CORK INSTITUTE OF TECHNOLOGY
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Programming for Data Analytics

Week8: Introduction to Pandas

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Contents

- Introduction to Pandas Series and Dataframe data structures.
- Reading data into a Dataframe
- Accessing Data from a Dataframe
- Merging and Grouping Data

Pandas

- NumPy is a great tool for dealing with **numeric matrices** and vectors in Python
  - For more complex data, such as tables it is limited.
- Fortunately, when dealing with complex data we can use the **Python Data Analysis Library** (a.k.a. pandas).
- Pandas is an open source library providing high-performance, easy-to-use data structures for the Python programming language.
  - Used primarily for data manipulation and analysis.
- Resources
  - http://pandas.pydata.org/pandas-docs/version/0.13.1/pandas.pdf

Data Structures in Pandas

- Pandas introduces two new data structures to Python –
  - **Series**
  - **DataFrame**

- Both of which are built on top of NumPy (which means it's very fast).

- **A Series** is a one-dimensional object similar to an array, list, or column in a table.

- Pandas will assign a **labelled index** to each item in the Series.
  - By default, each item will receive an index label from 0 to N, where N is the length of the Series minus one.

  - **S = Series(data, index = index)**
    - The data can be many different things such as a NumPy arrays, list of scalar values, dictionary

Series - Examples

```
import numpy as np
import pandas as pd

s1 = pd.Series(np.random.randn(5))
s2 = pd.Series(np.random.randn(5), index=['a','b','c','d','e'])
# number of indices must match number of data points

print (s1)
print (s2)
```

```
0    0.275735
1   -0.445412
2    0.163060
3   -0.364863
4   -0.069800
dtype: float64

a    0.068250
b    0.455478
c    1.356175
d    0.484393
e   -0.919080
dtype: float64
```

```
import pandas as pd

# Dictionary with annual car robberies in each Irish city
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125,' Galway': 360,
'Belfast': 300}

# if you pass a dictionary to a series, the keys becomes the
indixes of the Series
cities = pd.Series(d)

print (cities)
```

```
Belfast     300
Cork        150
Dublin      245
Galway      360
Limerick    125
dtype: int64
```

Series

- You can use the **index to select specific items** from the Series.
  - The first print will print the entire series
  - The second will print the item associated with index ‘b’ (note you can access one item at time using this method)
  - The third uses **double square brackets** and prints a subset of the original series (**note it returns a independent Series object**)

```
s1 = pd.Series([1, 2, 3, 4, 5], index=['a','b','c','d','e'])

print (s1)

print (s1['b'])

print (s1[['a', 'b']])
```

```
a    1
b    2
c    3
d    4
e    5
dtype: int64

2

a    1
b    2
dtype: int64
```

Series

- Another useful feature of a series is using boolean conditions
  - **irishCities <200** returns a Series of True/False values, which we then pass to our Series cities, returning the corresponding True items.

```
# Dictionary with annual car robberies in each Irish city
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125,' Galway': 360, 'Belfast': 300}

irishCities = pd.Series(d)

print (irishCities[ irishCities <200 ])

print (type(irishCities[irishCities <200]))
```

As with NumPy, relational operators return a **separate copy** of the data. The original series and the one returned by the relational operator don’t refer to the same copy of the same data.

```
Cork        150
Limerick    125
dtype: int64
<class 'pandas.core.series.Series'>
```

Series

- It is also very easy to change a value within a series.

```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast':
300}
irishCities = pd.Series(d)

print (irishCities)

irishCities["Cork"] = 180
irishCities["Kilkenny"] = 120

print (irishCities)
```

```
Galway     360
Belfast    300
Cork       150
Dublin     245
Limerick   125
dtype: int64

Galway     360
Belfast    300
Cork       180
Dublin     245
Limerick   125
Kilkenny   120
dtype: int64
```

Similar to the syntax we use for adding a key value pair to a dictionary.

Series

- What does the code below achieve?

```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast':
300}
irishCities = pd.Series(d)

print (irishCities)

irishCities[irishCities<160] = 100

print (irishCities)
```

```
Galway     360
Belfast    300
Cork       150
Dublin     245
Limerick   125
dtype: int64


Galway     360
Belfast    300
Cork       100
Dublin     245
Limerick   100
dtype: int64
```

This code will go through the Series setting any value that is currently less than 160 to a value of 100.
When you use Boolean selection coupled with assignment it selects the entries in the existing Series object to be changed.

Series

- Normal NumPy mathematical operations can be completed on Series objects as well.

```
d = {'Dublin': 245, 'Cork': 150, 'Limerick': 125, 'Galway': 360, 'Belfast': 300}
irishCities = pd.Series(d)

print (irishCities*100)

print (np.square(irishCities))
```

```
Belfast     30000
Cork        15000
Dublin      24500
Galway      36000
Limerick    12500
dtype: int64

Belfast      90000
Cork         22500
Dublin       60025
Galway      129600
Limerick     15625
dtype: int64
```

Notice in this example we still use NumPys square method but rather than passing it a NumPy array we pass it a Series instead

Series – len and unique function

- As with all data structures we have seen so far we can use the ***len()*** function to obtain the number of values stored in a Series (this also works for a dataframe, which return the number of rows)

- Another useful function to use with a Series object is the ***unique*** function, which returns all the unique data items in a specific series object (it is returned as a NumPy array).

```
import pandas as pd


seriesA = pd.Series(['A', 'C', 'B', 'B', 'A'])

print (pd.unique(seriesA))
```

```
['A' 'C' 'B']
```

Example

- Create a Pandas Series variable to store the data depicted in the table below (we will use the names as indices and the grades as the values).
- Write code that will return a Series containing all those that failed the exam.
- Next write code that will increase any grade less than 40 by 5%

Name	Grade
Jim	78
Elaine	23
Ted	65
Frank	88
Sarah	80
Tim	33

Example

```
import pandas as pd

studentDetails = {'Jim':78, 'Elaine':23, 'Ted':65, 'Frank':88, 'Sarah':80, 'Tim':33}
grades = pd.Series(studentDetails)

print grades[grades<40]


grades[grades<40] += 5

print (grades)
```

```
Elaine    23
Tim       33
dtype: int64

Elaine    28
Frank     88
Jim       78
Sarah     80
Ted       65
Tim       38
dtype: int64
```

It is possible to turn this Series into a one-column DataFrame with the to_frame method.

This method will use the Series name as the new column name:

```
>>> director.to_frame()
```

Discussion

Data Frame

- A DataFrame is a data structure comprised of **rows and columns** of data.
  - It is similar to a spreadsheet or a database table.
  - You can also think of a DataFrame as a **collection of Series objects** that share an index

- To create a DataFrame out of common Python data structures, we can pass a dictionary of lists to the DataFrame constructor.
- We can also easily create a dataframe by passing it a 2D NumPy array.

- The syntax for creating a data frame is as follows:
  - ***DataFrame(data, columns=listOfColumns)***

- Using the columns parameter allows us to tell the constructor how we'd like the columns ordered.

Creating a DataFrame

```
import pandas as pd

data = {'student': ['Jim Murphy', 'Ted Scully', 'Jason Oakley', 'Pat OBrien'],
        'grade': [67, 75, 56, 89],
        'department': ["Computing", "Chemistry", "Biology", "Maths"]}

students = pd.DataFrame(data)

print students
```

```
  department  grade      student
0  Computing     67   Jim Murphy
1  Chemistry     75   Ted Scully
2    Biology     56 Jason Oakley
3      Maths     89   Pat OBrien
```

Notice the **key becomes the columns headers** of the dataframe and the values of the dictionary (the list) populate the column.

Creating a DataFrame

```
import pandas as pd
data = {'student': ['Jim Murphy', 'Ted Scully', 'Jason Oakley', 'Pat OBrien'],
        'grade': [67, 75, 56, 89],
        'department': ["Computing", "Chemistry", "Biology", "Maths"]}

students = pd.DataFrame(data, columns=['student', 'grade', 'department'])

print students
```

```
          student     grade   department
0    Jim Murphy     67  Computing
1    Ted Scully     75     Chemistry
2  Jason Oakley     56    Biology
3    Pat OBrien     89      Maths
```

I can directly specify the names of the columns and the order in which they appear by including a columns argument when creating the dataframe. It is important that the names of the columns match the dictionary keys

Creating a DataFrame

- Rather than using a list as we did in the previous slide we can also create a dataframe by passing a dictionary of Series objects.

```
seriesA = pd.Series(np.random.rand(3), index=['a', 'b', 'c'])
seriesB = pd.Series(np.random.rand(4), index=['a', 'b', 'c', 'd'])
seriesC = pd.Series(np.random.rand(3), index=['b', 'c', 'd'])

df = pd.DataFrame({'one' : seriesA,
                   'two' : seriesB,
                           'three' : seriesC})
print df
```

```
 one          three      two
a  0.307010    NaN       0.396005
b  0.671142   0.263916   0.532836
c  0.116057   0.839463   0.826531
d       NaN   0.439335   0.984332
```

Creating a Dataframe

- In the example below we can easily create a dataframe from a 2D NumPy array. The array is passed as an argument when the dataframe is created.

```
import pandas as pd
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]], float)

df = pd.DataFrame(arr)

print df
```

Creating a Dataframe

- We can also specify column names when creating the dataframe.

```
import pandas as pd
import numpy as np


arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]], float)

df = pd.DataFrame(arr, columns=['colA', 'colB', 'colC'])
print
print df
```

```
   colA  colB  colC
0   1     2     3
1   4     5     6
2   7     8     9
```

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Dataframe

- The most common way of creating a dataframe is by reading existing data directly into a dataframe
- There are a number of ways of doing this
  - read_csv
  - read_excel
  - read_hdf
  - read_sql
  - read_json
  - read_sas …
- We will look at how to read from a CSV file.

Titanic - Dataset

- On April 15, 1912, during her maiden voyage, the Titanic sank after colliding with an iceberg, killing 1502 out of 2224 passengers and crew.

- Although there was some element of luck involved in surviving the sinking, some **groups of people were more likely to survive than others**, such as women, children, and the first-class passengers.

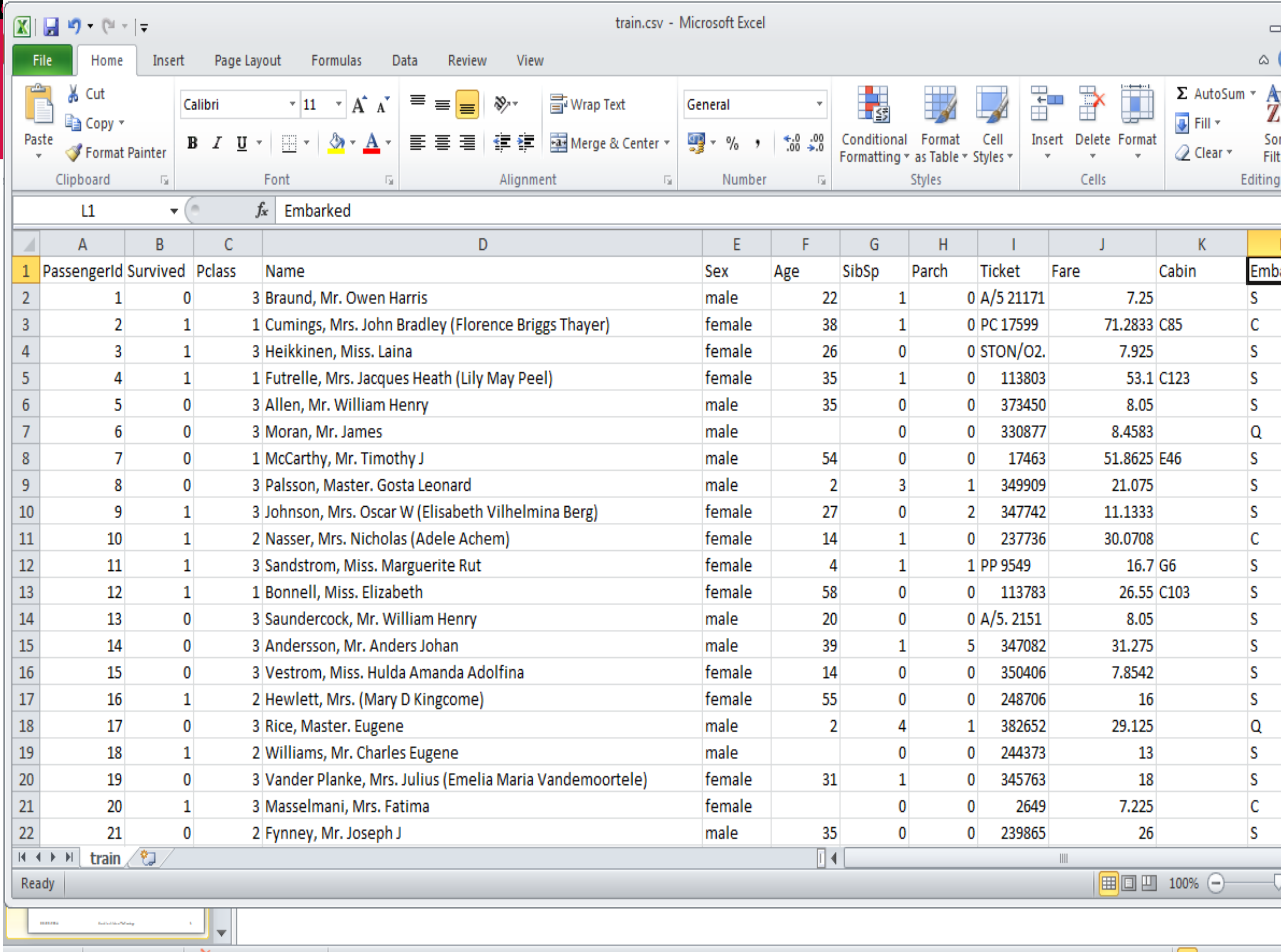
- The dataset we examine contains the details of **891 passengers aboard the titanic**. We will use this as an introduction to the Pandas library.

Titanic - Dataset

Available as .csv file on Blackboard.

VARIABLE DESCRIPTIONS:

survival	Survival (0 = No; 1 = Yes)
pclass	Passenger Class (1 = 1st; 2 = 2nd; 3 = 3rd)
name	Name
sex	Sex
age	Age
sibsp	Number of Siblings/Spouses Aboard
parch	Number of Parents/Children Aboard
ticket	Ticket Number
fare	Passenger Fare
cabin	Cabin
embarked	Port of Embarkation (C = Cherbourg; Q = Queenstown; S = Southampton)



L1 | fx | Embarked

	A	B	C	D	E	F	G	H	I	J	K	
1	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Emba
2	1	0	3	Braund, Mr. Owen Harris	male	22	1	0	A/5 21171	7.25		S
3	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Thayer)	female	38	1	0	PC 17599	71.2833	C85	C
4	3	1	3	Heikkinen, Miss. Laina	female	26	0	0	STON/O2.	7.925		S
5	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35	1	0	113803	53.1	C123	S
6	5	0	3	Allen, Mr. William Henry	male	35	0	0	373450	8.05		S
7	6	0	3	Moran, Mr. James	male		0	0	330877	8.4583		Q
8	7	0	1	McCarthy, Mr. Timothy J	male	54	0	0	17463	51.8625	E46	S
9	8	0	3	Palsson, Master. Gosta Leonard	male	2	3	1	349909	21.075		S
10	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27	0	2	347742	11.1333		S
11	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14	1	0	237736	30.0708		C
12	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4	1	1	PP 9549	16.7	G6	S
13	12	1	1	Bonnell, Miss. Elizabeth	female	58	0	0	113783	26.55	C103	S
14	13	0	3	Saundercock, Mr. William Henry	male	20	0	0	A/5. 2151	8.05		S
15	14	0	3	Andersson, Mr. Anders Johan	male	39	1	5	347082	31.275		S
16	15	0	3	Vestrom, Miss. Hulda Amanda Adolfina	female	14	0	0	350406	7.8542		S
17	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female	55	0	0	248706	16		S
18	17	0	3	Rice, Master. Eugene	male	2	4	1	382652	29.125		Q
19	18	1	2	Williams, Mr. Charles Eugene	male		0	0	244373	13		S
20	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vandemoortele)	female	31	1	0	345763	18		S
21	20	1	3	Masselmani, Mrs. Fatima	female		0	0	2649	7.225		C
22	21	0	2	Fynney, Mr. Joseph J	male	35	0	0	239865	26		S

Reading Data from a File

- To pull in the text file, we will use the pandas function *read_csv* method. Let us take a look at this function and what inputs it takes.
- The read_csv has a very large number of parameters such as specifying the delimiter, included headers, etc

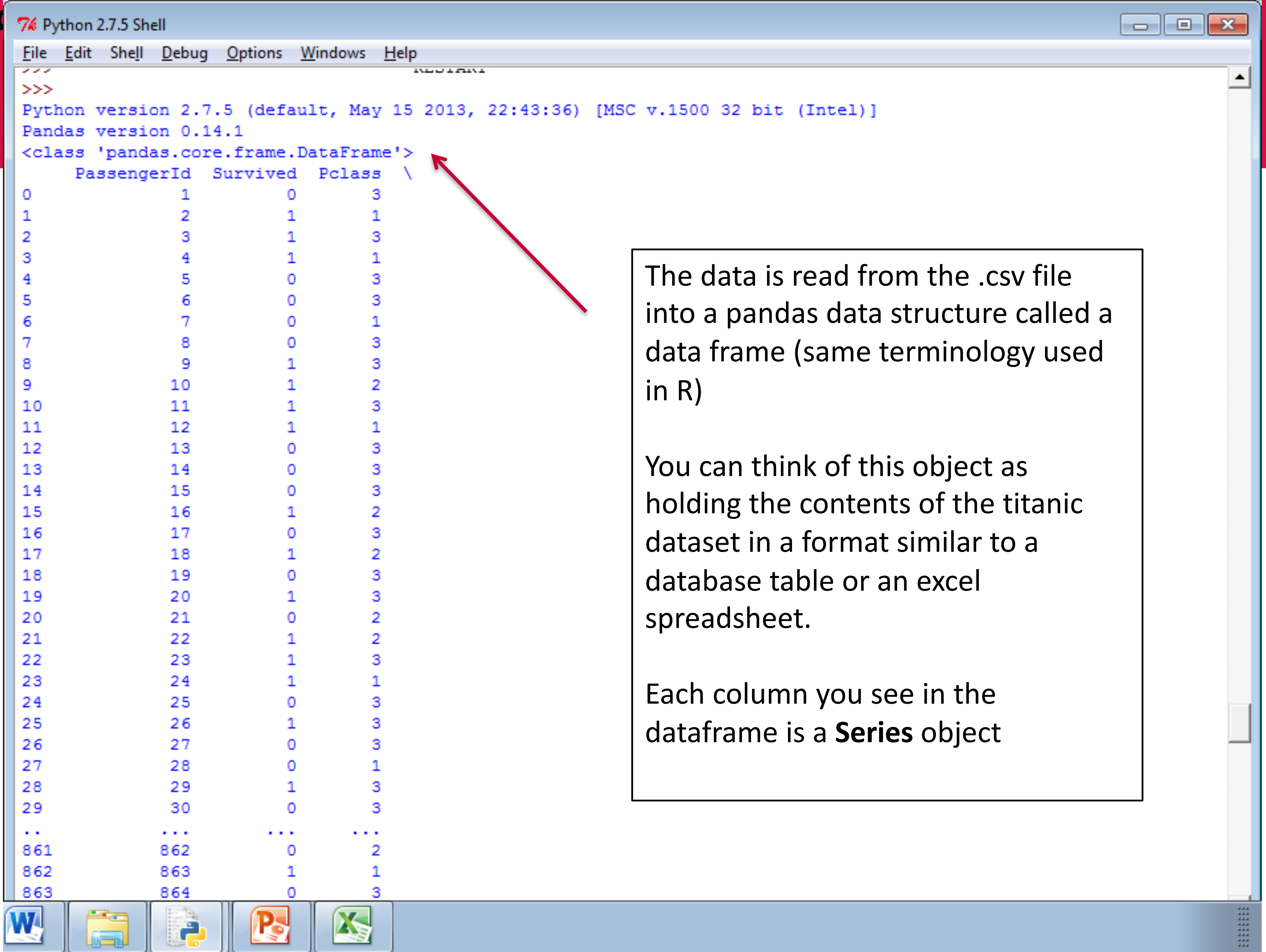
```
# General syntax to import specific functions in a library:
Import pandas as pd

df = pd.read_csv("titanic.csv")

print type(df)

print df
```

http://pandas.pydata.org/pandas-docs/stable/generated/pandas.read_csv.html



```
>>>
Python version 2.7.5 (default, May 15 2013, 22:43:36) [MSC v.1500 32 bit (Intel)]
Pandas version 0.14.1
<class 'pandas.core.frame.DataFrame'>
     PassengerId  Survived  Pclass  \
0              1         0       3
1              2         1       1
2              3         1       3
3              4         1       1
4              5         0       3
5              6         0       3
6              7         0       1
7              8         0       3
8              9         1       3
9             10         1       2
10            11         1       3
11            12         1       1
12            13         0       3
13            14         0       3
14            15         0       3
15            16         1       2
16            17         0       3
17            18         1       2
18            19         0       3
19            20         1       3
20            21         0       2
21            22         1       2
22            23         1       3
23            24         1       1
24            25         0       3
25            26         1       3
26            27         0       3
27            28         0       1
28            29         1       3
29            30         0       3
..           ...       ...     ...
861          862         0       2
862          863         1       1
863          864         0       3
```

The data is read from the .csv file into a pandas data structure called a data frame (same terminology used in R)

You can think of this object as holding the contents of the titanic dataset in a format similar to a database table or an excel spreadsheet.

Each column you see in the dataframe is a **Series** object

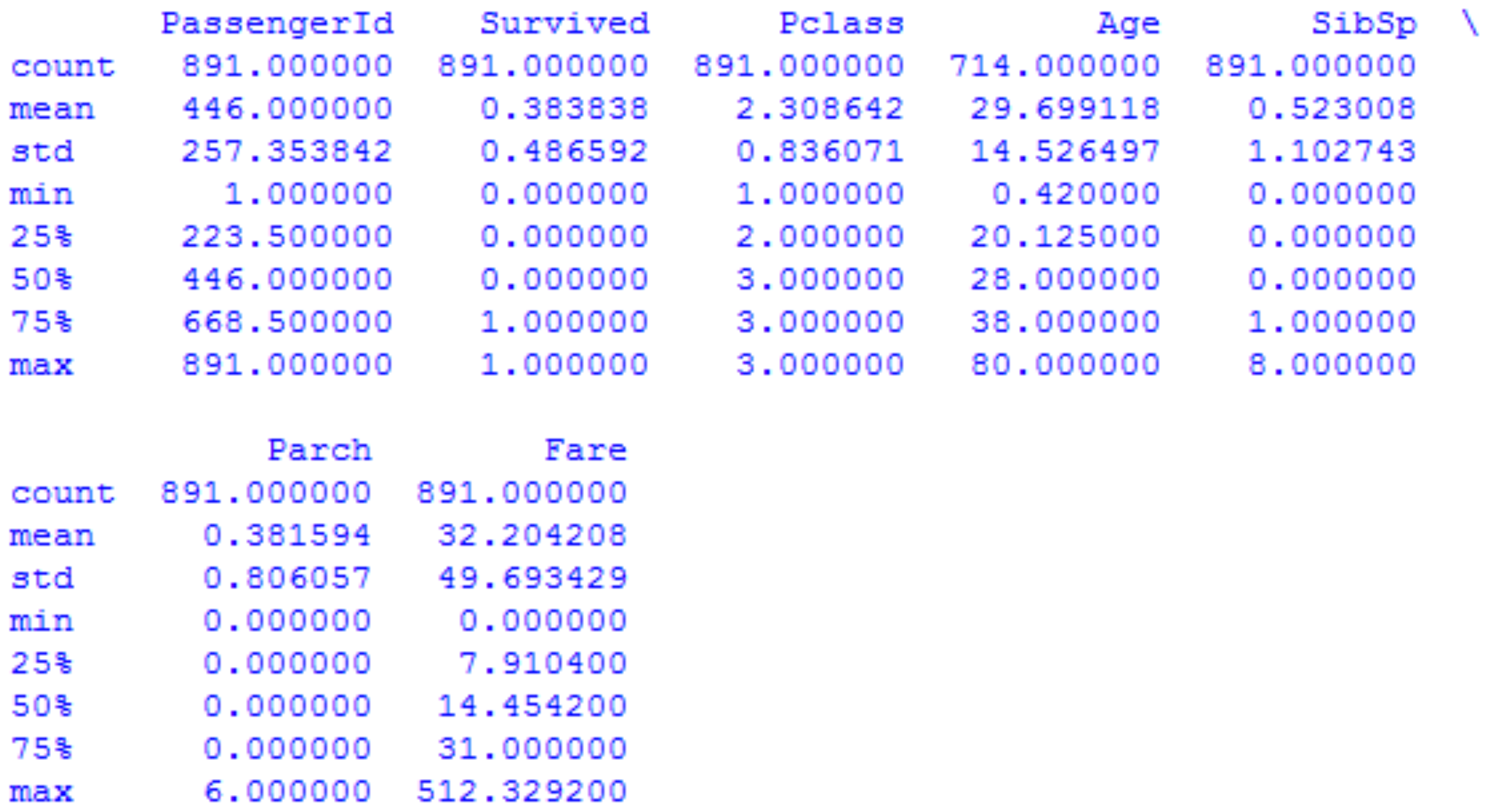
Describing a DataFrame

- DataFrame's have a very useful **describe** method, which is used for seeing **basic statistics** about the dataset's numeric columns.
  - It will return information on all columns of a numeric datatype, therefore some of the data may not be of use .
  - The data type of what is returned is itself a dataframe

```
df = pd.read_csv("titanic.csv")

print type(df)

print df.describe()
```



```
       PassengerId    Survived      Pclass         Age       SibSp  \
count   891.000000  891.000000  891.000000  714.000000  891.000000
mean    446.000000    0.383838    2.308642   29.699118    0.523008
std     257.353842    0.486592    0.836071   14.526497    1.102743
min       1.000000    0.000000    1.000000    0.420000    0.000000
25%     223.500000    0.000000    2.000000   20.125000    0.000000
50%     446.000000    0.000000    3.000000   28.000000    0.000000
75%     668.500000    1.000000    3.000000   38.000000    1.000000
max     891.000000    1.000000    3.000000   80.000000    8.000000

            Parch        Fare
count  891.000000  891.000000
mean     0.381594   32.204208
std      0.806057   49.693429
min      0.000000    0.000000
25%      0.000000    7.910400
50%      0.000000   14.454200
75%      0.000000   31.000000
max      6.000000  512.329200
```

We can easily see the average age of the passengers is 29.6 years old, with the youngest being 0.42 and the oldest being 80. The median age is 28, with the youngest quartile of users being 20 or younger, and the oldest quartile being at least 38

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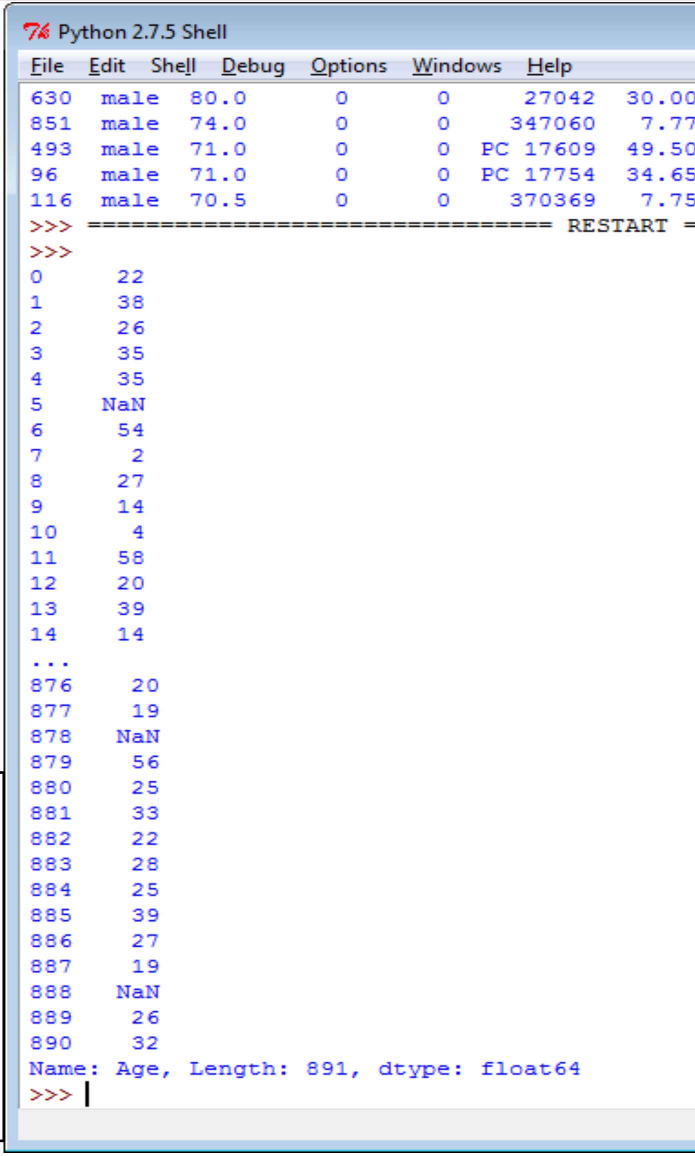
Accessing Column Data

- To select a column, we index with the name of the column:
- **dataframe[‘columnName’]**

```
df = pd.read_csv("titanic.csv")

print df['Age']
```

- Note this column is returned as a **Series object**

Alternatively, a column of data may be accessed using the dot notation with the column name as an attribute (df.Age). Although it works with this particular example, it is not best practice and is prone to error and misuse. Column names with spaces or special characters cannot be accessed in this manner.



```
630  male  80.0     0     0     27042  30.00
851  male  74.0     0     0    347060   7.77
493  male  71.0     0     0  PC 17609  49.50
96   male  71.0     0     0  PC 17754  34.65
116  male  70.5     0     0    370369   7.75
>>> ================================ RESTART =
>>>
0      22
1      38
2      26
3      35
4      35
5     NaN
6      54
7       2
8      27
9      14
10      4
11     58
12     20
13     39
14     14
...
876    20
877    19
878   NaN
879    56
880    25
881    33
882    22
883    28
884    25
885    39
886    27
887    19
888   NaN
889    26
890    32
Name: Age, Length: 891, dtype: float64
>>> |
```

Accessing Row Data

- To get the first 5 rows of a dataframe, we can use a slice: df[0:5] or df[:5].

```
df = pd.read_csv("titanic.csv")

firstEntries = df[:5]

print firstEntries
```

As with NumPy

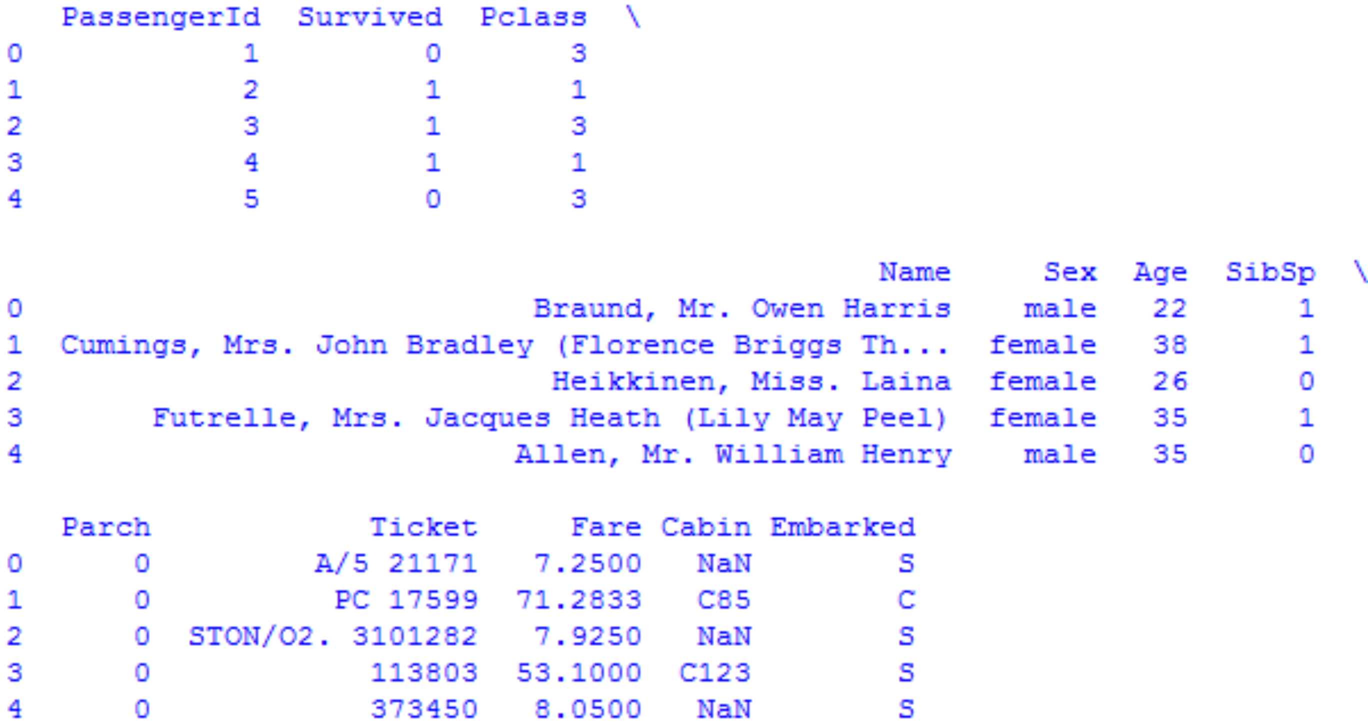
a slice **returns a view**

of the original data.

Any changes made to

view will be reflected

in the original dataframe

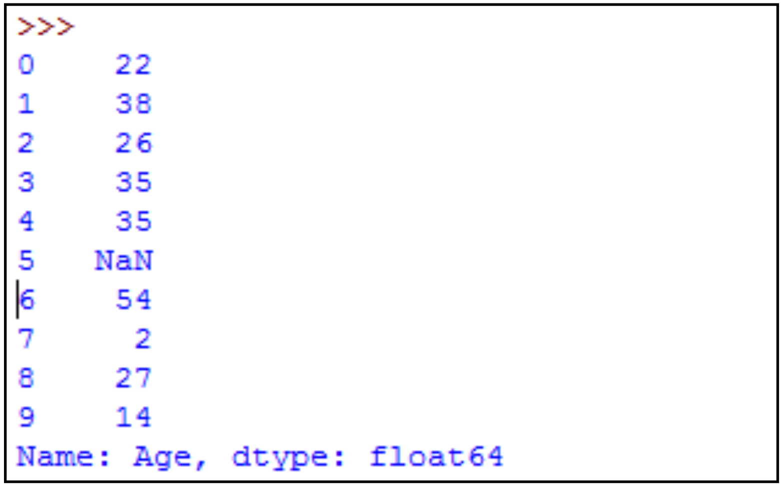


```
   PassengerId  Survived  Pclass  \
0            1         0       3
1            2         1       1
2            3         1       3
3            4         1       1
4            5         0       3

                                                Name     Sex   Age  SibSp  \
0                            Braund, Mr. Owen Harris    male   22      1
1  Cumings, Mrs. John Bradley (Florence Briggs Th...  female   38      1
2                             Heikkinen, Miss. Laina  female   26      0
3       Futrelle, Mrs. Jacques Heath (Lily May Peel)  female   35      1
4                           Allen, Mr. William Henry    male   35      0

   Parch            Ticket     Fare Cabin Embarked
0      0         A/5 21171   7.2500   NaN        S
1      0          PC 17599  71.2833   C85        C
2      0  STON/O2. 3101282   7.9250   NaN        S
3      0            113803  53.1000  C123        S
4      0            373450   8.0500   NaN        S
```

Accessing Rows and Individual Data Items

- We can combine the techniques we saw in the previous slides in order to get the first 10 rows of a specific column (age in this case):

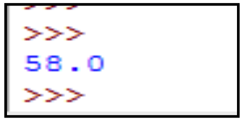
```
df = pd.read_csv("titanic.csv")
print df['Age'][:10]
```



```
>>>
0     22
1     38
2     26
3     35
4     35
5    NaN
6     54
7      2
8     27
9     14
Name: Age, dtype: float64
```

To access a specific data item within a data frame we can use the following **df[‘columnName’][rowNumber]**

```
df = pd.read_csv("titanic.csv")
print df['Age'][11]
```

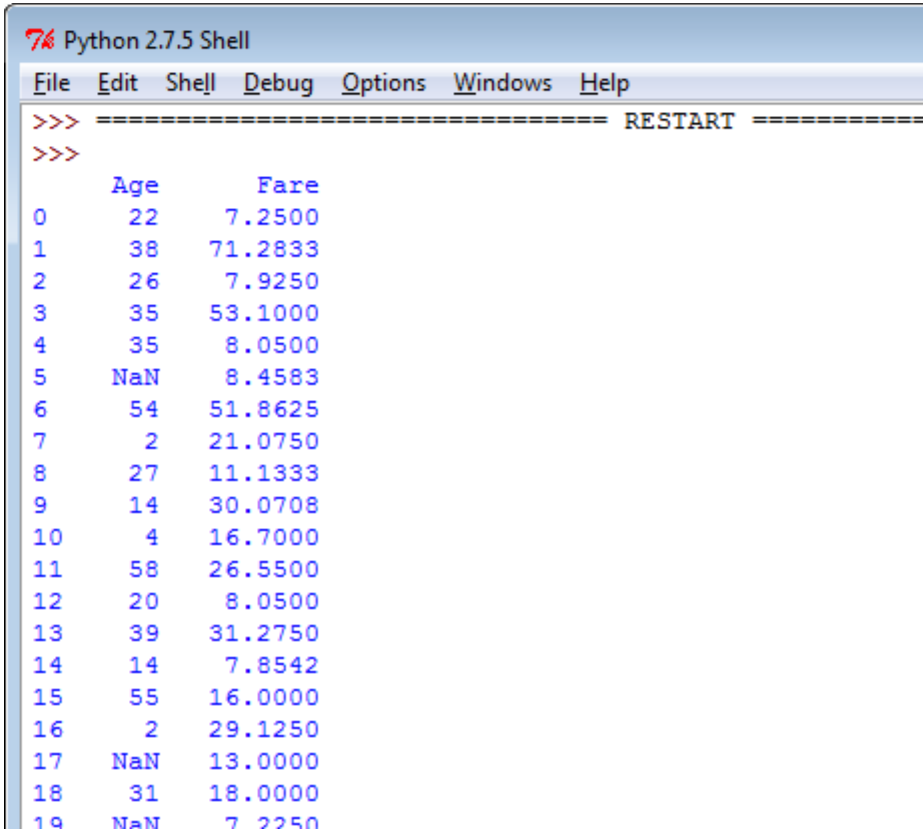


```
>>>
58.0
>>>
```

Selecting Multiple Columns

- Pandas makes it really easy to select a subset of the columns: just index which list of columns you want.
- Note this returns another dataframe
  - (note the **double square brackets**)

```
df = pd.read_csv("titanic.csv")
print df[['Age', 'Fare']]
```



```
>>> ================================ RESTART ==========
>>> 
     Age       Fare
0     22     7.2500
1     38    71.2833
2     26     7.9250
3     35    53.1000
4     35     8.0500
5    NaN     8.4583
6     54    51.8625
7      2    21.0750
8     27    11.1333
9     14    30.0708
10     4    16.7000
11    58    26.5500
12    20     8.0500
13    39    31.2750
14    14     7.8542
15    55    16.0000
16     2    29.1250
17   NaN    13.0000
18    31    18.0000
19   NaN     7.2250
```

Accessing Column (Series) Data

- We mentioned in a previous slide that you can also think of a DataFrame as a **group of Series objects** that share an index. When you access an individual column from a dataframe the datatype returned is a series.
  - Note if you extract multiple columns the data type returned is still a dataframe

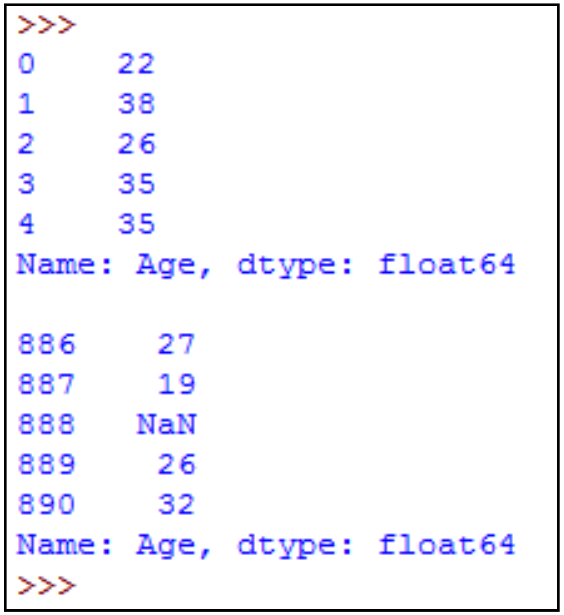
```
df = pd.read_csv("titanic.csv")

ages = df['Age']
print type(ages)

moreInfo = df[['Age', 'Name']]
print type(moreInfo)
```

```
<class 'pandas.core.series.Series'>
<class 'pandas.core.frame.DataFrame'>
```

Using Head and Tail

- To view a small sample of a Series or DataFrame object, use the head (start) and tail (end) methods. The default number of elements to display is five, but you can pass a number as an argument.

```
df = pd.read_csv("titanic.csv")
freqAges = df['Age']
print freqAges.head()
print
print freqAges.tail()
```



```
>>>
0      22
1      38
2      26
3      35
4      35
Name: Age, dtype: float64

886     27
887     19
888    NaN
889     26
890     32
Name: Age, dtype: float64
>>>
```

- If I want to capture the last 7 age values in the dataset

```
df = pd.read_csv("titanic.csv")
print df["Age"].tail(7)
```

Accessing Data - .head and .tail

- It is important to understand that if you **extract a column** from a dataframe you are working with a **view of the same data**.
- Both the dataframe and the column you have extracted refer to the same data.
- In the example below you will see that the change made to allAges will be reflected in the dataframe age column.

```
import pandas as pd

df = pd.read_csv('titanic.csv')

print df['Age'].head(5)

allAges = df['Age']

allAges[0] = 877
print df['Age'].head(5)
```

```
0    22
1    38
2    26
3    35
4    35
Name: Age, dtype: float64
0    877
1     38
2     26
3     35
4     35
Name: Age, dtype: float64
```

Counting – value_counts()

- A very useful method **value_counts()** can be used to count the **number of occurrences of each entry** in a column (it returns a Series object)

- It presents the results in **descending** order
- For examples, how many males and females are represented in dataset

```
df = pd.read_csv("titanic.csv")
print df['Sex'].value_counts()
```

```
male      577
female    314
dtype: int64
```

Titanic - Dataset

SPECIAL NOTES:

Pclass is a proxy for socio-economic status (SES)
1st ~ Upper; 2nd ~ Middle; 3rd ~ Lower

Age is in Years; Fractional if Age less than One (1)
If the Age is Estimated, it is in the form xx.5

With respect to the family relation variables (i.e. sibsp and parch) some relations were ignored. The following are the definitions used for sibsp and parch.

Sibling: Brother, Sister, Stepbrother, or Stepsister of Passenger Aboard Titanic
Spouse: Husband or Wife of Passenger Aboard Titanic (Mistresses and Fiancees Ignored)
Parent: Mother or Father of Passenger Aboard Titanic
Child: Son, Daughter, Stepson, or Stepdaughter of Passenger Aboard Titanic

Discussion

Thank you

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