Machine Learning for IoT
Lab 1 – Getting Started

HowTo 1: Working Environment Setup

You are required to install a collection of tools that will be used across the lab activities. To do that, you can follow the instructions reported below.
NB: We strongly suggest using a Unix operating system on your PC. All the instructions provided refers to Ubuntu.

1.1. In future labs, we will adopt the MQTT protocol to exchange messages between the Raspberry and the PC. For testing purposes, we will use the *Mosquitto* tool.
Setup the Mosquitto MQTT clients:

- Open a new shell and enter the following commands:

```
sudo apt update
sudo apt install -y mosquitto-clients
```

1.2. Download and install Python 3.7 (if not already installed)

```
sudo apt install -y python3.7 python3.7-venv
```

1.3. Setup the Python environment:

- Open a new shell.
- Create a new folder and create a new Python virtual environment named *py37*

```
python3.7 -m venv py37
```

- Activate the virtual environment:

```
source py37/bin/activate
```

NB: the virtual environment must be activated every time you open a new shell
Suggestion: check the official Python documentation at
https://docs.python.org/3/tutorial/venv.html

1.4. Setup the required python packages:

- Download from the *Portale* the *requirements.txt* file
- Upgrade pip:

```
pip install -U pip
```

- Install the requirements running the `pip` command:

```
pip install -r requirements.txt
```

HowTo 2: Raspberry Board Setup

2.1. Download and setup the Raspberry Pi OS:

- Download the OS image from the official Raspberry website: https://downloads.raspberrypi.org/raspios_full_armhf_latest
- Unzip the downloaded file.
- Download and install *balenaEtcher* from https://www.balena.io/etcher/
- Insert the SD card on your PC.
- Run *balenaEtcher* and flash the OS image in the SD card.
- Create a void file named ssh inside the main root of the SD card.
- Insert the SD card on your Raspberry.
- Power on the Raspberry connecting the board to the power supply.

2.2. Connect to the Raspberry via the `ssh` command:

- Connect the Raspberry to your PC via the ethernet cable
- Open a new shell and enter the following command:

```
ssh pi@raspberrypi.local
```

- Insert the default password (raspberry)

2.3. Setup the WiFi Connection on your Raspberry through the *raspi-config* utility

- Enter the following command:

```
sudo raspi-config
```

- Open Network Options, then Wireless LAN, and enter your network SSID and password.

2.4. Setup the Mosquitto MQTT broker and MQTT clients

- Enter the following commands:

```
sudo apt update
sudo apt install -y mosquitto mosquitto-clients
```

2.5. Setup the Python virtual environment

- Create a new folder and create a new Python virtual environment named *py3*

```
mkdir WORK_DIR
cd WORK_DIR
python3 -m venv py37
```

- Activate the virtual environment:

```
source py37/bin/activate
```

NB: the virtual environment must be activated every time you log-in into the board

2.6. Setup the required python packages:

- Download from the *Portale* the *rpi_requirements.txt* file.
- Copy the file to the *WORK_DIR* folder of your Raspberry (suggestion: use the Unix `scp` command).
- Install the requirements running the `pip` command (from the Raspberry):

```
pip install -r rpi_requirements.txt
```

2.7. Setup TensorFlow 2.3.0:

- Download from the *Portale* the TensorFlow wheel
- Copy the file to the *WORK_DIR* folder of your Raspberry
- Install the package running the pip command:

```
pip install tensorflow-2.3.0-cp37-none-linux_armv7l.whl
```

2.8. Install other dependencies:

```
sudo apt install -y libgpiod2
```

HowTo 3: Test the MQTT Connection

Mosquitto will be used to check if your PC and the Raspberry can communicate and exchange messages between each other.

3.1. Run a subscriber on your PC:

- Open a shell on your PC.
- Enter the following command:

```
mosquitto_sub -h raspberrypi -t test
```

3.2. Run a publisher on your Raspberry:

- Open a shell on your board.
- Send the “Hello World!” message with the following command:

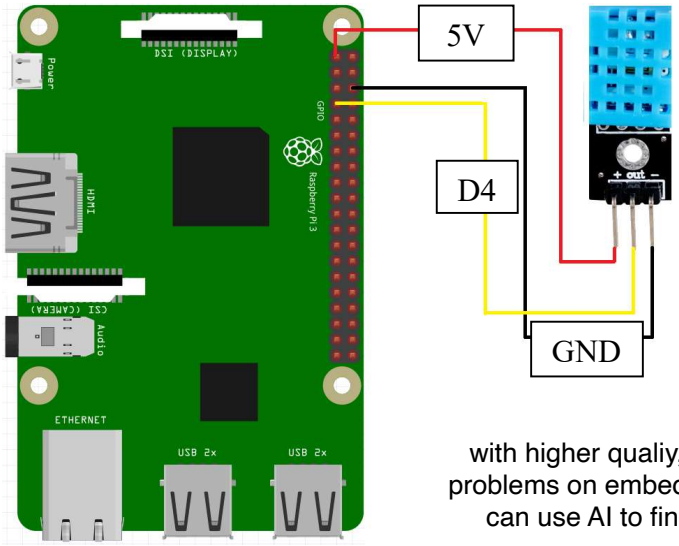
```
mosquitto_pub -h localhost -t test -m “Hello World!”
```

- Check if your PC has received the message on the subscriber shell.

Exercise 4: Sense Temperature and Humidity with the DHT-11

4.1. Write a Python script to collect temperature and humidity measurements with the Raspberry and the DHT-11 sensor. The script should take as inputs three parameters: the frequency of measurements (in seconds), the period of measurements (in seconds), and the output filename.

- Connect the DHT-11 sensor to your board.



with higher qualiy, the file is larger-> problems on embedded hardware, but I can use AI to find a good tradeoff

- Use the a*dafruit_dht* package to read temperature and humidity values:

```
from board import D4
import adafruit_dht

dht_device = adafruit_dht.DHT11(D4)
temperature = dht_device.temperature
humidity = dht_device.humidity
```

- Store the measurements in a csv file, where the first column reports the date (in *dd/mm/yyyy* format), the second the hour (in the *hh:mm:ss* format), the third the temperature value, and the fourth the humidity value.

  Suggestion: Check the *datetime* Python package
  https://docs.python.org/3.7/library/datetime.html

- Test your script with different values of frequency and period.
- Output example with frequency=5s and period=20s:

```
18/10/2020,09:45:34,21,65
18/10/2020,09:45:40,21,65
18/10/2020,09:45:45,21,65
18/10/2020,09:45:51,21,65
```

Exercise 5: Record Audio with the USB Microphone

5.1. Write a Python script to collect audio samples with the Raspberry and the USB microphone.

- Connect the USB microphone to the Raspberry.
- Use the *pyaudio* package to drive the microphone (with the blocking mode) and the *wave* package to store the samples on disk.

  Suggestion: check the packages documentation at
  http://people.csail.mit.edu/hubert/pyaudio/docs/#
  https://docs.python.org/3/library/wave.html

- Write the code to register a 3 second sample. Try different resolutions (Int8, Int16, Int32) and sampling rates (44.1 kHz and 48 kHz).
- Measure the execution time (in seconds) needed for sampling with the *time* method of the *time* package.
- Measure the execution time (in seconds) needed to store the data on disk.
- Measure the output .wav size (in KB) with *os.path.getsize* method from the *os* package
- Check the audio quality in the different cases and comment the results.

Exercise 6: (optional) Take Pictures with the PiCamera

6.1. Setup the PiCamera

- Connect the PiCamera to the Raspberry.

  Suggestion: check the documentation at
  https://projects.raspberrypi.org/en/projects/getting-started-with-picamera

- Enable the camera through the `raspi-config` utility:

  ```
  sudo raspi-config
  ```

  Select *Interfacing Options*, then *Camera*, and hit *Enter*. Choose *Yes*, then *Ok*. Go to *Finish* and you will be prompted to reboot.

6.2. Write a Python script to take pictures with the Raspberry and the PiCamera. The script should take as inputs: the image width (in pixels), the image height (in pixels), the framerate (in FPS), the number of pictures, the output format (png or jpg), the output directory.

- Use the *picamera* package to drive the camera module in Python.
- Measure the execution time (in seconds) needed for taking a picture and storing the picture on disk.
- Measure the output file size (in MB) with the *os.path.getsize* method.
- Test the script with different resolutions (e.g., 64x64 and 1024x1024) and output formats. Comment the results.

jpeg is lossy compressed format, png stored wihotu loss of quality, more data (also for moving it). Jpeg reducing the data so less movement of data. Convnets are resilient to errors???