PIV Pre-Readings

For students to do before starting PIV classes

Before classes start you must refresh what you learned in Linear Algebra and Probability courses, which must have been refreshed in other courses too (80% of students took one of Machine Learning, Deep Learning, Algorithms, Optimization before PIV).

Read the following documents : you'll need them in PIV

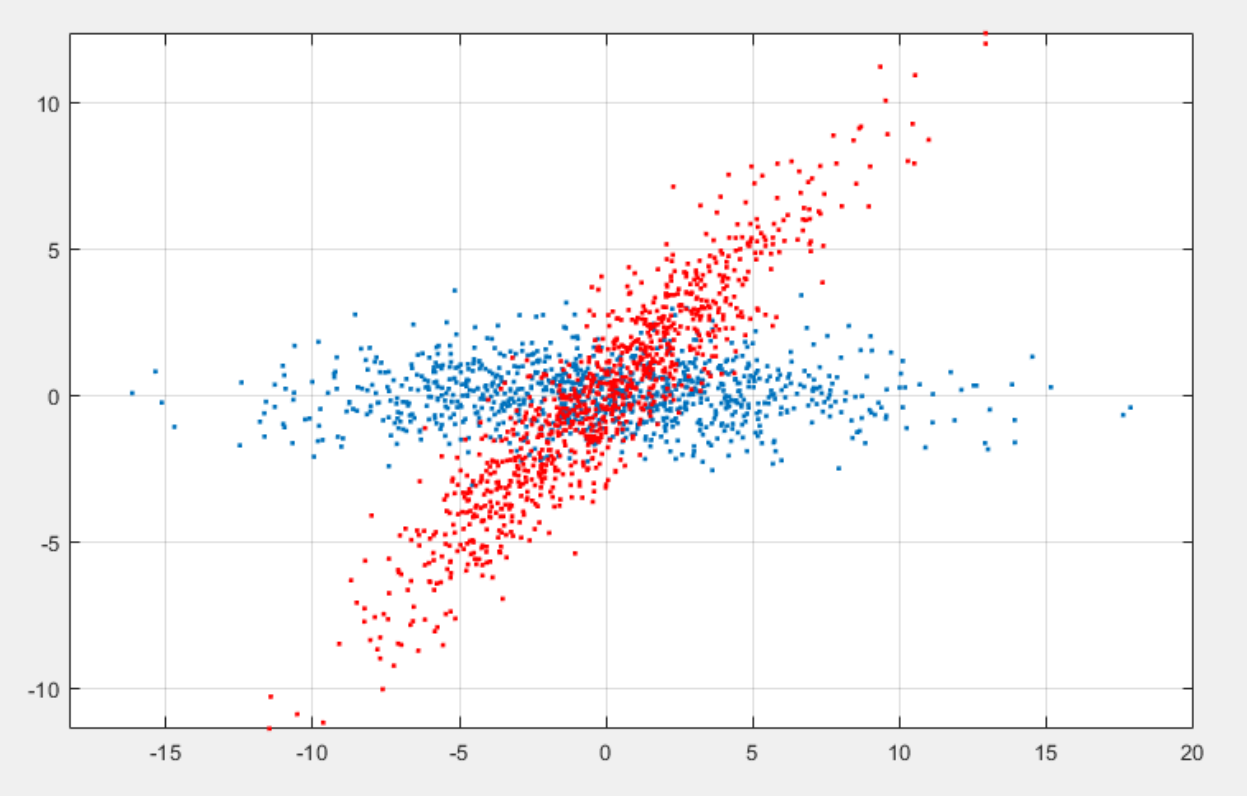
Linear Algebra Review (Ian Goodfellow's book)
https://drive.google.com/file/d/1KLLA-kgNPa_hwiiNia83OJhVSlGcGyhh/view?usp=drive_link

Probability Review (Ian Goodfellow's book)
https://drive.google.com/file/d/1VjwoLrDqNlXxnPTup_XNT-Ju5LTzSk2i/view?usp=drive_link

Algebra/Programming Exercises

Consider the data from file
https://drive.sipg.tecnico.ulisboa.pt/s/RAfzQKqq2mqSYad

shown in the figure below (variables X and Y)



$X_i = [x_{1_i} x_{2_i}]^T$ are the blue points and $Y = [y_1 y_2]^T$ the red plot the histogram of x_1 and x_2

Estimate the mean and covariance matrices of both sets.

What can you say about the relation x_1,x_2 and y_1,y_2 ?

answer : (X is uncorrelated and Y is correlated) ... agree ? why ?

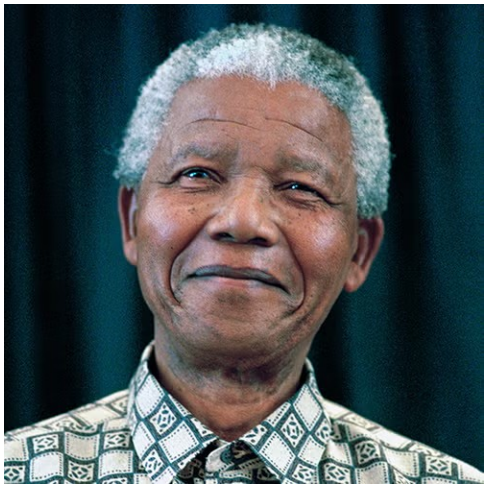
project the red data along the direction d=$[\frac{-1}{\sqrt{(2)}} \frac{1}{\sqrt{(2)}}]$ (The projection along a direction is given by the dot product $proj = d^T Y_i$).

Compute the variance of the projected points and plot the histogram. Comment any similarity with the distributions of X.

Compute the eigenvectors of the covariance matrix of Y and X . How would you relate Y with X ?

Goal : apply elementary decompositions to images.

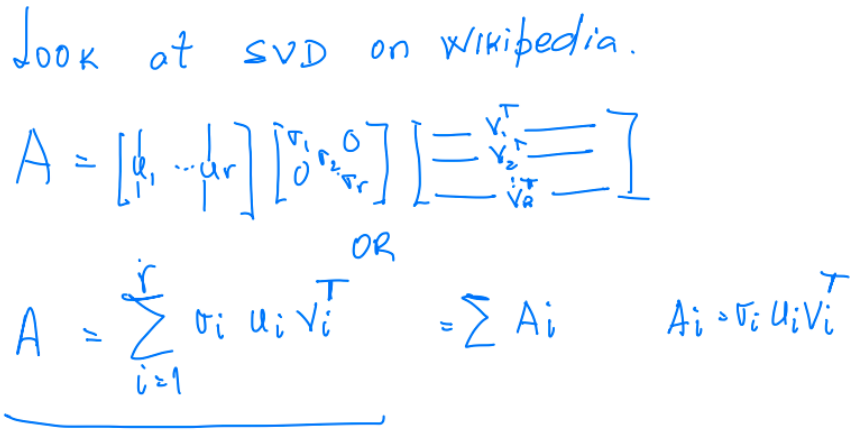
A digital image can be understood as a matrix (or vector or tensor !). To the image below or to one image of your choice, visualize the Singular Value Decomposition of that image.



(download from)

To be closer to “the algebra” we will use gray-level images, so:

- Read the linear algebra review appendix (from Ian Goodfellow’s book). In particular make notice of the annotations that were added.
- convert the image to gray scale or download it from here https://drive.google.com/file/d/1_DvWUR4kNRlJj7ogqhfMNEcWsBcuXe-r/view?usp=drive_link
- write a python or matlab script that does the following tasks
    - read the image and convert to gray level or read the gray level image if available(use matplotlib.pyplot module for example).
    - decompose the image (a numpy matrix) into singular vectores/values - the so called singular value decomposition (numpy.linalg.svd).
    - Reconstruct the image with an increasing number of “singular vectors/values”. In other words, as shown in the annex, if A is the image



- In short, generate all the subimages Ai (you may want to visualize them too) and sum the first k components (K in [1, 2 , ..., M], M= min size of row/cols)

$$A_K = \sum_{i}^{K} A_i$$

- Visualize each Ak (gray level images `plt.imshow(image, cmap='gray').` some functions may require some scaling or conversion to uint to be viewed).
- Plot the error E of the approximations. That is, plot the vector where each element is the norm of the difference Ek= || A - Ak|| . Comment on the shape of E
- Could you think of any other way of representing/decomposing the image ?

Besides the goal of introducing the programming environment and motivating the “algebra review” this exercise brings to the fore a striking fact : Images are “low rank” !!!!

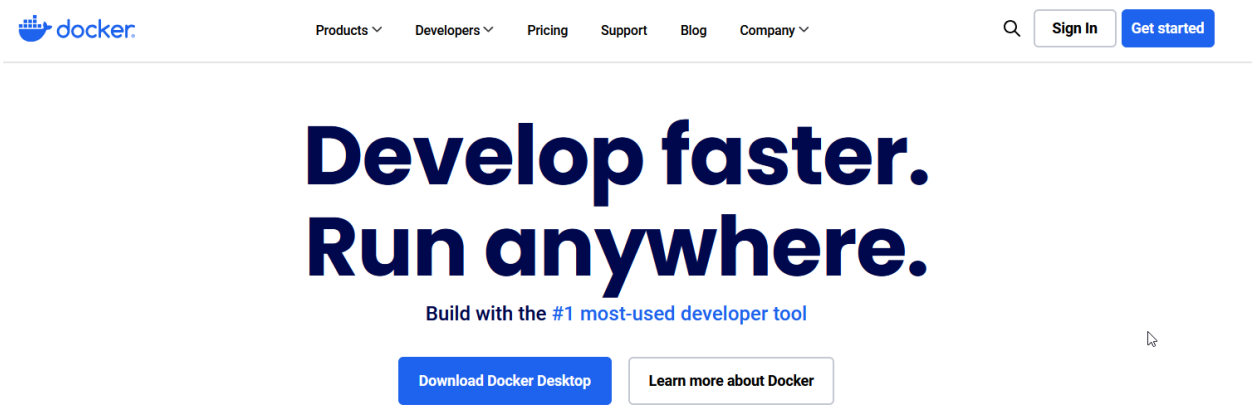
Try to apply the method to an image of a face. As you can see in the example below, with 2 or 3 columns alone you can identify that it is a face and with 4 or 5 more you know who is the person clearly. NOTE: this amounts to get 4 or 5 independent columns and generate all other columns of the image!

https://prod-files-secure.s3.us-west-2.amazonaws.com/a90c60b5-5835-4780-993b-a3fe1633541c/309c6b0d-4978-426e-a7a7-ef7849ffb803/WhatsApp_Video_2024-10-05_at_15.46.21.mp4

DOCKER CONTAINER: installing the working environment

You will use data from complex systems like Yolo. The best way of using it through the use of containers

Docker is the most popular container platform and easy to install and manage. Of course it consumes some extra resources, namely disk. You will need a few Gb of free disk ! We recommend you use linux for this.



Docker containers

Docker is the "swiss knife" of modern systems for software development and deployment. We will use it in the course but it is recommended that students get acquainted with the technology before classes start. If you find any difficulty do not worry we can solve it in the class.

You may explore documentation about docker https://www.docker.com/101-tutorial/ or here https://docs.docker.com/get-started/

Main steps to have the software environment installed :

1. Install docker engine https://docs.docker.com/get-docker/
2. Pull a jupyter notebook container with the environment installed - scikit-learn & the rest (~5Gb):
    a. Launch the docker desktop and in a terminal window type :

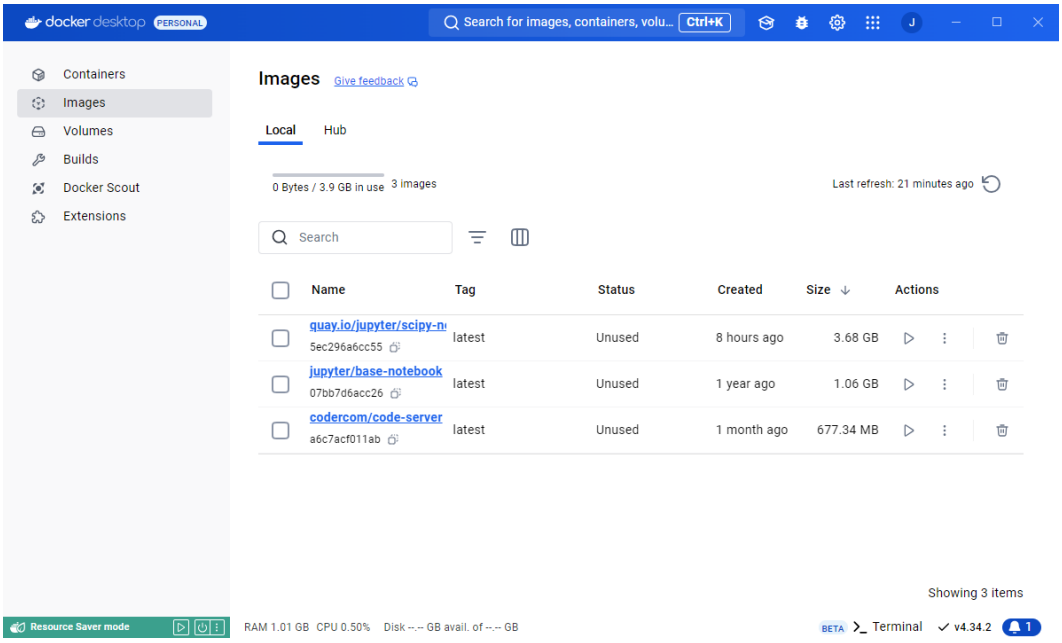
    docker pull jupyter/scipy-notebook

```
jpc@Macminijpc-5 Downloads % docker pull jupyter/scipy-notebook
Using default tag: latest
latest: Pulling from jupyter/scipy-notebook
aece8493d397: Already exists
fd92c719666c: Already exists
088f11eb1e74: Already exists
4f4fb700ef54: Pull complete
```

After it finished downloading type " **docker images** "

```
jpc@Macminijpc-5 Downloads % docker images
REPOSITORY                          TAG       IMAGE ID       CREATED         SIZE
quay.io/jupyter/scipy-notebook      latest    5ec296a6cc55   24 hours ago    3.69GB
jupyter/scipy-notebook              latest    ad65fcfebde3   11 months ago   4.14GB
jupyter/base-notebook               latest    07bb7d6acc26   11 months ago   1.07GB
```

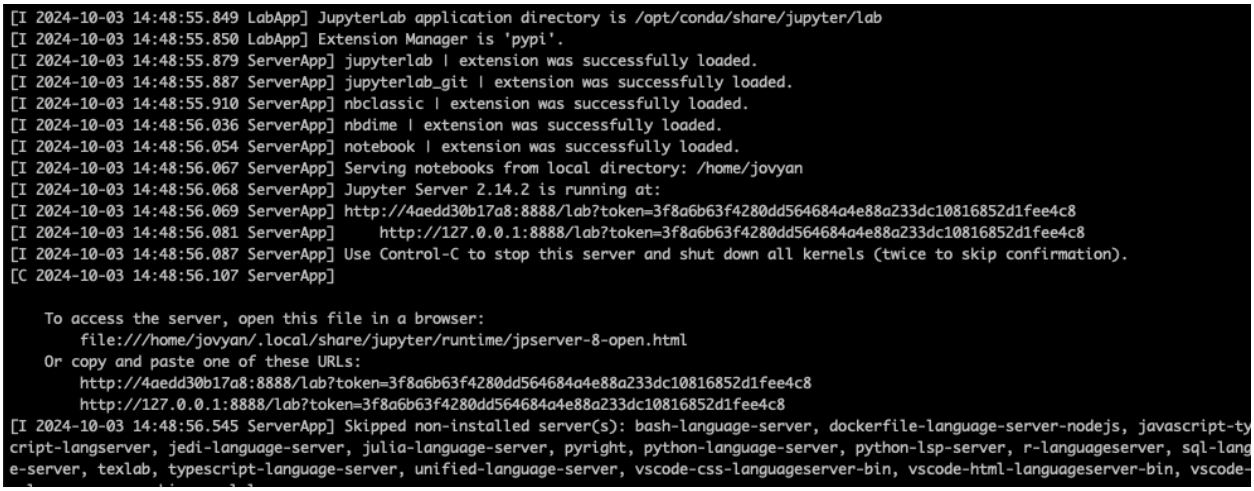
Alternatively check the images using the docker desktop app



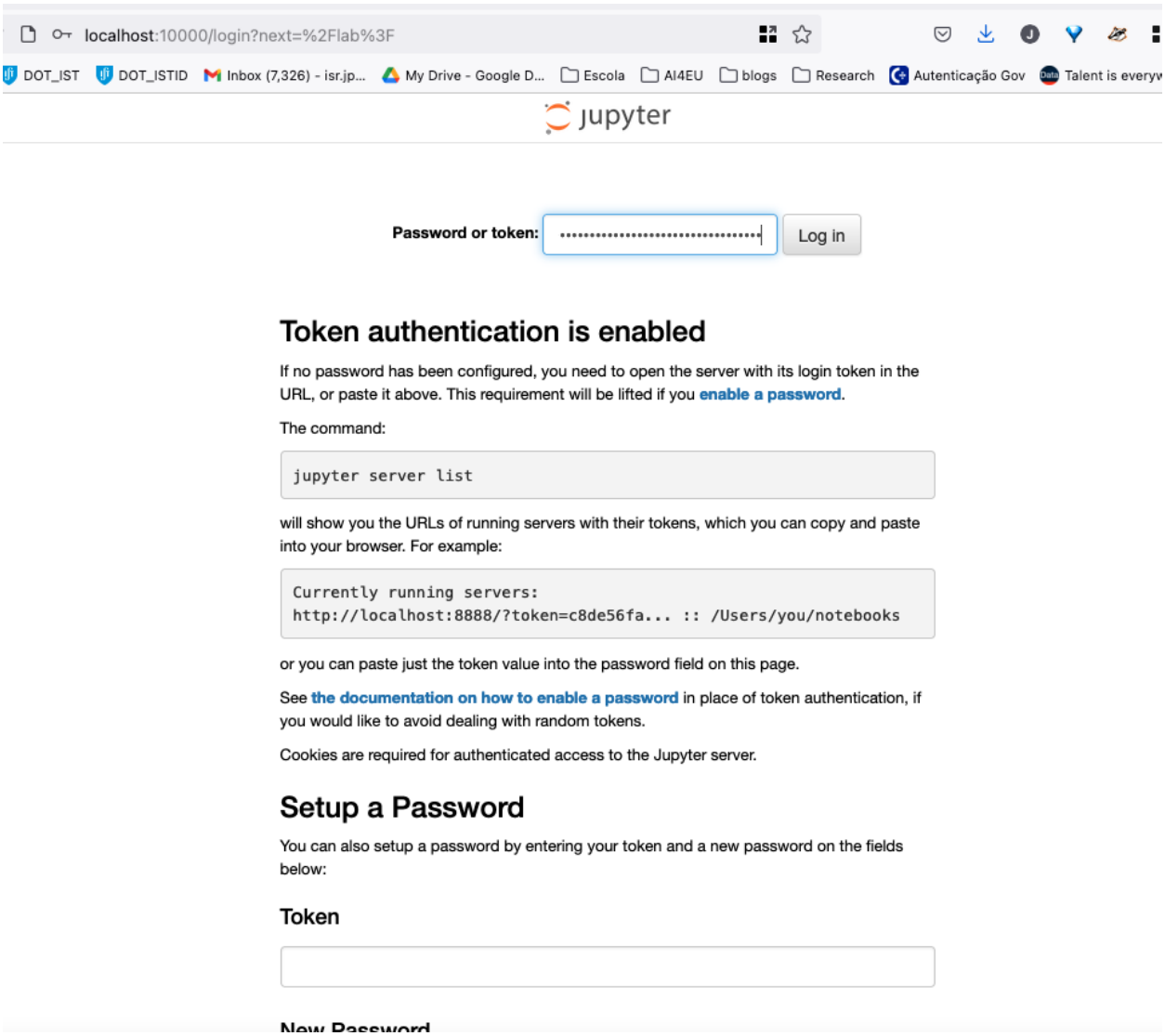
note: this picture includes other images, not required.

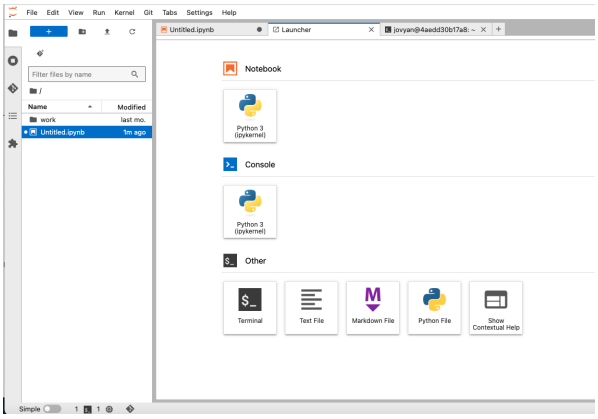
Launch a jupyter environment with docker

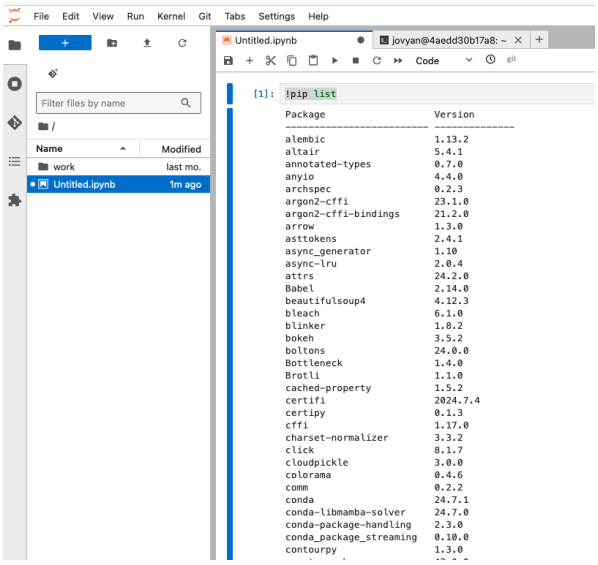
docker run -p 10000:8888 - -rm jupyter/scipy-notebook



Copy the token or ctrl-click in the link http://127.0.0.1 and open a browser window and type: http://localhost:10000 . You should see the jupyter login. Insert the token and ...voila !


localhost:10000/login?next=%2Flab%3F
DOT_IST
DOT_ISTID
Inbox (7,326) - isr.jp...
My Drive - Google D...
Escola
AI4EU
blogs
Research
Autenticação Gov
jupyter
Password or token:
Log in
Token authentication is enabled
If no password has been configured, you need to open the server with its login token in the URL, or paste it above. This requirement will be lifted if you enable a password.
The command:
jupyter server list
will show you the URLs of running servers with their tokens, which you can copy and paste into your browser. For example:
Currently running servers:
http://localhost:8888/?token=c8de56fa... :: /Users/you/notebooks
or you can paste just the token value into the password field on this page.
See the documentation on how to enable a password in place of token authentication, if you would like to avoid dealing with random tokens.
Cookies are required for authenticated access to the Jupyter server.
Setup a Password
You can also setup a password by entering your token and a new password on the fields below:
Token
New Password





To stop, either shutdown the notebook in the menu or CTR-C in the terminal.

To remove the non-working containers type:

docker container prune

Install other stuff

You can install anything you want here. Once the container is shutdown all changes will be deleted.

Some examples https://deepnote.com/guides/jupyter/how-to-run-jupyter-in-docker

Frequent actions :

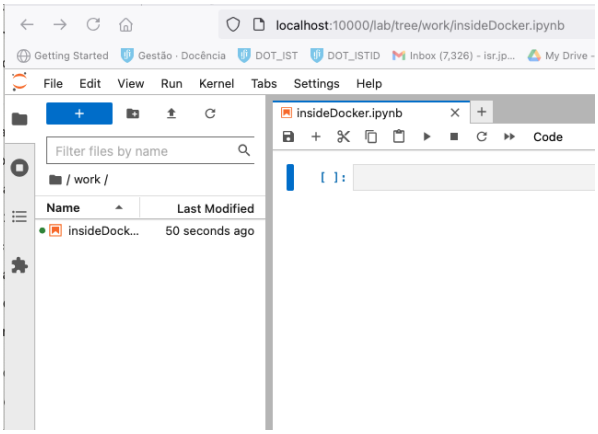
launch a container / stop a container /

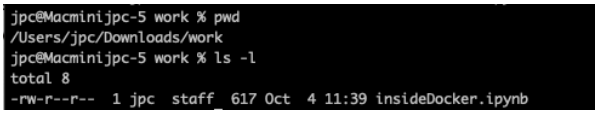
https://docs.docker.com/get-started/docker_cheatsheet.pdf

Making files and edits permanent - very important

Each time you close a container all the files you uploaded to the jupyter notebook will be lost (they are inside the container). To make storage permanent you may map a local folder (on your computer , called “the host”) to the container. In a way share a common folder between the container and the OS. When launching the docker container add the following command:

docker run -p 10000:8888 -v full_path_to_some_dir:/home/jovyan/work jupyter/scipy-notebook





Enjoy the huge offer of docker FOSS (Free Open Source Software)

Docker HUB http://hub.docker.com