Introduction to Numpy & Pandas

Viacheslav Moskalenko

Introduction to Data Science, Computer Science Department, Sumy State University

Topic Contents

- Introduction to Python
- Python Programming
- NumPy
- Plotting with Matplotlib
- Introduction to Python Pandas

Section 1

Python Features

Why Python ?

- Interpreted
- Intuitive and minimalistic code
- Expressive language
- Dynamically typed
- Automatic memory management

Python Features

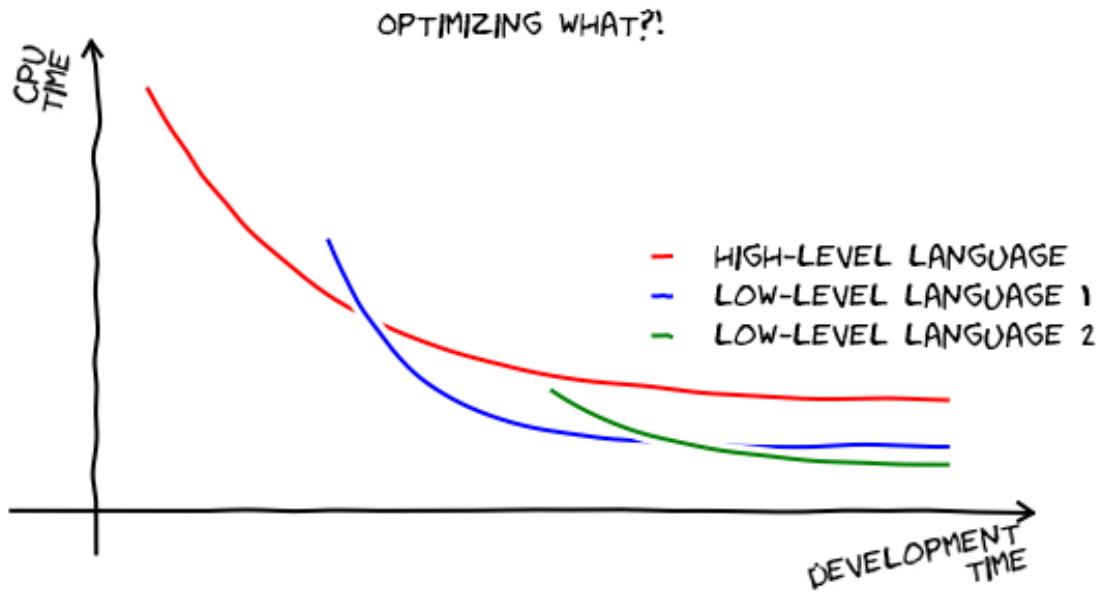
Advantages

- Ease of programming
- Minimizes the time to develop and maintain code
- Modular and object-oriented
- Large community of users
- A large standard and user-contributed library

Disadvantages

- Interpreted and therefore slower than compiled languages
- Decentralized with packages

Code Performance vs Development Time



Versions of Python

- Two versions of Python in use - Python 2 and Python 3
- Python 3 not backward-compatible with Python 2
- A lot of packages are available for Python 2
- Check version using the following command

Example

```
$ python --version
```

Section 2

Variables

- Variable names can contain alphanumerical characters and some special characters
- It is common to have variable names start with a lower-case letter and class names start with a capital letter
- Some keywords are reserved such as `'and'`, `'assert'`, `'break'`, `'lambda'`. A list of keywords are located at `https://docs.python.org/2.5/ref/keywords.html`
- Python is dynamically typed, the type of the variable is derived from the value it is assigned.
- A variable is assigned using the '=' operator

Variable types

- Variable types
  - Integer (`int`)
  - Float (`float`)
  - Boolean (`bool`)
  - Complex (`complex`)
  - String (`str`)
  - ...
  - User Defined! (classes)
- Documentation
  - https://docs.python.org/2/library/types.html
  - https://docs.python.org/2/library/datatypes.html

Variable types

- Use the type function to determine variable type

Example

```
>>> log_file = open("/home/srijithr/
    logfile","r")
>>> type(log_file)
file
```

Variable types

- Variables can be *cast* to a different type

Example

```
>>> share_of_rent = 295.50 / 2.0
>>> type(share_of_rent)
float
>>> rounded_share = int(share_of_rent)
>>> type(rounded_share)
int
```

Operators

- Arithmetic operators +, -, *, /, // (integer division for floating point numbers), '**' power
- Boolean operators `and`, `or` and `not`
- Comparison operators >, <, >= (greater or equal), <= (less or equal), == equality

Strings (str)

Example

```
>>> dir(str)
[..., 'capitalize', 'center', 'count', '
    decode', 'encode', 'endswith', '
    expandtabs', 'find', 'format', 'index',
     'isalnum', 'isalpha', 'isdigit', '
    islower', 'isspace', 'istitle', '
    isupper', 'join', 'ljust', 'lower', '
    lstrip', 'partition', 'replace', 'rfind
    ', 'rindex', 'rjust', 'rpartition', '
    rsplit', 'rstrip', 'split', 'splitlines
    ', 'startswith', 'strip', 'swapcase', '
    title', 'translate', 'upper', 'zfill']
```

Strings

Example

```
>>> greeting = "Hello world!"
>>> len(greeting)
12
>>> greeting
'Hello world'
>>> greeting[0] # indexing starts at 0
'H'
>>> greeting.replace("world", "test")
Hello test!
```

Printing strings

Example

```
# concatenates strings with a space
>>> print("Go", "Hokies")
Go Hokies
# concatenated without space
>>> print("Go" + "Tech" + "Go")
GoTechGo
# C-style string formatting
>>> print("Bar Tab = %f" %35.28)
Bar Tab = 35.280000
# Creating a formatted string
>>> total = "My Share = %.2f. Tip = %d" %
    (11.76, 2.352)
>>> print(total)
My Share = 11.76. Tip = 2
```

Lists

Array of elements of arbitrary type

Example

```
>>> numbers = [1,2,3]
>>> type(numbers)
list
>>> arbitrary_array = [1,numbers,"hello"]
>>> type(arbitrary_array)
list
```

Lists

Example

```
# create a new empty list
>>> characters = []
# add elements using ‘append’
>>> characters.append("A")
>>> characters.append("d")
>>> characters.append("d")
>>> print(characters)
['A', 'd', 'd']
```

Lists

Lists are *mutable* - their values can be changed.

Example

```
>>> characters = ["A","d","d"]
# Changing second and third element
>>> characters[1] = "p"
>>> characters[2] = "p"
>>> print(characters)
['A', 'p', 'p']
```

Lists

Example

```
>>> characters = ["A","d","d"]
# Inserting before "A","d","d"
>>> characters.insert(0, "i")
>>> characters.insert(1, "n")
>>> characters.insert(2, "s")
>>> characters.insert(3, "e")
>>> characters.insert(4, "r")
>>> characters.insert(5, "t")
>>>print(characters)
['i', 'n', 's', 'e', 'r', 't', 'A', 'd', '
   d']
```

Lists

Example

```
>>> characters = ['i', 'n', 's', 'e', 'r',
    't', 'A', 'd', 'd']
# Remove first occurrence of "A" from list
>>> characters.remove("A")
>>> print(characters)
['i', 'n', 's', 'e', 'r', 't', 'd', 'd']
# Remove an element at a specific location
>>> del characters[7]
>>> del characters[6]
>>> print(characters)
['i', 'n', 's', 'e', 'r', 't']
```

Tuples

Tuples are like lists except they are *immutable*. Difference is in performance

Example

```
>>> point = (10, 20)  # Note () for tuples
    instead of []
>>> type(point)
tuple
>>> point = 10,20
>>> type(point)
tuple
>>> point[2] = 40 # This will fail!
TypeError: 'tuple' object does not support
    item assignment
```

Dictionary

Dictionaries are lists of key-value pairs

Example

```
>>> prices = {"Eggs" : 2.30,
...           "Sausage" : 4.15,
...           "Spam" : 1.59,}
>>> type(prices)
dict
>>> print (prices)
{'Eggs': 2.3, 'Sausage': 4.15, 'Spam':
   1.59}
>>> prices["Spam"]
1.59
```

Conditional statements: if, elif, else

Example

```
>>> I_am_tired = False
>>> I_am_hungry = True
>>> if I_am_tired is True:    # Note the
    colon for a code block
...     print ("You have to teach!")
... elif I_am_hungry is True:
...     print ("No food for you!")
... else:
...     print "Go on...!"
...
No food for you!
```

Loops - For

Example

```
>>> for i in [1,2,3]: # i is an arbitrary
    variable for use within the loop
    section
...     print(i)
1
2
3
>>> for word in ["scientific", "computing"
    , "with", "python"]:
...     print(word)
scientific
computing
with
python
```

Loops - While

Example

```
>>>i = 0
>>>while i < 5:
...     print(i)
...     i = i + 1
0
1
2
3
4
```

Functions

Example

```
>>> def print_word_length(word):
...     """
...     Print a word and how many
    characters it has
...     """
...     print(word + " has " + str(len(
    word)) + " characters.")
>>>print_word_length("Diversity")
Diversity has 9 characters.
```

Functions - arguments

- Passing immutable arguments like integers, strings or tuples acts like *call-by-value*
  - They cannot be modified!
- Passing mutable arguments like lists behaves like *call-by-reference*

Functions - arguments

Call-by-value

Example

```
>>> def make_me_rich(balance):
            balance = 1000000
account_balance = 500
>>> make_me_rich(account_balance)
>>> print(account_balance)
500
```

Functions - arguments

Call-by-reference

Example

```
>>> def talk_to_advisor(tasks):
            tasks.insert(0, "Publish")
            tasks.insert(1, "Publish")
            tasks.insert(2, "Publish")
>>> todos = ["Graduate","Get a job","...",
   "Profit!"]
>>> talk_to_advisor(todos)
>>> print(todos)
 ["Publish","Publish","Publish","Graduate"
    ,"Get a job","...","Profit!"]
```

Functions - arguments

- However, you cannot assign a new object to the argument
  - A new memory location is created for this list
  - This becomes a local variable

Example

```
>>> def switcheroo(favorite_teams):
...     print (favorite_teams)
...     favorite_teams = ["Redskins"]
...     print (favorite_teams)
>>> my_favorite_teams = ["Hokies", "
   Nittany Lions"]
>>> switcheroo(my_favorite_teams)
["Hokies", "Nittany Lions"]
["Redskins"]
>>> print (my_favorite_teams)
["Hokies", "Nittany Lions"]
```

Functions - Multiple Return Values

Example

```
>>> def powers(number):
...     return number ** 2, number ** 3
>>> squared, cubed = powers(3)
>>> print(squared)
9
>>> print(cubed)
27
```

Functions - Default Values

Example

```
>>> def likes_food(person, food="Broccoli"
    , likes=True):
...     if likes:
...         print(str(person) + " likes "
    +  food)
...     else:
...         print(str(person) + " does not
    like " +  food)
>>> likes_food("Srijith", likes=False)
Srijith does not like Broccoli
```

Section 3

NumPy

Used in almost all numerical computations in Python

- Used for high-performance vector and matrix computations
- Provides fast precompiled functions for numerical routines
- Written in C and Fortran
- Vectorized computations

Why NumPy?

Example

```
>>> from numpy import *
>>> import time
>>> def trad_version():
      t1 = time.time()
      X = range(10000000)
      Y = range(10000000)
      Z = []
      for i in range(len(X)):
        Z.append(X[i] + Y[i])
      return time.time() - t1

>>> trad_version()
1.9738149642944336
```

Why NumPy?

Example

```
>>> def numpy_version():
        t1 = time.time()
        X = arange(10000000)
        Y = arange(10000000)
        Z = X + Y
        return time.time() - t1

>>> numpy_version()
 0.059307098388671875
```

Arrays

Example

```
>>> from numpy import *
#  the argument to the array function is a
    Python list
>>> v = array([1,2,3,4])
#  the argument to the array function is a
    nested Python list
>>> M = array([[1, 2], [3, 4]])
>>> type(v), type(M)
(numpy.ndarray, numpy.ndarray)
```

Arrays

Example

```
>>> v.shape, M.shape
((4,), (2, 2))
>>> M.size
4
>>> M.dtype
dtype('int64')
# Explicitly define the type of the array
>>> M = array([[1, 2], [3, 4]], dtype=
    complex)
```

Arrays - Using array-generating functions

Example

```
>>> x = arange(0, 10, 1) # arguments:
    start, stop, step
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
>>> linspace(0,10,11) # arguments: start,
    end and number of points ( start and
    end points are included )
array([  0.,   1.,   2.,   3.,   4.,   5.,
        6.,   7.,   8.,   9.,  10.])
```

Diagonal and Zero matrix

Example

```
>>> diag([1,2,3])
array([[1, 0, 0],
       [0, 2, 0],
       [0, 0, 3]])
>>> zeros((3,3))
array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
```

Array Access

Example

```
>>> M = random.rand(3,3)
>>> M
array([
[ 0.37389376,  0.64335721,  0.12435669],
[ 0.01444674,  0.13963834,  0.36263224],
[ 0.00661902,  0.14865659,  0.75066302]])
>>> M[1,1]
0.13963834214755588
```

Array Access

Example

```
# Access the first row
>>> M[1]
array(
[ 0.01444674,  0.13963834,  0.36263224])
# The first row can be also be accessed
   using this notation
>>> M[1,:]
array(
[ 0.01444674,  0.13963834,  0.36263224])
# Access the first column
>>> M[:,1]
array(
[ 0.64335721,  0.13963834,  0.14865659])
```

Array Access

Example

```
# You can also assign values to an entire
    row or column
>>> M[1,:] = 0
>>> M
array([
[ 0.37389376,  0.64335721,  0.12435669],
[ 0.        ,  0.        ,  0.        ],
[ 0.00661902,  0.14865659,  0.75066302]])
```

Array Slicing

Example

```
# Extract slices of an array
>>> M[1:3]
array([
[ 0.        ,  0.        ,  0.        ],
[ 0.00661902,  0.14865659,  0.75066302]])
>>> M[1:3,1:2]
array([
[ 0.        ],
[ 0.14865659]])
```

Array Slicing - Negative Indexing

Example

```
# Negative indices start counting from the
    end of the array
>>> M[-2]
array(
[ 0.,  0.,  0.])
>>> M[-1]
array(
[ 0.00661902,  0.14865659,  0.75066302])
```

Array Access - Strided Access

Example

```
# Strided access
>>> M[::2,::2]
array([[ 0.37389376,  0.12435669],
       [ 0.00661902,  0.75066302]])
```

Array Operations - Scalar

These operation are applied to all the elements in the array

Example

```
>>> M*2
array([
[ 0.74778752,  1.28671443,  0.24871338],
[ 0.        ,  0.        ,  0.        ],
[ 0.01323804,  0.29731317,  1.50132603]])
>>> M + 2
array([
[ 2.37389376,  2.64335721,  2.12435669],
[ 2.        ,  2.        ,  2.        ],
[ 2.00661902,  2.14865659,  2.75066302]])
```

Matrix multiplication

Example

```
>>> M * M # Element-wise multiplication
array([
[1.397965e-01,4.139085e-01,1.546458e-02],
[0.000000e+00,0.000000e+00,0.00000e+00],
[4.381141e-05,2.209878e-02,5.634949e-01]])
>>> dot(M,M) # Matrix multiplication
array([
[ 0.14061966,  0.25903369,  0.13984616],
[ 0.        ,  0.        ,  0.        ],
[ 0.00744346,  0.1158494 ,  0.56431808]])
```

Iterating over Array Elements

- In general, avoid iteration over elements
- Iterating is slow compared to a vector operation
- If you must, use the `for` loop
- In order to enable vectorization, ensure that user-written functions can work with vector inputs.
  - Use the `vectorize` function
  - Use the `any` or `all` function with arrays

Vectorize

Example

```
>>> def Theta(x):
...     """
...     Scalar implemenation of the
    Heaviside step function.
...     """
...     if x >= 0:
...         return 1
...     else:
...         return 0
...
>>> Theta(1.0)
1
>>> Theta(-1.0)
0
```

Vectorize

Without `vectorize` we would not be able to pass v to the function

Example

```
>>> v
array([1, 2, 3, 4])
>>> Tvec = vectorize(Theta)
>>> Tvec(v)
array([1, 1, 1, 1])
>>> Tvec(1.0)
array(1)
```

Arrays in conditions

Use the `any` or `all` functions associated with arrays

Example

```
>>> v
array([1, 2, 3, 4])
>>> (v > 3).any()
True
>>> (v > 3).all()
False
```

Section 4

Matplotlib

- Used for generating 2D and 3D scientific plots
- Support for LaTeX
- Fine-grained control over every aspect
- Many output file formats including PNG, PDF, SVG, EPS

Matplotlib - Customize matplotlibrc

- Configuration file 'matplotlibrc' used to customize almost every aspect of plotting
- On Linux, it looks in .config/matplotlib/matplotlibrc
- On other platforms, it looks in .matplotlib/matplotlibrc
- Use '`matplotlib.matplotlib_fname()`' to determine from where the current matplotlibrc is loaded
- Customization options can be found at `http://matplotlib.org/users/customizing.html`

Matplotlib

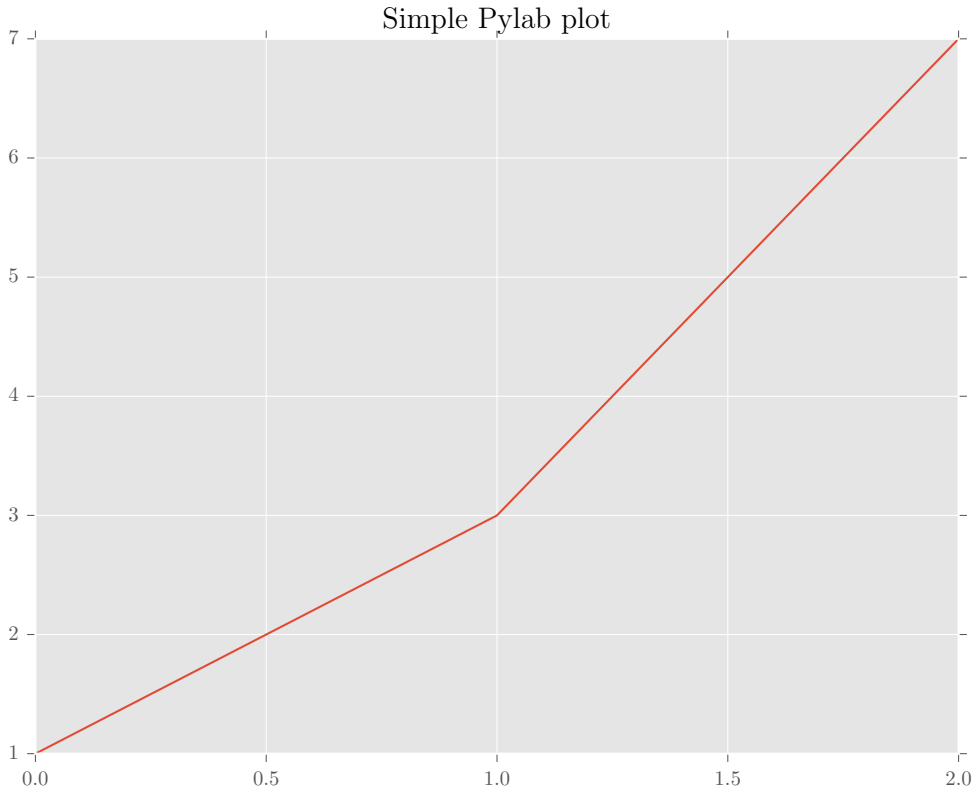
- Matplotlib is the entire library
- Pyplot - a module within Matplotlib that provides access to the underlying plotting library
- Pylab - a convenience module that combines the functionality of Pyplot with Numpy
- Pylab interface convenient for interactive plotting

Pylab

Example

```
>>> import pylab as pl
>>> pl.ioff()
>>> pl.isinteractive()
False
>>> x = [1,3,7]
>>> pl.plot(x)     # if interactive mode is
    off use show() after the plot command
[<matplotlib.lines.Line2D object at 0
   x10437a190>]
>>> pl.savefig('fig_test.pdf',dpi=600,
   format='pdf')
>>> pl.show()
```

Pylab

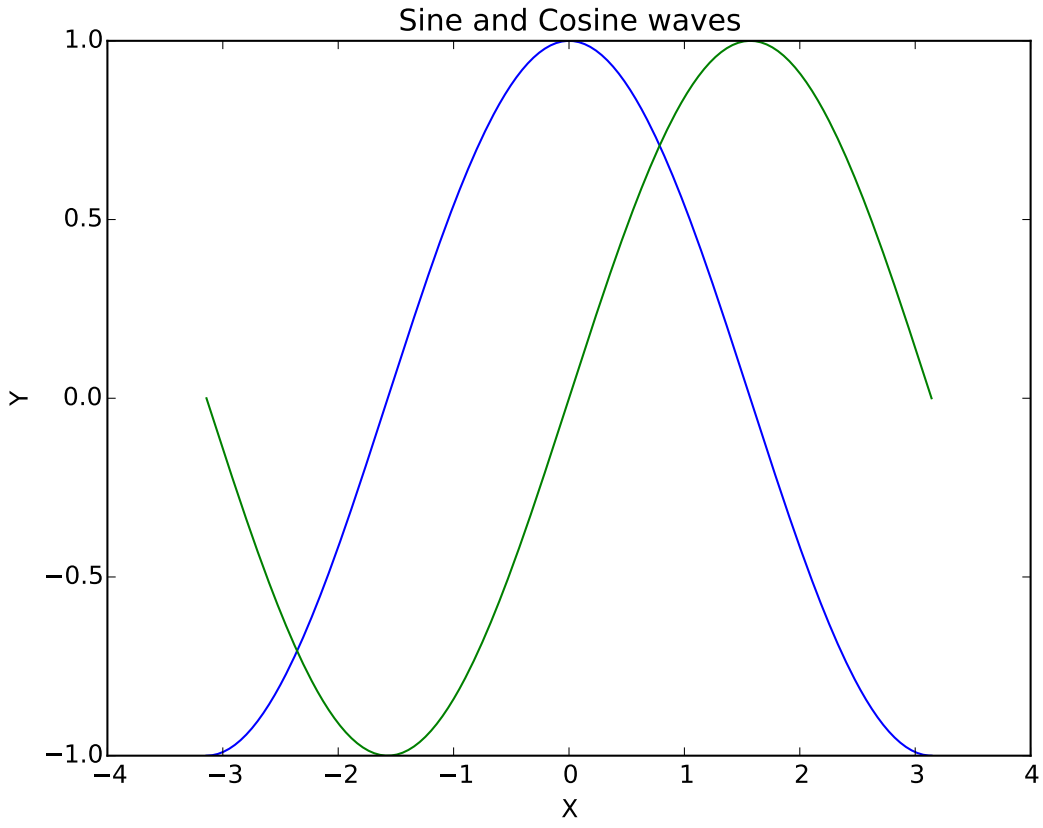


Pylab

Example

```
>>> X = np.linspace(-np.pi, np.pi, 256,
    endpoint=True)
>>> C, S = np.cos(X), np.sin(X)
# Plot cosine with a blue continuous line
    of width 1 (pixels)
>>> pl.plot(X, C, color="blue", linewidth
    =1.0, linestyle="-")
>>> pl.xlabel("X") ; pl.ylabel("Y")
>>> pl.title("Sine and Cosine waves")
# Plot sine with a green continuous line
    of width 1 (pixels)
>>> pl.plot(X, S, color="green", linewidth
    =1.0, linestyle="-")
>>> pl.show()
```

Pylab

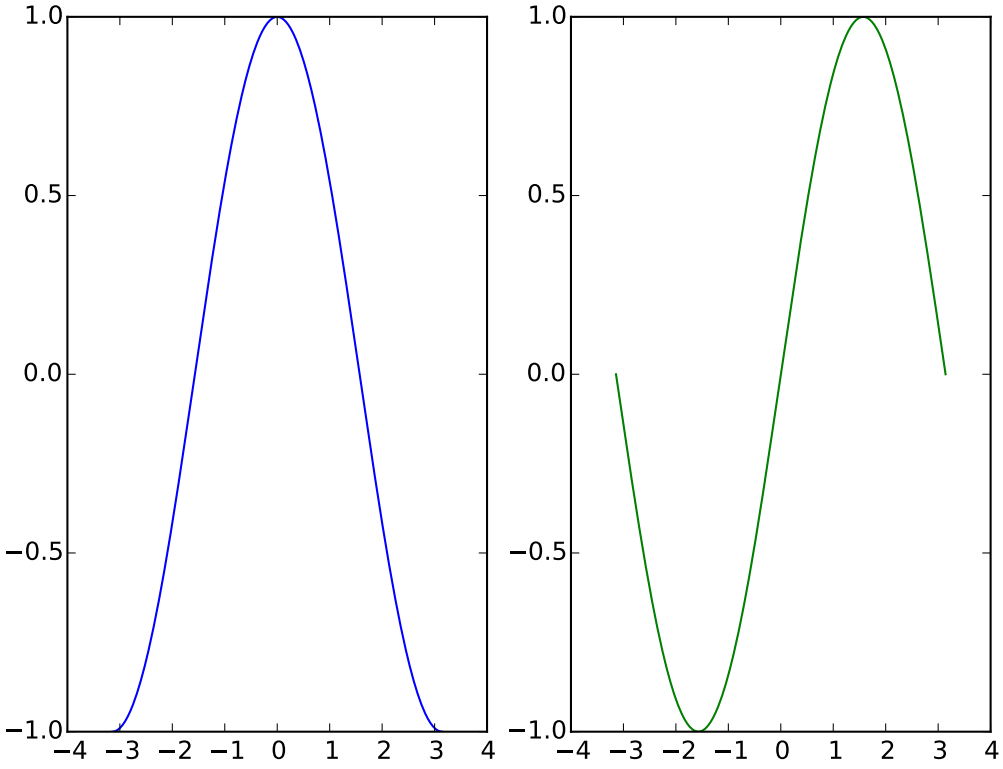


Pylab - subplots

Example

```
>>> pl.figure(figsize=(8, 6), dpi=80)
>>> pl.subplot(1, 2, 1)
>>> C, S = np.cos(X), np.sin(X)
>>> pl.plot(X, C, color="blue", linewidth
    =1.0, linestyle="-")
>>> pl.subplot(1, 2, 2)
>>> pl.plot(X, S, color="green", linewidth
    =1.0, linestyle="-")
>>> pl.show()
```

Pylab - subplots

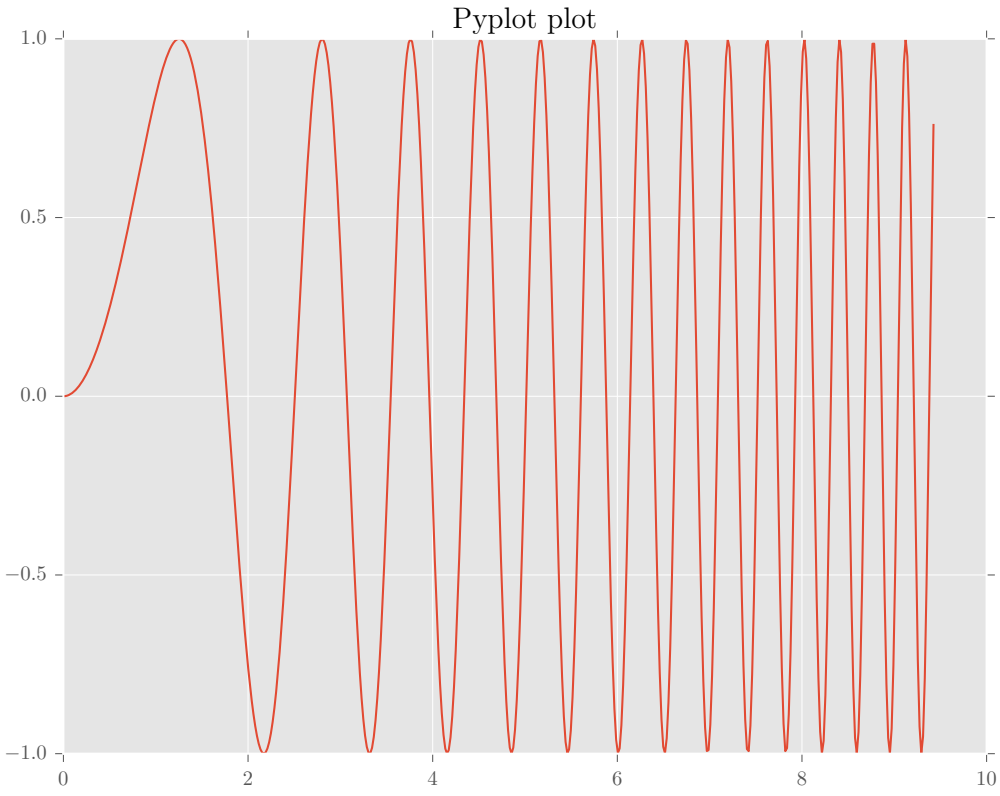


Pyplot

Example

```
>>>import matplotlib.pyplot as plt
>>>plt.isinteractive()
False
>>>x = np.linspace(0, 3*np.pi, 500)
>>>plt.plot(x, np.sin(x**2))
[<matplotlib.lines.Line2D object at 0
   x104bf2b10>]
>>>plt.title('Pyplot plot')
<matplotlib.text.Text object at 0
   x104be4450>
>>>savefig('fig_test_pyplot.pdf',dpi=600,
   format='pdf')
>>>plt.show()
```

Pyplot

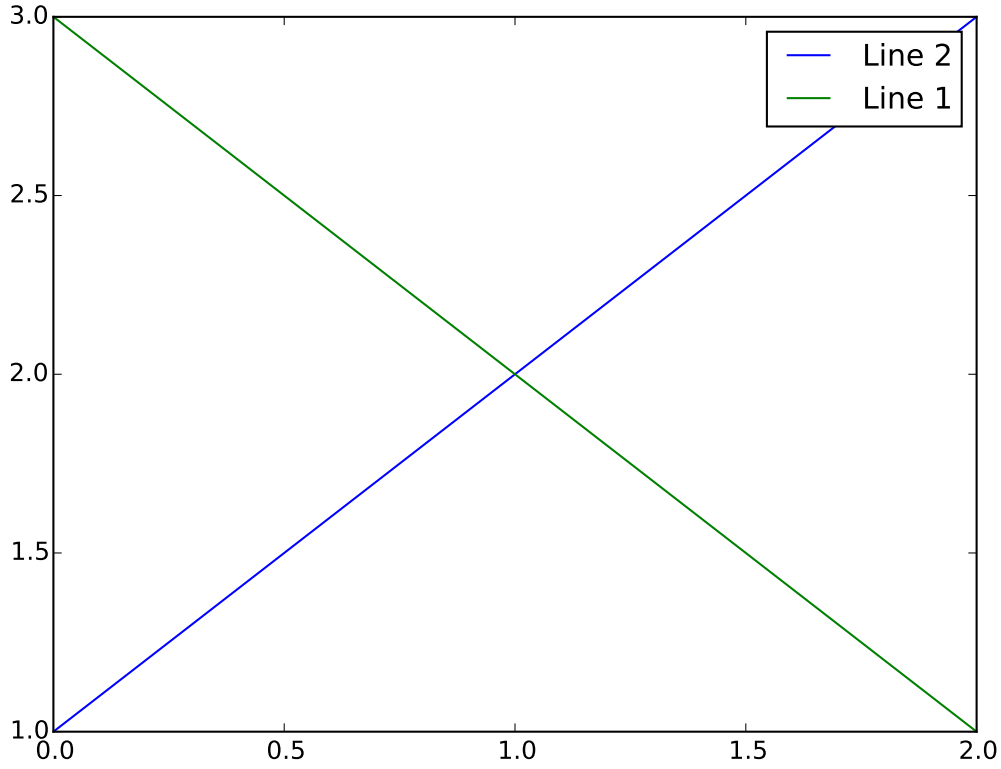


Pyplot - legend

Example

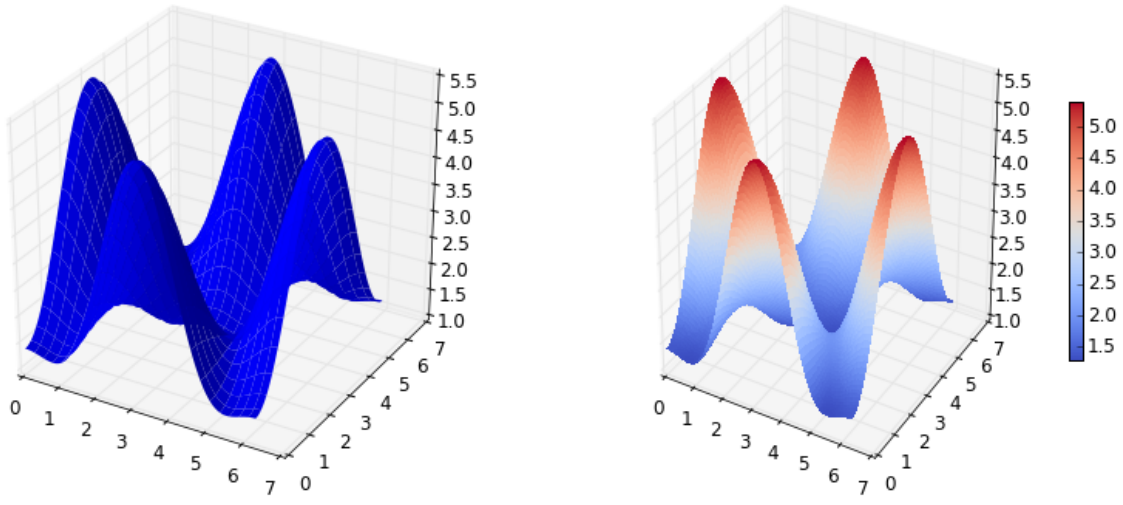
```
>>> import matplotlib.pyplot as plt
>>> line_up, = plt.plot([1,2,3], label='
    Line 2')
>>> line_down, = plt.plot([3,2,1], label='
    Line 1')
>>> plt.legend(handles=[line_up, line_down
    ])
<matplotlib.legend.Legend at 0x1084cc950>
>>> plt.show()
```

Pyplot - legend



Pyplot - 3D plots

Surface plots



Visit `http://matplotlib.org/gallery.html` for a gallery of plots produced by Matplotlib

Section 5

What is Pandas?

- Pandas is an open source, BSD-licensed library
- High-performance, easy-to-use data structures and data analysis tools
- Built for the Python programming language.

Pandas - import modules

Example

```
>>>from pandas import DataFrame, read_csv
# General syntax to import a library but
   no functions:
>>>import pandas as pd #this is how I
   usually import pandas
```

Pandas - Create a dataframe

Example

```
>>>d = {'one' : pd.Series([1., 2., 3.],
   index=['a', 'b', 'c']),
 'two' : pd.Series([1., 2., 3., 4.], index
    =['a', 'b', 'c', 'd'])}
>>>df = pd.DataFrame(d)
>>>df
   one   two
a  1.0   1.0
b  2.0   2.0
c  3.0   3.0
d  NaN   4.0
```

Pandas - Create a dataframe

Example

```
>>>names = ['Bob','Jessica','Mary','John',
    'Mel']
>>>births = [968, 155, 77, 578, 973]
#To merge these two lists together we will
    use the zip function.

>>>BabyDataSet = list(zip(names,births))
>>>BabyDataSet
[('Bob', 968), ('Jessica', 155), ('Mary',
    77), ('John', 578), ('Mel', 973)]
```

Pandas - Create a data frame and write to a csv file

Use the pandas module to create a dataset.

Example

```
>>>df = pd.DataFrame(data = BabyDataSet,
   columns=['Names', 'Births'])
>>>df.to_csv('births1880.csv',index=False,
   header=False)
```

Pandas - Read data from a file

Import data from the csv file

Example

```
>>>df = pd.read_csv(filename)
#Don't treat the first row as a header
>>>df = pd.read_csv(Location, header=None)
# Provide specific names for the columns
>>>df = pd.read_csv(Location, names=['
    Names','Births'])
```

Pandas - Get data types

Example

```
# Check data type of the columns
>>>df.dtypes
Names      object
Births      int64
dtype: object
# Check data type of Births column
>>>df.Births.dtype
dtype('int64')
```

Pandas - Take a look at the data

Example

```
>>>df.head(2)
           Names     Births
0          Bob   968
1      Jessica   155
>>>df.tail(2)
         Names     Births
3     John   578
4      Mel   973
>>>df.columns
Index([u'Names', u'Births'], dtype='object
    ')
```

Pandas - Take a look at the data

Example

```
>>>df.values
array([['Bob', 968],
       ['Jessica', 155],
       ['Mary', 77],
       ['John', 578],
       ['Mel', 973]], dtype=object)

>>>df.index
Int64Index([0, 1, 2, 3, 4], dtype='int64')
```

Pandas - Working on the data

Example

```
>>>df['Births'].plot()
# Maximum value in the data set
>>>MaxValue = df['Births'].max()
# Name associated with the maximum value
>>>MaxName = df['Names'][df['Births'] ==
    df['Births'].max()].values
```

Pandas - Describe the data

Example

```
>>>df['Names'].unique()
array(['Mary', 'Jessica', 'Bob', 'John', '
    Mel'], dtype=object)
>>>print(df['Names'].describe())
count      1000
unique        5
top         Bob
freq        206
Name: Names, dtype: object
```

Pandas - Add a column

Example

```
>>>d = [0,1,2,3,4,5,6,7,8,9]

# Create dataframe
>>>df = pd.DataFrame(d)
#Name the column
>>>df.columns = ['Rev']
#Add another one and set the value in that
    column
>>>df['NewCol'] = 5
```

Pandas - Accessing and indexing the data

Example

```
#Perform operations on columns
>>>df['NewCol'] = df['NewCol'] + 1
#Delete a column
>>>del df['NewCol']
#Edit the index name
>>>i = ['a','b','c','d','e','f','g','h','i
    ','j']
>>>df.index = i
```

Pandas - Accessing and indexing the data

Example

```
#Find based on index value
>>>df.loc['a']
>>>df.loc['a':'d']
#Do integer position based indexing
>>>df.iloc[0:3]
#Access using the column name
>>>df['Rev']
#Access multiple columns
>>>df[['Rev', 'test']]
#Subset the data
>>>df.ix[:3,['Rev', 'test']]
```

Pandas - Accessing and indexing the data

Example

```
#Find based on index value
>>>df.at['a','Rev']
0
>>>df.iat[0,0]
0
```

Pandas - Accessing and indexing for loc

- A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index. This use is not an integer position along the index)
- A list or array of labels ['a', 'b', 'c']
- A slice object with labels 'a':'f', (note that contrary to usual python slices, both the start and the stop are included!)
- A boolean array

Pandas - Accessing and indexing for iloc

- An integer e.g. 5
- A list or array of integers [4, 3, 0]
- A slice object with ints 1:7

Pandas - Accessing and indexing summarized

Example

```
loc:  only work on index
iloc: work on position
ix:     this is the most general and
   supports index and position based
   retrieval
at:   get scalar values, it's a very fast
   loc
iat:  get scalar values, it's a very fast
   iloc
```

Pandas - Missing data

How do you deal with data that is missing or contains NaNs

Example

```
>>>df = pd.DataFrame(np.random.randn(5, 3)
    , index=['a', 'c', 'e', 'f', 'h'],
columns=['one', 'two', 'three'])
>>>df.loc['a','two'] = np.nan
        one       two     three
a -1.192838       NaN -0.337037
c  0.110718 -0.016733 -0.137009
e  0.153456  0.266369 -0.064127
f  1.709607 -0.424790 -0.792061
h -1.076740 -0.872088 -0.436127
```

Pandas - Missing data

How do you deal with data that is missing or contains NaNs?

Example

```
>>>df.isnull()
      one     two   three
a   False    True   False
c   False   False   False
e   False   False   False
f   False   False   False
h   False   False   False
```

Pandas - Missing data

You can fill this data in a number of ways.

Example

```
>>>df.fillna(0)
          one         two       three
a -1.192838   0.000000  -0.337037
c  0.110718  -0.016733  -0.137009
e  0.153456   0.266369  -0.064127
f  1.709607  -0.424790  -0.792061
h -1.076740  -0.872088  -0.436127
```

Pandas - Query the data

Also, use the query method where you can embed boolean expressions on columns within quotes

Example

```
>>>df.query('one > 0')
          one       two     three
c   0.110718 -0.016733 -0.137009
e   0.153456  0.266369 -0.064127
f   1.709607 -0.424790 -0.792061
>>>df.query('one > 0 & two > 0')
          one       two     three
e   0.153456  0.266369 -0.064127
```

Pandas - Apply a function

You can apply any function to the columns in a dataframe

Example

```
>>>df.apply(lambda x: x.max() - x.min())
one      2.902445
two      1.138457
three    0.727934
```

Pandas - Applymap a function

You can apply any function to the element wise data in a dataframe

Example

```
>>>df.applymap(np.sqrt)
          one         two   three
a         NaN         NaN     NaN
c    0.332742         NaN     NaN
e    0.391735    0.516109     NaN
f    1.307520         NaN     NaN
h         NaN         NaN     NaN
```

Pandas - Query data

Determine if certain values exist in the dataframe

Example

```
>>>s = pd.Series(np.arange(5), index=np.
   arange(5)[::-1], dtype='int64')
>>>s.isin([2,4,6])
4    False
3    False
2     True
1    False
0     True
```

Pandas - Query data

Use the where method

Example

```
>>>s = pd.Series(np.arange(5), index=np.
    arange(5)[::-1], dtype='int64')
>>>s.where(s>3)
4    NaN
3    NaN
2    NaN
1    NaN
0      4
```

Pandas - Grouping the data

Creating a grouping organizes the data and returns a groupby object

Example

```
grouped = obj.groupby(key)
grouped = obj.groupby(key, axis=1)
grouped = obj.groupby([key1, key2])
```

Pandas - Grouping the data

Example

```
df = pd.DataFrame({'A' : ['foo', 'bar', '
    foo', 'bar',
'foo', 'bar', 'foo', 'foo'],
'B' : ['one', 'one', 'two', 'three',
'two', 'two', 'one', 'three'],
'C' : np.random.randn(8),
'D' : np.random.randn(8)})
```

Pandas - Grouping the data

Example

```
     A      B         C         D
0  foo    one  0.469112 -0.861849
1  bar    one -0.282863 -2.104569
2  foo    two -1.509059 -0.494929
3  bar  three -1.135632  1.071804
4  foo    two  1.212112  0.721555
5  bar    two -0.173215 -0.706771
6  foo    one  0.119209 -1.039575
7  foo  three -1.044236  0.271860
```

Pandas - Grouping the data

Group by either A or B columns or both

Example

```
>>>grouped = df.groupby('A')
>>>grouped = df.groupby(['A', 'B'])
# Sorts by default, disable this for
   potential speedup
>>>grouped = df.groupby('A',sort=False)
```

Pandas - Grouping the data

Get statistics for the groups

Example

```
>>>grouped.size()
>>>grouped.describe()
>>>grouped.count()
```

Pandas - Grouping the data

Print the grouping

Example

```
>>>list(grouped)
 A      B            C           D
 1   bar     one  -1.303028  -0.932565
 3   bar   three   0.135601   0.268914
 5   bar     two  -0.320369   0.059366)
 0   foo     one   1.066805  -1.252834
 2   foo     two  -0.180407   1.686709
 4   foo     two   0.228522  -0.457232
 6   foo     one  -0.553085   0.512941
 7   foo   three  -0.346510   0.434751)]
```

Pandas - Grouping the data

Get the first and last elements of each grouping. Also, apply the 'sum' function to each column

Example

```
>>>grouped.first()
A       B           C           D
bar   one  -1.303028  -0.932565
foo   one   1.066805  -1.252834
# Similar results can be obtained with g.
   last()
>>>grouped.sum()
 A            C           D
bar  -1.487796  -0.604285
foo   0.215324   0.924336
```

Pandas - Grouping the data

Group aggregation

Example

```
>>>grouped.aggregate(np.sum)
A                C           D
bar  -1.487796  -0.604285
foo   0.215324   0.924336
```

Pandas - Grouping the data

Apply multiple functions to a grouped column

Example

```
>>>grouped['C'].agg([np.sum, np.mean])

A              sum       mean

bar  -1.487796  -0.495932
foo   0.215324   0.043065
```

Pandas - Grouping the data

Visually inspecting the grouping

Example

```
>>>w = grouped['C'].agg([np.sum, np.mean])
   .plot()
>>>import matplotlib.pyplot as plt
>>>plt.show()
```

Pandas - Grouping the data

Apply a transformation to the grouping

Example

```
>>>f = lambda x: x*2
>>>transformed = grouped.transform(f)
>>>print transformed
```

Pandas - Grouping the data

Apply a filter to select a group based on some criterion.

Example

```
>>>grouped.filter(lambda x: sum(x['C']) >
    0)
```

```
     A      B         C         D
0  foo    one  1.066805 -1.252834
2  foo    two -0.180407  1.686709
4  foo    two  0.228522 -0.457232
6  foo    one -0.553085  0.512941
7  foo  three -0.346510  0.434751
```