForwardX11 to yes**
- Uncomment **11DisplayOffset 10**
- Press **esc**, then type **:wq** and press **enter**

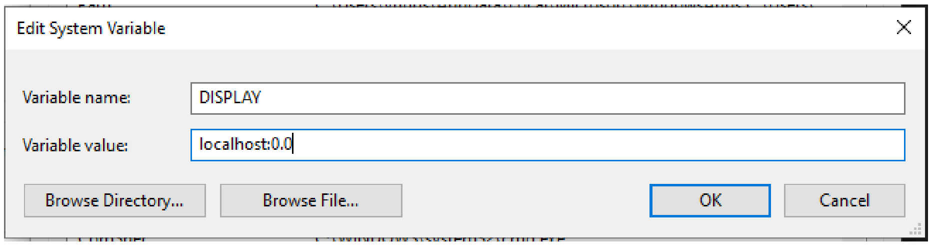


```
#AllowAgentForwarding yes
#AllowTcpForwarding yes
#GatewayPorts no
X11Forwarding yes
X11DisplayOffset 10
```

2. **On the the Host**

1. **Install X11 Server in Client Computer (Windows 10)**

- In order to run X11 Forwarding over SSH, we must be running an X server program on the host Computer. There are several X server programs available on the internet, one of them is VcXsrv.
- Download latest VcXsrv from: https://github.com/ArcticaProject/vcxsrv/releases
- Install & Run VcXsrv in our host computer
- Add "DISPLAY = localhost:0.0" to Windows Environment Variable. Add to user variables by clicking at the New Tab. Click OK

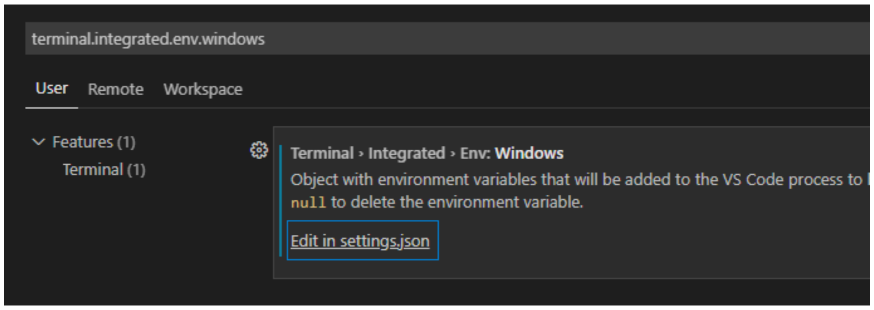

Edit System Variable

Variable name: DISPLAY

Variable value: localhost:0.0

2. Setup DISPLAY variable on VS Code

- Open VS Code and press F1 (or Click View-> Command Palette)
- Search and open Preferences: Open Setting (UI)
- Search terminal.integrated.env.windows in VS Code Setting UI


terminal.integrated.env.windows

Terminal › Integrated › Env: Windows

Object with environment variables that will be added to the VS Code process to
`null` to delete the environment variable.

Edit in settings.json

- Click Edit in setting.js
- Modify terminal.integrated.env.windows in setting.js to :

```
"terminal.integrated.env.windows": {
          "DISPLAY": "127.0.0.1:0.0"
  }
```

3. Modify SSH Connection in VS Code

- Press F1 (or Click View-> Command Palette)
- Search : Remote-SSH: Open SSH Configuration File…
- Change your Jetson Nano SSH connection in VS Code from :

Host <YOUR_CONNECTION_NAME>
HostName <YOUR_JETSON_IP>
User <YOUR_JETSON_USERNAME>
ForwardAgent yes
ForwardX11 yes
ForwardX11Trusted yes

4. Test X11 Forwarding in VS Code

- Connect to Jetson agx orin board using remote ssh on the VS Code
- Check the DISPLAY variable
  >> echo $DISPLAY (if is empty then there could be an issue)
- Open remote terminal in VS Code, and type gedit

6.0 Yolov8 object Counting Inference

In this section, students are familiarized with more AI applications. Students will be able to do Yolov8_object counting.

- Create a new notebook kernel yolov8_counting.ipynb
- Download the video in the host PC
  https://basicai-asset.s3.amazonaws.com/www/blogs/yolov8-object-counting/street.mp4
- Copy the paste the video to the my-notebooks folder in the VS Code
- Copy, paste , and run the below code:
- Try more counting exercise from the link:
  https://docs.ultralytics.com/guides/object-counting/#real-world-applications

6.0 Home Exercise:

1. Study and perform face recognition inference using Yolov8. \
2. Try Yolov9 and Yolov10

Further reading and exercises:

1. Yolov8 Object Counting:
   https://medium.com/@BasicAI-Inc/yolo-object-counting-step-by-step-guide-yolo-v8-8bdda5cad970
2. Roboflow notebooks for AI: https://github.com/roboflow/notebooks?tab=readme-ov-file
3. Set up X11 forwarding: https://bhs-av.github.io/devlog/2019-11-11-x11-forwarding/

```
import cv2
```

```python
from ultralytics import YOLO
from ultralytics.solutions import object_counter as oc

input_video_path = "/home/eeuser/my-notebooks/street.mp4"
output_video_path = "/home/eeuser/my-notebooks/street_object_counting.mp4"

video_capture = cv2.VideoCapture(input_video_path)
assert video_capture.isOpened(), "Illegal or non-existing video file"

video_width, video_height, video_fps = (
    int(video_capture.get(p))
    for p in (cv2.CAP_PROP_FRAME_WIDTH, cv2.CAP_PROP_FRAME_HEIGHT,
cv2.CAP_PROP_FPS)
)

video_writer = cv2.VideoWriter(
    output_video_path, cv2.VideoWriter_fourcc(*"mp4v"), video_fps,
(video_width, video_height)
)

yolo = YOLO("yolov8n.engine")           #using tensorrt

object_counter = oc.ObjectCounter()
object_counter.set_args(
    view_img=True,
    reg_pts=[(0, 540), (1280, 540)],
    classes_names=yolo.names,
    draw_tracks=True
)

while video_capture.isOpened():
    success, frame = video_capture.read()
    if not success:
        break

    tracks = yolo.track(frame, persist=True, show=False, classes=[0, 2])
    frame = object_counter.start_counting(frame, tracks)
    #video_writer.write(frame)    #uncomment if you want to save the video
    cv2.imshow("video", frame)

    if cv2.waitKey(1) == ord('q'):
       break

video_capture.release()
video_writer.release()
cv2.destroyAllWindows()
```