Python Tips for Data Scientist

Wenqiang Feng and Jing Yang

November 27, 2021

CONTENTS

Welcome to my **Python Tips for Data Scientist** notes! In those notes, you will learn some useful tips for Data Scientist daily work. The PDF version can be downloaded from HERE.

CHAPTER

ONE

PREFACE

Chinese proverb

The palest ink is better than the best memory. – old Chinese proverb

1.1 About

1.1.1 About this note

This document is a summary of our valueable experiences in using `Python` for `Data Scientist` daily work. The PDF version can be downloaded from HERE.

You may download and distribute it. Please be aware, however, that the note contains typos as well as inaccurate or incorrect description.

In this repository, we try to use the detailed `Data Scientist` related demo code and examples to share some useful python tips for Data Scientist work. If you find your work wasn't cited in this note, please feel free to let me know.

Although we are by no means a python programming and Data Scientist expert, We decided that it would be useful for us to share what we learned about Python in the form of easy note with detailed example. We hope those notes will be a valuable tool for your studies.

The notes assume that the reader has a preliminary knowledge of `python` programing, `LaTex` and `Linux`. And this document is generated automatically by using sphinx. More details can be found at [Georg2018].

1.1.2 About the authors

- **Wenqiang Feng**
  - Data Scientist and PhD in Mathematics
  - University of Tennessee, Knoxville
  - Webpage: http://web.utk.edu/~wfeng1
  - Email: von198@gmail.com
- **Xu Gao**
  - Data Scientist/Quantitative Analyst and PhD in Statistics
  - Statistics, University of California, Irvine
  - Webpage: https://sites.google.com/view/xugao
  - Email: duncangao@gmail.com, xgao2@uci.edu
- **Upendra Madam**
  - Senior Data Engineer
  - Computer and Information Sciences
  - University of Texas, Arlington
  - Email: upendra1991@gmail.com

- **Declaration**

  The work of Wenqiang Feng was supported by the IMA, while working at IMA. However, any opinion, finding, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the IMA, UTK, UCI, DST and Google.

1.2 Motivation for this note

No matter you like it or not, Python has been one of the most popular programming languages. I have been using `Python` for almost 4 years. Frankly speaking, I wasn't impressed and attracted by `Python` at the first using. After starting working in industry, I have to use `Python`. Graduately I recognize the elegance of Python and use it as one of my main programming language. But I foud that:

- Most of the `Python` books or tutorials which emphasize on programming will overwhelme the green hand.
- While most of the `Python` books or tutorials for `Data Scientist` or `Data Analysis` didn't cover some essential skills from the engineer side.

So I want to keep some of my valuable tips which are heavily applied in my daily work.

1.3 Feedback and suggestions

Your comments and suggestions are highly appreciated. I am more than happy to receive corrections, suggestions or feedbacks through email (Wenqiang Feng: von198@gmail.com, XuGao: duncangao@gmail.com) for improvements.

CHAPTER

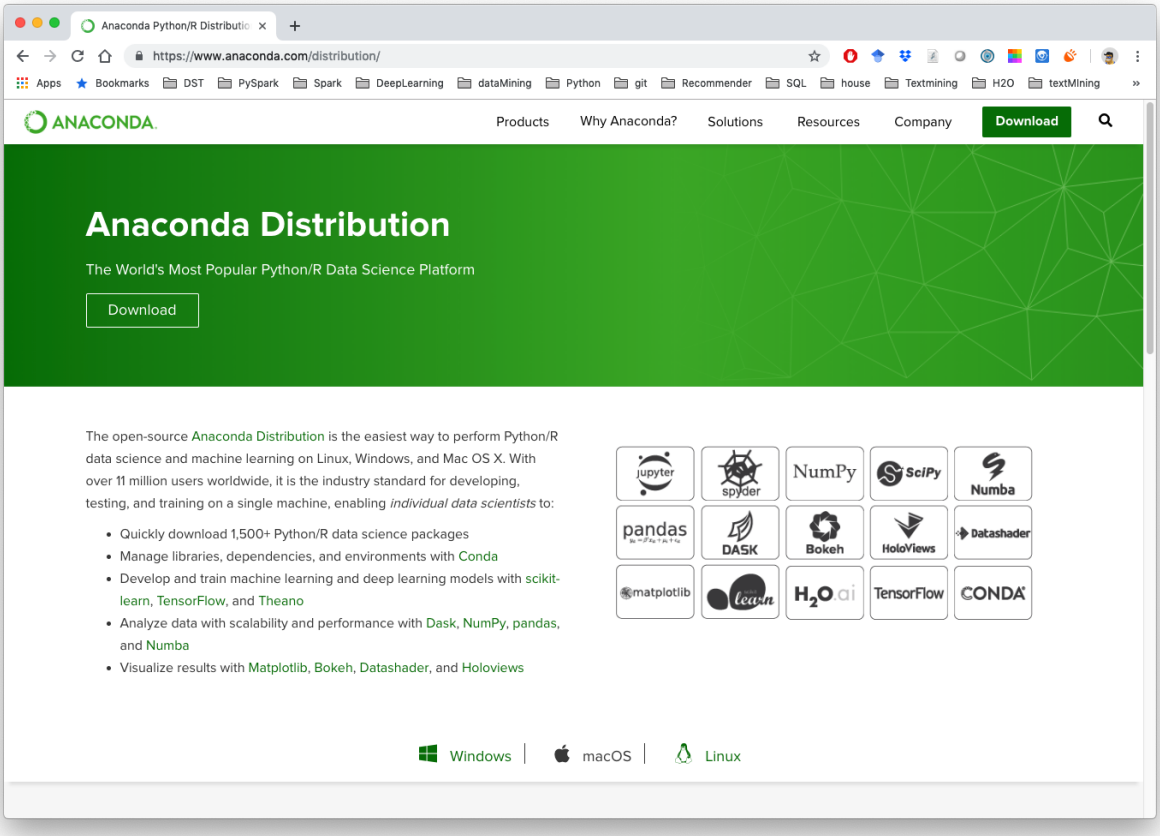
TWO

PYTHON INSTALLATION

Note: This Chapter *Python Installation* is for beginner. If you have some `Python` programming experience, you may skip this chapter.

No matter what operator system is, I will strongly recommend you to install `Anaconda` which contains `Python`, `Jupyter`, `spyder`, `Numpy`, `Scipy`, `Numba`, `pandas`, `DASK`, `Bokeh`, `HoloViews`, `Datashader`, `matplotlib`, `scikit-learn`, `H2O.ai`, `TensorFlow`, `CONDA` and more.

Download link: https://www.anaconda.com/distribution/


Anaconda Python/R Distributio
https://www.anaconda.com/distribution/
Apps
Bookmarks
DST
PySpark
Spark
DeepLearning
dataMining
Python
git
Recommender
SQL
house
Textmining
H2O
textMIning
ANACONDA.
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Why Anaconda?
Solutions
Resources
Company
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Download
The open-source Anaconda Distribution is the easiest way to perform Python/R data science and machine learning on Linux, Windows, and Mac OS X. With over 11 million users worldwide, it is the industry standard for developing, testing, and training on a single machine, enabling individual data scientists to:
Quickly download 1,500+ Python/R data science packages
Manage libraries, dependencies, and environments with Conda
Develop and train machine learning and deep learning models with scikit-learn, TensorFlow, and Theano
Analyze data with scalability and performance with Dask, NumPy, pandas, and Numba
Visualize results with Matplotlib, Bokeh, Datashader, and Holoviews
jupyter
spyder
NumPy
SciPy
Numba
pandas
DASK
Bokeh
HoloViews
Datashader
matplotlib
learn
H2O.ai
TensorFlow
CONDA
Windows
macOS
Linux

CHAPTER

THREE

NOTEBOOKS

Note: This Chapter *Notebooks* is for beginner. If you have alreay know `Nteract`, `Zeppelin` and `Python`, you may skip this chapter.

If you are a Data Scientist, it's not enough to just know `Jupyter Notebook`. You should also take a look at `nbviewer`, `Nteract` and `Zeppelin` notebooks.

3.1 Nteract

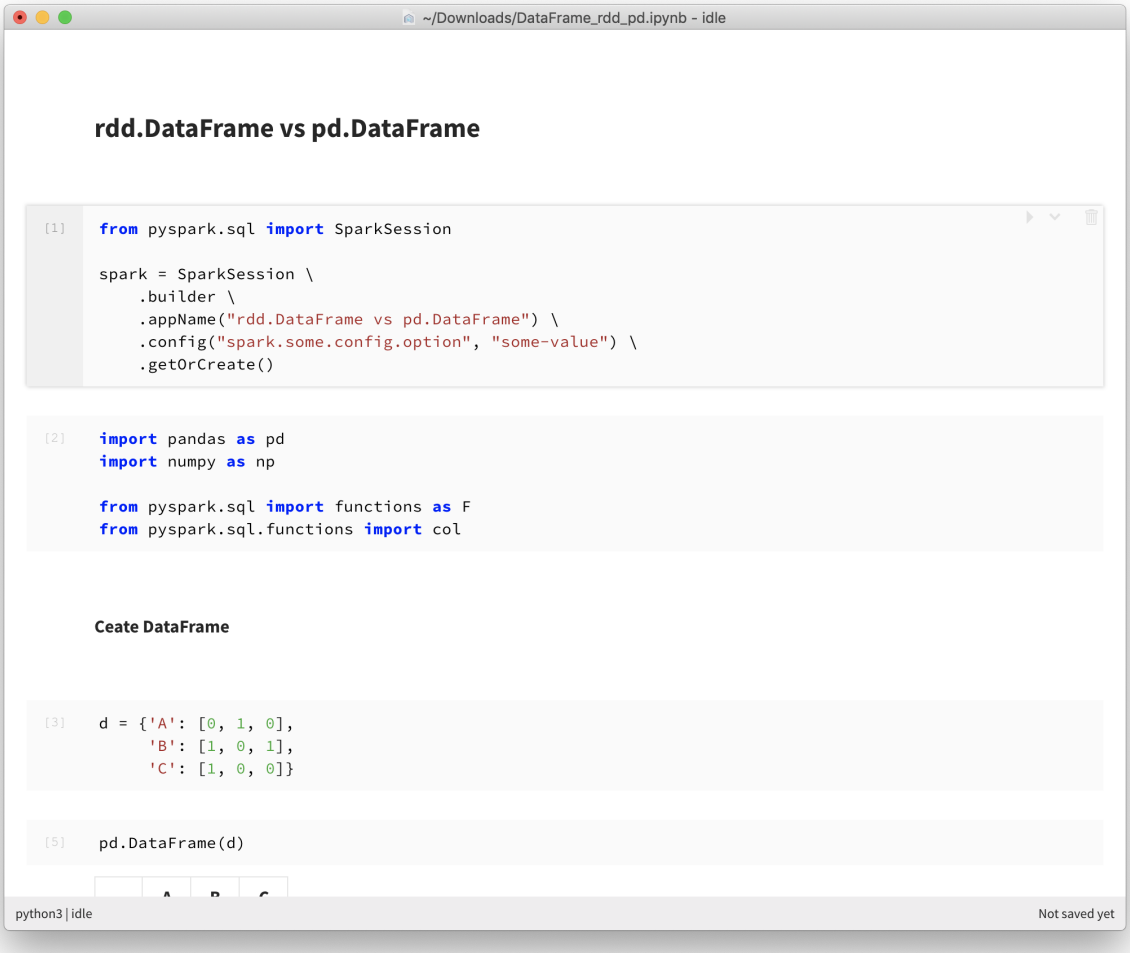
`Nteract` is an amazing `.ipynb` reader. You can open and run the `.ipynb` by just double clicking the `.ipynb` file.

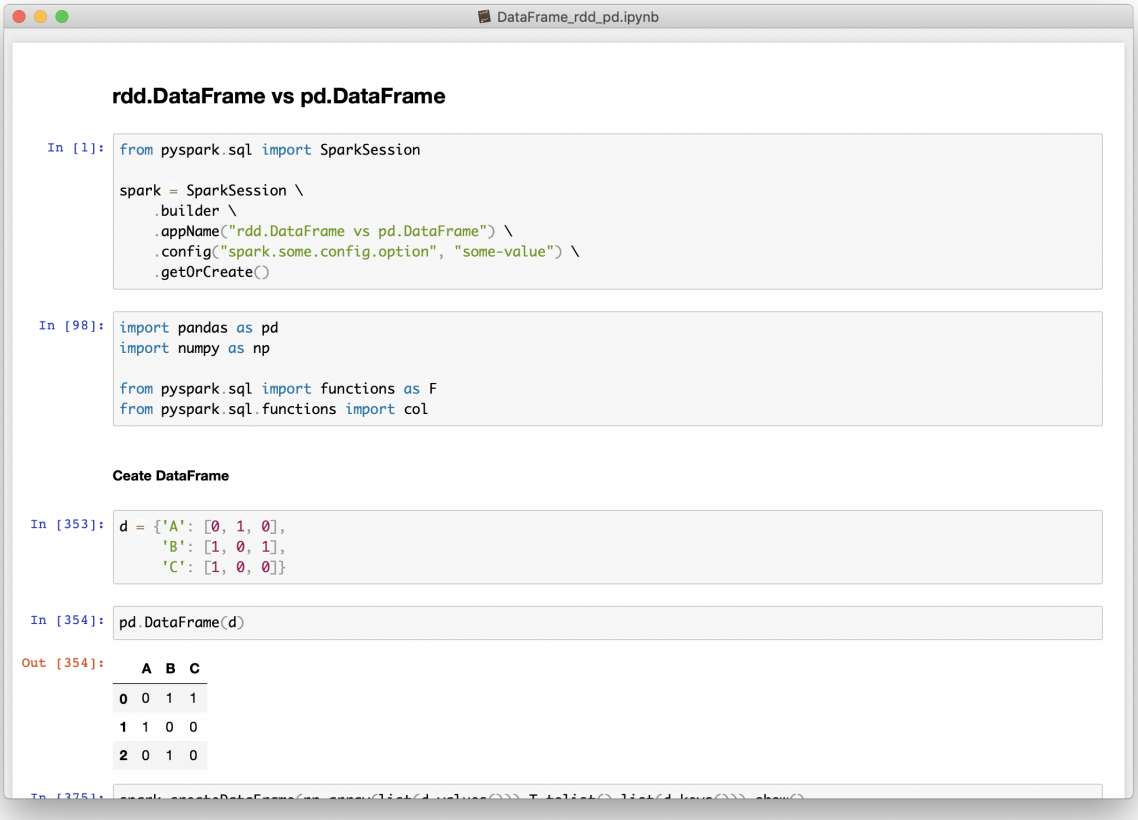
Download from: https://nteract.io/

3.2 Jupyter Notebook Viewer

If you are a MAC user, you can also install the Jupyter Notebook Viewer `–nbviewer-app` which is much faster than `Nteract`.

Download from: https://github.com/tuxu/nbviewer-app

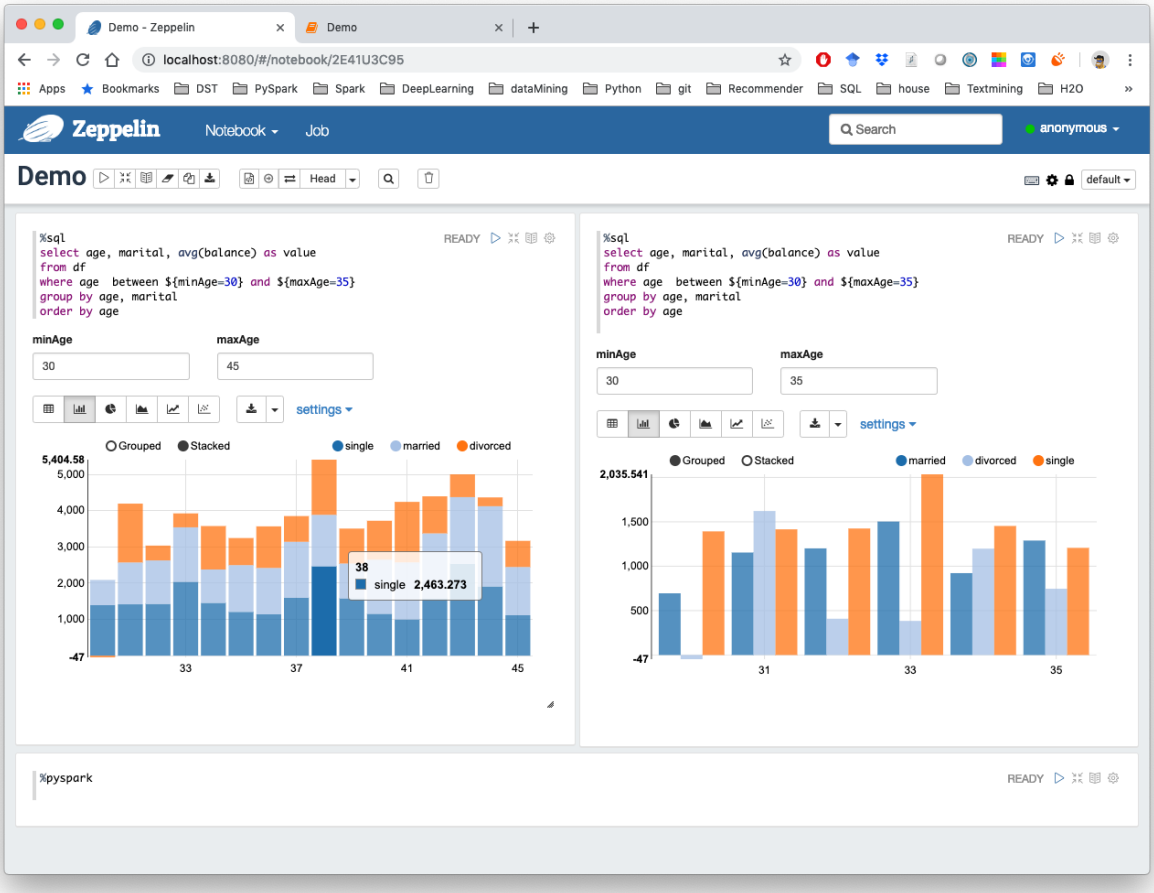

~/Downloads/DataFrame_rdd_pd.ipynb - idle
rdd.DataFrame vs pd.DataFrame
[1]
from pyspark.sql import SparkSession
spark = SparkSession \
.builder \
.appName("rdd.DataFrame vs pd.DataFrame") \
.config("spark.some.config.option", "some-value") \
.getOrCreate()
[2]
import pandas as pd
import numpy as np
from pyspark.sql import functions as F
from pyspark.sql.functions import col
Ceate DataFrame
[3]
d = {'A': [0, 1, 0],
'B': [1, 0, 1],
'C': [1, 0, 0]}
[5]
pd.DataFrame(d)
python3 | idle
Not saved yet


DataFrame_rdd_pd.ipynb
rdd.DataFrame vs pd.DataFrame
In [1]:
from pyspark.sql import SparkSession
spark = SparkSession \
.builder \
.appName("rdd.DataFrame vs pd.DataFrame") \
.config("spark.some.config.option", "some-value") \
.getOrCreate()
In [98]:
import pandas as pd
import numpy as np
from pyspark.sql import functions as F
from pyspark.sql.functions import col
Ceate DataFrame
In [353]:
d = {'A': [0, 1, 0],
'B': [1, 0, 1],
'C': [1, 0, 0]}
In [354]:
pd.DataFrame(d)
Out [354]:
A B C
0 0 1 1
1 1 0 0
2 0 1 0

3.3 Apache Zeppelin

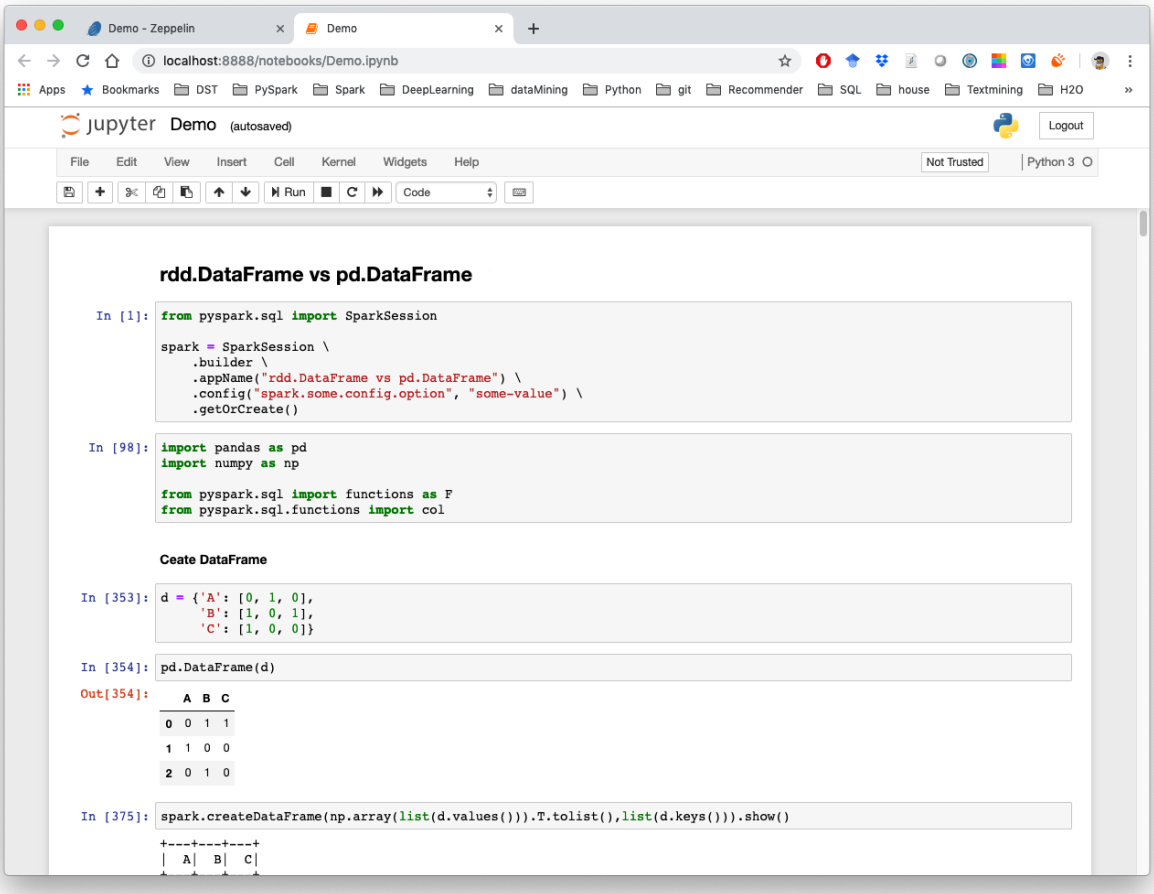
The `Zeppelin` (Apache Zeppelin) is an open-source Web-based notebook that enables data-driven, interactive data analytics and collaborative documents with `Python`, `PySpark`, `SQL`, `Scala` and more.

Download from: https://zeppelin.apache.org/



3.4 Jupyter Notebook

The `Jupyter Notebook` (Ipython Notebook) is an open-source web application that allows you to create and share documents that contain `live code`, `equations`, `visualizations` and `narrative text`. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.


Demo - Zeppelin
Demo
localhost:8888/notebooks/Demo.ipynb
Apps Bookmarks DST PySpark Spark DeepLearning dataMining Python git Recommender SQL house Textmining H2O
jupyter Demo (autosaved)
Logout
File Edit View Insert Cell Kernel Widgets Help
Not Trusted
Python 3
Run
Code
rdd.DataFrame vs pd.DataFrame
In [1]:
from pyspark.sql import SparkSession
spark = SparkSession \
.builder \
.appName("rdd.DataFrame vs pd.DataFrame") \
.config("spark.some.config.option", "some-value") \
.getOrCreate()
In [98]:
import pandas as pd
import numpy as np
from pyspark.sql import functions as F
from pyspark.sql.functions import col
Ceate DataFrame
In [353]:
d = {'A': [0, 1, 0],
'B': [1, 0, 1],
'C': [1, 0, 0]}
In [354]:
pd.DataFrame(d)
Out[354]:
A B C
0 0 1 1
1 1 0 0
2 0 1 0
In [375]:
spark.createDataFrame(np.array(list(d.values())).T.tolist(),list(d.keys())).show()
+---+---+---+
| A| B| C|

CHAPTER

FOUR

CONFIDENTIAL INFORMATION

Chinese proverb

Be mindful of guarding against harm from others, and stay away from placing harming upon others.

If you are a real Data Scientist, you have to share your code with your colleagues or release your code for Code Review or Quality assurance(QA). You will definitely do not want to have your `User Information` in the code. So you can save them in login.txt in a safe folder:

```
runawayhorse001
PythonTips
```

and use the following code to import your `User Information`:

```
#User Information
try:
    login = pd.read_csv(r'login.txt', header=None)
    user = login[0][0]
    pw = login[0][1]
    print('User information is ready!')
except:
    print('Login information is not available!!!')
```

You may also want to get the `User Information` by using `os.environ` in `Python`:

```
try:
    user = os.environ['LOGNAME']
except OSError:
    user = os.environ['USER']
except OSError:
    user = os.environ['USERNAME']
    print(err)
except OSError as err:
    print('The user information is not available!!!')
```

CHAPTER

FIVE

PRIMER FUNCTIONS

Note: This Chapter *Primer Functions* is for beginner. If you have some `Python` programming experience, you may skip this chapter.

The following `functions` have been heavily used in my daily Data Scientist work.

5.1 *

Single asterisk as used in function declaration allows variable number of arguments passed from calling environment. Inside the function it behaves as a tuple.

:: Python Code:

```
my_list = [1,2,3]
print(my_list)
print(*my_list)
```

:: Ouput:

```
[1, 2, 3]
1 2 3
```

5.2 range

:: Python Code:

```
print(range(5))
print(*range(5))
print(*range(3,8))
```

:: Ouput:

```
range(0, 5)
0 1 2 3 4
3 4 5 6 7
```

5.3 random

More details can be found at:

a. random: https://docs.python.org/3/library/random.html#random.randint

b. np.random: https://docs.scipy.org/doc/numpy/reference/routines.random.html

5.3.1 random.random

:: Python Code:

```
import random
random.random()

# (b - a) * random() + a
random.uniform(3,8)
```

:: Ouput:

```
0.33844051243073625
7.772024014335885
```

5.3.2 np.random

:: Python Code:

```
np.random.random_sample()
np.random.random_sample(4)
np.random.random_sample([2,4])

# (b - a) * random_sample() + a
a = 3; b = 8
(b-a)*np.random.random_sample([2,4])+a
```

:: Ouput:

```
0.11919402208670005
array([0.07384755, 0.9005251 , 0.30030561, 0.38221819])
array([[0.76851156, 0.56973309, 0.47074505, 0.7814957 ],
       [0.5778028 , 0.94653057, 0.51193493, 0.48693931]])

array([[4.65799262, 6.32702018, 6.55545234, 5.45877784],
       [7.69941994, 4.68709357, 5.49790728, 4.60913966]])
```

5.4 round

Sometimes, we really do not need the scientific decimals for `output` results. So you can use this function to round an array to the given number of decimals.

:: Python Code:

```
np.round(np.random.random_sample([2,4]),2)
```

:: Ouput:

```
array([[0.76, 0.06, 0.41, 0.4 ],
       [0.07, 0.51, 0.84, 0.76]])
```

5.5 TODO..

:: Python Code:

```

```

:: Ouput:

```

```

:: Python Code:

```

```

:: Ouput:

```

```

:: Python Code:

```
```

:: Ouput:

```
```

:: Python Code:

```
```

:: Ouput:

```
```

CHAPTER

SIX

DATA STRUCTURES

Note: This Chapter *Data Structures* is for beginner. If you have some `Python` programming experience, you may skip this chapter.

6.1 List

`list` is one of data sctructures which is heavily using in my daily work.

6.1.1 Create list

1. Create empty list

The empty list is used to initialize a list.

:: Python Code:

```
my_list = []
type(my_list)
```

:: Ouput:

```
list
```

I applied the empty list to initialize my `silhouette score` list when I try to find the optimal number of the clusters.

:: Example:

```
min_cluster = 3
max_cluster =8
```

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```
# silhouette_score
scores = []

for i in range(min_cluster, max_cluster):
    score = np.round(np.random.random_sample(),2)
    scores.append(score)

print(scores)
```

:: Ouput:

```
[0.16, 0.2, 0.3, 0.87, 0.59]
```

6.1.2 Unpack list

:: Example:

```
num = [1,2,3,4,5,6,7,8,9,10]
print(*num)
```

:: Ouput:

```
1 2 3 4 5 6 7 8 9 10
```

6.1.3 Methods of list objects

Methods of list objects:

Name	Description
list. `append(x)`	Add an item to the end of the list
list. `extend(iterable)`	Extend the list by appending all
list. `insert(i, x)`	Insert an item at a given position
list. `remove(x)`	Remove the first item
list. `pop([i])`	Remove the item at given position
list. `clear()`	Remove all items from the list
list. `index(x[,s[,e]])`	Return zero-based index in the list
list. `count(x)`	Return the number of times x
list. `sort(key,reverse)`	Sort the items of the list
list. `reverse()`	Reverse the elements of the list
list. `copy()`	Return a shallow copy[1] of list

[1] Shallow Copy vs Deep Copy Reference: https://stackoverflow.com/posts/184780/revisions

6.2 Tuple

A tuple is an assortment of data, separated by commas, which makes it similar to the Python list, but a tuple is fundamentally different in that a tuple is "immutable." This means that it cannot be changed, modified, or manipulated.

6.3 Dictionary

`dict` is one of another data sctructures which is heavily using in my daily work. I heavily applied the `dict` in my `PyAudit` package, more details can be found at PyAudit.

6.3.1 Create `dict` from lists

:: Example:

```
col_names = ['name','Age', 'Sex', 'Car']
col_values = ['Michael', '30', 'Male', ['Honda','Tesla']]
#
d = {key: value for key, value in zip(col_names, col_values)}
print(d)
#
import pandas as pd

df = pd.DataFrame(d)
print(df)
```

:: Ouput:

```
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car': ['Honda
↪', 'Tesla']}
      name Age   Sex    Car
0  Michael  30  Male  Honda
1  Michael  30  Male  Tesla
```

Shallow copy:

The variables A and B refer to different areas of memory, when B is assigned to A the two variables refer to the same area of memory. Later modifications to the contents of either are instantly reflected in the contents of other as they share contents.

Deep Copy:

6.3.2 dict.get()

When `get()` is called, Python checks if the specified key exists in the dict. If it does, then `get()` returns the value of that key. If the key does not exist, then `get()` returns the value specified in the second argument to `get()`. A good application of `get()` can be found at *Update Keys in Dict*.

:: Example:

```
data1 = d.get("name", "best")
data2 = d.get("names", "George")
print(data1)  # Michael
print(data2)  # George
```

:: Ouput:

```
Michael
George
```

6.3.3 Looping Techniques

:: Example:

```
print([(key, val) for key, val in d.items()])
```

:: Ouput:

```
[('name', 'Michael'), ('Age', '30'), ('Sex', 'Male'), ('Car',␣
↪['Honda', 'Tesla'])]
```

6.3.4 Update Values in Dict

1. Replace values in dict

   :: Example:

   ```
   replace = {'Car': ['Tesla S', 'Tesla X']}
   print(d)
   d.update(replace)
   print(d)
   ```

   :: Ouput:

```
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car
↪': ['Honda', 'Tesla']}
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car
↪': ['Tesla S', 'Tesla X']}
```

2. Add key and values in dict

:: Example:

```
# add key and values in dict
added = {'Kid': ['Tom', 'Jim']}
print(d)
d.update(added)
print(d)
```

:: Ouput:

```
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car
↪': ['Tesla S', 'Tesla X']}
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car
↪': ['Tesla S', 'Tesla X'], 'Kid': ['Tom', 'Jim']}
```

6.3.5 Update Keys in Dict

:: Example:

```
# update keys in dict
mapping = {'Car': 'Cars', 'Kid': 'Kids'}
#
print({mapping.get(key, key): val for key, val in d.items()})
```

:: Ouput:

```
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Car': [
↪'Tesla S', 'Tesla X'], 'Kid': ['Tom', 'Jim']}
{'name': 'Michael', 'Age': '30', 'Sex': 'Male', 'Cars': [
↪'Tesla S', 'Tesla X'], 'Kids': ['Tom', 'Jim']}
```

6.4 One line if-else statement

6.4.1 With filter

::syntax:

```
[ RESUT for x in seq if COND ]
```

:: Python Code:

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

[x for x in num if x%2 ==0]
```

:: Ouput:

```
[2, 4, 6, 8, 10]
```

6.4.2 Without filter

::syntax:

```
[ RESUT1 if COND1  else RESUT2 if COND2 else RESUT3 for x in␣
↪seq]
```

:: Python Code:

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

['Low' if 1<= x <=3 else 'Median' if 3<x<8 else 'High' for x␣
↪in num]
```

:: Ouput:

```
['Low',
 'Low',
 'Low',
 'Median',
 'Median',
 'Median',
 'Median',
 'High',
 'High',
 'High']
```

[VanderPlas2016] [McKinney2013]

CHAPTER

SEVEN

DATA READ AND INGESTION WITH DATABASE

7.1 Data Ingestion from Local to DataBase

```
# User Information
try:
    login = pd.read_csv(r'login.txt', header=None)
    user = login[0][0]
    pw = login[0][1]
    print('User information is ready!')
except:
    print('Login information is not available!!!')

# Database information
host = '##.###.###.##'
db_name = 'db_name'
table_name = 'table_name'

# Setup connection
conn = psycopg2.connect(host=host, database=db_name, user=user,␣
↪password=pw)
cur = conn.cursor()

# Creat table in DataBase
conn.commit()
query = """
    DROP TABLE IF EXISTS {table_name};
    CREATE TABLE {table_name}
    (   id character varying(20)
      , val1 double precision
      , val2 double precision
      , val3 double precision
      , val4 text
    )
    DISTRIBUTED BY (id);
```

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```
    GRANT SELECT ON TABLE {table_name} TO xxxx;
    """.format(table_name=table_name)
cur.execute(query)
conn.commit()


# load the data
df = pd.read_csv('xx.csv')

# Write dataframe to memory as csv
csv_io = io.StringIO()
df.to_csv(csv_io, sep='\t', header=True, index=False)
csv_io.seek(0)

# Copy the dataframe in memory to GP
conn.commit()
copy_sql = """
           COPY {table_name} FROM stdin WITH CSV HEADER
           DELIMITER as '\t'
           """.format(table_name=table_name)
cur.copy_expert(sql=copy_sql, file=csv_io)
conn.commit()
```

Note: You can also use `copy_to` to copy the dataframe from local memory to GP

```
cur.copy_to(df, table_name)
```

7.2 Data Read from DataBase to Local

```
# User information
try:
    login = pd.read_csv(r'login.txt', header=None)
    user = login[0][0]
    pw = login[0][1]
    print('User information is ready!')
except:
    print('Login information is not available!!!')

# Database information
host = '##.###.###.##'
db_name = 'db_name'
```

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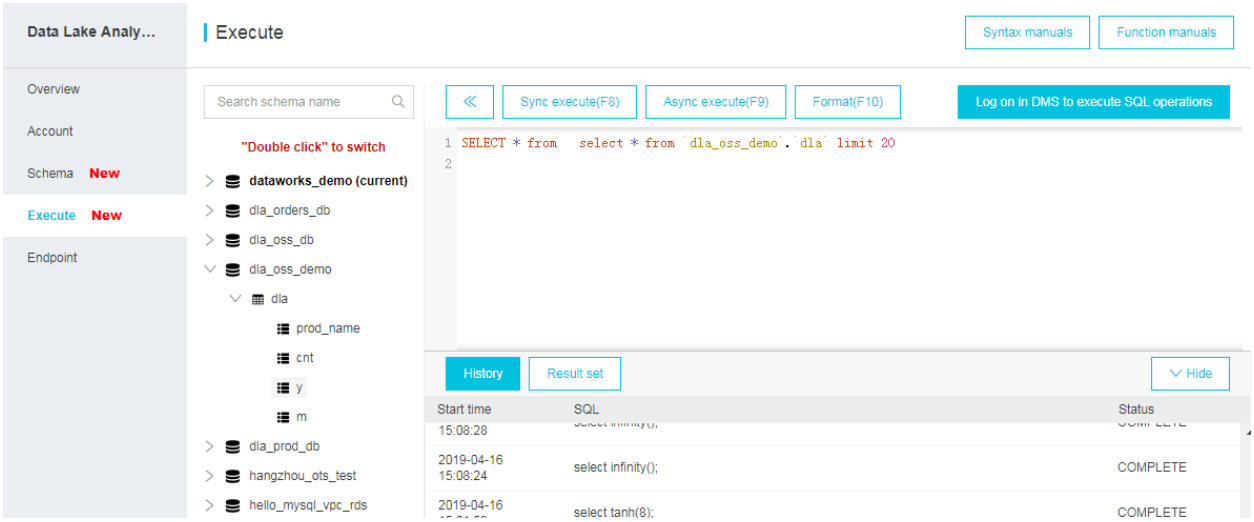
```
table_name = 'table_name'

# Setup connection
conn = psycopg2.connect(host=host, database=db_name, user=user,␣
↪password=pw)
cur = conn.cursor()

# Read table
sql = """
      select *
      from {table_name}
      """.format(table_name=table_name)
dp = pd.read_sql(sql, conn)
```

7.3 Hive and Impala Tabel Ingestion



CHAPTER

EIGHT

PD.DATAFRAME MANIPULATION

Note: This Chapter *Notebooks* is for beginner. If you have some `Python` programming experience, you may skip this chapter.

8.1 TODO..

CHAPTER

NINE

RDD . DATAFRAME MANIPULATION

Note: This Chapter *Notebooks* is for beginner. If you have some `Python` programming experience, you may skip this chapter.

9.1 TODO..

CHAPTER

TEN

PD.DATAFRAME VS PD.DATAFRAME

10.1 Create DataFrame

10.1.1 From List

```
my_list = [['a', 1, 2], ['b', 2, 3],['c', 3, 4]]
col_name = ['A', 'B', 'C']
```

:: Python Code:

```
# caution for the columns=
pd.DataFrame(my_list,columns= col_name)
#
spark.createDataFrame(my_list, col_name).show()
```

:: Comparison:

```
                  +---+---+---+
                  |  A|  B|  C|
   A  B  C        +---+---+---+
0  a  1  2        |  a|  1|  2|
1  b  2  3        |  b|  2|  3|
2  c  3  4        |  c|  3|  4|
                  +---+---+---+
```

Attention: Pay attentation to the parameter `columns=` in `pd.DataFrame`. Since the default value will make the list as rows.

:: Python Code:

```
# caution for the columns=
pd.DataFrame(my_list, columns= col_name)
#
pd.DataFrame(my_list, col_name)
```

:: Comparison:

```
   A  B  C              0  1  2
0  a  1  2          A   a  1  2
1  b  2  3          B   b  2  3
2  c  3  4          C   c  3  4
```

10.1.2 From Dict

```
d = {'A': [0, 1, 0],
     'B': [1, 0, 1],
     'C': [1, 0, 0]}
```

:: Python Code:

```
pd.DataFrame(d)for
# Tedious for PySpark
spark.createDataFrame(np.array(list(d.values())).T.tolist(),list(d.
↪keys())).show()
```

:: Comparison:

```
                    +---+---+---+
                    |  A|  B|  C|
   A  B  C          +---+---+---+
0  0  1  1          |  0|  1|  1|
1  1  0  0          |  1|  0|  0|
2  0  1  0          |  0|  1|  0|
                    +---+---+---+
```

10.2 Load DataFrame

10.2.1 From DataBase

Most of time, you need to share your code with your colleagues or release your code for Code Review or Quality assurance(QA). You will definitely do not want to have your `User Information` in the code. So you can save them in login.txt:

```
runawayhorse001
PythonTips
```

and use the following code to import your `User Information`:

```
#User Information
try:
    login = pd.read_csv(r'login.txt', header=None)
    user = login[0][0]
    pw = login[0][1]
    print('User information is ready!')
except:
    print('Login information is not available!!!')

#Database information
host = '##.###.###.##'
db_name = 'db_name'
table_name = 'table_name'
```

:: Comparison:

```
conn = psycopg2.connect(host=host, database=db_name, user=user,␣
↪password=pw)
cur = conn.cursor()

sql = """
      select *
      from {table_name}
      """.format(table_name=table_name)
dp = pd.read_sql(sql, conn)
```

```
# connect to database
url = 'jdbc:postgresql://'+host+':5432/'+db_name+'?user='+user+'&
↪password='+pw
properties ={'driver': 'org.postgresql.Driver', 'password': pw,'user':␣
↪user}
ds = spark.read.jdbc(url=url, table=table_name, properties=properties)
```

Attention: Reading tables from Database with PySpark needs the proper drive for the corresponding Database. For example, the above demo needs org.postgresql.Driver and you need to download it and put it in `jars` folder of your spark installation path. I download postgresql-42.1.1.jar from the official website and put it in jars folder.

10.2.2 From `.csv`

:: Comparison:

```
# pd.DataFrame dp: DataFrame pandas
dp = pd.read_csv('Advertising.csv')
#rdd.DataFrame. dp: DataFrame spark
ds = spark.read.csv(path='Advertising.csv',
#                   sep=',',
#                   encoding='UTF-8',
#                   comment=None,
                    header=True,
                    inferSchema=True)
```

10.2.3 From `.json`

Data from: http://api.luftdaten.info/static/v1/data.json

```
dp = pd.read_json("data/data.json")
ds = spark.read.json('data/data.json')
```

:: Python Code:

```
dp[['id','timestamp']].head(4)
#
ds[['id','timestamp']].show(4)
```

:: Comparison:

```
                                                  +----------+-----------
↪--------+
                                                  |        id|          ␣
↪timestamp|
           id  timestamp                          +----------+-----------
↪--------+
0   2994551481  2019-02-28 17:23:52               |2994551481|2019-02-28␣
↪17:23:52|
1   2994551482  2019-02-28 17:23:52               |2994551482|2019-02-28␣
↪17:23:52|
2   2994551483  2019-02-28 17:23:52               |2994551483|2019-02-28␣
↪17:23:52|
3   2994551484  2019-02-28 17:23:52               |2994551484|2019-02-28␣
↪17:23:52|
                                                  +----------+-----------
↪--------+
                                                  only showing top 4 rows
```

10.3 First n Rows

:: Python Code:

```
dp.head(4)
#
ds.show(4)
```

:: Comparison:

```
      TV  Radio  Newspaper  Sales
0  230.1   37.8       69.2   22.1
1   44.5   39.3       45.1   10.4
2   17.2   45.9       69.3    9.3
3  151.5   41.3       58.5   18.5
```

```
+-----+-----+---------+-----+
|   TV|Radio|Newspaper|Sales|
+-----+-----+---------+-----+
|230.1| 37.8|     69.2| 22.1|
| 44.5| 39.3|     45.1| 10.4|
| 17.2| 45.9|     69.3|  9.3|
|151.5| 41.3|     58.5| 18.5|
+-----+-----+---------+-----+
only showing top 4 rows
```

10.4 Column Names

:: Python Code:

```
dp.columns
#
ds.columns
```

:: Comparison:

```
Index(['TV', 'Radio', 'Newspaper', 'Sales'], dtype='object')
['TV', 'Radio', 'Newspaper', 'Sales']
```

10.5 Data types

:: Python Code:

```
dp.dtypes
#
ds.dtypes
```

:: Comparison:

```
TV           float64                      [('TV', 'double'),
Radio        float64                       ('Radio', 'double'),
Newspaper    float64                       ('Newspaper', 'double'),
Sales        float64                       ('Sales', 'double')]
dtype: object
```

10.6 Replace Data types

```
my_list = [('a', 2, 3),
           ('b', 5, 6),
           ('c', 8, 9),
           ('a', 2, 3),
           ('b', 5, 6),
           ('c', 8, 9)]
col_name = ['col1', 'col2', 'col3']


dp = pd.DataFrame(my_list,columns=col_name)
ds = spark.createDataFrame(dp)

dp.dtypes
```

```
col1    object
col2     int64
col3     int64
dtype: object
```

:: Python Code:

```
d = {'col2': 'string','col3':'string'}
dp = dp.astype({'col2': 'str','col3':'str'})
ds = ds.select(*list(set(ds.columns)-set(d.keys())),
               *(col(c[0]).astype(c[1]).alias(c[0]) for c in d.
 ↪items()))
```

:: Comparison:

```
col1    object
col2    object          [('col1', 'string'), ('col2', 'string'), (
 ↪'col3', 'string')]
col3    object
dtype: object
```

10.7 Fill Null

```
my_list = [['a', 1, None], ['b', 2, 3],['c', 3, 4]]
dp = pd.DataFrame(my_list,columns=['A', 'B', 'C'])
ds = spark.createDataFrame(my_list, ['A', 'B', 'C'])
#
dp.head()
ds.show()
```

:: Comparison:

```
                                    +------+---+----+
                                    |     A|  B|   C|
        A  B    C                   +------+---+----+
0    male  1  NaN                   |  male|  1|null|
1  female  2  3.0                   |female|  2|   3|
2    male  3  4.0                   |  male|  3|   4|
                                    +------+---+----+
```

:: Python Code:

```
dp.fillna(-99)
#
ds.fillna(-99).show()
```

:: Comparison:

```
                                    +------+---+----+
                                    |     A|  B|   C|
        A  B    C                   +------+---+----+
0    male  1  -99                   |  male|  1| -99|
1  female  2  3.0                   |female|  2|   3|
2    male  3  4.0                   |  male|  3|   4|
                                    +------+---+----+
```

10.8 Replace Values

:: Python Code:

```
# caution: you need to chose specific col
dp.A.replace(['male', 'female'],[1, 0], inplace=True)
dp
#caution: Mixed type replacements are not supported
ds.na.replace(['male','female'],['1','0']).show()
```

:: Comparison:

```
   A  B    C                    +---+---+----+
0  1  1  NaN                    |  A|  B|   C|
1  0  2  3.0                    +---+---+----+
2  1  3  4.0                    |  1|  1|null|
                                |  0|  2|   3|
                                |  1|  3|   4|
                                +---+---+----+
```

10.9 Rename Columns

10.9.1 Rename all columns

:: Python Code:

```
dp.columns = ['a','b','c','d']
dp.head(4)
#
ds.toDF('a','b','c','d').show(4)
```

:: Comparison:

```
      a     b     c     d                +-----+----+----+----+
0  230.1  37.8  69.2  22.1                |    a|   b|   c|   d|
1   44.5  39.3  45.1  10.4                +-----+----+----+----+
2   17.2  45.9  69.3   9.3                |230.1|37.8|69.2|22.1|
3  151.5  41.3  58.5  18.5                | 44.5|39.3|45.1|10.4|
                                          | 17.2|45.9|69.3| 9.3|
                                          |151.5|41.3|58.5|18.5|
                                          +-----+----+----+----+
                                          only showing top 4 rows
```

10.9.2 Rename one or more columns

```
mapping = {'Newspaper':'C','Sales':'D'}
```

:: Python Code:

```
dp.rename(columns=mapping).head(4)
#
new_names = [mapping.get(col,col) for col in ds.columns]
ds.toDF(*new_names).show(4)
```

:: Comparison:

```
      TV  Radio     C     D
0  230.1   37.8  69.2  22.1
1   44.5   39.3  45.1  10.4
2   17.2   45.9  69.3   9.3
3  151.5   41.3  58.5  18.5
```

```
+-----+-----+----+----+
|   TV|Radio|   C|   D|
+-----+-----+----+----+
|230.1| 37.8|69.2|22.1|
| 44.5| 39.3|45.1|10.4|
| 17.2| 45.9|69.3| 9.3|
|151.5| 41.3|58.5|18.5|
+-----+-----+----+----+
only showing top 4 rows
```

Note: You can also use `withColumnRenamed` to rename one column in PySpark.

:: Python Code:

```
ds.withColumnRenamed('Newspaper','Paper').show(4
```

:: Comparison:

```
+-----+-----+-----+-----+
|   TV|Radio|Paper|Sales|
+-----+-----+-----+-----+
|230.1| 37.8| 69.2| 22.1|
| 44.5| 39.3| 45.1| 10.4|
| 17.2| 45.9| 69.3|  9.3|
|151.5| 41.3| 58.5| 18.5|
+-----+-----+-----+-----+
only showing top 4 rows
```

10.10 Drop Columns

```
drop_name = ['Newspaper','Sales']
```

:: Python Code:

```
dp.drop(drop_name,axis=1).head(4)
#
ds.drop(*drop_name).show(4)
```

:: Comparison:

```
      TV  Radio                +-----+-----+
0  230.1   37.8                |   TV|Radio|
1   44.5   39.3                +-----+-----+
2   17.2   45.9                |230.1| 37.8|
3  151.5   41.3                | 44.5| 39.3|
                                | 17.2| 45.9|
                                |151.5| 41.3|
                                +-----+-----+
                                only showing top 4 rows
```

10.11 Filter

```
dp = pd.read_csv('Advertising.csv')
#
ds = spark.read.csv(path='Advertising.csv',
                    header=True,
                    inferSchema=True)
```

:: Python Code:

```
dp[dp.Newspaper<20].head(4)
#
ds[ds.Newspaper<20].show(4)
```

:: Comparison:

```
                                                +-----+-----+---------
 ↪+-----+
                                                |  ␣
 ↪TV|Radio|Newspaper|Sales|
       TV  Radio  Newspaper  Sales              +-----+-----+---------
 ↪+-----+
7   120.2   19.6       11.6   13.2              |120.2| 19.6|     11.
 ↪6| 13.2|
8     8.6    2.1        1.0    4.8              |  8.6|  2.1|      1.
 ↪0|  4.8|
11  214.7   24.0        4.0   17.4              |214.7| 24.0|      4.
 ↪0| 17.4|
13   97.5    7.6        7.2    9.7              | 97.5|  7.6|      7.
 ↪2|  9.7|
                                                +-----+-----+---------
 ↪+-----+
                                                only showing top 4 rows
```

:: Python Code:

```
dp[(dp.Newspaper<20)&(dp.TV>100)].head(4)
#
ds[(ds.Newspaper<20)&(ds.TV>100)].show(4)
```

:: Comparison:

```
                                                    +-----+-----+---------
 ↪+-----+
                                                    |  ␣
 ↪TV|Radio|Newspaper|Sales|
       TV  Radio  Newspaper  Sales                  +-----+-----+---------
 ↪+-----+
7   120.2   19.6       11.6   13.2                  |120.2| 19.6|     11.
 ↪6| 13.2|
11  214.7   24.0        4.0   17.4                  |214.7| 24.0|      4.
 ↪0| 17.4|
19  147.3   23.9       19.1   14.6                  |147.3| 23.9|     19.
 ↪1| 14.6|
25  262.9    3.5       19.5   12.0                  |262.9|  3.5|     19.
 ↪5| 12.0|
                                                    +-----+-----+---------
 ↪+-----+
                                                    only showing top 4 rows
```

10.12 With New Column

:: Python Code:

```
dp['tv_norm'] = dp.TV/sum(dp.TV)
dp.head(4)
#
ds.withColumn('tv_norm', ds.TV/ds.groupBy().agg(F.sum("TV")).
 ↪collect()[0][0]).show(4)
```

:: Comparison:

```
                                                    +-----+-----+---------
 ↪+-----+--------------------+
                                                    |  ␣
 ↪TV|Radio|Newspaper|Sales|             tv_norm|
      TV  Radio  Newspaper  Sales    tv_norm      +-----+-----+---------
 ↪+-----+--------------------+
0  230.1   37.8       69.2   22.1  0.007824       |230.1| 37.8|     69.
 ↪2| 22.1|0.007824268493802813|
```

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```
1   44.5   39.3       45.1   10.4  0.001513     | 44.5| 39.3|     45.
↪1| 10.4|0.001513167961643...|
2   17.2   45.9       69.3    9.3  0.000585     | 17.2| 45.9|     69.
↪3|  9.3|5.848649200061207E-4|
3  151.5   41.3       58.5   18.5  0.005152     |151.5| 41.3|     58.
↪5| 18.5|0.005151571824472517|
                                                +-----+-----+---------
↪+-----+--------------------+
                                                only showing top 4 rows
```

:: Python Code:

```
dp['cond'] = dp.apply(lambda c: 1 if ((c.TV>100)&(c.Radio<40)) else 2␣
↪if c.Sales> 10 else 3,axis=1)
#
ds.withColumn('cond',F.when((ds.TV>100)&(ds.Radio<40),1)\
                      .when(ds.Sales>10, 2)\
                      .otherwise(3)).show(4)
```

:: Comparison:

```
                                                +-----+-----+---------
↪+-----+----+
                                                |  ␣
↪TV|Radio|Newspaper|Sales|cond|
     TV  Radio  Newspaper  Sales  cond         +-----+-----+---------
↪+-----+----+
0  230.1   37.8       69.2   22.1     1         |230.1| 37.8|     69.
↪2| 22.1|   1|
1   44.5   39.3       45.1   10.4     2         | 44.5| 39.3|     45.
↪1| 10.4|   2|
2   17.2   45.9       69.3    9.3     3         | 17.2| 45.9|     69.
↪3|  9.3|   3|
3  151.5   41.3       58.5   18.5     2         |151.5| 41.3|     58.
↪5| 18.5|   2|
                                                +-----+-----+---------
↪+-----+----+
                                                only showing top 4 rows
```

:: Python Code:

```
dp['log_tv'] = np.log(dp.TV)
dp.head(4)
#
ds.withColumn('log_tv',F.log(ds.TV)).show(4)
```

:: Comparison:

```
                                                    +-----+-----+---------
↪+-----+------------------+
                                                    |  ␣
↪TV|Radio|Newspaper|Sales|            log_tv|
      TV  Radio  Newspaper  Sales    log_tv     +-----+-----+---------
↪+-----+------------------+
0  230.1   37.8       69.2   22.1  5.438514     |230.1| 37.8|     69.
↪2| 22.1|  5.43851399704132|
1   44.5   39.3       45.1   10.4  3.795489     | 44.5| 39.3|     45.
↪1| 10.4|3.7954891891721947|
2   17.2   45.9       69.3    9.3  2.844909     | 17.2| 45.9|     69.
↪3|  9.3|2.8449093838194073|
3  151.5   41.3       58.5   18.5  5.020586     |151.5| 41.3|     58.
↪5| 18.5| 5.020585624949423|
                                                    +-----+-----+---------
↪+-----+------------------+
                                                    only showing top 4 rows
```

:: Python Code:

```
dp['tv+10'] = dp.TV.apply(lambda x: x+10)
dp.head(4)
#
ds.withColumn('tv+10', ds.TV+10).show(4)
```

:: Comparison:

```
                                                    +-----+-----+---------
↪+-----+-----+
                                                    |  ␣
↪TV|Radio|Newspaper|Sales|tv+10|
      TV  Radio  Newspaper  Sales  tv+10        +-----+-----+---------
↪+-----+-----+
0  230.1   37.8       69.2   22.1  240.1        |230.1| 37.8|     69.
↪2| 22.1|240.1|
1   44.5   39.3       45.1   10.4   54.5        | 44.5| 39.3|     45.
↪1| 10.4| 54.5|
2   17.2   45.9       69.3    9.3   27.2        | 17.2| 45.9|     69.
↪3|  9.3| 27.2|
3  151.5   41.3       58.5   18.5  161.5        |151.5| 41.3|     58.
↪5| 18.5|161.5|
                                                    +-----+-----+---------
↪+-----+-----+
                                                    only showing top 4 rows
```

10.13 Join

```
leftp = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                      'B': ['B0', 'B1', 'B2', 'B3'],
                      'C': ['C0', 'C1', 'C2', 'C3'],
                      'D': ['D0', 'D1', 'D2', 'D3']},
                      index=[0, 1, 2, 3])

rightp = pd.DataFrame({'A': ['A0', 'A1', 'A6', 'A7'],
                       'F': ['B4', 'B5', 'B6', 'B7'],
                       'G': ['C4', 'C5', 'C6', 'C7'],
                       'H': ['D4', 'D5', 'D6', 'D7']},
                       index=[4, 5, 6, 7])

lefts = spark.createDataFrame(leftp)
rights = spark.createDataFrame(rightp)
```

```
    A   B   C   D                   A   F   G   H
0  A0  B0  C0  D0               4  A0  B4  C4  D4
1  A1  B1  C1  D1               5  A1  B5  C5  D5
2  A2  B2  C2  D2               6  A6  B6  C6  D6
3  A3  B3  C3  D3               7  A7  B7  C7  D7
```

10.13.1 Left Join

:: Python Code:

```
leftp.merge(rightp,on='A',how='left')
#
lefts.join(rights,on='A',how='left')
     .orderBy('A',ascending=True).show()
```

:: Comparison:

```
                                        +---+---+---+---+----+----+----
↪+
                                        |  A|  B|  C|  D|   F|   G|  ␣
↪H|
    A   B   C   D    F    G    H        +---+---+---+---+----+----+----
↪+
0  A0  B0  C0  D0   B4   C4   D4        | A0| B0| C0| D0|  B4|  C4| ␣
↪D4|
1  A1  B1  C1  D1   B5   C5   D5        | A1| B1| C1| D1|  B5|  C5| ␣
↪D5|
```

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```
2  A2  B2  C2  D2  NaN  NaN  NaN          | A2| B2| C2|␣
↪D2|null|null|null|
3  A3  B3  C3  D3  NaN  NaN  NaN          | A3| B3| C3|␣
↪D3|null|null|null|
                                          +---+---+---+---+----+----+----
↪+
```

10.13.2 Right Join

:: Python Code:

```
leftp.merge(rightp,on='A',how='right')
#
lefts.join(rights,on='A',how='right')
     .orderBy('A',ascending=True).show()
```

:: Comparison:

```
                                          +---+----+----+----+---+---+---
↪+
                                          |  A|   B|   C|   D|  F|  G| ␣
↪H|
   A    B    C    D   F   G   H          +---+----+----+----+---+---+---
↪+
0  A0   B0   C0   D0  B4  C4  D4          | A0|  B0|  C0|  D0| B4| C4|␣
↪D4|
1  A1   B1   C1   D1  B5  C5  D5          | A1|  B1|  C1|  D1| B5| C5|␣
↪D5|
2  A6  NaN  NaN  NaN  B6  C6  D6          | A6|null|null|null| B6| C6|␣
↪D6|
3  A7  NaN  NaN  NaN  B7  C7  D7          | A7|null|null|null| B7| C7|␣
↪D7|
                                          +---+----+----+----+---+---+---
↪+
```

10.13.3 Inner Join

:: Python Code:

```
leftp.merge(rightp,on='A',how='inner')
#
lefts.join(rights,on='A',how='inner')
     .orderBy('A',ascending=True).show()
```

:: Comparison:

```
                                +---+---+---+---+---+---+---+
                                |  A|  B|  C|  D|  F|  G|  H|
    A   B   C   D   F   G   H   +---+---+---+---+---+---+---+
0  A0  B0  C0  D0  B4  C4  D4   | A0| B0| C0| D0| B4| C4| D4|
1  A1  B1  C1  D1  B5  C5  D5   | A1| B1| C1| D1| B5| C5| D5|
                                +---+---+---+---+---+---+---+
```

10.13.4 Full Join

:: Python Code:

```
leftp.merge(rightp,on='A',how='full')
#
lefts.join(rights,on='A',how='full')
     .orderBy('A',ascending=True).show()
```

:: Comparison:

```
                                      +---+----+----+----+----+----+----+-
 ↪---+
                                      |  A|   B|   C|   D|   F|   G|
 ↪  H|
    A    B    C    D    F    G    H   +---+----+----+----+----+----+----+-
 ↪---+
0  A0   B0   C0   D0   B4   C4   D4   | A0|  B0|  C0|  D0|  B4|  C4|
 ↪ D4|
1  A1   B1   C1   D1   B5   C5   D5   | A1|  B1|  C1|  D1|  B5|  C5|
 ↪ D5|
2  A2   B2   C2   D2  NaN  NaN  NaN   | A2|  B2|  C2|
 ↪D2|null|null|null|
3  A3   B3   C3   D3  NaN  NaN  NaN   | A3|  B3|  C3|
 ↪D3|null|null|null|
4  A6  NaN  NaN  NaN   B6   C6   D6   | A6|null|null|null|  B6|  C6|
 ↪ D6|
5  A7  NaN  NaN  NaN   B7   C7   D7   | A7|null|null|null|  B7|  C7|
 ↪ D7|
                                      +---+----+----+----+----+----+----+-
 ↪---+
```

10.14 Concat Columns

```
my_list = [('a', 2, 3),
           ('b', 5, 6),
           ('c', 8, 9),
           ('a', 2, 3),
           ('b', 5, 6),
           ('c', 8, 9)]
col_name = ['col1', 'col2', 'col3']
#
dp = pd.DataFrame(my_list,columns=col_name)
ds = spark.createDataFrame(my_list,schema=col_name)
```

```
  col1  col2  col3
0    a     2     3
1    b     5     6
2    c     8     9
3    a     2     3
4    b     5     6
5    c     8     9
```

:: Python Code:

```
dp['concat'] = dp.apply(lambda x:'%s%s'%(x['col1'],x['col2']),axis=1)
dp
#
ds.withColumn('concat',F.concat('col1','col2')).show()
```

:: Comparison:

```
  col1  col2  col3 concat
0    a     2     3     a2
1    b     5     6     b5
2    c     8     9     c8
3    a     2     3     a2
4    b     5     6     b5
5    c     8     9     c8
```

```
+----+----+----+------+
|col1|col2|col3|concat|
+----+----+----+------+
|   a|   2|   3|    a2|
|   b|   5|   6|    b5|
|   c|   8|   9|    c8|
|   a|   2|   3|    a2|
|   b|   5|   6|    b5|
|   c|   8|   9|    c8|
+----+----+----+------+
```

10.15 GroupBy

:: Python Code:

```
dp.groupby(['col1']).agg({'col2':'min','col3':'mean'})
#
ds.groupBy(['col1']).agg({'col2': 'min', 'col3': 'avg'}).show()
```

:: Comparison:

```
      col2  col3                          +----+---------+---------+
col1                                      |col1|min(col2)|avg(col3)|
a        2     3                          +----+---------+---------+
b        5     6                          |   c|        8|      9.0|
c        8     9                          |   b|        5|      6.0|
                                          |   a|        2|      3.0|
                                          +----+---------+---------+
```

10.16 Pivot

:: Python Code:

```
pd.pivot_table(dp, values='col3', index='col1', columns='col2',␣
↪aggfunc=np.sum)
#
ds.groupBy(['col1']).pivot('col2').sum('col3').show()
```

:: Comparison:

```
                                  +----+----+----+----+
col2    2     5     8              |col1|   2|   5|   8|
col1                              +----+----+----+----+
a     6.0   NaN   NaN              |   c|null|null|  18|
b     NaN  12.0   NaN              |   b|null|  12|null|
c     NaN   NaN  18.0              |   a|   6|null|null|
                                  +----+----+----+----+
```

10.17 Unixtime to Date

```
from datetime import datetime

my_list = [['a', int("1284101485")], ['b', int("2284101485")],['c',␣
↪int("3284101485")]]
col_name = ['A', 'ts']

dp = pd.DataFrame(my_list,columns=col_name)
ds = spark.createDataFrame(dp)
```

:: Python Code:

```
dp['datetime'] = pd.to_datetime(dp['ts'], unit='s').dt.tz_localize('UTC
↪')
dp

spark.conf.set("spark.sql.session.timeZone", "UTC")
from pyspark.sql.types import DateType
ds.withColumn('date', F.from_unixtime('ts')).show() #.cast(DateType())
```

:: Comparison:

```
                                                  +---+----------+-------
↪------------+
                                                  |  A|        ts|      ␣
↪        date|
   A          ts                    datetime      +---+----------+-------
↪------------+
0  a  1284101485 2010-09-10 06:51:25+00:00      |  a|1284101485|2010-
↪09-10 06:51:25|
1  b  2284101485 2042-05-19 08:38:05+00:00      |  b|2284101485|2042-
↪05-19 08:38:05|
2  c  3284101485 2074-01-25 10:24:45+00:00      |  c|3284101485|2074-
↪01-25 10:24:45|
                                                  +---+----------+-------
↪------------+
```

CHAPTER

ELEVEN

KAGGLE COMPETITIONS

Chinese proverb

practice makes perfect.

11.1 TODO..

CHAPTER

TWELVE

PACKAGE WRAPPER

It's super easy to wrap your own package in Python. I packed some functions which I frequently used in my daily work. You can download and install it from My ststspy library. The hierarchical structure and the directory structure of this package are as follows.

12.1 Hierarchical Structure

```
├── README.md
├── __init__.py
├── requirements.txt
├── setup.py
├── statspy
│   ├── __init__.py
│   ├── basics.py
│   └── tests.py
└── test
    ├── nb
    │   └── t.test.ipynb
    └── test1.py

3 directories, 9 files
```

From the above hierarchical structure, you will find that you have to have `__init__.py` in each directory. I will explain the `__init__.py` file with the example below:

12.2 Set Up

```
from setuptools import setup, find_packages

try:
    with open("README.md") as f:
        long_description = f.read()
except IOError:
    long_description = ""

try:
    with open("requirements.txt") as f:
        requirements = [x.strip() for x in f.read().splitlines() if x.
↪strip()]
except IOError:
    requirements = []

setup(name='statspy',
      install_requires=requirements,
      version='1.0',
      description='Statistics python library',
      author='Wenqiang Feng',
      author_email='von198@gmail.com',
      license="MIT",
      url='git@github.com:runawayhorse001/statspy.git',
      packages=find_packages(),
      long_description=long_description,
      long_description_content_type="text/markdown",
      classifiers=[
        "License :: OSI Approved :: MIT License",
        "Programming Language :: Python",
        "Programming Language :: Python :: 2",
        "Programming Language :: Python :: 3",
      ],
      include_package_data=True
     )
```

12.3 Requirements

```
pandas
numpy
scipy
patsy
matplotlib
```

12.4 ReadMe

```
# StatsPy

This is my statistics python library repositories.
The ``API`` can be found at: https://runawayhorse001.github.io/statspy.
If you want to colne and install it, you can use

- clone

```{bash}
git clone git@github.com:runawayhorse001/statspy.git
```
- install

```{bash}
cd statspy
pip install -r requirements.txt
python setup.py install
```
- uninstall

```{bash}
pip uninstall statspy
```

- test

```{bash}
cd statspy/test
python test1.py
```
```

CHAPTER

THIRTEEN

PUBLISH PACKAGE TO PYPI

In this chapter, you'll learn how to upload your own package to PyPI.

13.1 Register PyPI account

If you do not have a PyPI accout, you need to register an account at https://pypi.org/account/register .

13.2 Install `twine`

```
pip install twine
```

13.3 Build Your Package

```
python setup.py sdist bdist_wheel
```

Then you will get a new folder `dist`:

```
.
├── PyAudit-1.0-py3-none-any.whl
├── PyAudit-1.0-py3.6.egg
└── PyAudit-1.0.tar.gz
```

13.4 Upload Your Package

```
twine upload dist/*
```

During the uploading processing, you need to provide your PyPI account `username` and `password`:

```
Enter your username: runawayhorse001
Enter your password:
```

13.5 Package at PyPI

Here is my `PyAudit` package at [PyPI](https://pypi.org/project/PyAudit). You can install `PyAudit` using:

```
pip install PyAudit
```

CHAPTER

FOURTEEN

MODEL DEPLOYMENT WITH FLASK

In this chapter, you'll learn how to deployment your model with `flask`. The main idea and code (I made some essential modification to make it work for Python 3) are from the Git repo:https://github.com/llSourcell/how_to_deploy_a_keras_model_to_production. So the copyright belongs to the original author.

14.1 Install `flask`

```
pip install Flask
```

14.2 Train and Save your model

You can use the following code to train and save your `CNN` model:

```
#python 2/3 compatibility
from __future__ import print_function
#simplified interface for building models
import keras
#our handwritten character labeled dataset
from keras.datasets import mnist
#because our models are simple
from keras.models import Sequential
#dense means fully connected layers, dropout is a technique to improve␣
↪convergence, flatten to reshape our matrices for feeding
#into respective layers
from keras.layers import Dense, Dropout, Flatten
#for convolution (images) and pooling is a technique to help choose␣
↪the most relevant features in an image
from keras.layers import Conv2D, MaxPooling2D
from keras import backend as K
```

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```
#mini batch gradient descent ftw
batch_size = 128
#10 difference characters
num_classes = 10
#very short training time
epochs = 12

#input image dimensions
#28x28 pixel images.
img_rows, img_cols = 28, 28

#the data downloaded, shuffled and split between train and test sets
#if only all datasets were this easy to import and format
(x_train, y_train), (x_test, y_test) = mnist.load_data()

#this assumes our data format
#For 3D data, "channels_last" assumes (conv_dim1, conv_dim2, conv_dim3,
↪ channels) while
#"channels_first" assumes (channels, conv_dim1, conv_dim2, conv_dim3).
if K.image_data_format() == 'channels_first':
    x_train = x_train.reshape(x_train.shape[0], 1, img_rows, img_cols)
    x_test = x_test.reshape(x_test.shape[0], 1, img_rows, img_cols)
    input_shape = (1, img_rows, img_cols)
else:
    x_train = x_train.reshape(x_train.shape[0], img_rows, img_cols, 1)
    x_test = x_test.reshape(x_test.shape[0], img_rows, img_cols, 1)
    input_shape = (img_rows, img_cols, 1)

#more reshaping
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')

#convert class vectors to binary class matrices
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

#build our model
model = Sequential()
```

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```
#convolutional layer with rectified linear unit activation
model.add(Conv2D(32, kernel_size=(3, 3),
                 activation='relu',
                 input_shape=input_shape))
#again
model.add(Conv2D(64, (3, 3), activation='relu'))
#choose the best features via pooling
model.add(MaxPooling2D(pool_size=(2, 2)))
#randomly turn neurons on and off to improve convergence
model.add(Dropout(0.25))
#flatten since too many dimensions, we only want a classification␣
↪output
model.add(Flatten())
#fully connected to get all relevant data
model.add(Dense(128, activation='relu'))
#one more dropout for convergence' sake :)
model.add(Dropout(0.5))
#output a softmax to squash the matrix into output probabilities
model.add(Dense(num_classes, activation='softmax'))
#Adaptive learning rate (adaDelta) is a popular form of gradient␣
↪descent rivaled only by adam and adagrad
#categorical ce since we have multiple classes (10)
model.compile(loss=keras.losses.categorical_crossentropy,
              optimizer=keras.optimizers.Adadelta(),
              metrics=['accuracy'])

#train
model.fit(x_train, y_train,
          batch_size=batch_size,
          epochs=epochs,
          verbose=1,
          validation_data=(x_test, y_test))
 #how well did it do?
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])

#Save the model
# serialize model to JSON
model_json = model.to_json()
with open("model.json", "w") as json_file:
    json_file.write(model_json)
# serialize weights to HDF5
model.save_weights("model.h5")
print("Saved model to disk")
```

14.3 Deplyment with Flask

```
#our web app framework!

#you could also generate a skeleton from scratch via
#http://flask-appbuilder.readthedocs.io/en/latest/installation.html

#Generating HTML from within Python is not fun, and actually pretty cumbersome because you have to do the
#HTML escaping on your own to keep the application secure. Because of that Flask configures the Jinja2 template engine
#for you automatically.
#requests are objects that flask handles (get set post, etc)
from flask import Flask, render_template,request
#scientific computing library for saving, reading, and resizing images
#from scipy.misc import imsave, imread, imresize
# import cv2 library for saving, reading, and resizing images
import cv2
#for matrix math
import numpy as np
#for importing our keras model
import keras.models
#for regular expressions, saves time dealing with string data
import re
# for convert base64 string to image
import base64

#system level operations (like loading files)
import sys
#for reading operating system data
import os
#tell our app where our saved model is
sys.path.append(os.path.abspath("./model"))
from load import *
#initalize our flask app
app = Flask(__name__)
#global vars for easy reusability
global model, graph
#initialize these variables
model, graph = init()

#decoding an image from base64 into raw representation
def convertImage(imgData1):
        imgData1 = imgData1.decode("utf-8")
        imgstr = re.search(r'base64,(.*)',imgData1).group(1)
        #print(imgstr)
```

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```
        imgstr_64 = base64.b64decode(imgstr)
        with open('output/output.png','wb') as output:
                output.write(imgstr_64)


@app.route('/')
def index():
        #initModel()
        #render out pre-built HTML file right on the index page
        return render_template("index.html")

@app.route('/predict/',methods=['GET','POST'])
def predict():
        #whenever the predict method is called, we're going
        #to input the user drawn character as an image into the model
        #perform inference, and return the classification
        #get the raw data format of the image
        imgData = request.get_data()
        #print(imgData)
        #encode it into a suitable format
        convertImage(imgData)
        print("debug")
        #read the image into memory
        x = cv2.imread('output/output.png',0)
        #compute a bit-wise inversion so black becomes white and vice␣
↪versa
        x = np.invert(x)
        #make it the right size
        x = cv2.resize(x,(28,28))
        #imshow(x)
        #convert to a 4D tensor to feed into our model
        x = x.reshape(1,28,28,1)
        print("debug2")
        #in our computation graph
        with graph.as_default():
                #perform the prediction
                out = model.predict(x)
                #print(out)
                print(np.argmax(out,axis=1))
                print("debug3")
                #convert the response to a string
                response = np.array_str(np.argmax(out,axis=1))
                return response
```

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```
if __name__ == "__main__":
        #decide what port to run the app in
        port = int(os.environ.get('PORT', 5000))
        #run the app locally on the givn port
        app.run(host='0.0.0.0', port=port)
        #optional if we want to run in debugging mode
        #app.run(debug=False)
```

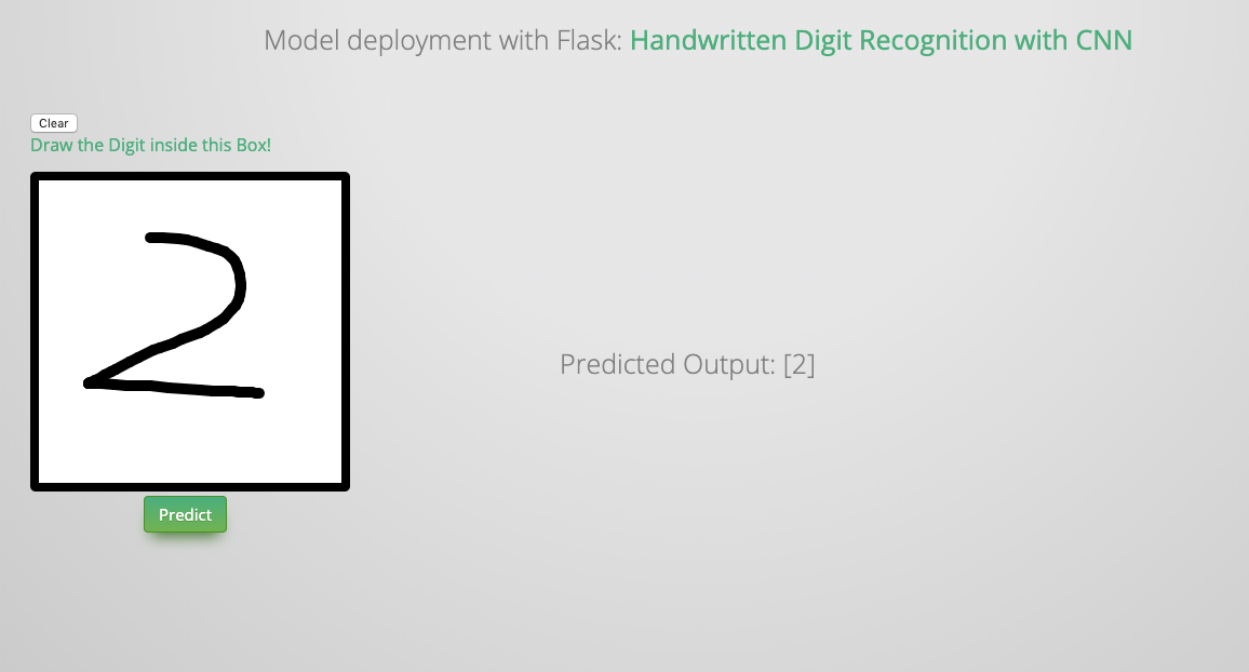
14.4 Lunch your app on server

14.4.1 1. Lunch the APP

```
python app.py
```

14.4.2 2. Run the APP

Open the browser with: http://0.0.0.0:5000



CHAPTER

FIFTEEN

API BOOK

If you developed an amazing library or tool, you need to teach the users how to use it. Now a `API` book is necessary and a good `API` book will save a lot of time for the users. The Sphinx provides an awesome auto `API` book generator. The followings are my statistics python library: `statspy` API demo book:

15.1 Basics Module

15.1.1 `rnorm`

`statspy.basics.`**`rnorm`**(*n*, *mean=0*, *sd=1*)

Random generation for the normal distribution with mean equal to mean and standard deviation equation to sd same functions as rnorm in r: `rnorm(n, mean=0, sd=1)`

Parameters

- **`n`** – the number of the observations
- **`mean`** – vector of means
- **`sd`** – vector of standard deviations

Returns the vector of the random numbers

Author Wenqiang Feng

Email von198@gmail.com

15.1.2 dnorm

statspy.basics.**dnorm**(*x*, *mean=0*, *sd=1*, *log=False*)

Density of the normal distribution with mean equal to mean and standard deviation equation to sd same functions as rnorm in r: `dnorm(x, mean=0, sd=1, log=FALSE)`

Parameters

- **x** – the vector od quantiles
- **mean** – vector of means
- **sd** – vector of standard deviations

Returns the list of the density

Author Wenqiang Feng

Email von198@gmail.com

15.1.3 runif

statspy.basics.**runif**(*n*, *min=0*, *max=1*)

Random generation from the uniform distribution same functions as rnorm in r: `runif(n, min=0, max=1)`

Parameters

- **n** – the number of the observations
- **min** – the lower limit of the distribution
- **max** – the upper limit of the distribution

Returns the list of n uniform random numers

Author Wenqiang Feng

Email von198@gmail.com

15.2 Tests Module

15.2.1 T-test

statspy.tests.**t_test**(*x*, *y=None*, *mu=0.0*, *conf_level=0.95*)

Performs one and two sample t-tests on vectors of data.

same functions as t.test in r: `t.test(x, ...)`

```
t.test(x, y = NULL,
```

```
alternative = c("two.sided", "less", "greater"),
mu = 0, paired = FALSE, var.equal = FALSE,
conf.level = 0.95, ...)
```

Parameters

- **x** – a (non-empty) numeric vector of data values.
- **y** – an optional (non-empty) numeric vector of data values.
- **mu** – vector of standard deviations.
- **conf_level** – confidence level of the interval.

Returns the vector of the random numbers.

Author Wenqiang Feng

Email von198@gmail.com

CHAPTER

SIXTEEN

MAIN REFERENCE

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