Capturing, Preparing and Working with data

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Outline

- ✓ Basic File IO in Python
- ✓ NumPy V/S Pandas (what to use?)
- ✓ NumPy
- ✓ Pandas
- ✓ Accessing text, CSV, Excel files using pandas
- ✓ Accessing SQL Database

Basic IO operations in Python

- Before we can read or write a file, we have to open it using Python's built-in **open()** function.

syntax

```
fileobject = open(filename [, accessmode][, buffering])
```

- **filename** is a name of a file we want to open.
- **accessmode** is determines the mode in which file has to be opened (list of possible values given below)
- If **buffering** is set to 0, no buffering will happen, if set to 1 line buffering will happen, if grater than 1 then the number of buffer and if negative is given it will follow system default buffering behaviour.

M	Description
r	Read only (default)
rb	Read only in binary format
r+	Read and Write both
rb+	Read and Write both in binary format

M	Description (create file if not exist)
w	Write only
wb	Write only in binary format
w+	Read and Write both
wb+	Read and Write both in binary format

M	Description
a	Opens file to append, if file not exist will create it for write
ab	Append in binary format, if file not exist will create it for write
a+	Append, if file not exist it will create for read & write both
ab+	Read and Write both in binary format

Example : Read file in Python

- **read(size)** will read specified bytes from the file, if we don't specify size it will return whole file.

readfile.py

```
1 f = open('college.txt')
2 data = f.read()
3 print(data)
```

college.txt

```
Jadavpur University- Kolkata
At Salt Lake City- Salt Lake Bypass,
Kolkata-700106, INDIA
```

- **reallines()** method will return list of lines from the file.

readlines.py

```
1 f = open('college.txt')
2 lines = f.readlines()
3 print(lines)
```

OUTPUT

```
[Jadavpur University- Kolkata\n', 'At Salt Lake City-
Salt Lake Bypass,\n', 'Kolkata-700106, INDIA']
```

- We can use for loop to get each line separately,

readlinesfor.py

```
1 f = open('college.txt')
2 lines = f.readlines()
3 for l in lines :
4     print(l)
```

OUTPUT

```
Jadavpur University- Kolkata

At Salt Lake City- Salt Lake Bypass,

Kolkata-700106, INDIA
```

How to write path?

- We can specify relative path in argument to **open** method, alternatively we can also specify absolute path.
- To specify absolute path,
  - In windows, f=open('D:\\folder\\subfolder\\filename.txt')
  - In mac & linux, f=open('/user/folder/subfolder/filename.txt')

- We suppose to close the file once we are done using the file in the Python using **close()** method.

closefile.py

```
1 f = open('college.txt')
2 data = f.read()
3 print(data)
4 f.close()
```

Handling errors using “with” keyword

- It is possible that we may have typo in the filename or file we specified is moved/deleted, in such cases there will be an error while running the file.
- To handle such situations we can use new syntax of opening the file using **with** keyword.

fileusingwith.py

```
1 with open('college.txt') as f :
2     data = f.read()
3     print(data)
```

- When we open file using with we **need not** to **close** the file.

Example : Write file in Python

- **write()** method will write the specified data to the file.

readdemo.py

```
1 with open('college.txt','a') as f :
2     f.write('Hello world')
```

- If we open file with '**w**' mode it will overwrite the data to the existing file or will create new file if file does not exists.
- If we open file with '**a**' mode it will append the data at the end of the existing file or will create new file if file does not exists.

Reading CSV files without any library functions

- A comma-separated values file is a delimited text file that uses a comma to separate values.
- Each line of is a data record, Each record consists of many fields, separated by commas.
- Example :

Book1.csv

```
studentname,enrollment,cpi
abcd,123456,8.5
bcde,456789,2.5
cdef,321654,7.6
```

readlines.py

```
1  with open('Book1.csv') as f :
2    rows = f.readlines()
3    isFirstLine = True
4    for r in rows :
5      if isFirstLine :
6          isFirstLine = False
7          continue
8      cols = r.split(',')
9      print('Student Name = ', cols[0], end=" ")
10     print('\tEn. No. = ', cols[1], end=" ")
11     print('\tCPI = \t', cols[2])
```

- We can use Microsoft Excel to access CSV files.
- In the later sessions we will access CSV files using different libraries, but we can also access CSV files without any libraries. **(Not recommend)**

NumPy v/s Pandas

- Developers built pandas on top of NumPy, as a result every task we perform using pandas also goes through NumPy.
- To obtain the **benefits of pandas**, we need to **pay a performance penalty** that some testers say is **100 times slower** than NumPy for similar task.
- Nowadays computer hardware are powerful enough to take care for the performance issue, but when **speed** of execution is **essential NumPy** is always the **best** choice.
- We can use **pandas** to make writing code **easier** and **faster**, pandas will reduce potential coding errors.
- Pandas provide rich **time-series** functionality, **data alignment**, **NA**-friendly statistics, **groupby**, **merge**, etc.. methods, if we use NumPy we have to implement all these methods manually.
- So,
  - ↪ if we want **performance** we should use **NumPy**,
  - ↪ if we want **ease of coding** we should use **pandas**.

Lets Learn
NumPy

NumPy

- NumPy (Numeric Python) is a Python library to manipulate arrays.
- Almost all the libraries in python rely on NumPy as one of their main building block.
- NumPy provides functions for domains like Algebra, Fourier transform etc..
- NumPy is incredibly fast as it has bindings to C libraries.
- Install :
  - conda install numpy

OR
  - pip install numpy

NumPy Array

- The most important object defined in NumPy is an N-dimensional array type called **ndarray**.
- It describes the **collection** of **items** of the **same type**, Items in the collection can be accessed using a **zero-based index**.
- An instance of **ndarray** class can be constructed in many different ways, the basic ndarray can be created as below.

syntax

```
import numpy as np
a= np.array(list | tuple | set | dict)
```

numpyarray.py

```
1 import numpy as np
2 a= np.array(['jadavpur','university','Kolkata'])
3 print(type(a))
4 print(a)
```

Output

```
<class 'numpy.ndarray'>
['jadavpur' 'university' 'Kolkata']
```

NumPy Array (Cont.)

- **arange**(*start,end,step*) function will create NumPy array starting from *start* till *end* (not included) with specified *steps*.

numpyarange.py

```
1 import numpy as np
2 b = np.arange(0,10,1)
3 print(b)
```

Output

```
[0 1 2 3 4 5 6 7 8 9]
```

- **zeros**(n) function will return NumPy array of given shape, filled with zeros.

numpyzeros.py

```
1 import numpy as np
2 c = np.zeros(3)
3 print(c)
4 c1 = np.zeros((3,3)) #have to give as tuple
5 print(c1)
```

Output

```
[0. 0. 0.]

[[0. 0. 0.] [0. 0. 0.] [0. 0. 0.]]
```

- **ones**(n) function will return NumPy array of given shape, filled with ones.

NumPy Array (Cont.)

- **eye**(*n*) function will create 2-D NumPy array with ones on the diagonal and zeros elsewhere.

numpyeye.py

```
1 import numpy as np
2 b = np.eye(3)
3 print(b)
```

Output

```
[[1. 0. 0.]
 [0. 1. 0.]
 [0. 0. 1.]]
```

- **linspace**(*start,stop,num*) function will return evenly spaced numbers over a specified interval.

numpylinspace.py

```
1 import numpy as np
2 c = np.linspace(0,1,11)
3 print(c)
```

Output

```
[0. 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
0.9 1. ]
```

- **Note:** in **arange** function we have given start, stop & **step,** whereas in **lispace** function we are giving start,stop & **number of elements** we want.

Array Shape in NumPy

- We can grab the shape of ndarray using its **shape property**.

numpyarange.py

```
1 import numpy as np
2 b = np.zeros((3,3))
3 print(b.shape)
```

Output

```
(3,3)
```

- We can also **reshape** the array using reshape method of **ndarray.**

numpyarange.py

```
1 import numpy as np
2 re1 = np.random.randint(1,100,10)
3 re2 = re1.reshape(5,2)
4 print(re2)
```

Output

```
[[29 55]
 [44 50]
 [25 53]
 [59 6]
 [93 7]]
```

- **Note:** the number of elements and multiplication of rows and cols in new array must be equal.
  - **Example :** here we have old one-dimensional array of 10 elements and reshaped shape is (5,2)

    so, 5 * 2 = 10, which means it is a valid reshape

NumPy Random

- **rand**(p1,p2….,pn) function will create **n-dimensional array** with **random data** using uniform distrubution, if we **do not** specify any parameter it will return **random float** number.

numpyrand.py

```
1 import numpy as np
2 r1 = np.random.rand()
3 print(r1)
4 r2 = np.random.rand(3,2) # no tuple
5 print(r2)
```

Output

```
0.2393725320849050 5

[[0.58924723 0.09677878]
 [0.97945337 0.76537675]
 [0.73097381 0.51277276]]
```

- **randint**(low,high,num) function will create one-dimensional array with ***num*** random integer data between ***low*** and ***high***.

numpyrandint.py

```
1 import numpy as np
2 r3 = np.random.randint(1,100,10)
3 print(r3)
```

Output

```
[78 78 17 98 19 26 81 67 23 24]
```

- We can reshape the array in any shape using **reshape** method, which we learned in previous slide.

NumPy Random (Cont.)

- **randn**(p1,p2….,pn) function will create **n-dimensional array** with **random data** using standard normal distribution, if we **do not** specify any parameter it will return **random float** number.

numpyrandn.py

```
1 import numpy as np
2 r1 = np.random.randn()
3 print(r1)
4 r2 = np.random.randn(3,2) # no tuple
5 print(r2)
```

Output

```
-0.1535961758111037

[[ 0.40967905 -0.21974532]
 [-0.90341482 -0.69779498]
 [ 0.99444948 -1.45308348]]
```

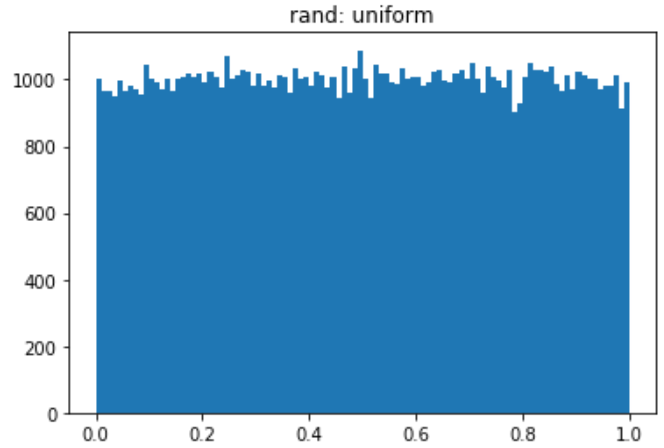
- **Note: rand** function will generate random number using uniform distribution, whereas **randn** function will generate random number using standard normal distribution.
- We are going to learn the difference using visualization technique (as a data scientist, We have to use visualization techniques to convince the audience)

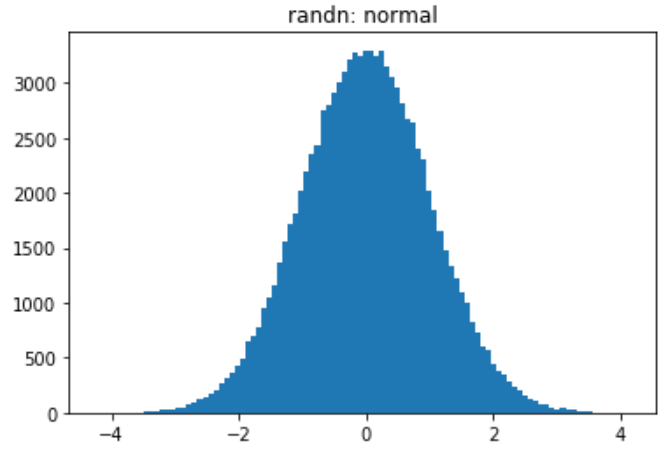
Visualizing the difference between rand & randn

- We are going to use matplotlib library to visualize the difference.
  - You need not to worry if you are not getting the syntax of matplotlib, we are going to learn it in detail in Unit-4

matplotdemo.py

```
1  import numpy as np
2  from matplotlib import pyplot as plt
3  %matplotlib inline
4  samplesize = 100000
5  uniform = np.random.rand(samplesize)
6  normal = np.random.randn(samplesize)
7  plt.hist(uniform,bins=100)
8  plt.title('rand: uniform')
9  plt.show()
10 plt.hist(normal,bins=100)
11 plt.title('randn: normal')
12 plt.show()
```





Aggregations

- **min**() function will return the minimum value from the ndarray, there are two ways in which we can use min function, example of both ways are given below.

numpymin.py

```
1 import numpy as np
2 l = [1,5,3,8,2,3,6,7,5,2,9,11,2,5,3,4,8,9,3,1,9,3]
3 a = np.array(l)
4 print('Min way1 = ',a.min())
5 print('Min way2 = ',np.min(a))
```

Output

```
Min way1 = 1
Min way2 = 1
```

- **max**() function will return the maximum value from the ndarray, there are two ways in which we can use min function, example of both ways are given below.

numpymax.py

```
1 import numpy as np
2 l = [1,5,3,8,2,3,6,7,5,2,9,11,2,5,3,4,8,9,3,1,9,3]
3 a = np.array(l)
4 print('Max way1 = ',a.max())
5 print('Max way2 = ',np.max(a))
```

Output

```
Max way1 = 11
Max way2 = 11
```

Aggregations (Cont.)

- NumPy support many aggregation functions such as min, max, argmin, argmax, sum, mean, std, etc…

numpymin.py

```
1 l = [7,5,3,1,8,2,3,6,11,5,2,9,10,2,5,3,7,8,9,3,1,9,3]
2 a = np.array(l)
3 print('Min = ',a.min())
4 print('ArgMin = ',a.argmin())
5 print('Max = ',a.max())
6 print('ArgMax = ',a.argmax())
7 print('Sum = ',a.sum())
8 print('Mean = ',a.mean())
9 print('Std = ',a.std())
```

Output

```
Min = 1
ArgMin = 3
Max = 11
ArgMax = 8
Sum = 122
Mean = 5.304347826086956
Std = 3.042235771223635
```

Using axis argument with aggregate functions

- When we apply aggregate functions with multidimensional ndarray, it will apply aggregate function to all its dimensions (axis).

numpyaxis.py

```
1 import numpy as np
2 array2d = np.array([[1,2,3],[4,5,6],[7,8,9]])
3 print('sum = ',array2d.sum())
```

Output

```
sum = 45
```

- If we want to get sum of rows or cols we can use axis argument with the aggregate functions.

numpyaxis.py

```
1 import numpy as np
2 array2d = np.array([[1,2,3],[4,5,6],[7,8,9]])
3 print('sum (cols)= ',array2d.sum(axis=0)) #Vertical
4 print('sum (rows)= ',array2d.sum(axis=1)) #Horizontal
```

Output

```
sum (cols) = [12 15 18]
sum (rows) = [6 15 24]
```

Single V/S Double bracket notations

- There are two ways in which you can access element of multi-dimensional array, example of both the method is given below

numpybrackets.py

```
1 arr =
2 np.array([['a','b','c'],['d','e','f'],['g','h','i']])
3 print('double = ',arr[2][1]) # double bracket notaion
4 print('single = ',arr[2,1]) # single bracket notation
```

Output

```
double = h
single = h
```

- Both method is valid and provides exactly the same answer, but single bracket notation is recommended as in double bracket notation it will create a temporary sub array of third row and then fetch the second column from it.
- Single bracket notation will be easy to read and write while programming.

Slicing ndarray

- Slicing in python means taking elements from one given index to another given index.
- Similar to Python List, we can use same syntax **`array[start:end:step]`** to slice ndarray.
  - Default start is 0
  - Default end is length of the array
  - Default step is 1

numpyslice1d.py

```
1 import numpy as np
2 arr =
  np.array(['a','b','c','d','e','f','g','h'])
3 print(arr[2:5])
4 print(arr[:5])
5 print(arr[5:])
6 print(arr[2:7:2])
7 print(arr[::-1])
```

Output

```
['c' 'd' 'e']
['a' 'b' 'c' 'd' 'e']
['f' 'g' 'h']
['c' 'e' 'g']
['h' 'g' 'f' 'e' 'd' 'c'
'b' 'a']
```

Array Slicing Example

a =

	C-0	C-1	C-2	C-3	C-4
R-0	1	2	3	4	5
R-1	6	7	8	9	10
R-2	11	12	13	14	15
R-3	16	17	18	19	20
R-4	21	22	23	24	25

- Example :
  - a[2][3] =
  - a[2,3] =
  - a[2] =
  - a[0:2] =
  - a[0:2:2] =
  - a[::-1] =
  - a[1:3,1:3] =
  - a[3:,:3] =
  - a[:,::-1] =

Slicing multi-dimensional array

- Slicing multi-dimensional array would be same as single dimensional array with the help of single bracket notation we learn earlier, lets see an example.

numpyslice1d.py

```
arr =
np.array([['a','b','c'],['d','e','f'],['g','h',
'i']])
print(arr[0:2 , 0:2]) #first two rows and cols
print(arr[::-1]) #reversed rows
print(arr[: , ::-1]) #reversed cols
print(arr[::-1,::-1]) #complete reverse
```

Output

```
[['a' 'b']
 ['d' 'e']]
[['g' 'h' 'i']
 ['d' 'e' 'f']
 ['a' 'b' 'c']]
[['c' 'b' 'a']
 ['f' 'e' 'd']
 ['i' 'h' 'g']]
[['i' 'h' 'g']
 ['f' 'e' 'd']
 ['c' 'b' 'a']]
```

Warning : Array Slicing is mutable !

- When we slice an array and apply some operation on them, it will also make changes in original array, as it will not create a copy of a array while slicing.
- Example,

numpyslice1d.py

```
1 import numpy as np
2 arr = np.array([1,2,3,4,5])
3 arrsliced = arr[0:3]
4
5 arrsliced[:] = 2 # Broadcasting
6
7 print('Original Array = ', arr)
8 print('Sliced Array = ',arrsliced)
```

Output

```
Original Array = [2 2 2 4 5]
Sliced Array = [2 2 2]
```

NumPy Arithmetic Operations

numpyop.py

```
1  import numpy as np
2  arr1 = np.array([[1,2,3],[1,2,3],[1,2,3]])
3  arr2 = np.array([[4,5,6],[4,5,6],[4,5,6]])
4
5  arradd1 = arr1 + 2 # addition of matrix with scalar
6  arradd2 = arr1 + arr2 # addition of two matrices
7  print('Addition Scalar = ', arradd1)
8  print('Addition Matrix = ', arradd2)
9
10 arrsub1 = arr1 - 2 # substraction of matrix with
   scalar
11 arrsub2 = arr1 - arr2 # substraction of two matrices
12 print('Substraction Scalar = ', arrsub1)
13 print('Substraction Matrix = ', arrsub2)
14 arrdiv1 = arr1 / 2 # substraction of matrix with
   scalar
15 arrdiv2 = arr1 / arr2 # substraction of two matrices
16 print('Division Scalar = ', arrdiv1)
17 print('Division Matrix = ', arrdiv2)
```

Output

```
Addition Scalar =  [[3 4 5]
 [3 4 5]
 [3 4 5]]
Addition Matrix =  [[5 7 9]
 [5 7 9]
 [5 7 9]]
Substraction Scalar =  [[-1  0  1]
 [-1  0  1]
 [-1  0  1]]
Substraction Matrix =  [[-3 -3 -3]
 [-3 -3 -3]
 [-3 -3 -3]]
Division Scalar =  [[0.5 1.  1.5]
 [0.5 1.  1.5]
 [0.5 1.  1.5]]
Division Matrix =  [[0.25 0.4  0.5
]
 [0.25 0.4  0.5 ]
 [0.25 0.4  0.5 ]]
```

NumPy Arithmetic Operations (Cont.)

numpyop.py

```
1  import numpy as np
2  arrmul1 = arr1 * 2 # multiply matrix with scalar
3  arrmul2 = arr1 * arr2 # multiply two matrices
4  print('Multiply Scalar = ', arrmul1)
5  #Note : its not metrix multiplication*
6  print('Multiply Matrix = ', arrmul2)
7  # In order to do matrix multiplication
8  arrmatmul = np.matmul(arr1,arr2)
9  print('Matrix Multiplication = ',arrmatmul)
10 # OR
   arrdot = arr1.dot(arr2)
11 print('Dot = ',arrdot)
12 # OR
13 arrpy3dot5plus = arr1 @ arr2
14 print('Python 3.5+ support = ',arrpy3dot5plus)
```

Output

```
Multiply Scalar =  [[2 4 6]
 [2 4 6]
 [2 4 6]]
Multiply Matrix =  [[ 4 10 18]
 [ 4 10 18]
 [ 4 10 18]]
Matrix Multiplication =  [[24 30
36]
 [24 30 36]
 [24 30 36]]
Dot =  [[24 30 36]
 [24 30 36]
 [24 30 36]]
Python 3.5+ support =  [[24 30 36]
 [24 30 36]
 [24 30 36]]
```

Sorting Array

- The sort() function returns a sorted copy of the input array.

syntax

```
import numpy as np
# arr = our ndarray
np.sort(arr,axis,kind,order)
# OR arr.sort()
```

Parameters

```
arr     = array to sort (inplace)
axis    = axis to sort (default=0)
kind    = kind of algo to use
('quicksort' <- default,
'mergesort', 'heapsort')
order   = on which field we want
to sort (if multiple fields)
```

- Example :

numpysort.py

```
1 import numpy as np
2 arr =
  np.array(['Delhi','Rajasthan','Indore','Ooty',
  'Etawah'])
3 print("Before Sorting = ", arr)
4 arr.sort() # or np.sort(arr)
5 print("After Sorting = ",arr)
```

Output

```
Before Sorting =  ['Delhi'
'Rajasthan' 'Indore' 'Ooty'
'Etawah']
After Sorting =  ['Delhi'
'Etawah' 'Indore' 'Ooty'
'Rajasthan']
```

Sort Array Example

numpysort2.py

```
1 import numpy as np
2 dt = np.dtype([('name', 'S10'),('age', int)])
3 arr2 =
  np.array([('Delhi',200),('ABC',300),('XYZ',10
  0)],dtype=dt)
4 arr2.sort(order='name')
5 print(arr2)
```

Output

```
[(b'ABC', 300) (b'Delhi',
200) (b'XYZ', 100)]
```

Conditional Selection

- Similar to arithmetic operations when we apply any comparison operator to Numpy Array, then it will be applied to each element in the array and a new bool Numpy Array will be created with values True or False.

numpycond1.py

```
1 import numpy as np
2 arr = np.random.randint(1,100,10)
3 print(arr)
4 boolArr = arr > 50
5 print(boolArr)
```

Output

```
[25 17 24 15 17 97 42 10 67
22]
[False False False False
False  True False False  True
False]
```

numpycond2.py

```
1 import numpy as np
2 arr = np.random.randint(1,100,10)
3 print("All = ",arr)
4 boolArr = arr > 50
5 print("Filtered = ", arr[boolArr])
```

Output

```
All =  [31 94 25 70 23  9 11
77 48 11]
Filtered =  [94 70 77]
```

Lets Learn

Pandas

Pandas

- Pandas is an open source library built on top of NumPy.
- It allows for fast data cleaning, preparation and analysis.
- It excels in performance and productivity.
- It also has built-in visualization features.
- It can work with the data from wide variety of sources.
- Install :
  - conda install pandas

OR
  - pip install pandas

Outline (Pandas)

- ✓ Series
- ✓ Data Frames
- ✓ Accessing text, CSV, Excel files using pandas
- ✓ Accessing SQL Database
- ✓ Missing Data
- ✓ Group By
- ✓ Merging, Joining & Concatenating
- ✓ Operations

Series

- Series is an one-dimensional* array with axis labels.
- It supports both integer and label-based index but index must be of hashable type.
- If we do not specify index it will assign integer zero-based index.

syntax

```
import pandas as pd
s = pd.Series(data,index,dtype,copy=False)
```

Parameters

```
data    = array like Iterable
index   = array like index
dtype   = data-type
copy    = bool, default is False
```

pandasSeries.py

```
1 import pandas as pd
2 s = pd.Series([1, 3, 5, 7, 9, 11])
3 print(s)
```

Output

```
0     1
1     3
2     5
3     7
4     9
5    11
dtype: int64
```

Series (Cont.)

- We can then access the elements inside Series just like array using square brackets notation.

pdSeriesEle.py

```
1 import pandas as pd
2 s = pd.Series([1, 3, 5, 7, 9, 11])
3 print("S[0] = ", s[0])
4 b = s[0] + s[1]
5 print("Sum = ", b)
```

Output

```
S[0] = 1
Sum = 4
```

- We can specify the data type of Series using **dtype** parameter

pdSeriesdtype.py

```
1 import pandas as pd
2 s = pd.Series([1, 3, 5, 7, 9, 11], dtype='str')
3 print("S[0] = ", s[0])
4 b = s[0] + s[1]
5 print("Sum = ", b)
```

Output

```
S[0] = 1
Sum = 13
```

Series (Cont.)

- We can specify index to Series with the help of **index** parameter

pdSeriesdtype.py

```
1 import numpy as np
2 import pandas as pd
3 i = ['name','address','phone','email','website']
4 d = [‘kolkata','ju',123','d@d.com',‘jaduniv.ac.in']
5 s = pd.Series(data=d,index=i)
6 print(s)
```

Output

```
name                kolkata
address                  ju
phone                   123
email               d@d.com
website    jaduniv.ac.in
dtype: object
```

Creating Time Series

- We can use some of pandas inbuilt date functions to create a time series.

pdSeriesEle.py

```
1 import numpy as np
2 import pandas as pd
3 dates = pd.to_datetime("27th of July, 2020")
4 i = dates + pd.to_timedelta(np.arange(5),
  unit='D')
5 d = [50,53,25,70,60]
6 time_series = pd.Series(data=d,index=i)
7 print(time_series)
```

Output

```
2020-07-27    50
2020-07-28    53
2020-07-29    25
2020-07-30    70
2020-07-31    60
dtype: int64
```

Data Frames

- Data frames are two dimensional data structure, i.e. data is aligned in a tabular format in rows and columns.
- Data frame also contains labelled axes on rows and columns.
- Features of Data Frame :
  - It is size-mutable
  - Has labelled axes
  - Columns can be of different data types
  - We can perform arithmetic operations on rows and columns.
- Structure :

	PDS	Algo	SE	INS
101				
102				
103				
….				
160				

Data Frames (Cont.)

Syntax :

syntax

```
import pandas as pd
df = pd.DataFrame(data,index,columns,dtype,copy=False)
```

Parameters

```
data    = array like Iterable
index   = array like row index
columns = array like col index
dtype   = data-type
copy    = bool, default is False
```

Example :

pdDataFrame.py

```
1 import numpy as np
2 import pandas as pd
3 randArr = np.random.randint(0,100,20).reshape(5,4)
4 df =
  pd.DataFrame(randArr,np.arange(101,106,1),['PDS','A
  lgo','SE','INS'])
5 print(df)
```

Output

```
     PDS  Algo  SE  INS
101    0    23  93   46
102   85    47  31   12
103   35    34   6   89
104   66    83  70   50
105   65    88  87   87
```

Data Frames (Cont.)

- Grabbing the column

dfGrabCol.py

```
1 import numpy as np
2 import pandas as pd
3 randArr = np.random.randint(0,100,20).reshape(5,4)
4 df =
  pd.DataFrame(randArr,np.arange(101,106,1),['PDS',
  'Algo','SE','INS'])
5 print(df['PDS'])
```

Output

```
101     0
102    85
103    35
104    66
105    65
Name: PDS, dtype: int32
```

- Grabbing the multiple column

dfGrabMulCol.py

```
1 print(df['PDS', 'SE'])
```

Output

```
      PDS  SE
101     0  93
102    85  31
103    35   6
104    66  70
105    65  87
```

Data Frames (Cont.)

Grabbing a row

dfGrabRow.py

```
1 print(df.loc[101]) # using labels
2 #OR
3 print(df.iloc[0]) # using zero based index
```

Output

```
PDS      0
Algo     23
SE       93
INS      46
Name: 101, dtype: int32
```

Grabbing Single Value

dfGrabSingle.py

```
1 print(df.loc[101, 'PDS']) # using labels
```

Output

```
0
```

Deleting Row

dfDelCol.py

```
1 df.drop('103',inplace=True)
2 print(df)
```

Output

```
      PDS   Algo   SE   INS
101     0     23   93    46
102    85     47   31    12
104    66     83   70    50
105    65     88   87    87
```

Data Frames (Cont.)

Creating new column

dfCreateCol.py

```
1 df['total'] = df['PDS'] + df['Algo'] +
  df['SE'] + df['INS']
2 print(df)
```

Output

```
      PDS   Algo   SE   INS   total
101     0     23   93    46     162
102    85     47   31    12     175
103    35     34    6    89     164
104    66     83   70    50     269
105    65     88   87    87     327
```

Deleting Column and Row

dfDelCol.py

```
1 df.drop('total',axis=1,inplace=True)
2 print(df)
```

Output

```
      PDS   Algo   SE   INS
101     0     23   93    46
102    85     47   31    12
103    35     34    6    89
104    66     83   70    50
105    65     88   87    87
```

Data Frames (Cont.)

Getting Subset of Data Frame

dfGrabSubSet.py

```
1 print(df.loc[[101,104], [['PDS','INS']])
```

Output

```
     PDS  INS
101    0   46
104   66   50
```

Selecting all cols except one

dfGrabExcept.py

```
1 print(df.loc[:, df.columns != 'Algo' ])
```

Output

```
     PDS  SE  INS
101    0  93   46
102   85  31   12
103   35   6   89
104   66  70   50
105   65  87   87
```

Conditional Selection

- Similar to NumPy we can do conditional selection in pandas.

dfCondSel.py

```
1 import numpy as np
2 import pandas as pd
3 np.random.seed(121)
4 randArr =
  np.random.randint(0,100,20).reshape(5,4)
5 df =
  pd.DataFrame(randArr,np.arange(101,106,1)
  ,['PDS','Algo','SE','INS'])
6 print(df)
7 print(df>50)
```

Output

```
      PDS   Algo     SE   INS
101    66     85      8    95
102    65     52     83    96
103    46     34     52    60
104    54      3     94    52
105    57     75     88    39
       PDS   Algo     SE    INS
101   True   True  False   True
102   True   True   True   True
103  False  False   True   True
104   True  False   True   True
105   True   True   True  False
```

- Note : we have used np.random.seed() method and set seed to be 121, so that when you generate random number it matches with the random number I have generated.

Conditional Selection (Cont.)

- We can then use this boolean DataFrame to get associated values.

dfCondSel.py

```
1 dfBool = df > 50
2 print(df[dfBool])
```

Output

	PDS	Algo	SE	INS
101	66	85	NaN	95
102	65	52	83	96
103	NaN	NaN	52	60
104	54	NaN	94	52
105	57	75	88	NaN

- Note : It will set NaN (Not a Number) in case of False

- We can apply condition on specific column.

dfCondSel.py

```
1 dfBool = df['PDS'] > 50
2 print(df[dfBool])
```

Output

	PDS	Algo	SE	INS
101	66	85	8	95
102	65	52	83	96
104	54	3	94	52
105	57	75	88	39

Setting/Resetting index

- In our previous example we have seen our index does not have name, if we want to specify name to our index we can specify it using **`DataFrame.index.name`** property.

dfCondSel.py

```
1 df.index.name('RollNo')
```

Note: We have name to our index now

Output

```
        PDS Algo SE INS
RollNo
101      66   85  8  95
102      65   52 83  96
103      46   34 52  60
104      54    3 94  52
105      57   75 88  39
```

- We can use pandas built-in methods to set or reset the index
  - `pd.set_index('NewColumn',inplace=True)`, will set new column as index,
  - `pd.reset_index()`, will reset index to zero based numberic index.

Setting/Resetting index (Cont.)

- `set_index(new_index)`

dfCondSel.py

```
1 df.set_index('PDS') #inplace=True
```

Note: We have PDS as our index now

Output

```
     Algo  SE  INS
PDS
66     85   8   95
65     52  83   96
46     34  52   60
54      3  94   52
57     75  88   39
```

- `reset_index()`

dfCondSel.py

```
1 df.reset_index()
```

Note: Our **RollNo(index)** become new column, and we now have zero based numeric index

Output

```
   RollNo  PDS  Algo  SE  INS
0     101   66    85   8   95
1     102   65    52  83   96
2     103   46    34  52   60
3     104   54     3  94   52
4     105   57    75  88   39
```

Multi-Index DataFrame

- Hierarchical indexes (AKA multiindexes) help us to organize, find, and aggregate information faster at almost no cost.
- Example where we need Hierarchical indexes

Numeric Index/Single Index

	Col	Dep	Sem	RN	S1	S2	S3
0	ABC	CE	5	101	50	60	70
1	ABC	CE	5	102	48	70	25
2	ABC	CE	7	101	58	59	51
3	ABC	ME	5	101	30	35	39
4	ABC	ME	5	102	50	90	48
5	Darshan	CE	5	101	88	99	77
6	Darshan	CE	5	102	99	84	76
7	Darshan	CE	7	101	88	77	99
8	Darshan	ME	5	101	44	88	99

Multi Index

			RN	S1	S2	S3
Col	Dep	Sem				
ABC	CE	5	101	50	60	70
		5	102	48	70	25
		7	101	58	59	51
	ME	5	101	30	35	39
		5	102	50	90	48
Darshan	CE	5	101	88	99	77
		5	102	99	84	76
		7	101	88	77	99
	ME	5	101	44	88	99

Multi-Index DataFrame (Cont.)

- Creating multiindexes is as simple as creating single index using **`set_index`** method, only difference is in case of multiindexes we need to provide list of indexes instead of a single string index, lets see and example for that

dfMultiIndex.py

```
1 dfMulti =
  pd.read_csv('MultiIndexDemo.csv')
2 dfMulti.set_index(['Col','Dep','Sem'],
  inplace=True)
3 print(dfMulti)
```

Output

```
                    RN  S1  S2  S3
Col     Dep Sem
ABC     CE  5      101  50  60  70
            5      102  48  70  25
            7      101  58  59  51
        ME  5      101  30  35  39
            5      102  50  90  48
Darshan CE  5      101  88  99  77
            5      102  99  84  76
            7      101  88  77  99
        ME  5      101  44  88  99
```

Multi-Index DataFrame (Cont.)

- Now we have multi-indexed DataFrame from which we can access data using multiple index
- For Example
  - Sub DataFrame for all the students of JU

dfGrabDarshanStu.py

```
1 print(dfMulti.loc[‘Jadavpur'])
```

Output (JU)

```
             RN   S1   S2   S3
Dep Sem
CE  5       101   88   99   77
    5       102   99   84   76
    7       101   88   77   99
ME  5       101   44   88   99
```

  - Sub DataFrame for Computer Engineering students from JU

dfGrabDarshanCEStu.py

```
1 print(dfMulti.loc[' Jadavpur ','CE'])
```

Output (JU->CE)

```
       RN   S1   S2   S3
Sem
5     101   88   99   77
5     102   99   84   76
7     101   88   77   99
```

Reading in Multiindexed DataFrame directly from CSV

- **`read_csv`** function of pandas provides easy way to create multi-indexed DataFrame directly while fetching the CSV file.

dfMultiIndex.py

```
1 dfMultiCSV =
  pd.read_csv('MultiIndexDemo.csv'
  ,index_col=[0,1,2])
  #for multi-index in cols we can
  use header parameter
2 print(dfMultiCSV)
```

Output

			RN	S1	S2	S3
Col	Dep	Sem				
CU	CE	5	101	50	60	70
		5	102	48	70	25
		7	101	58	59	51
	ME	5	101	30	35	39
		5	102	50	90	48
JU	CE	5	101	88	99	77
		5	102	99	84	76
		7	101	88	77	99
	ME	5	101	44	88	99

Cross Sections in DataFrame

- The `xs()` function is used to get cross-section from the Series/DataFrame.
- This method takes a key argument to select data at a particular level of a MultiIndex.
- Syntax :

syntax

```
DataFrame.xs(key, axis=0, level=None, drop_level=True)
```

- Example :

dfMultiIndex.py

```
1 dfMultiCSV =
  pd.read_csv('MultiIndexDemo.csv',
  index_col=[0,1,2])
2 print(dfMultiCSV)
3 print(dfMultiCSV.xs('CE',axis=0,level='Dep'))
```

```
=== Parameters ===
key :  label
axis : Axis to retrieve
       cross section
level : level of key
drop_level : False if you
want to preserve the level
```

Output

```
 RN   S1   S2   S3
Col       Sem
CU        5    101  50   60   70
          5    102  48   70   25
          7    101  58   59   51
JU        5    101  88   99   77
          5    102  99   84   76
          7    101  88   77   99
```

Dealing with Missing Data

- There are many methods by which we can deal with the missing data, some of most commons are listed below,
  - dropna, will drop (delete) the missing data (rows/cols)
  - fillna, will fill specified values in place of missing data
  - interpolate, will interpolate missing data and fill interpolated value in place of missing data.

Groupby in Pandas

- Any groupby operation involves one of the following operations on the original object. They are
  - **Splitting** the Object
  - **Applying** a function
  - **Combining** the results
- In many situations, we split the data into sets and we apply some functionality on each subset.
- we can perform the following operations
  - **Aggregation** – computing a summary statistic
  - **Transformation** – perform some group-specific operation
  - **Filtration** – discarding the data with some condition
- Basic ways to use of `groupby` method
  - `df.groupby('key')`
  - `df.groupby(['key1','key2'])`
  - `df.groupby(key,axis=1)`

College	Enno	CPI
JU	123	8.9
JU	124	9.2
JU	125	7.8
JU	128	8.7
CU	211	5.6
CU	212	6.2
CU	215	3.2
CU	218	4.2
BESU	312	5.2
BESU	315	6.5
BESU	315	5.8

College	Mean CPI
JU	8.65
CU	4.8
BESU	5.83

Groupby in Pandas (Cont.)

- Example : Listing all the groups

dfGroup.py

```
1 dfIPL = pd.read_csv('IPLDataSet.csv')
2 print(dfIPL.groupby('Year').groups)
```

Output

```
{2014: Int64Index([0, 2, 4, 9],
dtype='int64'),
2015: Int64Index([1, 3, 5, 10],
dtype='int64'),
2016: Int64Index([6, 8],
dtype='int64'),
2017: Int64Index([7, 11],
dtype='int64')}
```

Groupby in Pandas (Cont.)

- Example : Group by multiple columns

dfGroupMul.py

```
1 dfIPL = pd.read_csv('IPLDataSet.csv')
2 print(dfIPL.groupby(['Year','Team']).groups)
```

Output

```
{(2014, 'Devils'): Int64Index([2],
dtype='int64'),
 (2014, 'Kings'): Int64Index([4],
dtype='int64'),
 (2014, 'Riders'): Int64Index([0],
dtype='int64'),
 .........
 .........
 (2016, 'Riders'): Int64Index([8],
dtype='int64'),
 (2017, 'Kings'): Int64Index([7],
dtype='int64'),
 (2017, 'Riders'): Int64Index([11],
dtype='int64')}
```

Groupby in Pandas (Cont.)

- Example : Iterating through groups

dfGroupIter.py

```
1 dfIPL = pd.read_csv('IPLDataSet.csv')
2 groupIPL = dfIPL.groupby('Year')
3 for name,group in groupIPL :
4   print(name)
5   print(group)
```

Output

```
2014
     Team  Rank  Year  Points
0  Riders     1  2014     876
2  Devils     2  2014     863
4   Kings     3  2014     741
9  Royals     4  2014     701
2015
      Team  Rank  Year  Points
1   Riders     2  2015     789
3   Devils     3  2015     673
5    kings     4  2015     812
10  Royals     1  2015     804
2016
     Team  Rank  Year  Points
6   Kings     1  2016     756
8  Riders     2  2016     694
2017
      Team  Rank  Year  Points
7    Kings     1  2017     788
11  Riders     2  2017     690
```

Groupby in Pandas (Cont.)

- Example : Aggregating groups

dfGroupAgg.py

```
1 dfSales = pd.read_csv('SalesDataSet.csv')
2 print(dfSales.groupby(['YEAR_ID']).count(
  )['QUANTITYORDERED'])
3 print(dfSales.groupby(['YEAR_ID']).sum()[
  'QUANTITYORDERED'])
4 print(dfSales.groupby(['YEAR_ID']).mean()
  ['QUANTITYORDERED'])
```

Output

```
YEAR_ID
2003    1000
2004    1345
2005     478
Name: QUANTITYORDERED, dtype:
int64
YEAR_ID
2003    34612
2004    46824
2005    17631
Name: QUANTITYORDERED, dtype:
int64
YEAR_ID
2003    34.612000
2004    34.813383
2005    36.884937
Name: QUANTITYORDERED, dtype:
float64
```

Groupby in Pandas (Cont.)

- Example : Describe details

dfGroupDesc.py

```
1 dfIPL =
  pd.read_csv('IPLDataSet.csv')
2 print(dfIPL.groupby('Year').desc
  ribe()['Points'])
```

Output

```
        count  mean   std    min
        25%    50%    75%    max
Year
2014    4.0    795.25 87.439026    701.0
        731.0  802.0  866.25 876.0
2015    4.0    769.50 65.035888    673.0
        760.0  796.5  806.00 812.0
2016    2.0    725.00 43.840620    694.0
        709.5  725.0  740.50 756.0
2017    2.0    739.00 69.296465    690.0
        714.5  739.0  763.50 788.0
```

Concatenation in Pandas

- Concatenation basically glues together DataFrames.
- Keep in mind that dimensions should match along the axis you are concatenating on.
- You can use **pd.concat** and pass in a list of DataFrames to concatenate together:

dfConcat.py

```
1 dfCX = pd.read_csv('CX_Marks.csv',index_col=0)
2 dfCY = pd.read_csv('CY_Marks.csv',index_col=0)
3 dfCZ = pd.read_csv('CZ_Marks.csv',index_col=0)
4 dfAllStudent = pd.concat([dfCX,dfCY,dfCZ])
5 print(dfAllStudent)
```

Output

```
     PDS  Algo  SE
101   50    55  60
102   70    80  61
103   55    89  70
104   58    96  85
201   77    96  63
202   44    78  32
203   55    85  21
204   69    66  54
301   11    75  88
302   22    48  77
303   33    59  68
304   44    55  62
```

- Note : We can use `axis=1` parameter to concat columns.

Join in Pandas

- `df.join()` method will efficiently join multiple DataFrame objects by **index**(or column specified) .
- some of important **Parameters :**
  - **dfOther :** Right Data Frame
  - **on** (Not recommended) **:** specify the column on which we want to join (Default is index)
  - **how :** How to handle the operation of the two objects.
    - **left**: use calling frame's index *(Default)*.
    - **right**: use dfOther index.
    - **outer**: form union of calling frame's index with other's index (or column if on is specified), and sort it. lexicographically.
    - **inner**: form intersection of calling frame's index (or column if on is specified) with other's index, preserving the order of the calling's one.

Join in Pandas (Example)

dfJoin.py

```
1 dfINS =
  pd.read_csv('INS_Marks.csv',index_col=0)
2 dfLeftJoin = allStudent.join(dfINS)
3 print(dfLeftJoin)
4 dfRightJoin =
  allStudent.join(dfINS,how='right')
5 print(dfRightJoin)
```

Output - 1

	PDS	Algo	SE	INS
101	50	55	60	55.0
102	70	80	61	66.0
103	55	89	70	77.0
104	58	96	85	88.0
201	77	96	63	66.0
202	44	78	32	NaN
203	55	85	21	78.0
204	69	66	54	85.0
301	11	75	88	11.0
302	22	48	77	22.0
303	33	59	68	33.0
304	44	55	62	44.0

Output - 2

	PDS	Algo	SE	INS
301	11	75	88	11
302	22	48	77	22
303	33	59	68	33
304	44	55	62	44
101	50	55	60	55
102	70	80	61	66
103	55	89	70	77
104	58	96	85	88
201	77	96	63	66
203	55	85	21	78
204	69	66	54	85

Merge in Pandas

- Merge DataFrame or named Series objects with a database-style join.
- Similar to join method, but used when we want to join/merge with the columns instead of index.
- some of important **Parameters :**
  - **dfOther :** Right Data Frame
  - **on :** specify the column on which we want to join (Default is index)
  - **left_on :** specify the column of left Dataframe
  - **right_on :** specify the column of right Dataframe
  - **how :** How to handle the operation of the two objects.
    - **left**: use calling frame's index *(Default)*.
    - **right**: use dfOther index.
    - **outer**: form union of calling frame's index with other's index (or column if on is specified), and sort it. lexicographically.
    - **inner**: form intersection of calling frame's index (or column if on is specified) with other's index, preserving the order of the calling's one.

Merge in Pandas (Example)

dfMerge.py

```
1 m1 = pd.read_csv('Merge1.csv')
2 print(m1)
3 m2 = pd.read_csv('Merge2.csv')
4 print(m2)
5 m3 = m1.merge(m2,on='EnNo')
6 print(m3)
```

Output

```
   RollNo       EnNo Name
0     101   11112222  Abc
1     102   11113333  Xyz
2     103   22224444  Def

       EnNo   PDS   INS
0   11112222    50    60
1   11113333    60    70

   RollNo       EnNo Name   PDS   INS
0     101   11112222  Abc    50    60
1     102   11113333  Xyz    60    70
```

Read CSV in Pandas

- `read_csv()` is used to read Comma Separated Values (CSV) file into a pandas DataFrame.
- some of important **Parameters :**
  - **filePath :** str, path object, or file-like object
  - **sep :** separator (Default is comma)
  - **header:** Row number(s) to use as the column names.
  - **index_col :** index column(s) of the data frame.

readCSV.py

```
1 dfINS = pd.read_csv('Marks.csv',index_col=0,header=0)
2 print(dfINS)
```

Output

```
     PDS  Algo  SE   INS
101   50    55  60  55.0
102   70    80  61  66.0
103   55    89  70  77.0
104   58    96  85  88.0
201   77    96  63  66.0
```

Read Excel in Pandas

- Read an Excel file into a pandas DataFrame.
- Supports *xls*, *xlsx*, *xlsm*, *xlsb*, *odf*, *ods* and *odt* file extensions read from a local filesystem or URL. Supports an option to read a single sheet or a list of sheets.
- some of important **Parameters :**
  - **excelFile :** str, bytes, ExcelFile, xlrd.Book, path object, or file-like object
  - **sheet_name :** sheet no in integer or the name of the sheet, can have list of sheets.
  - **index_col :** index column of the data frame.

Read from MySQL Database

- We need two libraries for that,
  - conda install **sqlalchemy**
  - conda install **pymysql**
- After installing both the libraries, import `create_engine` from `sqlalchemy` and `import pymysql`

importsForDB.py

```
1 from sqlalchemy import create_engine
2 import pymysql
```

- Then, create a database connection string and create engine using it.

createEngine.py

```
1 db_connection_str = 'mysql+pymysql://username:password@host/dbname'
2 db_connection = create_engine(db_connection_str)
```

Read from MySQL Database (Cont.)

- After getting the engine, we can fire any sql query using **`pd.read_sql`** method.
- `read_sql` is a generic method which can be used to read from any sql (MySQL,MSSQL, Oracle etc…)

readSQLDemo.py

```
1 df = pd.read_sql('SELECT * FROM cities', con=db_connection)
2 print(df)
```

Output

```
     CityID    CityName       City          Description          CityCode
0         1      Kolkata     Kolkata    Description here             KOL
1         2    Aurangabad  Aurangabad   Description here             AGD
2         3      Shimla      Shimla     Description here             SHA
```