Programming for Data Analysis

A. M. Sadeghzadeh, Ph.D.

Sharif University of Technology
Computer Engineering Department (CE)
Machine Learning MicroMaster

July 11, 2023

Today's Agenda

Course logistics

Course information

- Course Name: Programming for Data Analysis
  - Time: Sat-Mon 18:00-19:30
  - Room: https://vc.sharif.edu/ch/amsadeghzadeh

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  - Amir Mahdi Sadeghzadeh (amsadeghzadeh@gmail.com)
    - Office: CE-501
    - Office hours: by appointment and through email

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  - Notebooks and Lecture slides
  - Discussions and HWs

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- TAs
  - TBA

References

1. Wes McKinney, Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter, 3rd edition, 2022.
2. ”Python Programming for Data Science” By Tomas Beuzen
3. Jake VanderPlas, Python Data Science Handbook, 2016.

Course objective

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- Gain knowledge on the main principles of programming in the Data science context
- Develop ability to handle and visualise data
- Apply computational thinking in various applications domains

Course outline

- Python Basics
  - Basic Python Data Types
  - Lists and Tuples
  - Dictionaries
  - Control Flow
  - Conditions
  - Functions and Loops
  - Random Sample Generation

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  - Data analysis with scipy and numpy
- Data Visualization
  - Exploratory Data Analysis
  - Visualizing Data with Matplotlib, Seaborn, and plotly

Grading Policy

- Homework (30%)
- Mini-Exams (10%)
- Final (60%).

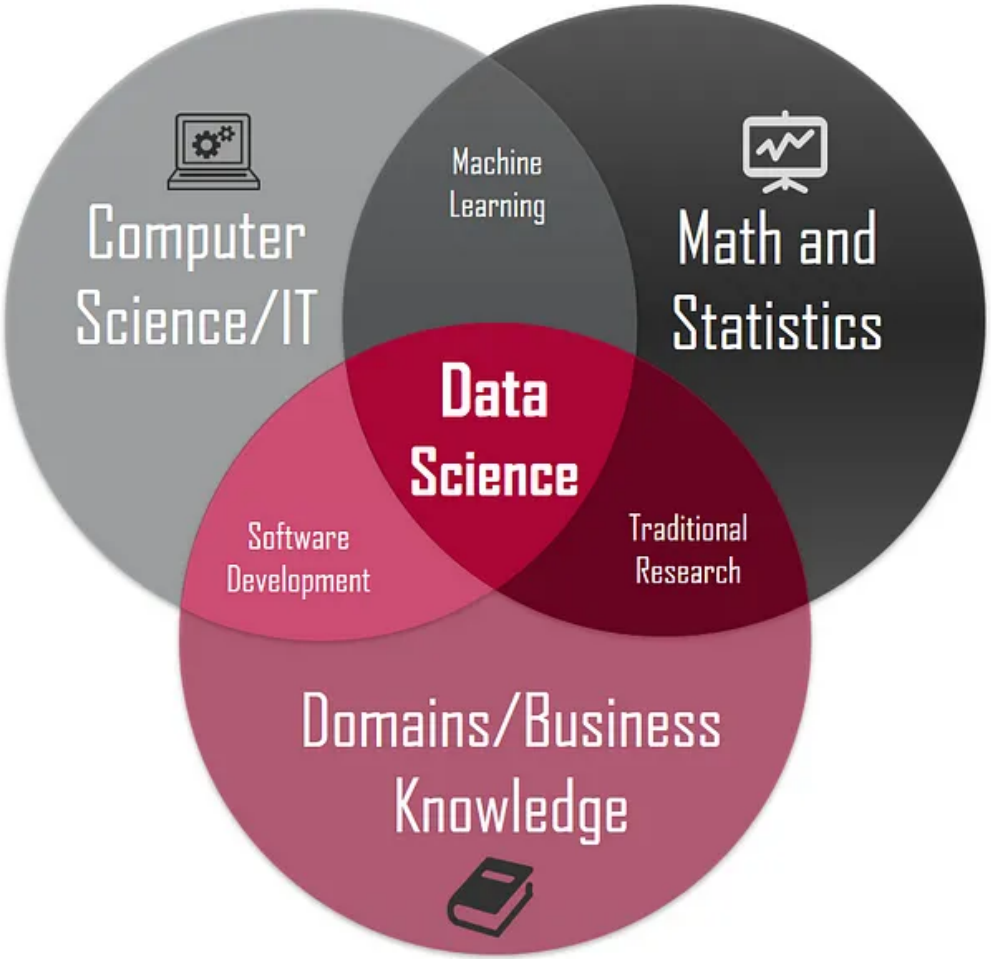
!

Enjoy the course :)

Introduction

What is Data Science?

Data science is an interconnected field that involves the use of **statistical and computational methods** to extract **insightful information and knowledge from data**.



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- **Recommendation Systems**: Data Science is used in recommendation systems to suggest products,

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  1. **Tabular** or spreadsheet-like data in which each column may be a different type (string, numeric, date, or otherwise). This includes most kinds of data commonly stored in relational databases or tab- or comma-delimited text files.
  2. **Multidimensional** arrays (matrices).
  3. **Multiple tables** of data interrelated by key columns (what would be primary or foreign keys for a SQL user).
  4. Evenly or unevenly spaced **time series**.

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  4. Evenly or unevenly spaced **time series**.

This is by no means a complete list. Even though it may not always be obvious, **a large percentage of datasets can be transformed into a structured form** that is more suitable for analysis and modeling.

Why Python for Data Analysis?

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In recent years, Python's improved **open source libraries (such as pandas and scikit-learn)** have made it a popular choice for data analysis tasks.

What people are increasingly finding is that Python is a suitable language **not only for doing research and prototyping but also for building the production systems**.

Essential Python Libraries

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- numpy
- pandas
- matplotlib
- scipy
- scikit-learn

NumPy

NumPy, short for Numerical Python, has long been a cornerstone of **numerical computing in Python**. It provides the data structures, algorithms, and library glue needed for most scientific applications involving numerical data in Python.

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NumPy contains, among other things:

- A fast and efficient **multidimensional array object ndarray**
- Functions for performing element-wise **computations with arrays or mathematical operations between arrays**
- Tools for **reading and writing array-based datasets** to disk
- **Linear algebra** operations, Fourier transform, and **random number generation**

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The primary objects in pandas that will be used in this course are the **DataFrame**, a tabular, column-oriented data structure with both row and column labels, and the Series, a one-dimensional labeled array object.

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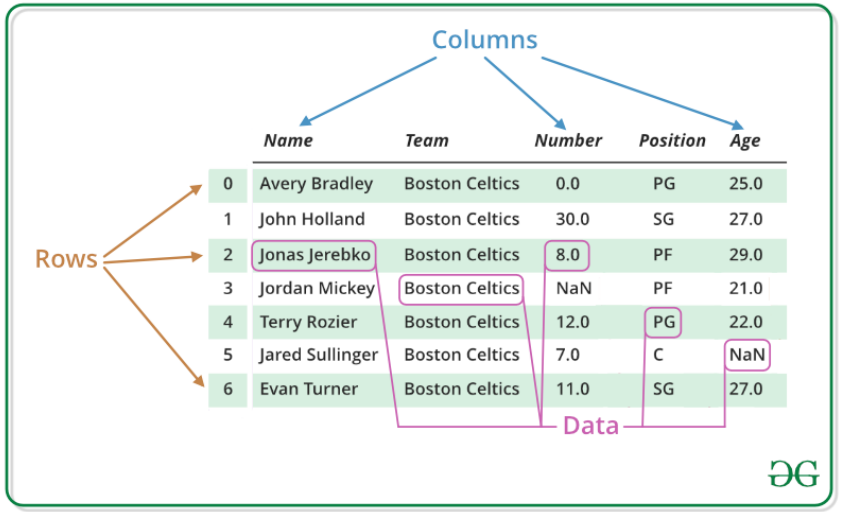
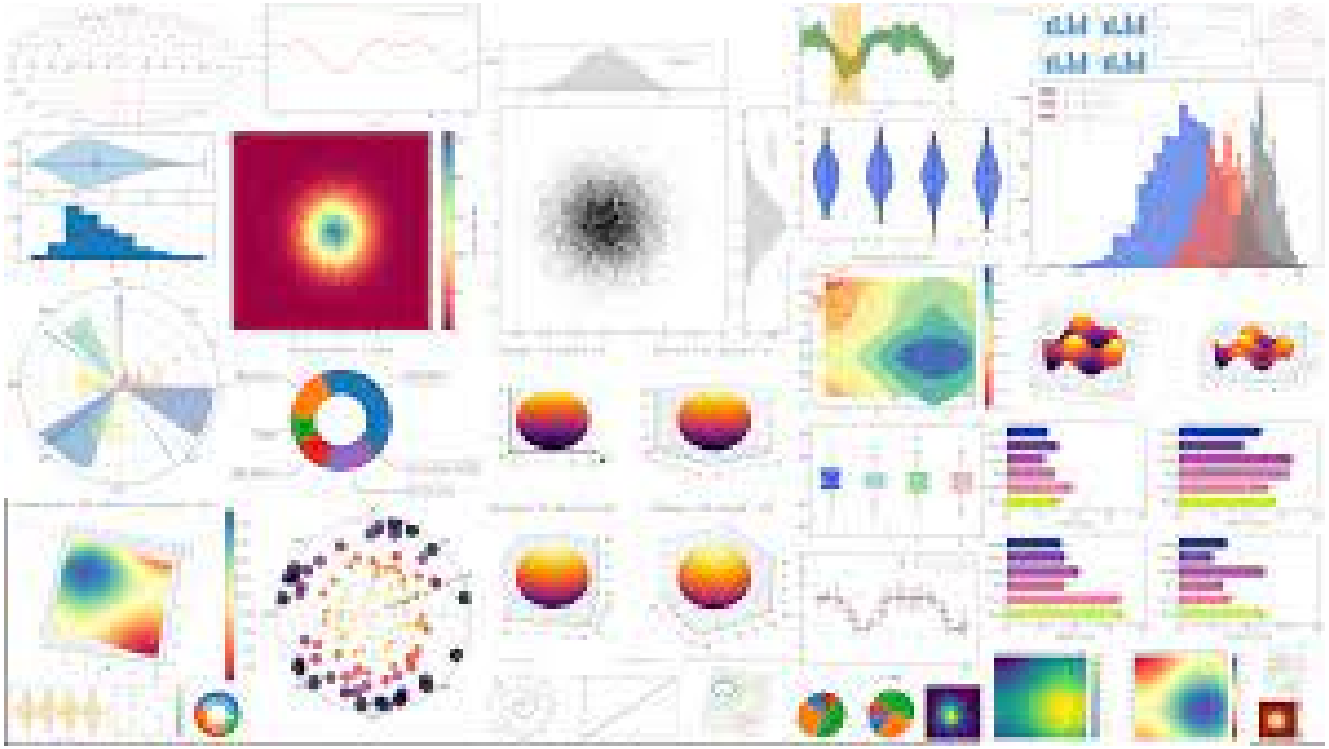
The primary objects in pandas that will be used in this course are the **DataFrame**, a tabular, column-oriented data structure with both row and column labels, and the Series, a one-dimensional labeled array object.

- pandas blends the array-computing ideas of **NumPy** with the kinds of data manipulation capabilities found in spreadsheets and **relational databases** (such as SQL).
- Since data manipulation, preparation, and cleaning are such important skills in data analysis, **pandas is one of the primary focuses of this course**.



Matplotlib

Matplotlib is the most popular Python library for producing plots and other two-dimensional data visualizations.



SciPy

SciPy is a collection of packages addressing a number of foundational problems in scientific computing

- scipy.integrate
  - Numerical integration routines and differential equation solvers
- scipy.linalg
  - Linear algebra routines and matrix decompositions extending beyond those provided in numpy.linalg
- scipy.optimize
  - Function optimizers (minimizers) and root finding algorithms
- scipy.signal
  - Signal processing tools

Scikit-learn

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It includes submodules for such models as:

- Classification: SVM, nearest neighbors, random forest, logistic regression, etc.
- Regression: Lasso, ridge regression, etc.
- Clustering: k-means, spectral clustering, etc.
- Dimensionality reduction: PCA, feature selection, matrix factorization, etc.
- Model selection: Grid search, cross-validation, metrics
- Preprocessing: Feature extraction, normalization

Python

The Python Interpreter

The Python interpreter runs a program by executing one statement at a time.

```
$ python
Python 3.10.4 | packaged by conda-forge | (main, Mar 24 2022, 17:38:57)
[GCC 10.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> a = 5
>>> print(a)
5
```

The >>> you see is the prompt after which you'll type code expressions.

To exit the Python interpreter, you can either type exit()

Running Program from Python File

Running Python programs is as simple as calling python with a .py file as its first argument. Suppose we had created hello_world.py with these contents:

hello_world.py

```
print("Hello world")
```

You can run it by executing the following command (the hello_world.py file must be in your current working terminal directory):

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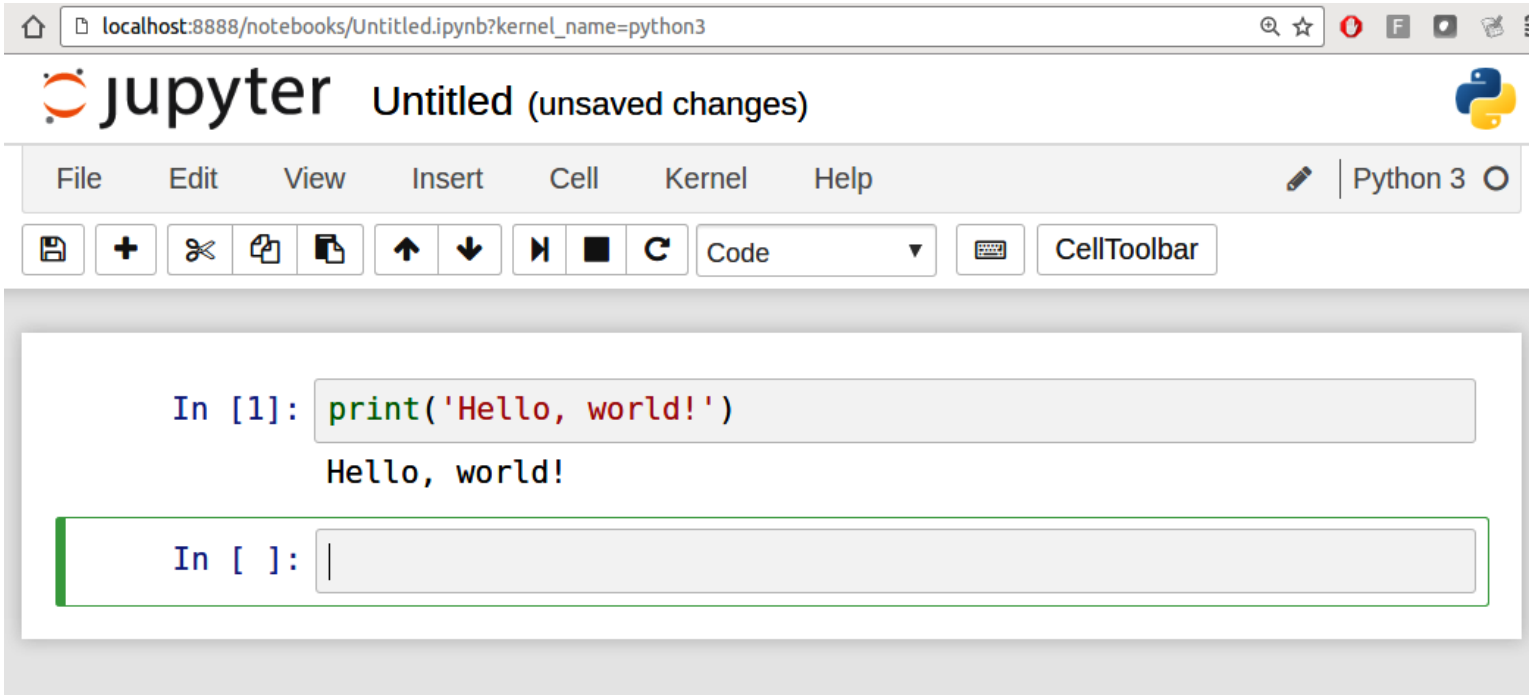
While some Python programmers execute all of their Python code in this way, those doing **data analysis or scientific computing make use of IPython**, an enhanced Python interpreter, or **Jupyter notebooks, web-based code notebooks** originally created within the IPython project.

Running the Jupyter Notebook

One of the major components of the Jupyter project is the notebook, a type of interactive document for code, text (including Markdown), data visualizations, and other output. The Python Jupyter kernel uses the IPython system for its underlying behavior.



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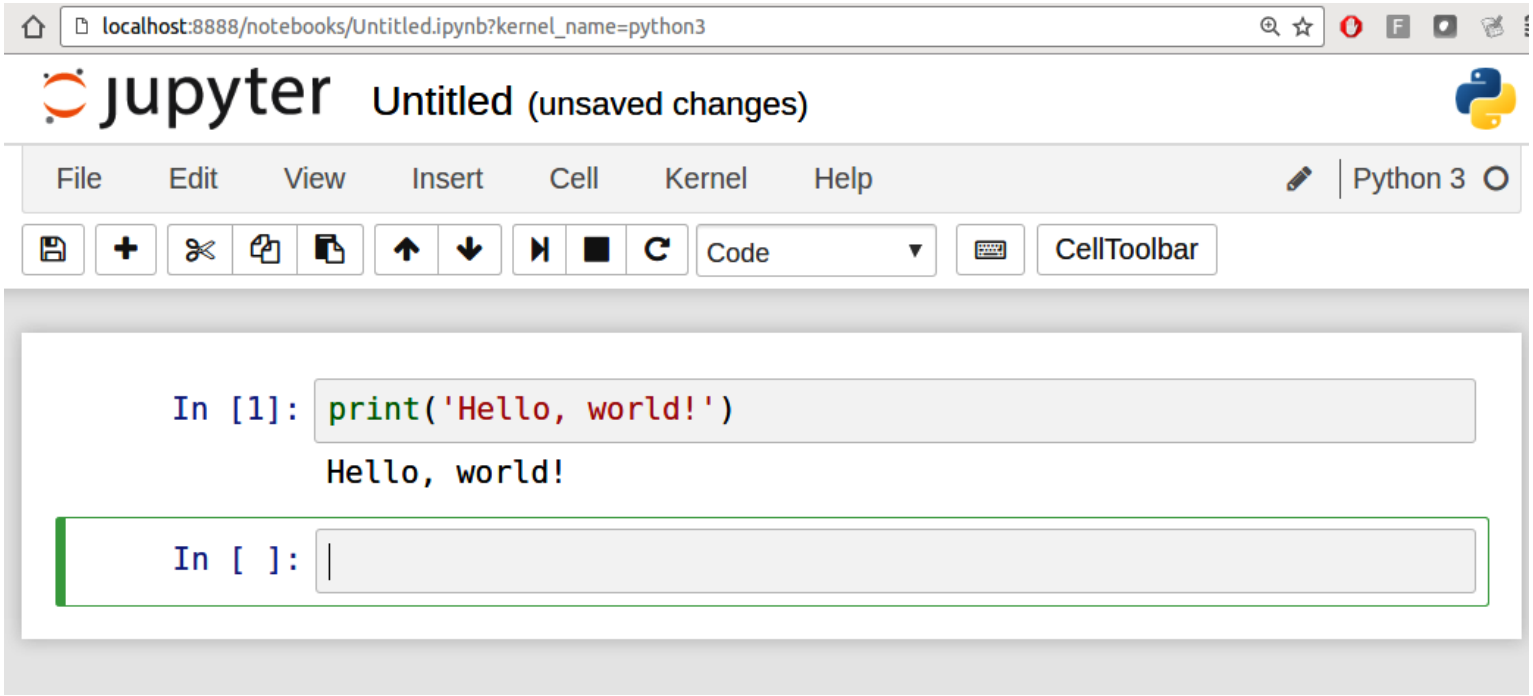
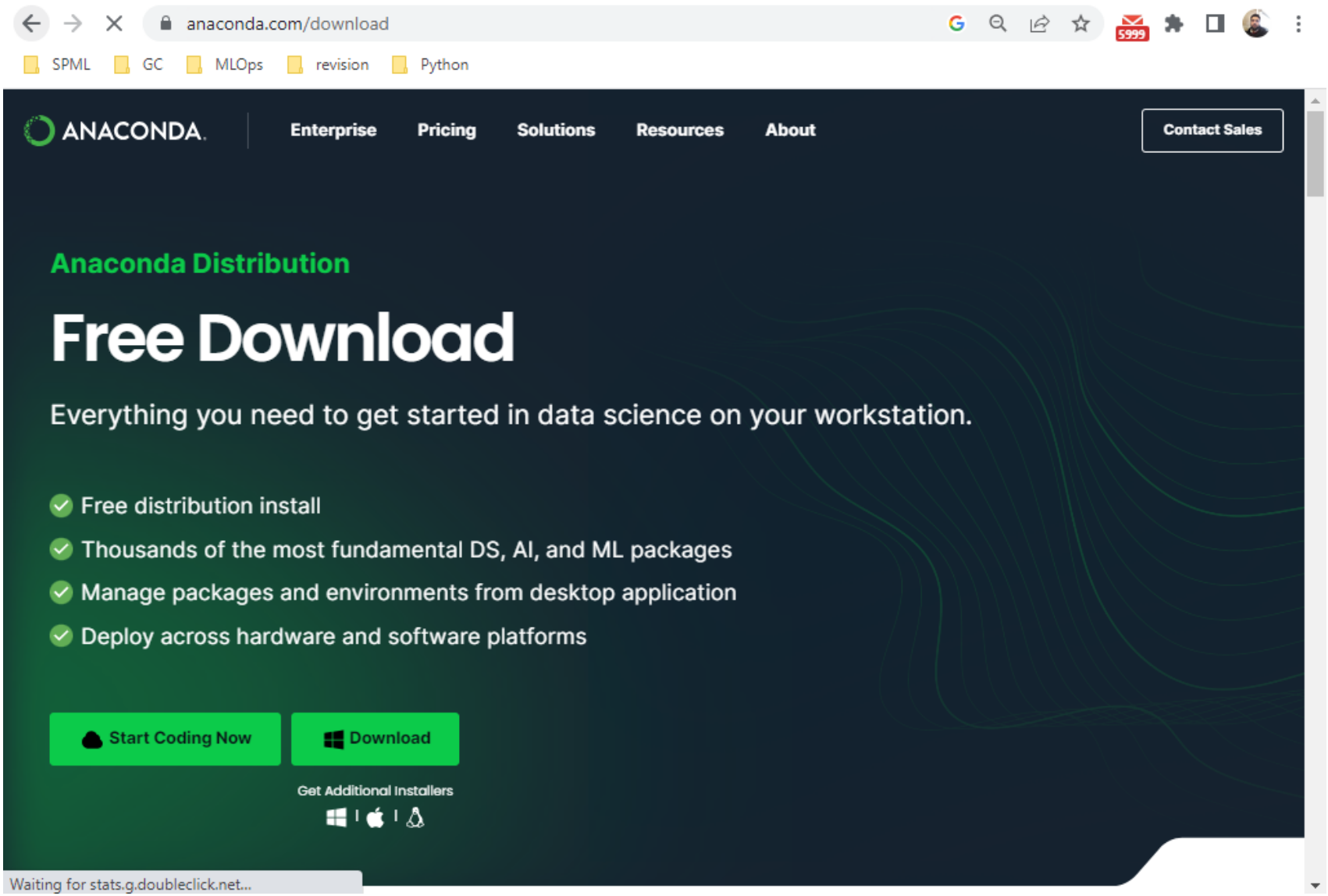
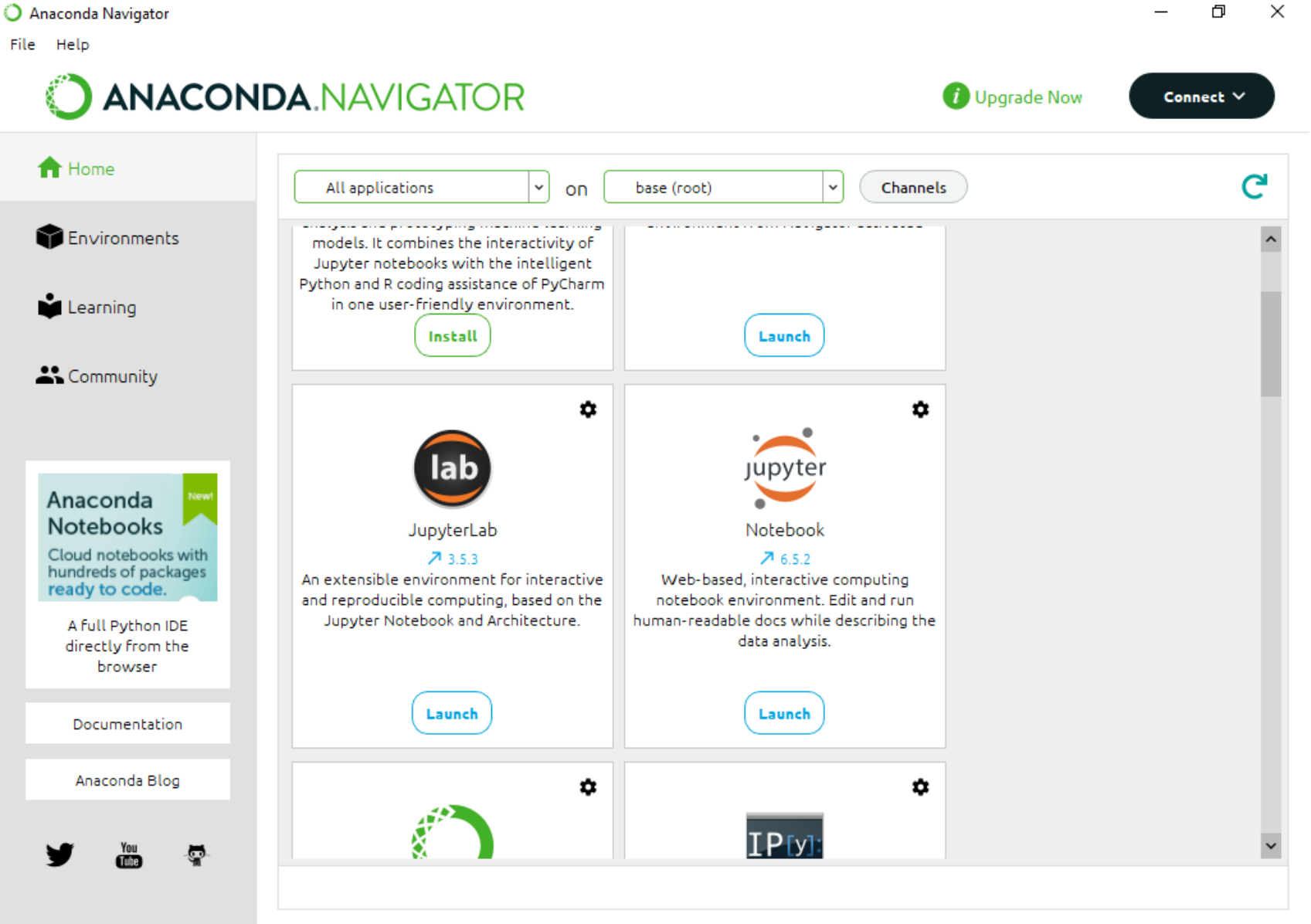


When you **save the notebook** (see ”Save and Checkpoint” under the notebook File menu), it creates a file with the extension **.ipynb**.

Installation and Setup - ANACONDA



ANACONDA Navigator



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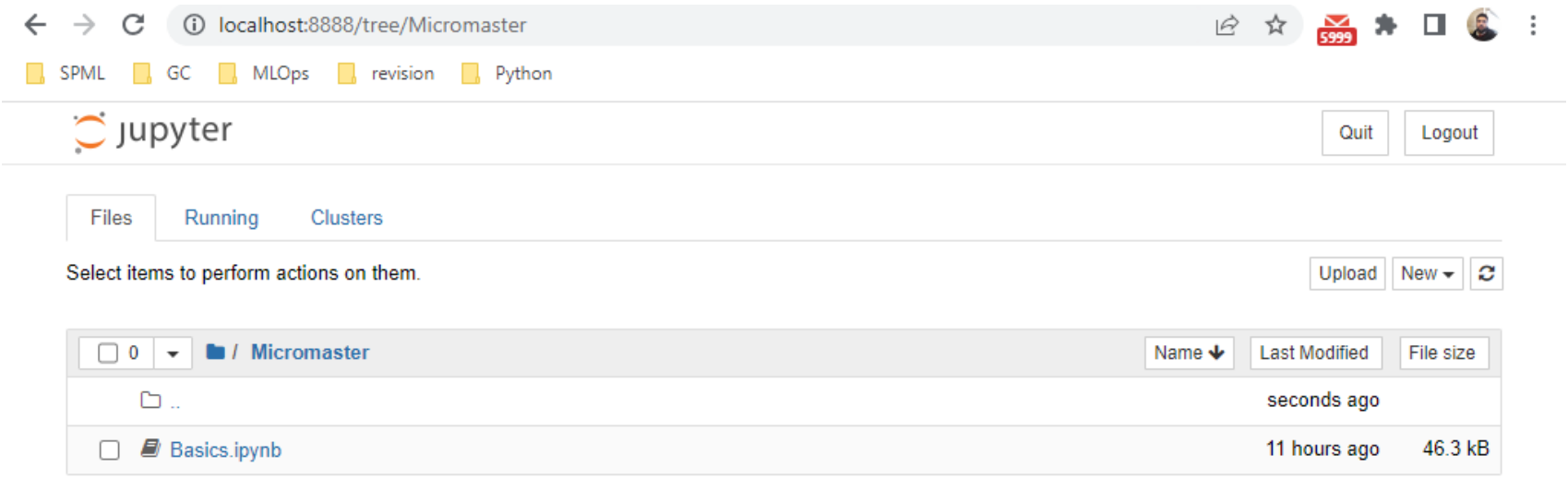

Jupyter Notebook

localhost:8888/notebooks/Micromaster/Basics.ipynb

SPML GC MLOps revision Python

jupyter Basics Last Checkpoint: 11 hours ago (autosaved) Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 (ipykernel)

Run Markdown

none	NoneType	Null Object	represents no value	None

Numeric data types

There are three distinct numeric types: `integers`, `floating point numbers`, and `complex numbers` (not covered here). We can determine the type of an object in Python using `type()`. We can print the value of the object using `print()`.

In [ ]:
```
x = 42
```

In [ ]:
```
type(x)
```

In [ ]:
```
print(x)
```

In Jupyter/IPython (an interactive version of Python), the last line of a cell will automatically be printed to screen so we don't actually need to explicitly call `print()`.

In [ ]:
```
x  # Anything after the pound/hash symbol is a comment and will not be run
```

In [ ]:
```
pi = 3.14159
pi
```

In [ ]:
```
type(pi)
```