2695 Introduction to Machine Learning
Masters Program in Economics, Finance and Management

PYTHON SETUP

Python is becoming the most popular programming language for ML

Source: TechVidvan

Python libraries

Write your first python program interactively

- IPython is a powerful interactive shell for Python programming.
- In 2014, Jupyter project (http://jupyter.org/) was created as a spin-off project from IPython. It is language-agnostic.
  - JUlia + PYthon + R
- Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations.
- Jupyter notebook system allows you to author content in Markdown to create a rich documentation with code and text.

https://github.com/adam-p/markdown-here/wiki/Markdown-Cheatsheet

- We will be using **JupyterLab,** the next generation of the Jupyter Notebook.

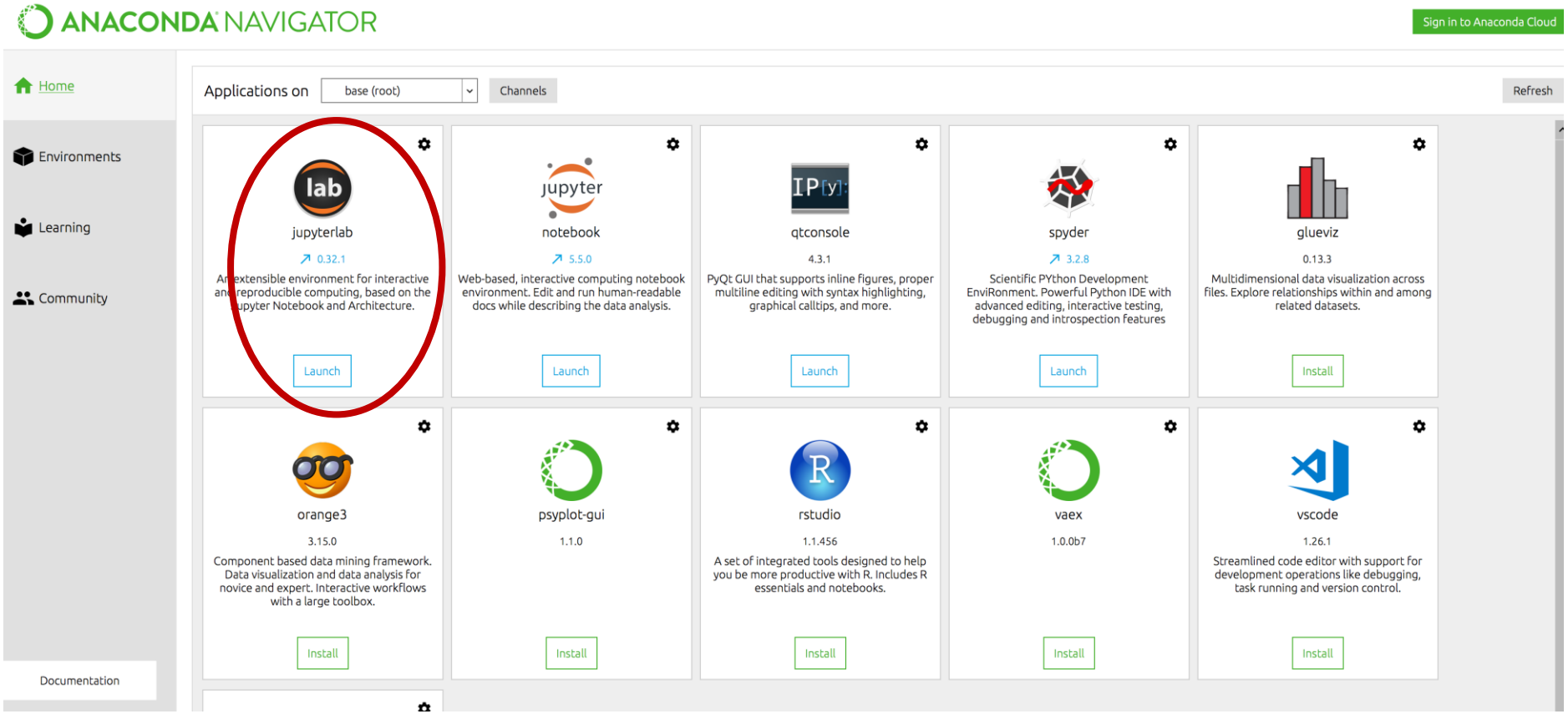
So, how do we get started with python?

- A **software distribution** is a pre-built and pre-configured collection of packages that can be installed and used on a system.
- A **package manager** is a tool that automates the process of installing, updating, and removing packages.
- **Anaconda** is a Python and R distribution platform, contains a package manager **Conda**.
- Many data science packages come preinstalled with Anaconda.
- You can download a free Anaconda Distribution at: *https://www.anaconda.com/products/distribution*

What does ANACONDA interface look like?

Anaconda comes with a suite of graphical tools called Anaconda Navigator

- **JupyterLab** is an interactive programming environment (execute-explore vs. edit-compile-run): *experiment and evaluation*
- **Spyder** is an integrated development environment (IDE): *module development*



Conda seems ok, but I am used to pip. Is there a difference?

- **Pip** (Pip Installs Packages) is Python's officially-sanctioned package manager.
- Pip vs Conda:
  - Pip is a general-purpose manager for Python packages; conda is a language-agnostic cross-platform environment manager
  - Pip installs python packages within any environment; conda installs any package within conda environments.
  - For *our* use, pip and conda are mostly interchangeable.

Nice explanations of anaconda details:
https://jakevdp.github.io/blog/2016/08/25/conda-myths-and-misconceptions/

Virtual environments

- Python has different versions, packages have different versions. What if for two projects you need different versions of the same package?

- **Virtual environment** is an isolated environment that allows us to keep these dependencies in separate “sandboxes”.

- We can have many different environments, as they take up little space, each with separate package versions.

Let's get started

STEP 1: **Install Anaconda**

- Install Anaconda environment on your laptop
  - Download open-source Individual Edition Anaconda distribution for Python according to your OS (https://www.anaconda.com/download/)
  - It is free for solo practitioners, students, and researchers
  - Follow the installation instruction (https://docs.anaconda.com/anaconda/install/)
  - If your computer is short in storage, you may also consider Miniconda (no packages pre-installed)
  - To verify everything is working, open Anaconda prompt and write:

    python --version

    conda -- version
  - Confirm that you have the latest version of conda:

    conda update conda

    (Update any package, if necessary, by typing y to proceed)

Step 2: Create conda virtual environment for this class

- To **create a virtual environment** named *ml2025,* type from Anaconda Prompt

  conda create -n ml2025 python=3.12

  when conda asks you to proceed, type y

- Activate your environment:

  conda activate ml2025

  the active environment---the one you are currently using---is shown in parentheses () or brackets [] at the beginning of your command prompt:

- List all packages in environment

  Environment active: *conda list*

  Environment not active *conda list -n ml2025*

- Check if a specific package is installed:

  Environment active: *conda list <package name>*

  Environment not active *conda list -n ml2025 <package name>*

`-n, --name`

Name of environment.

Step 2: Create conda virtual environment for this class

- Deactivate your environment

```
conda deactivate
```

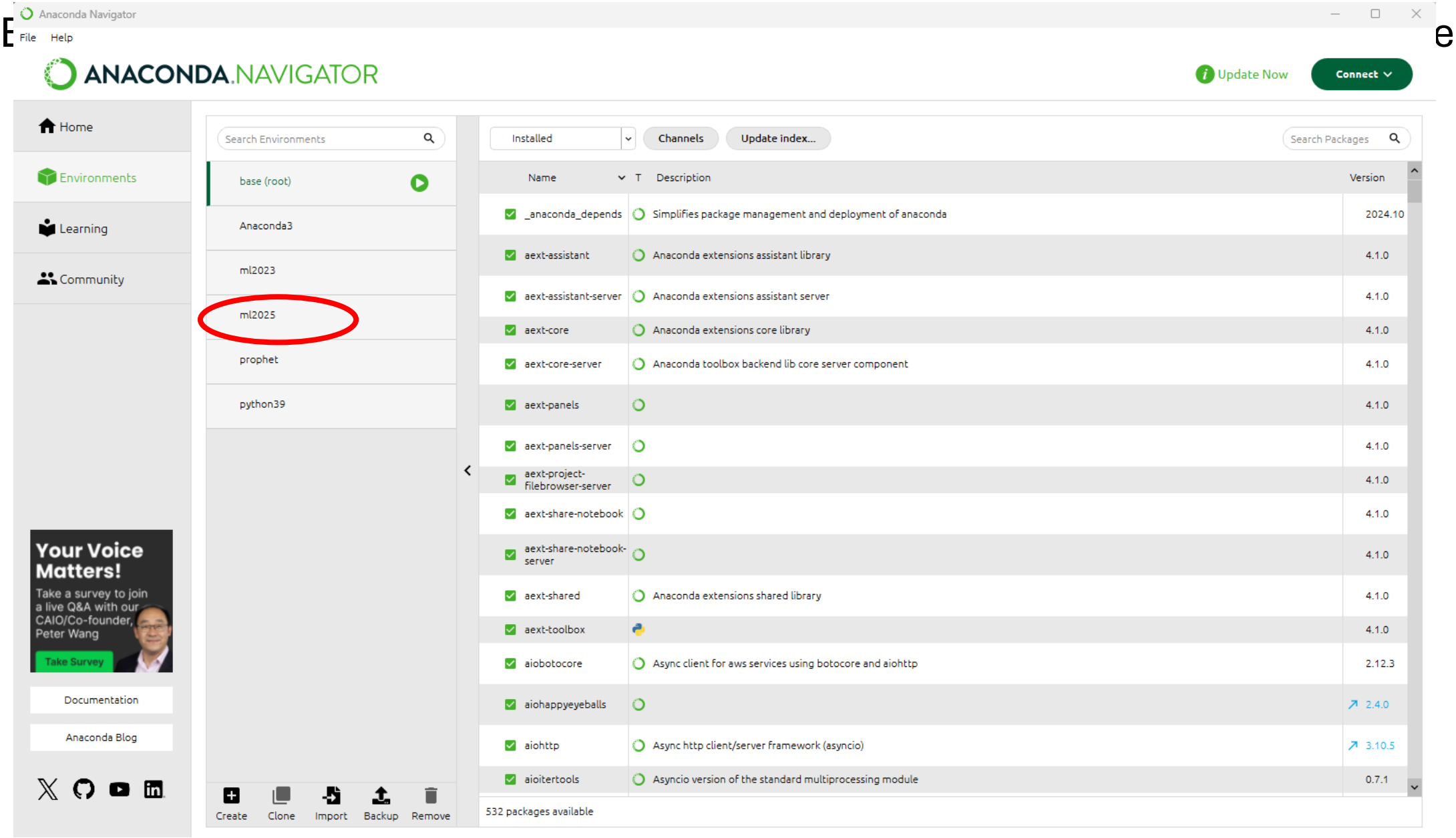
- Delete an environment (no need to do now)

```
conda env remove -n ml2025
```

- List all environments

```
conda env list
```

E ents)


Anaconda Navigator
File Help
ANACONDA.NAVIGATOR
Update Now
Connect
Home
Environments
Learning
Community
Search Environments
base (root)
Anaconda3
ml2023
ml2025
prophet
python39
Installed
Channels
Update index...
Search Packages
Name T Description Version
_anaconda_depends Simplifies package management and deployment of anaconda 2024.10
aext-assistant Anaconda extensions assistant library 4.1.0
aext-assistant-server Anaconda extensions assistant server 4.1.0
aext-core Anaconda extensions core library 4.1.0
aext-core-server Anaconda toolbox backend lib core server component 4.1.0
aext-panels 4.1.0
aext-panels-server 4.1.0
aext-project-filebrowser-server 4.1.0
aext-share-notebook 4.1.0
aext-share-notebook-server 4.1.0
aext-shared Anaconda extensions shared library 4.1.0
aext-toolbox 4.1.0
aiobotocore Async client for aws services using botocore and aiohttp 2.12.3
aiohappyeyeballs 2.4.0
aiohttp Async http client/server framework (asyncio) 3.10.5
aioitertools Asyncio version of the standard multiprocessing module 0.7.1
Create
Clone
Import
Backup
Remove
532 packages available
Your Voice Matters!
Take a survey to join a live Q&A with our CAIO/Co-founder, Peter Wang
Take Survey
Documentation
Anaconda Blog

Step 3: Install the packages we will use during this course

- Install a package

  Environment active: `conda install <package_name>`

  Environment not active `conda install –n ml2025 <package name>`

- Install mutiple packages

  ```
  conda install pandas numpy
  ```

- Upgrade a package

  ```
  conda update <package name>
  ```

- Install a package with a specific version

  ```
  conda install <package name> = <version number>
  ```

- Remove a package

  ```
  conda remove <package name>
  ```

Some of the packages we will use during this course

- **pandas** data manipulation and analysis
- **numpy** mathematical functions
- **scikit-learn** machine learning (`conda install conda-forge::scikit-learn`)

  Referred to as ***sklearn*** when importing, example: from **sklearn**.metrics import mean_squared_error
- **xgboost, lightgbm, catboost** gradient boosting

  Xgboost Installed as: conda install -c conda-forge py-xgboost

  lightgbm installed as: conda install -c conda-forge lightgbm

  catboost installed as: as conda install -c conda-forge catboost
- **pytorch** and **torchvision** neural networks (conda install pytorch torchvision cpuonly -c pytorch)
- **shap** interpreting ML models

  Installed as: conda install -c conda-forge shap
- **matplotlib, seaborn** data visualization
- **spacy, nltk** text analysis

  conda install -c conda-forge spacy

  conda install nltk
- **imbalanced learn** classification with imbalanced classes

  conda install -c conda-forge imbalanced-learn
- **aequitas** Bias and Fairness Audit Toolkit

  Installed as: pip install aequitas

Important note

- As each student may have their own hardware and software configuration, we cannot guarantee that it will be possible to install all the packages on all the configurations.
- If a problem is encountered:
  - Follow the recommended steps in the notebook or lecture notes
  - Google for similar errors (sometimes a package should be upgraded or downgraded to work within a specific setting)
  - Consider making a new environment to test installation of a new package before you start downgrading or upgrading already installed packages in a working environment
  - Ask TA or instructor for help
  - Use Google colab notebook, it will be accepted for homework and project submissions.

Step 4: Use the conda environment in your jupyter notebook

- Install ipykernel in *ml2025* environment (allows Jupyter to recognize the environment as a kernel)

```
conda install ipykernel
```

- Add the *ml2025* environment as a kernel for Jupyter

```
python -m ipykernel install --user --name=ml2025
```

- Deactivate the environment

```
conda deactivate
```

To list existing kernels

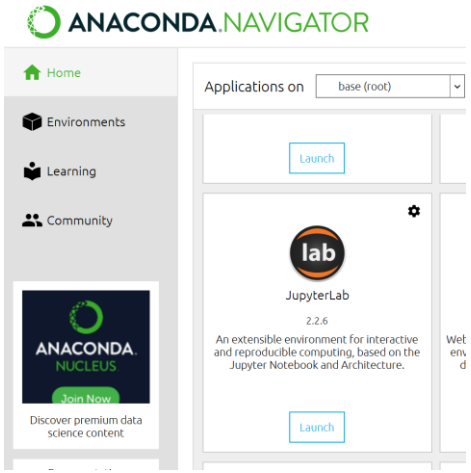
```
jupyter kernelspec list
```

Note: A notebook **kernel** is a “computational engine” that executes the code contained in a Notebook document

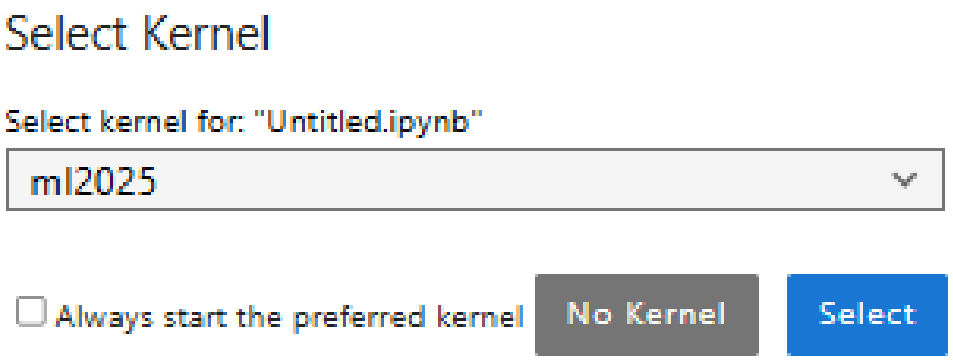
https://saturncloud.io/blog/how-to-use-conda-environment-in-a-jupyter-notebook/

Step 4: Use the conda environment in your jupyter notebook

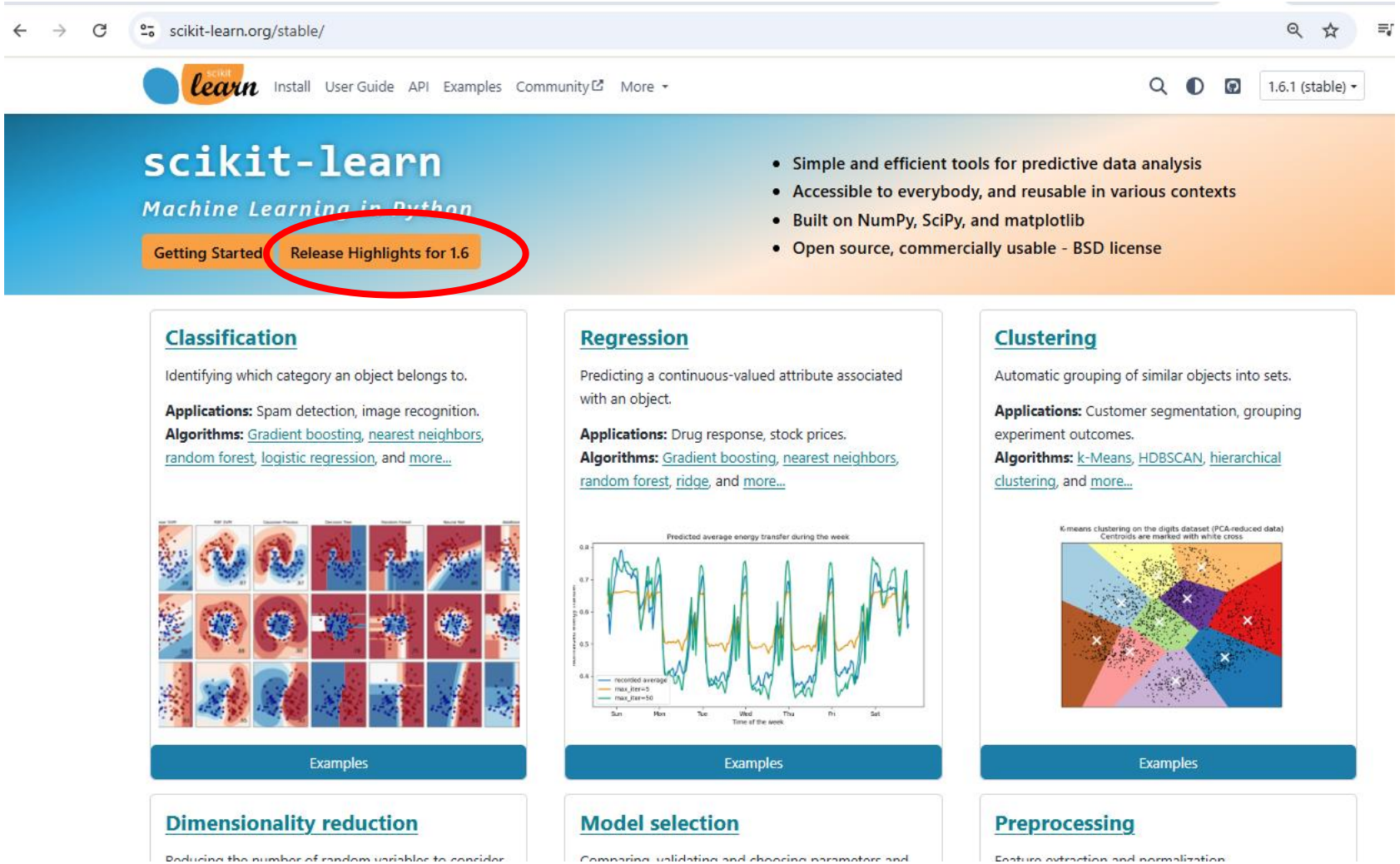
- From Anaconda Navigator Launch **JupyterLab (not Jupyter Notebook!)**



- Select from list of kernels the kernel *ml2025*



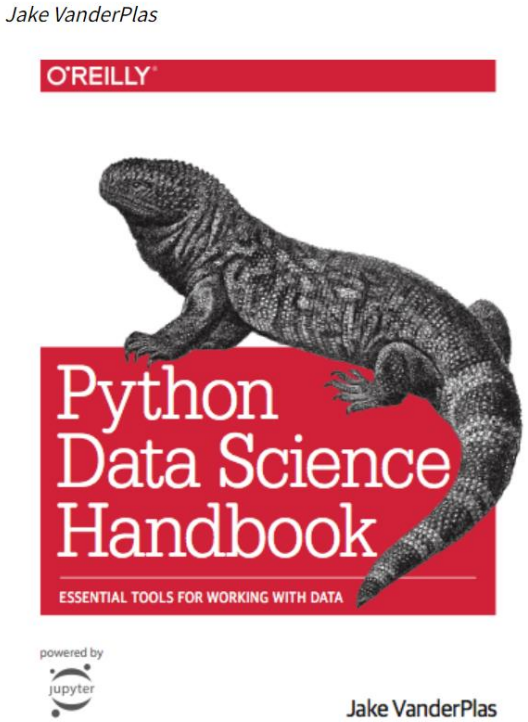
Scikit-learn: Machine Learning in python



Good reference on coding how-to's

https://jakevdp.github.io/PythonDataScienceHandbook/

Python Data Science Handbook



Good reference on coding how-to's

https://vedraiyani.github.io/notes-1/ipynb/index.html

Preprocessing Structured Data

- Convert Pandas Categorical Data For Scikit-Learn
- Delete Observations With Missing Values
- Deleting Missing Values
- Detecting Outliers
- Discretize Features
- Encoding Ordinal Categorical Features
- Handling Imbalanced Classes With Downsampling
- Handling Imbalanced Classes With Upsampling
- Handling Outliers
- Impute Missing Values With Means
- Imputing Missing Class Labels
- Imputing Missing Class Labels Using k-Nearest Neighbors
- Normalizing Observations
- One-Hot Encode Features With Multiple Labels
- One-Hot Encode Nominal Categorical Features
- Preprocessing Categorical Features
- Preprocessing Iris Data
- Rescale A Feature
- Standardize A Feature

Trees And Forests

- Outlier Detection With Isolation Forests
- Adaboost Classifier
- Decision Tree Classifier
- Decision Tree Regression
- Feature Importance
- Feature Selection Using Random Forest
- Handle Imbalanced Classes In Random Forest
- Random Forest Classifier
- Random Forest Classifier Example
- Random Forest Regression
- Select Important Features In Random Forest
- Titanic Competition With Random Forest
- Visualize A Decision Tree

Nearest Neighbors

- Identifying Best Value Of k
- K-Nearest Neighbors Classification
- Radius-Based Nearest Neighbor Classifier

Feature Engineering

- Dimensionality Reduction On Sparse Feature Matrix
- Dimensionality Reduction With Kernel PCA
- Dimensionality Reduction With PCA
- Feature Extraction With PCA
- Group Observations Using K-Means Clustering
- Se
- Se
- TS
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Feature Selection

- ANOVA F-value For Feature Selection
- Chi-Squared For Feature Selection
- Drop Highly Correlated Features
- Re
- Vc
- Vc

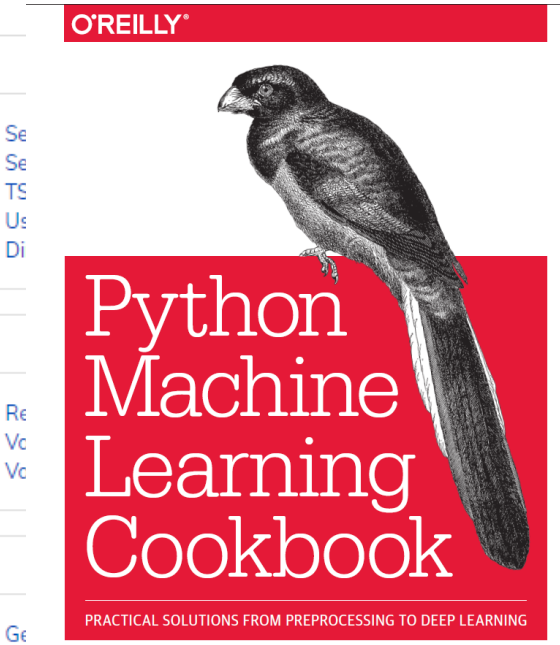
Model Evaluation

- Accuracy
- Create Baseline Classification Model
- Create Baseline Regression Model
- Cross Validation Pipeline
- Cross Validation With Parameter Tuning Using Grid Search
- Cross-Validation
- Custom Performance Metric
- F1 Score
- Ge
- Ne
- Pl
- Pl
- Plot The Validation Curve
- Precision
- Recall
- Split Data Into Training And Test Sets

Model Selection

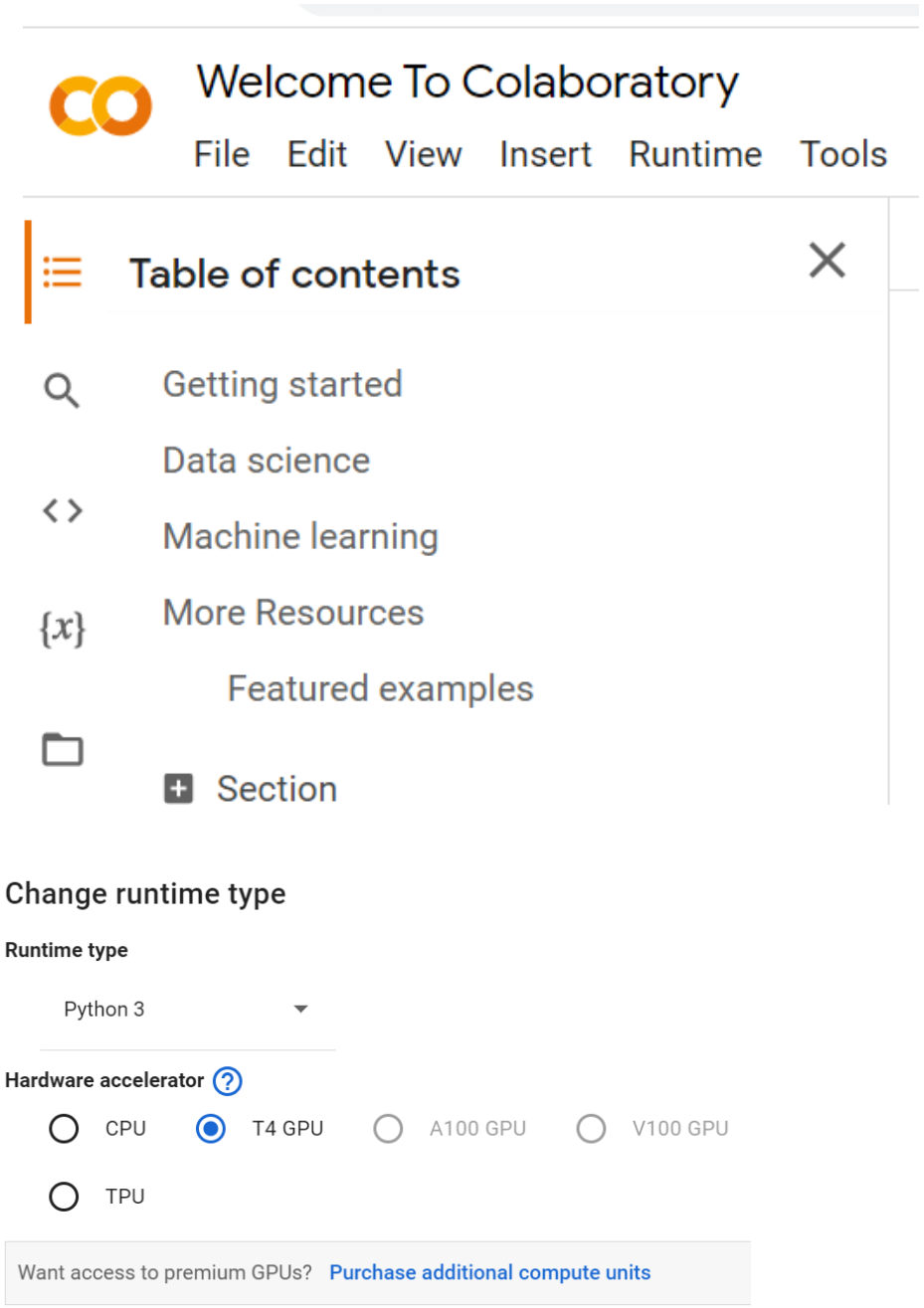
- Find Best Preprocessing Steps During Model Selection
- Hyperparameter Tuning Using Grid Search
- Hyperparameter Tuning Using Random Search
- Model Selection Using Grid Search
- Pipelines With Parameter Optimization

Linear Regression



Chris Albon

Using colab



- Google Colab (https://colab.research.google.com/) is an extension of Jupyter notebook that runs on the Google Cloud. This platform provides various different computing resources, such as CPUs, **GPUs** free of charge.
- Colab allows you to use and share Jupyter notebooks with others without having to download, install, or run anything.
- Google Colab has a 'maximum lifetime' limit of running notebooks that is 12 hours with the browser open, and the 'Idle' notebook instance is interrupted after 90 minutes.
- Colab notebooks can be shared with other users and opened by multiple users at a time. If one person makes a change, the others will be able to see the change after a short delay. However, if two people edit the document at the same time, one person's changes must be discarded upon refreshing.
- https://research.google.com/colaboratory/faq.html