Computational Decision Making for Regular People

02: Python Crash Course

October 22, 2024

Nathan Davis Barrett

Today's Outline

1. What is Python / Anaconda?
2. Installing Python (and necessary packages)
3. Writing your first Python code
4. Introduction to Jupyter Lab
5. Key Python concepts
   - 5.1 Variables (integers, floats, strings, lists)
   - 5.2 Loops
   - 5.3 Functions
   - 5.4 Data Structures
6. Key Python packages
   - 6.1 Numpy
   - 6.2 Matplotlib
   - 6.3 Pandas (if there is time)

NOTE: Today's class might feel like a firehose. Don't worry if you don't perfectly grasp everything today. You'll have plenty of time to practice.

What is Python / Anaconda?

What is Python?

- Python is a computer language (a set grammatical rules) in conjunction with a computer program that reads written statements and performs the commands written therein.
- You can write Python code in any place you can write words (even on paper, if you want).
- But you can only execute Python code in the Python software package.

What is Anaconda (a.k.a. "conda")?

- The Python language normally is used in conjunction with a bunch of pre-built packages that allow you to do a variety of things.
- Anaconda is another computer program that helps you manage your installation / version of Python in addition to all the other libraries you may have installed.
- One of the easiest ways to download, maintain, and get packages for Python is through Anaconda.
- Anaconda comes with a bunch of extra bells and whistles that we con't need for this course. So we'll use a smaller version called "miniconda".

Installing Python (Anaconda)

1. Visit the following website in your internet browser:
   https://docs.anaconda.com/miniconda/miniconda-install/
2. Follow the instructions relevant to your operating system (Windows or Mac)
   - Remember (e.g. write down) the key steps to run the anaconda program once it's been installed. You'll need to run this program every time you want to run and/or edit any Python scripts. I'll refer to this program as the "command line".
   - Windows: Start Menu > Anaconda Prompt
   - Mac: Terminal Application (e.g. Command + Space > Terminal)
3. Copy and Paste these commands into the command line to install all the packages we'll need for this course (click "Enter" between commands).
   - conda install -c conda-forge jupyterlab
   - conda install numpy
   - conda install conda-forge::matplotlib
   - conda install -c conda-forge pyomo
   - conda install anaconda::pandas

Writing Your First Python Code

- Python commands can be executed in bug batches (called scripts) or one-by-one from the command line.
- We’ll cover your to write scripts later
- For now, in the command line, type ”python” followed by Enter.
- You’ll notice that the command line looks like it’s changed. You should now see three ’>>>’ characters followed by a blinking block. This is the ”Python shell” anything you type here will be executed as a Python command.
- The easiest Python command to write is as follows. Type this command and click Enter.
  - print(”Hello World”)
- You should see ”Hello World” repeated back to you. The ”print” command tells Python to print whatever you tell it to your screen. In this case, we told Python to print the message ”Hello World”.
- To exit out of the Python shell, type ”quit()” followed by Enter.
- This should return you to the normal command line.

Introduction to Jupyter Lab

- Typing commands like this one by one into the Python shell can get really tedious.
- Jupyter Lab is a nice program that has a graphical user interface that lets you see your Python code, it's output, and several other useful options all in an organized way.
- We installed Jupyter Lab a couple of slides ago using Anaconda.
- To launch Jupyter Lab, type "jupyter-lab" followed by Enter.
  - It may ask you which internet browser you'd like to use, or it may prompt you to copy and paste a URL into your internet browser. Unless an internet browser tab automatically opens up, follow the instructions that get written to the screen.
- Jupyter Lab organizes your python code and it's output into one concise file called a "Notebook". Notebooks are nice since they allow you to combine Python code, written text, images, etc. all in one place.

Opening up Lecture Materials

- To download all the Jupter Notebooks we'll use for the rest of the course, follow these instructions.
- Go to the course website: https://github.com/NathanDavisBarrett/ComputationalDecisionMakingCourse
- Click on the green "<> Code" Button.
- Click on Download ZIP from the dropdown menu that appears.
- Open up the file that is downloaded and extract the "ComputationalDecisionMakingCourse" folder to somewhere on your computer that you'd like to store it.
- Back in Jupyter Lab, there should be a file navigation bar on the right-hand side of the internet browser tab. Use this file navigation bar to navigate to the ComputationalDecisionMakingCourse folder you just extracted.
- Open up the 02_PythonCrashCourse folder and double-click on the "Lecture_02_Notebook.ipynb" file. This should open the Jupyter Notebook we'll use for the rest of today.

Python: Basic Arithmetic

$$5 \times 5 = 25$$

$$12 \times 12 = 144$$

$$123 \times 7 = ?$$

$$14 \times 17 = ?$$

```
print(123 * 7)
print(14 * 17)
```

Python: Variables

- variableName = value

Type	Description	Syntax
int	An integer number	A number with no decimal in it
float	A ”floating point” (a.k.a. decimal) number	A number with a decimal in it
char	An alphabetic character	A single character in single quotes
str	A string of alphabetic characters	Several characters in double quotes
bool	A boolean True or False (binary 0 or 1) value	”True” or ”False

- Exercises:
    1. Create a variable named ’x’ and assign it a value of 37
    2. Create a variable named ’y’ and assign it a value of 15.2
    3. Create a variable named ’z’ and assign it a value of ’x + y’
    4. Print the value of ’z’

1. Create a variable named ’name1’ and assign it a value of ”Joe”
2. Create a variable named ’age1’ and assign it a value of 37
3. Print the value of ’age1 + name1’. Before you execute the command, what do you think will happen?
4. Execute the command. What happens?

Python: Iterable Variables

Lists:

- A list of other variables / values
- listName = [__elements__]
- Access individual elements using listName[index]
- ”index” is the element’s position within the list
- **NOTE:** The creators of Python defined it in such a say what the ”1st” element in a list is located at index 0.

```
myList = [”element1”,”element2”,”element3”]
print(myList[0])
print(myList[2])
```

Sets:

- Very similar to a list but with not specific order.
- Thus there are no indices.
- setName = {__elements__}

Why the distinction?

- Sometimes the order of a collection of data is important
  - Order within a queue
  - When data is corresponding between multiple lists
  - When we want values neatly sorted
- Other times we specifically don’t want things ordered
  - e.g. If I simply wanted a collection of the names of each student in class today.

Python: Functions

- For when we have a section of code that we're going to need to repeat.
- **Pro Tip:** To keep your code clean and relatively free of errors, try to minimize the amount of copying and pasting that you do.
- Syntax:

```
def functionName(parameters):
    Code to Repeat Here...
```

- Python keeps track of when a function starts and stops using indentation.

```
print((1+2)/3)
print((15+14)/5)
print((38+29)/32)
```

```
def AddThenDivide(a,b,c):
    addedNumbers = a + b
    finalResult = addedNumbers / c
    return finalResult

print(AddThenDivide(1,2,3))
print(AddThenDivide(15,14,5))
print(AddThenDivide(38,29,32))
```

Python: Loops

```
print(AddThenDivide(1,2,3))
print(AddThenDivide(15,14,5))
print(AddThenDivide(38,29,32))
```

There is still a good bit of copy and paste.
This is where we can use a loop. (**Exersize**)

```
aList = [1,2,3,4,5]
bList = [6,7,8,9,10]

aPlusBList = [0,0,0,0,0]
for i in range(len(aList)):
   aPlusBList[i] = aList[i] + bList[i]
```

```
aPlusBList = [aList[i] + bList[i] for i in
range(len(aList))]
```

- Three key players:
  - A list, set, etc. to iterate over
  - A temporary variable to hold each element individually at different times
  - Some code we want to repeat for each element
- Two different syntaxes:
  1. for tempVar in myList:

     ```
        Some Code Here
     ```
  2. [Some Code Here for tempVar in myList]
- Two related, built-in Python functions:
  - *len*(*myList*): Gives the number of elements in myList
  - *range*(*num*): Produces a list of all integers from 0 to "num"

If/Else Conditions

NOTE: The notion of an if/else condition exists in Python, but NOT in mathematical modeling. We'll cover how to re-create the behavior of an if/else condition in mathematical modeling in a couple of weeks.

Often in logic, and in code, we want to do some things only if a certain condition is or is not met. We do this in Python using a collection of *if*, *else*, and *elif* statements.

Syntax:

```
if condition1:
    Do some stuff
elif condition 2:
    Do some other stuff
else:
    Do some other other stuff
```

greater than	a > b
greater than or equal to	a >= b
less than	a < b
less than or equal to	a <= b
equal to	a == b
not equal to	a != b

```
a = 5
b = 3
if a <= b:
    print(”a <= b”)
elif a > b:
    print(”a > b”)
```

List / Function / Loop / If Exercise

Please try to complete this exercise on your own.
I'll circle around and help if anyone needs it.

Python: Custom Data Structures

A quick note on this topic: Unless you want to, you won’t need create any custom data structures in this class. So it’s not as important to understand exactly how this is done as much as it is important to realize that these exist. We’ll be using lots of ”custom” data structures that have been created by other people.

- Custom data structures are called classes.
- A class can have named variables inside of it.
- A class can also have functions inside of it.

```
people = [Person(”Joe”,37),Person(”Sally”,41),Person(”Jacob”,17)]

print(people[0].age)
print(people[2].name)
people[0].printInfo()
```

Python Packages

- We can import other people's code into our code!
- Syntax:
  - import packageName
  - import packageName as myPersonalAbbreviation
  - from packageNAme import specificFunctionName
- Important packages we'll use in this course:
  - numpy
  - matplotlib
  - pandas
  - pyomo

Numpy

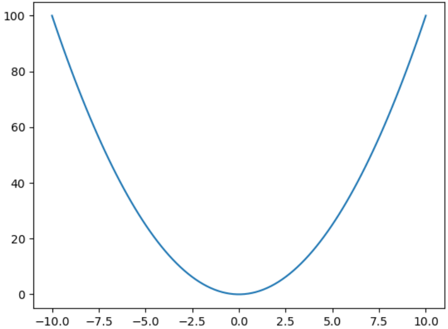
- A package for all things math
- import numpy as np
- Complex math functions like $\sqrt{}$ ("np.sqrt"), log ("np.log")
- A very simple way to deal with lists (or at least a custom version of lists called "arrays")
  - Arrays can be added, multiplied, divided, etc. automatically implementing element-wise addition, multiplication, division, etc.
  - Arrays can be automatically generated:
    - np.linspace
    - np.arange
  - Arrays can be "sliced"
- See examples in the Jupyter Notebook

Matplotlib

- A package for all things plotting or graphing
- import matplotlib.pyplot as plt
- Most important function: plt.plot()

```
xData = np.linspace(-10,10,100)
yData = xData * xData

plt.plot(xData,yData)
```



Examples: https://matplotlib.org/stable/api/_as_gen/matplotlib.pyplot.plot.html

Pandas

- Lots of uses. But in this class we'll mainly use it to import and export excel files.
- import pandas as pd
- Main Data Structure: pd.DataFrame
  - More or less a table. Each column has a specific name.
  - Columns can be accessed using "myDataFrame[columnName].to_numpy()"
  - Write to Excel: "myDataFrame.to_excel("fileName.xlsx", index=False)
  - Read from Excel: pd.read_excel("fileName.xlsx")
- See examples in the Jupyter Notebook

Next Class

- The Pyomo Python Package
  - This is the Python package that lets you type in mathematical models (like what we made last class) in almost the same syntax.
  - Then, using the Pyomo Package, you can have the computer find the optimal solution of those models.
- **Please install "SCIP" in preparation for next class:**
  1. Visit https://www.scipopt.org/index.php#download
  2. Select your operating system (OS) (Windows or Mac)
  3. Scroll down slightly to "Precompiled Packages"
  4. There should be a highlighted blue link starting with "SCIPOptSuite-..."
  5. Click that link to download the SCIP solver.
  6. Double-click the downloaded file to install the SCIP solver. Follow the instructions that pop up to finish the installation.

Again, Today's class might have felt like a firehose. Don't worry if you don't perfectly grasp everything today. You'll have plenty of time to practice as we move forward.