Python Fundamentals ODSC Europe 2023

Philip Tracton

Lecture Summary

- Intro and Background
- Tools and Installation
- Basic Python

Introduction

- Instructor: Philip Tracton
- BS in EE from University of Maryland
- MS in EE from California State University at Northridge
- Works on embedded software, ASIC, FPGA and DSP
- Employed at Medtronic for over 20 years.
- Teaching at UCLA Extension since 2010.

Course Goals

1. Learn Python basics
2. Become familiar with Jupyter Labs
3. Be able to expand your learning on your own from here

Tools We Will Need

1. Python Intepreter and Libraries
2. Jupyter Labs

Python Interpreter

- We will be using the latest version of Anaconda Python
    - Free
    - Open Source
    - Runs on Windows, Mac and Linux
    - Comes with many popular 3rd party libraries
    - Comes with conda – a tool to manage the libraries

Jupyter Lab

Jupyter Lab is an interactive environment for running python code. It is very common in the data science world for exploring code and data.

White Space

- PEP 8 rules on White Space
- Most controversial aspect of Python.
- White space used to distinguish blocks
- Tab == Space!
- Comments and empty lines are ignored
- Avoid using Tab
- Use and editor/IDE that is Python aware

Code Example:

```python
def factorial(n=1):
    """
    This is the function's comment, it explains
    what the function does, how it does it and why
↪   it
    does it
    """
    if n == 1:
        return n
    else:
        return n * factorial(n - 1)


if __name__ == "__main__":
    # Single line comment example!
    print(factorial(5))
```

Coding Standards

- Python has specified the coding standards for code written in this language
- This is PEP 8
- If you are in doubt about a style issue with the way you write Python, refer to PEP 8 and follow it

Comments

- Python comments start with '#'
- Multi-line comments can be put in triple quotes """ THIS IS A COMMENT """

Duck Typing

- “If it walks like a duck and quacks like a duck...”
- No type checking unless absolutely necessary
- Python will let you change the data type of a variable at any time!

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WARNING

BE CAREFUL!
Variables can change type if you are not careful

Variables

- PEP 8 Rules on variable names
- Create variable with assignment:
  - a = 5
- Variables are references!
- Variables are memory managed
- Data pointed to by variable is destroyed when variable goes out of scope
- Assigning a variable to another creates new reference
  - b = a

Integer Data Types

Official documentation

- Integers have unlimited precision.
- Many built in functions
- Tools to convert formats

Integer Operations

x+y	Addition of x and y
x-y	Subtraction of y from x
x * y	Multiplication of x and y
x/y	Divides x by y and returns a float
x//y	Divides x by y and truncates fractional part to return an integer
x%y	Returns the modulus (remainder) of x divided by y
x**y	Raises x to the power of y
-x	negates x

Integer Functions

abs(x)	Returns the absolute value of x
divmod(x,y)	Returns the quotient and remainder of x divided by y as a tuple
pow(x, y)	Raises x to the power of y, same as x ** y
pow(x,y,z)	Faster alternative to (x ** y)%z
round(x, n)	Returns x rounded to n integeral digits
bin(x)	Returns a string that is a binary representation of x, bin(5) =”0b101”
hex(x)	Returns a string that is a hexadecimal representation of x, hex(30) =”0x1e”
int(x)	Converts object x to an integer or raises an error
int(s, base)	converts string s to an integer
oct(x)	Returns a string that is a octal representation of x, oct(30) =”036”

Floating Point

- Holds double precision values
- Range depends on compiler and platform that we are running
- Float performs all the same operations as the integer type
- float_var = 1.0

Strings

This is Python 3 Strings Documentation

- immutable sequence of Unicode characters
- Arbitrary length
- Support usual comparison operations
- Can use single, double or tripple quotation marks to create a string
- string_var = 'This is a string'
- string_var = “This is a string”
- string_var = "'This is a string"'

String Operations

s[x]	Access index x in the string
s[:x]	Access from the start of the string to index x
s[x:]	Access from index x to the end of the string
s[x:y]	Access from index x to index y
s[x:y:z]	Access from index x to index y byte steps of z
s1+s2	Concatenation of 2 strings
s *n	Multiply the string n times, creates a new string with n copies of the old string
len(s)	Length of string s
c in s	Returns a Boolean True if c is in s
c not in s	Returns a Boolean True if c is not in s

String Methods

This is a list of the commonly used methods.
The full list starts here.

str.capitalize()	Capitalize the first character
str.format(*args, **kwargs)	Reformat the string with the specified parameters
str.join(iterable)	Concatenate a list of strings
str.lower()	Returns strings as alll lower-case characters
str.split(sep=None, maxsplit=-1)	split the string into a list of strings based on sep delimiter
str.strip([chars])	Return the string with those characters removed.

Lists

- Official Documentation
- List contains arbitrary objects
- Mutable
- Can be sorted
- list_var = [] # Creates an empty list
- list_var = [1,2,"String"] # Creates an list with data

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list.append(x)	add x onto the end of the list
list.extend(L)	extend the list with a new list L
list.insert(i,x)	insert x at position i in the list
list.pop(i)	remove the item from position i, if i is not specified, remove the last item
list.sort()	sort items in place

Dictionaries

- Official Documentation
- Dictionaries contain arbitrary key/value pairs
- Like an associative array
- Keys must be unique and hashable
- Lookup is O(1)
- No sorting order
- Dictionary is mutable!
- Literals:
  - dict_var = {key1:value1, key2:value2...}
  - empty_dict = { }

Dictionary Operations and Methods

len(d)	Returns the number of key/value pairs
value = d[key]	Returns the value for this key, an error if key does not exist
d[key] = value	Creates or replaces this key and associates this data with it
del d[key]	Deletes this key/value
key in d	Returns True if it is, False if it is not
d.keys()	Returns a list of keys
d.values	Returns a list of values
d.update(dict)	Adds the passed in dictionary to d
d.items()	Returns a list of key/value tuples

Lab

LAB 1

Lecture Summary

- If-Else
- For Loops
- While Loops
- Functions

If Statements

- Official Documentation
- elif and else are optional

Code Example:

```python
if __name__ == "__main__":
    x = 4
    if x == 4:
        print("We are 4")
    elif x == 5:
        print("We are 5")
    else:
        print("Default to something else")
```

For Statements

- Official Documentation
- Do not specify start, stop and step like C
- Iterate over a list, file or string
- range function returns a list of numbers to iterate over
- break will exit the loop
- else: will execute at the end of the loop if the exit is normal (not break)

Code Example:

```python
if __name__ == "__main__":
    languages = ["python", "java", "c", "lisp",
    ↪   "perl"]
    for x in languages:
        print(x)
    for x in range(10):
        print(x)
    else:
        print("Done")
    for x in range(10):
        print(x)
        if x > 4:
            break
    else:
        print("Done")
    my_dict = {1: "One", 2: "Two", 3: "Three"}
    for k, v in my_dict.items():
        print(k, v)
```

While Statements

Code Example:

- Official Documentation
- As long as the expression in the while statement evaluates to True, the loop will process
- break can exit the loop
- else: will execute at the end of the loop if the exit is normal (not break)

```python
if __name__ == "__main__":
    languages = ["python", "java", "c", "lisp",
    ↪  "perl"]
    count = 0
    while count < len(languages):
        print(languages[count])
        count += 1
    count = 0
    while count in range(10):
        print(count)
        count += 1
    else:
        print("Done")
    count = 0
    while count in range(10):
        print(count)
        count += 1
        if count > 4:
            break
    else:
        print("Done")
```

Basic Exceptions

- Exceptions are pythons way of handling errors
- Exception Documentation
- Exception Tutorial
- You must have try and except, all other elements are optional
- Each exception block is tried in order
- Use liberally and do not let errors go silently
- A blank except: will catch any exception.

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```python

def key_trigger(key=None):
    d = {1: "One"}
    return d[key]


def trigger(x, y):
    return x / y


if __name__ == "__main__":

    try:
        print(key_trigger(1))
        print(key_trigger())  # KeyError
        print(trigger(1, 2))
        print(trigger(1, 0))  # ZeroDivisionError
    except ZeroDivisionError as e:
        print("Exception: %s" % (e.args))
    except KeyError:
        print("Key Error")
    else:
        print("All is well")
    finally:
        print("Finally")
```

Functions

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Psuedo Code Example:

```
def function_name ( < optional list of parameters > ):
    """
    Function doc string that explains how the function
    works
    """
    ... code goes here...
    return < optional return value >
```

Names and DocStrings

- PEP 8 rules on Function Names
- Use good clear names for the functions, should indicate what the function does
- Avoid abbreviations
- Docstrings are comments that come right after the def line of the function. It should indicate what the function does and how to use it.
- Docstrings have their own PEP, PEP 257
- Although PEP 8 also has some thoughts

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All functions in your labs must have doc strings!

Function Arguments

- Does not type check
    - you can manually check if you wish
- All values are passed by reference
    - immutable types can't be modified by a function
- Arguments are local variables
- Arguments go out of scope when functions return
- Without a return statement, the function returrns **None**

Default Arguments

- Specify a default value for a function argument
- If no value is given for this parameter when the function is called, the default value is used
- This is very handy!

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Code Example:

```
"""
This Is An Example Program For Learning Python
"""


def function_example(param1="Hi", param2=False):
    """
    This is the function's doc string,
    it is a comment that explains the
    function and how to use it.

    This function takes 2 parameters (param 1 and
↪   param2)
    and prints them out.

    EX: function_example("1", "One")
    """
    print(param1, param2)
    return


if __name__ == "__main__":
```

Named Arguments

- Use name arguments to comment the code (use good names!)
- Can be used to skip arguments

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    and prints them out.

    EX: function_example("1", "One")
    """
    print(param1, param2)
    return


if __name__ == "__main__":
    function_example()
    function_example("1", "One")
    function_example(param2="there!")
    function_example(param2="order",
    ↪   param1="Reverse")
```

Files

- Official Documentation
- open(path [,mode]) – returns file object
- Mode specifies file mode
  - r open for read
  - w open for write, creates file if needed
  - a open for append
  - r+ open for update (r+w)
  - w+ open for update (r+w), truncate!
  - rb, wb, ab, rb+, wb+ open in binary mode
- Mode defaults to 'r'

File Reading

- read([size]) – read size bytes
    - Returns string
- readline([size]) – read line
- readlines() - read all lines

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```python

if __name__ == "__main__":
    #    try:
    f = open("LICENSE.txt")
    lines = f.readlines()
    f.close()
    # except:
    #    print("Failed")

    for x in lines:
        print(x)

    #
    # Shorter version
    #
    for line in open("LICENSE.txt"):
        print(line)
```

File Writing

- write(str) – writes string to file
- writelines(list) – writes sequence of strings to
- file flush () - flushes write buffer

File Writing

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- file flush () - flushes write buffer

```python

if __name__ == "__main__":
    try:
        f = open("example.txt", "w")
    except:
        print("Failed to open for write")
    f.write("Put this string in the file\n")
    f.writelines(["String 1\n", "String 2\n"])
    f.flush()
    f.close()
```

File Other

- close() - flush buffer and close file
- fileno() - get OS file handle
- tell() - get file position
- seek(offset [,whence]) – set file position
    - os.SEEK_SET
    - os.SEEK_CUR
    - os.SEEK_END
- truncate([size]) – cut off file length

Printing to a File

- Official Documentation
- file defaults to stdout
- it can be changed to any file you want

Printing to a File

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```python

if __name__ == "__main__":

    try:
        f = open("example2.txt", "w")
    except:
        print("Failed to open for write")

    print("HELLO to a file!", file=f)
    f.close()
```

Lab

LAB 2

Lecture Summary

- import
- numpy
- Matplotlib
- pandas

Import

- The Python Import System
- This is how we bring in code from one module to another
- Gain access to built in python libraries
- Gain access to downloaded 3rd party libraries
- Create your own to organize your code

Numpy

- Numerical Processing library for python
- Lots of tools are built on top of this
- It is a large library with lots of guides and features
- ndarrays can be multi-dimensional

ndarray

- This is the key datatype of numpy.
- Similar to a list but expects all data to be numeric and the same type.
- You can create an ndarray from lists
- Lots of features to ndarray

Code Example:

```python
import numpy as np

vector = np.array([1, 2, 3, 4, 5], dtype=np.int8)
print(f"Vector 1D = {vector} {vector.shape}")

vector2d = np.array([[1, 2, 3], [4, 5, 6]],
↪   dtype=np.complex128)
print(f"Vector 2D = {vector2d}")

vector3d = np.ones((2, 3, 2))  # or np.zeros
print(f"Vector 3D = {vector3d}")

A = np.array([[1, 1], [0, 1]])
B = np.array([[2, 0], [3, 4]])
print(f"Add \n{A + B}\n")
print(f"Element Mult \n{A * B}\n")  # elementwise
↪   product
print(f"Dot Product \n{A @ B}\n")  # matrix
↪   product
print(f"Dot Product Method \n{A.dot(B)}\n")
```

Matplotlib

- One of many plotting libraries for Python
  - Matplotlib
  - Bokeh
  - Seaborn
  - Plotly
- Comes with a lot of documentation
  - Examples
  - Cheat Sheet
  - Getting Started

Basic Plotting

- Plotting
- plot and pair of x and y values.
- add to the legend in the order added to the plot
- Can set x and y axis labels
- Can set a title
- Grid can be enabled or disabled
- Need to show the plot to get it to display

Code Example:

```python
import matplotlib
import matplotlib.pyplot as plt
import numpy as np

x_vals = np.linspace(-2 * np.pi, 2 * np.pi, 100)
sin_wave = np.sin(x_vals)
cos_wave = np.cos(x_vals)

fig, ax = plt.subplots()

ax.plot(x_vals, sin_wave, "ro")
ax.plot(
    x_vals,
    cos_wave,
)
ax.legend(["sine", "cosine"])
plt.xlabel("X-Axis")
plt.ylabel("Y-Axis")
plt.title("Plot Title")
plt.grid(True)
plt.show()
```

SubPlots

- You can also visualize multiple plots in the same image.

Code Example:

```
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import matplotlib.pyplot as plt
import numpy as np

x_vals = np.linspace(-2 * np.pi, 2 * np.pi, 100)
sin_wave = np.sin(x_vals)
cos_wave = np.cos(x_vals)

fig, axs = plt.subplots(2, sharex=True,
↪   sharey=True)
fig.suptitle("Sharing both axes")
axs[0].plot(x_vals, sin_wave, "g")
axs[1].plot(x_vals, cos_wave, "r")
plt.show()
```

Pandas

- Pandas Library
- Goal of being the high-level building block for doing practical, real world data analysis in Python
- It's like having a spreadsheet tool built into python
- Comes with extensive documentation
- Has a quick 10 minute guide

Data Series

- Documentation
- Start Up
- a one-dimensional labeled array capable of holding any data type
- It's like numpy's ndarray structure

Code Example:

```python
import numpy as np
import pandas as pd

s = pd.Series(np.random.randn(5), index=["a",
↪  "b", "c", "d", "e"])
print(f"Series = {s} dtype = {s.dtype}")
print(s["a"])
print(s * 2)
```

DataFrame

- Documentation
- Start Up
- This is the key data structure of pandas
- a 2-dimensional labeled data structure with columns of potentially different types.
- You can think of it like a spreadsheet or SQL table.
- Can quickly load a csv file, read_csv
- The info method prints information about a DataFrame including the index dtype and columns, non-null values and memory usage.
- The columns field holds a list of the labels for the columns
- The head method This function returns the first n rows for the object based on position. It is useful for quickly testing if your object has the right type of data in it.
- The query method returns the specified columns

Code Example:

```python
import numpy as np
import pandas as pd


def get_stock_by_symbol(name=None):
    if name is None:
        return None
    # This is risky code!  What if the stock
    ↪  symbol passed in does not exist?
    # Silently return an empty frame
    return stock_data_frame.query(f"Name ==
    ↪  '{name}'")


stock_data_file =
↪  "../../Lecture/all_stocks_5yr.csv"
stock_data_frame = pd.read_csv(stock_data_file)
print(stock_data_frame.info())
print(stock_data_frame.columns)
print(stock_data_frame.head(10))
stock = get_stock_by_symbol(name="GOOG")
print(stock)
print(np.mean(stock))
```

Plotting Pandas

- Matplotlib has special date formatting handlers
- There are tools for formatting the date with autofmt_xdate
- Pandas can convert to the correct date time formate with to_datetime
- gca is Get Current Axis
- gcf is Get Current Figure

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stock_data_file = "../../Lecture/all_stocks_5yr.csv"
stock_data_frame = pd.read_csv(stock_data_file)
stock = get_stock_by_symbol(name="GOOG")
plt.gca().xaxis.set_major_formatter(mdates.DateFormat
plt.gca().xaxis.set_major_locator(mdates.DayLocator(i
plt.gcf().autofmt_xdate()
plt.plot(pd.to_datetime(stock["date"].values), stock["high"].values)
plt.plot(pd.to_datetime(stock["date"].values), stock["low"].values)
plt.legend(["high", "low"])
plt.xlabel("Dates")
plt.ylabel("Price ($)")
plt.title(f"Stock High and Low of {stock['Name'].values[0]}")
plt.grid(True)
plt.show()
```

Lab

LAB 3

Lab

LAB 3

THANK YOU

THANK YOU FOR ATTENDING!
BEST OF LUCK IN YOUR DATA SCIENCE ENDEAVORS!