XCS234 Azure Guide

This guide will help you set up and use Azure Virtual Machines for any assignment work in XCS234 that you'd like. Before you start, it cannot be stressed enough: **to not leave your machine running when you are not using it, they will automatically shut down after 15 minutes of inactivity**!

Access and Setup

Azure Labs Subscription for this Class

We are using Azure Lab Services to manage VMs for the XCS224n course. Every student will be allocated 40 hours total to use however you'd like. **It's important for you to manage credit wisely in order to make the most efficient use of it (see next section).**

Credit has been assigned per student and everyone's instances are preconfigured with Linux DSVM (Data Science Virtual Machine) images so you can expect some packages/tools to be installed.

Best Practices for Managing Credit

Azure virtual machines are charged at a flat rate for each minute they are turned on. This is irrespective of:

- whether you are ssh'd to the machine at that time
- whether you are running any processes on the machine at that time
- the computational intensity of the processes you're running
- whether you're using GPUs

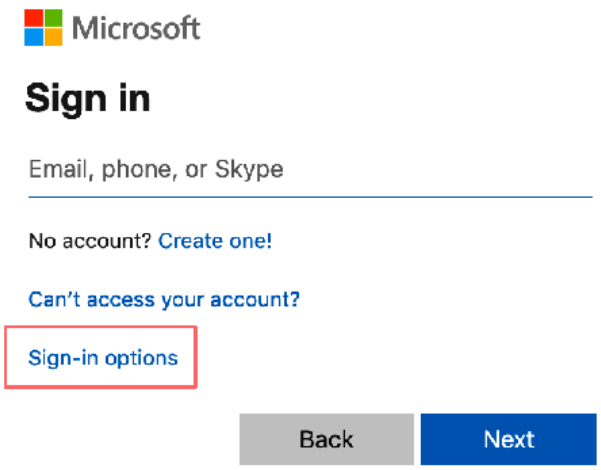
Therefore, the most important thing for managing credit wisely is to **carefully turn your VM on and off only when you need it**.

We advise you to **develop your code on your local machine** (for example your laptop with the CPU version of Pytorch installed) for debugging (i.e., work on your new code until you are able to complete several training iterations without errors), then run your code on your Azure VM when it's time to train on a GPU.

Registration

1. Go to this link **https://labs.azure.com/register/31tpszoi7**

2. You'll be presented with a large number of options to register. They are:
   A. Logging in with an existing Microsoft account using the email/phone associated with it
   or
   B. Logging in with a Skype account
   or
   C. If you click 'Sign-in Options' you will also be presented with the option to sign in using your GitHub credentials

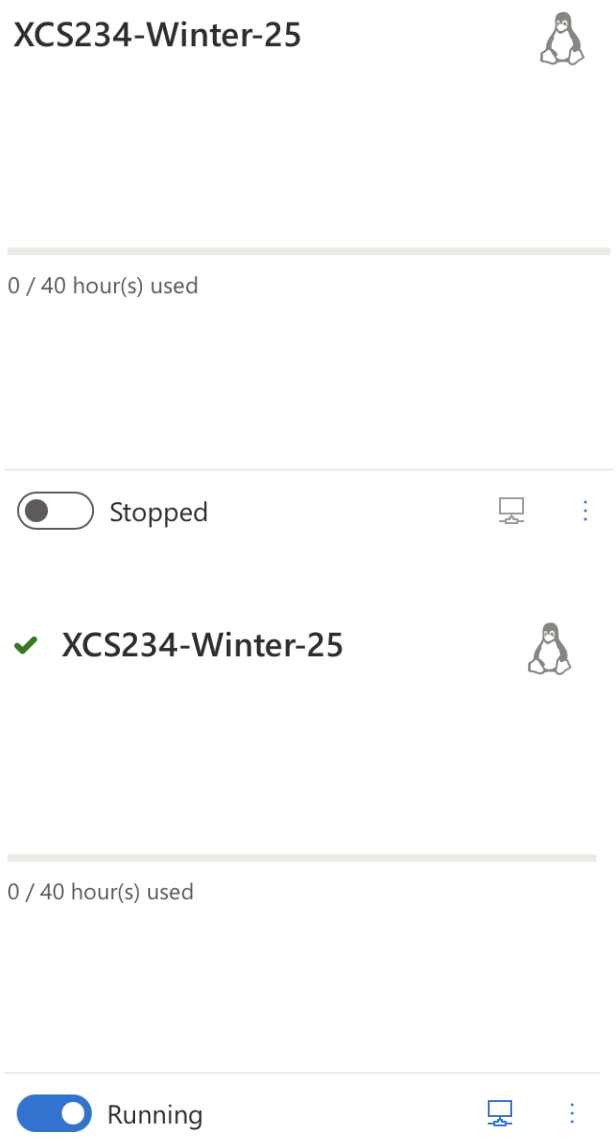


Once you've done A, B, or C - follow any additional prompt instructions (depends on which way you chose) - and you will be registered for the lab!

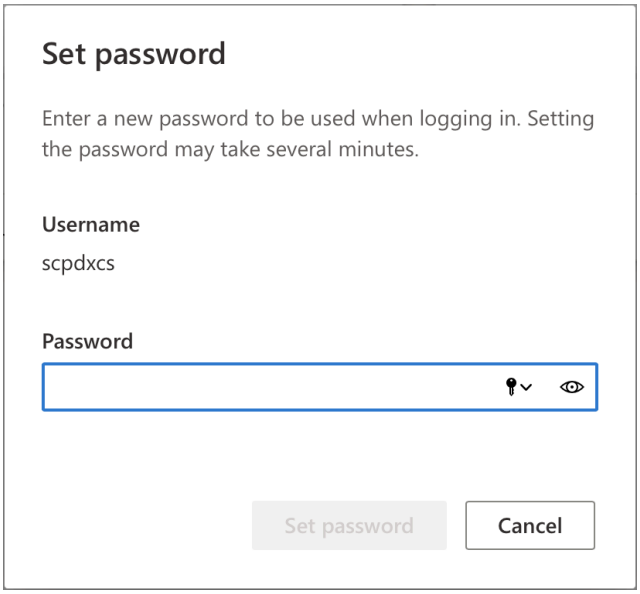
Connecting to a VM

1. After signing in you'll be directed to an Azure Lab Services portal where you can view all your virtual machines. Unless you've used Azure Lab Services before, you'll see only one machine along with your remaining hours.

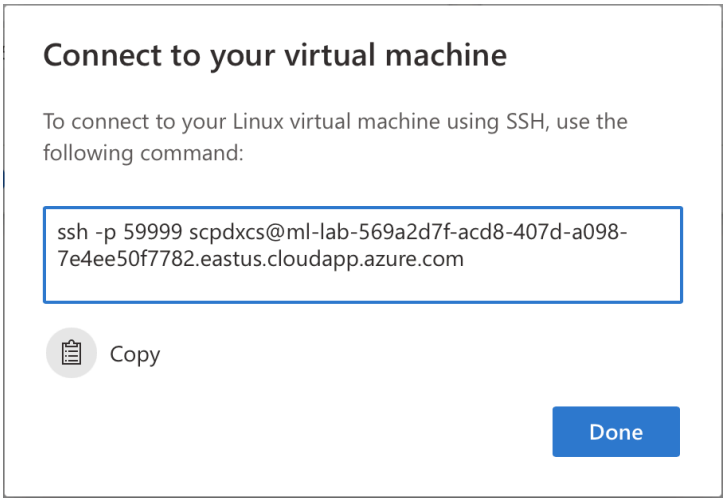
   Click on the 'Stopped' button to start the instance (this will take a few minutes). When it is up and running, it will look like this and say "Running" in the bottom status bar:



2. Click the monitor icon in the window above and you'll be asked to set the instance password (make sure you remember/record this password as you will be asked to enter it when logging into to your VM via SSH).



3. Click on the monitor icon and select *'connect via SSH'* to get the SSH link.



4. Copy the link and paste it into your terminal

```
Welcome to Ubuntu 20.04.6 LTS (GNU/Linux 5.15.0-1073-azure x86_64)

 System information as of Sat Oct  5 21:12:04 UTC 2024

  System load:  0.33               Processes:             191
  Usage of /:   57.9% of 145.19GB  Users logged in:       1
  Memory usage: 1%                 IPv4 address for eth0: 10.0.0.82
  Swap usage:   0%

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
   just raised the bar for easy, resilient and secure K8s cluster deployment.

   https://ubuntu.com/engage/secure-kubernetes-at-the-edge

Expanded Security Maintenance for Applications is not enabled.

30 updates can be applied immediately.
1 of these updates is a standard security update.
To see these additional updates run: apt list --upgradable

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

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


**************************************************************************
* Welcome to the Ubuntu 20.04 Data Science Virtual Machine!              *
*                                                                        *
* You can access this DSVM, view the graphical desktop with              *
* X2Go, or run JupyterLab from a browser on your computer                *
* For more information, see the docs at https://aka.ms/dsvm/docs.        *
**************************************************************************

Last login: Sat Oct  5 20:01:55 2024 from 80.128.182.47
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.
```

5. Important, to assure the GPU is fully available before continuing, run the following command in the terminal:

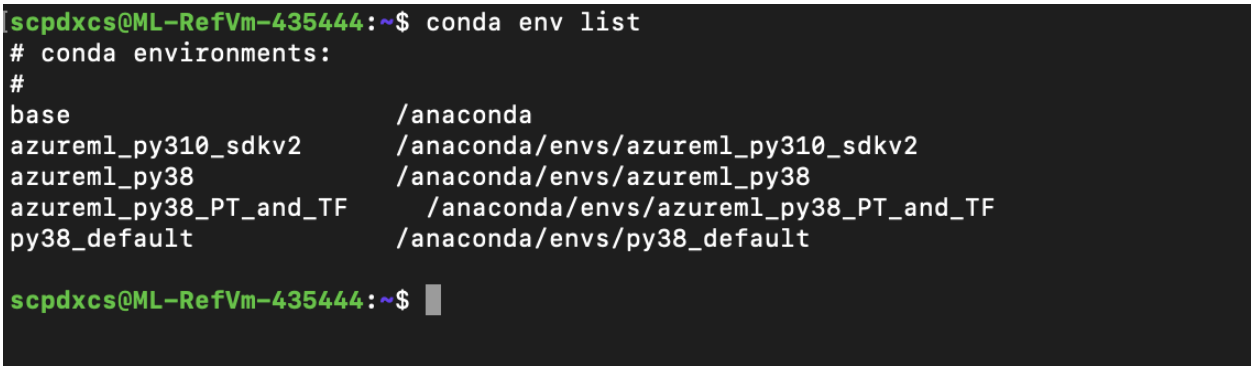
   ```
   nvidia-smi
   ```

   You should be getting the following:

```
[scpdxcs@lab02WMGF:~$ nvidia-smi
Sat Oct  5 21:14:15 2024
+---------------------------------------------------------------------------------------+
| NVIDIA-SMI 535.183.01             Driver Version: 535.183.01   CUDA Version: 12.2     |
|-----------------------------------------+----------------------+----------------------+
| GPU  Name                 Persistence-M | Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp   Perf          Pwr:Usage/Cap |         Memory-Usage | GPU-Util  Compute M. |
|                                         |                      |               MIG M. |
|=========================================+======================+======================|
|   0  Tesla V100-PCIE-16GB           On  | 00000001:00:00.0 Off |                  Off |
| N/A   28C    P0              23W / 250W |      0MiB / 16384MiB |      0%      Default |
|                                         |                      |                  N/A |
+-----------------------------------------+----------------------+----------------------+

+---------------------------------------------------------------------------------------+
| Processes:                                                                            |
|  GPU   GI   CI        PID   Type   Process name                            GPU Memory |
|        ID   ID                                                             Usage      |
|=======================================================================================|
|  No running processes found                                                           |
+---------------------------------------------------------------------------------------+
```

6. Anaconda

The VM template comes with Anaconda already installed and multiple environments are already available as can be seen below:



The `azureml_py38_PT_and_TF` environment comes with PyTorch and Tensorflow pre-installed. Check the next points for more information.

7. Check that Pytorch can access the GPUs by first activating the `azureml_py38_PT_and_TF` environment, opening Python and typing the following:

```
$ python
import torch
torch.cuda.current_device()
torch.cuda.device(0)
torch.cuda.device_count()
torch.cuda.get_device_name()
torch.version.cuda
torch.__version__
```

You should see something like this:

```
(azureml_py38_PT_and_TF) scpdxcs@lab0J3AT2:~$ python
Python 3.10.8 | packaged by conda-forge | (main, Nov 22 2022, 08:23:14) [GCC 10.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import torch
>>> torch.cuda.current_device()
0
>>> torch.cuda.device(0)
<torch.cuda.device object at 0x7fd57b9d8100>
>>> torch.cuda.device_count()
1
>>> torch.cuda.get_device_name()
'Tesla V100-PCIE-16GB'
>>> torch.version.cuda
'12.4'
>>> torch.__version__
'2.6.0+cu124'
>>>
```

If you receive error messages or find that this isn't working, post to Slack and/or reach out to your Course Facilitator.

Practical Guide for Using the VM

Managing Processes on a VM

In developing your deep learning models, you will likely have to leave certain processes, such as Tensorboard and your training script, running for multiple hours. If you leave a script running on a VM and log-off, your process will likely be disrupted. Furthermore, it is often quite nice to be able to have multiple terminal windows open with different processes all visible at the same time, without having to SSH into the same machine multiple different times.

TMUX or "Terminal Multiplexer" is a very simple solution to all the problems above.

Essentially, TMUX makes it such that in a single SSH session, you can virtually have multiple terminal windows open, all doing completely separate things. Also, you can actually tile these windows such that you have multiple terminal sessions all visible in the same window.

The basic commands are below. Terminal commands are prefaced with a " $ " otherwise the command is a keyboard shortcut.

TMUX Cheatsheet

1. Start a new session with the default name (an integer) `$ tmux`
2. Start a new session with a user-specified name `$ tmux new -s [name]`
3. Attach to a new session `$ tmux a -t [name]`
4. Switch to a session `$ tmux switch -t [name]`
5. Detach from a session `$ tmux detach OR ctrl - b - d`
6. List sessions `$ tmux list-sessions`
7. Kill a session `ctrl - b - x`
8. Split a pane horizontally `ctrl - b - "`
9. Split a pane vertically `ctrl - b - %`
10. Move to pane `ctrl - b - [arrow_key]`

Managing Code Deployment to a VM

You are welcome to use scp/rsync to manage your code deployments to the VM. However, a better solution is to use a version control system, such as **Git**. This way, you can easily keep track of the code you have deployed, what state it's in and even create multiple branches on a VM or locally and keep them sync'd.

The simplest way to accomplish this is as follows.

1. Create a Git repo on Github, Bitbucket or whatever hosted service you prefer.
2. Create an SSH key on your VM. (see the link below)
3. Add this SSH key to your Github/service profile.
4. Clone the repo via SSH on your laptop and your VM.
5. When the project is over, delete the VM SSH key from your Github/service account.

Resources:

- Github SSH key tutorial
- Codecademy Git tutorial (great for Git beginners to get started)

*Note: If you use Github to manage your code, you must keep the repository **private** until the class is over.*

Another option is to use a tool called `scp`, which stands for "secure copy". `scp` uses a similar command to `ssh` for transferring files to and from your VM. Let's say you can access your VM with the following `ssh` command:

```
ssh -p 54003 scpdxcs@ml-lab-XXXXXXXXXXXXX.southcentralus.cloudapp.azure.com
```

To transfer files to the VM from your local machine, use the following command (differences highlighted):

```
scp -r -P 54003 path/to/local/file scpdxcs@ml-lab-XXXXXXXXXXXXX.southcentralus.cloudapp.azure.com:path/to/remote/destination
```

To transfer files from the VM to your local machine, use the following command:

```
scp -r -P 54003 scpdxcs@ml-lab-XXXXXXXXXXXXX.southcentralus.cloudapp.azure.com:path/to/remote/file path/to/local/destination
```

The `-r` option indicates that a recursive copy should be performed, meaning that you can transfer an entire directory structure with just this one command! (note that the `-p` (lowercase) is now a `-P` (uppercase))

Note: scp commands copies files all the time regardless of the file changes from the source to the destination; however, *rsync* will only copy files when the file is updated on the source location. So if you have a large file (such as a model), then rsync could be helpful, here is the tutorial on how to use it. Just remember trailing slash (/) is important as in the tutorial.

Here is an example of *rsync* command with specific port that can be found from Azure web:

```
rsync  -arvz -e  'ssh -p PORT_NO' --progress /Users/name/SCPD/XCS224N/PROJ/
scpdxcs@ml-lab-xxx:/home/scpdxcs/SCPD/XCS224N/PROJ
```

Managing Memory, CPU and GPU Usage on a VM

If your processes are suddenly stopping or being killed after you start a new process, it's probably because you're running out of memory (either on the GPU or just normal RAM).

First of all, it's important to check that you are not running multiple memory hungry processes that maybe have slipped into the background (or a stray TMUX session).

You can **see/modify which processes you are running** by using the following commands.

1. View all processes `$ ps au`
2. To search among processes for those containing the a query, use `$ ps -fA | grep [query]`.
   For example, to see all python processes run `ps -fA | grep python.`
3. Kill a process `$ kill -9 [PID]`

You can find the PID (or Process ID) from the output of (1) and (2).

To **monitor your normal RAM and CPU usage**, you can use the following command: `$ htop` (Hit `q` on your keyboard to quit.)

To **monitor your GPU memory usage**, you can use the `$ nvidia-smi` command. If training is running very slowly, it can be useful to see whether you are actually using your GPU fully. (In most cases, when using the GPU for any major task, utilization will be close to 100%, so that number itself doesn't indicate an Out of Memory (OOM) problem.)

However, it may be that **your GPU is running out of memory simply because your model is too large** (i.e. requires too much memory for a single forward and backward pass) to fit on the GPU. In that case, you need to either:

1. Train using multiple GPUs (this is troublesome to implement, and costs much more on Azure)
2. Reduce the size of your model to fit on one GPU. This means reducing e.g. the number of layers, the size of the hidden layers, or the maximum length of your sequences (if you're training a model that takes sequences as input).
3. Lower the batch size used for the model. Note, however, that this will have other effects as well (as we have discussed previously in class).

Accessing Tensorboard

When running tensorboard for the assignments, you will need to run the following two steps to ensure that you can access the tensorboard runs via your local machine.

Step 1: Configure port 6006

1. `ssh -p <vm port> -N -f -L localhost:6006:localhost:6006 username@<your VM public ip address>`

`i.e  ssh -p 59022 -N -f -L localhost:6006:localhost:6006 scpdxcs@ml-lab-xxxxxxxxxxxx.southcentralus.cloudapp.azure.com`

Step 2: Go inside VM and Run Tensorboard

Next you will need to run your tensorboard command as follows

1. `tensorboard --logdir <some directory> --port 6006`

Tunneling on Azure VM for Jupyter

(Thanks Luis Valerio Hernandez for sharing this method!)

You may need to run the notebook located in the server from your own computer. In that case, you will need to establish a tunnel between your local computer and the remote computer. Below are the necessary steps to establish it.

[Reference: documentation for using jupyter with multiple options.]

Step 1: Setup SSH Tunnel

Access your remote machine with a regular ssh command with an additional part that establishes a tunnel between a `local port` and `target port` as exemplified below.

```
PS C:\Users\Admin> ssh -p 63616 xcs224u_student@***********.southcentralus.cloudapp.azu
re.com -L 8080:localhost:8888
xcs224n_student@ml-lab-d96b8b7c-aabd-428a-874a-c14ab55dff7a.southcentralus.cloudapp.azure.com's
password:

(Some welcome messages here)

Last login: Wed Mar 11 08:43:55 2020 from 73.158.65.76
xcs224n_student@ML-EnvVm-00047:~$
```

Step 2: Run Jupyter

Simply run the jupyter as usual with an ip parameter [and an optional --port=#### parameter].

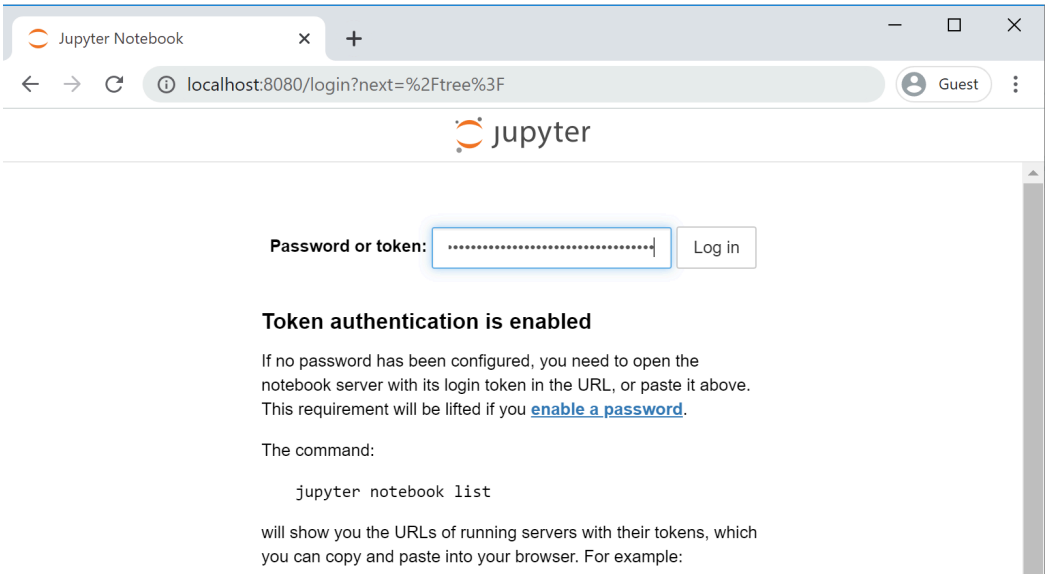
```
xcs224n_student@ML-EnvVm-00047:~/Desktop/cs224u$ jupyter notebook --no-browser --ip='0.0.0.0'
--port=8888
[I 08:51:55.080 NotebookApp] JupyterLab extension loaded from
/data/anaconda/envs/py35/lib/python3.5/site-packages/jupy
terlab
[I 08:51:55.080 NotebookApp] JupyterLab application directory is
/data/anaconda/envs/py35/share/jupyter/lab
[I 08:51:56.273 NotebookApp] sparkmagic extension enabled!
[I 08:51:56.273 NotebookApp] Serving notebooks from local directory:
/data/home/xcs224n_student/Desktop/cs224u
[I 08:51:56.273 NotebookApp] The Jupyter Notebook is running at:
[I 08:51:56.273 NotebookApp] http://(ML-EnvVm-00047 or
127.0.0.1):8888/?token=990b86c0ee61f2ba4f3808baa24bc6696c1b407c5
da63cba
[I 08:51:56.273 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip
confirmation).
[C 08:51:56.274 NotebookApp]

   Copy/paste this URL into your browser when you connect for the first time,
   to login with a token:
       http://(ML-EnvVm-00047 or 127.0.0.1):8888/?token=990b86c0ee61f2ba4f3808baa24bc6696c1b407c5da63cba
```

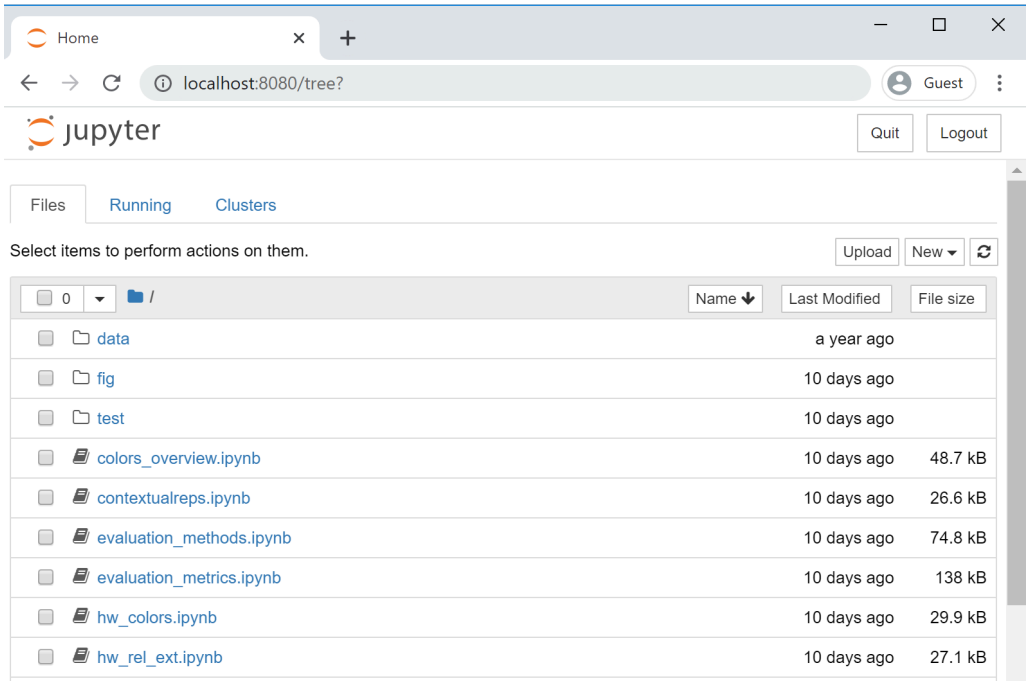
Step 3: Access Jupyter

Go to the link `http://localhost:8080` in the browser of your local machine and enter the `token`

As of 9/26/2021, Chrome browser on Mac did warn about the certificate, but didn't give me an option to go ahead and connect.

Safari (version 15) on Mac warned, but gave an option to continue. Once you accept that you will continue, a connection will be established.





Step 4: Enjoy :)

This is the most important step! Enjoy experimenting with Jupyter on Azure VM :)