Introduction to Pandas' DataFrame

A Library that is Used for Data Manipulation and Analysis Tool

Using Powerful Data Structures

By

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Pandas First Steps: install and import

- Pandas is an easy package to install. Open up your terminal program (shell or cmd) and install it using either of the following commands:

```
$ conda install pandas
          OR
$ pip  install  pandas
```

- For **`jupyter notebook`** users, you can run this cell:

```
!pip install pandas
```

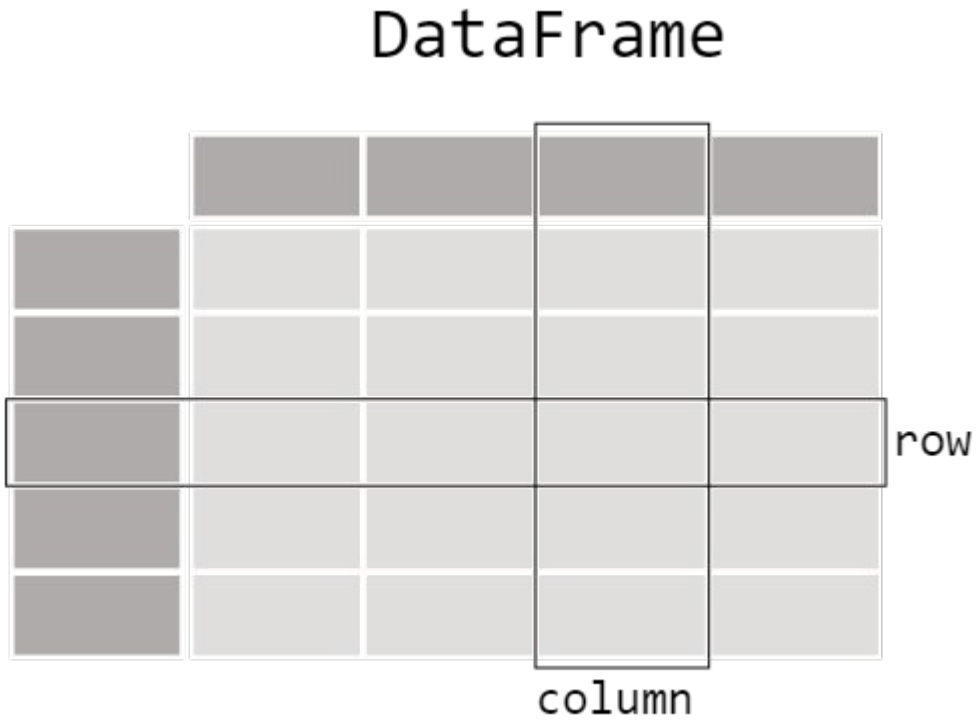
  - The **`!`** at the beginning runs cells as if they were in a terminal.

- To import pandas we usually import it with a shorter name since it's used so much:

```
import pandas as pd
```

Installation: https://pandas.pydata.org/pandas-docs/stable/getting_started/install.html

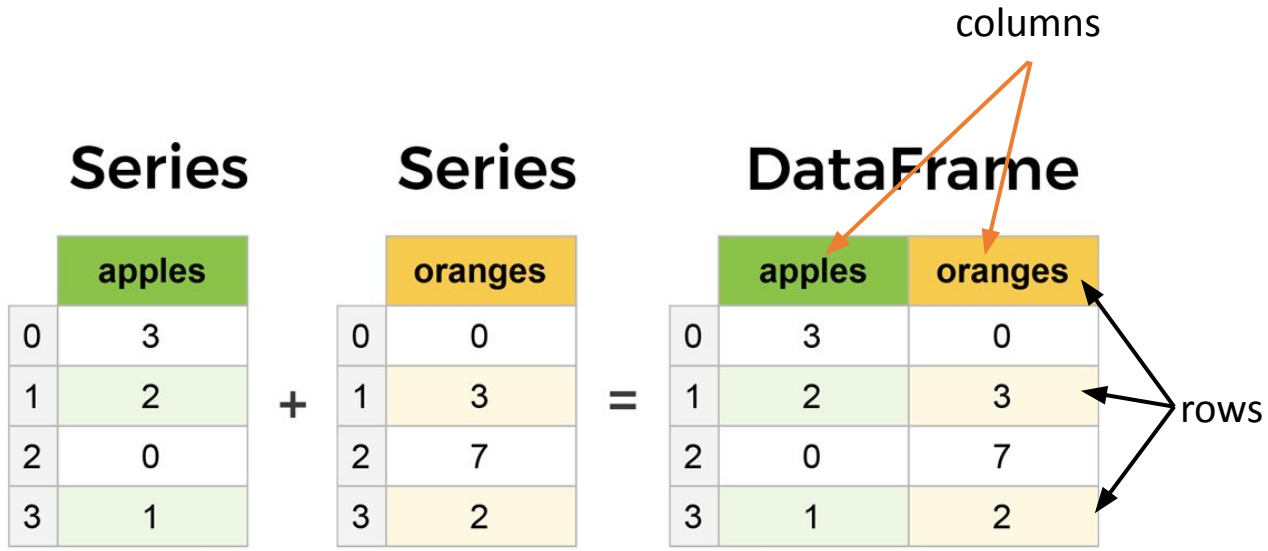
pandas: Data Table Representation



Core components of pandas: Series & DataFrames

- The primary two components of pandas are the Series and DataFrame.
  - Series is essentially a column, and
  - DataFrame is a multi-dimensional table made up of a collection of Series.
- DataFrames and Series are quite similar in that many operations that you can do with one you can do with the other, such as filling in null values and calculating the mean.
  - A Data frame is a two-dimensional data structure, i.e., data is aligned in a tabular fashion in rows and columns.

- Features of DataFrame
  - Potentially columns are of different types
  - Size – Mutable
  - Labeled axes (*rows* and *columns*)
  - Can Perform Arithmetic operations on rows and columns



Types of Data Structure in Pandas

Data Structure	Dimensions	Description
Series	1	1D labeled homogeneous array with immutable size
Data Frames	2	General 2D labeled, size mutable tabular structure with potentially heterogeneously typed columns.
Panel	3	General 3D labeled, size mutable array.

- **Series & DataFrame**
  - Series is a one-dimensional array (1D Array) like structure with homogeneous data.
  - DataFrame is a two-dimensional array (2D Array) with heterogeneous data.
- **Panel**
  - Panel is a three-dimensional data structure (3D Array) with heterogeneous data.
  - It is hard to represent the panel in graphical representation.
  - But a panel can be illustrated as a container of DataFrame

pandas.DataFrame

```
pandas.DataFrame(data, index , columns , dtype , copy )
```

- data: data takes various forms like *ndarray*, *series*, *map*, *lists*, *dict*, constants and also another *DataFrame*.
- index: For the **row labels**, that are to be used for the resulting frame, Optional, Default is *np.arrange(n)* if no index is passed.
- columns: For **column labels**, the optional default syntax is - *np.arrange(n)*. This is only true if no index is passed.
- dtype: Data type of each column.
- copy: This command (or whatever it is) is used for copying of data, if the default is False.

- **Create DataFrame**
  - A pandas DataFrame can be created using various inputs like –
    - Lists
    - dict
    - Series
    - Numpy ndarrays
    - Another DataFrame

Creating a DataFrame from scratch

Creating a DataFrame from scratch

- There are many ways to create a DataFrame from scratch, but a great option is to just use a simple dict. But first you must import pandas.

```
import pandas as pd
```

- Let's say we have a fruit stand that sells apples and oranges. We want to have a column for each fruit and a row for each customer purchase. To organize this as a dictionary for pandas we could do something like:

```
data = { 'apples':[3, 2, 0, 1] , 'oranges':[0, 3, 7, 2] }
```

- And then pass it to the pandas DataFrame constructor:

```
df = pd.DataFrame(data)
```

	apples	oranges
0	3	0
1	2	3
2	0	7
3	1	2

How did that work?

- Each (key, value) item in data corresponds to a column in the resulting DataFrame.
- The Index of this DataFrame was given to us on creation as the numbers `0-3`, but we could also create our own when we initialize the DataFrame.
- E.g. if you want to have customer names as the index:

```
df = pd.DataFrame(data, index=['Ahmad', 'Ali', 'Rashed', 'Hamza'])
```

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

- So now we could locate a customer's order by using their names:

```
df.loc['Ali']
```

```
apples      2
oranges     3
Name: Ali, dtype: int64
```

pandas.DataFrame.from_dict

```
pandas.DataFrame.from_dict(data, orient='columns', dtype=None, columns=None)
```

- **data** : dict
  - Of the form **{field:array-like}** or **{field:dict}**.

- **orient** : **{'columns', 'index'}**, default '**columns**'
  - The "orientation" of the data.
  - If the keys of the passed dict should be the columns of the resulting DataFrame, pass 'columns' (default).
  - Otherwise if the keys should be rows, pass 'index'.

- **dtype** : **dtype**, default **None**
  - Data type to force, otherwise infer.

- **columns** : **list**, default **None**
  - Column labels to use when **orient='index'**. Raises a **ValueError** if used with **orient='columns'**.

https://pandas.pydata.org/pandas-docs/version/0.23/generated/pandas.DataFrame.from_dict.html

pandas' **orient** keyword

```
data = {'col_1':[3, 2, 1, 0], 'col_2':['a','b','c','d']}

pd.DataFrame.from_dict(data)
```

	col_1	col_2
0	3	a
1	2	b
2	1	c
3	0	d

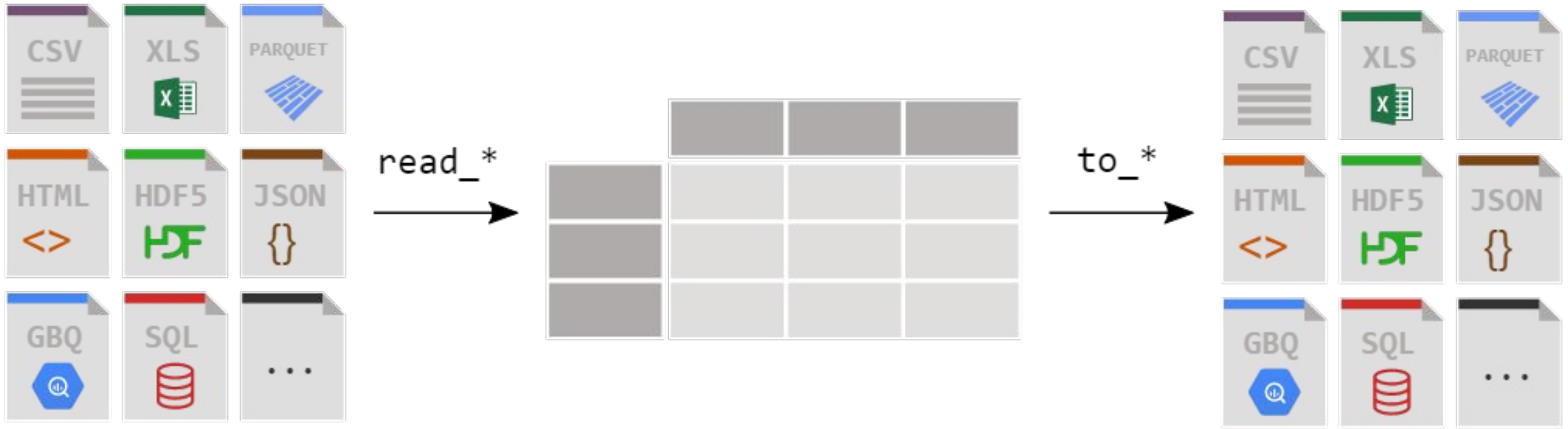
```
data = {'row_1':[3, 2, 1, 0], 'row_2':['a','b','c','d']}
pd.DataFrame.from_dict(data,
                       orient='index')
```

	0	1	2	3
row_1	3	2	1	0
row_2	a	b	c	d

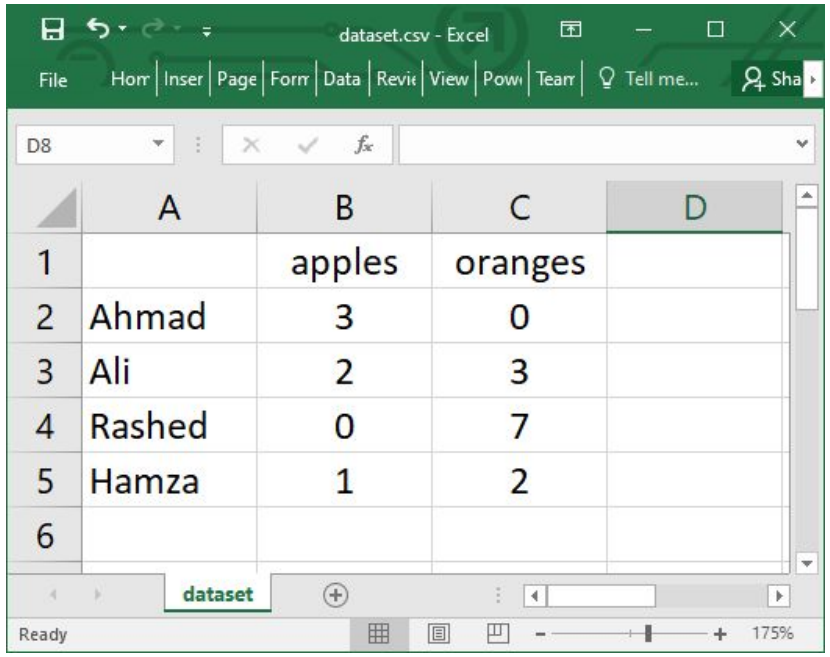
```
data = {'row_1':[3, 2, 1, 0], 'row_2':['a','b','c','d']}

pd.DataFrame.from_dict(data,
                       orient  = 'index',
                       columns = ['A','B','C','D'])
```

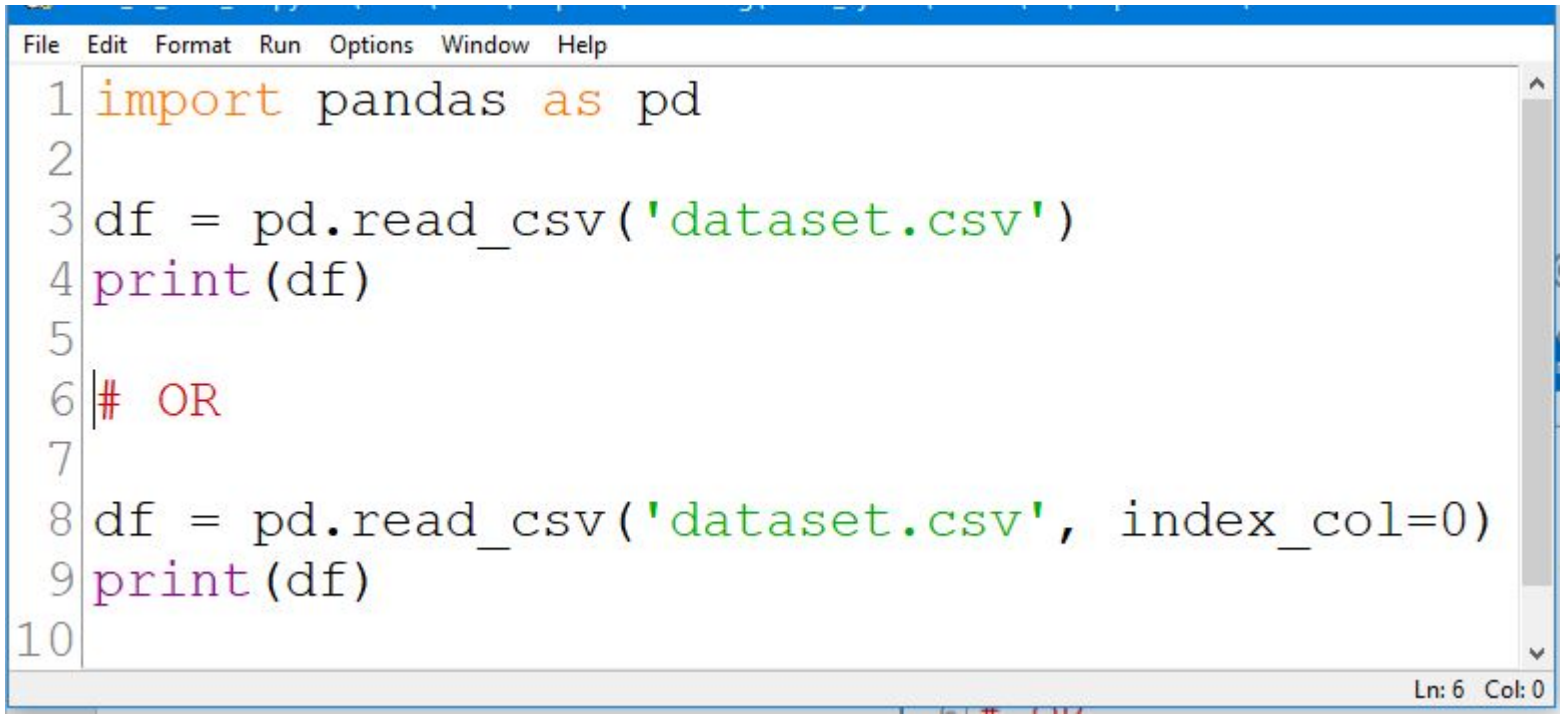
	A	B	C	D
row_1	3	2	1	0
row_2	a	b	c	d

Loading a DataFrame from files



Reading data from a CSV file





Reading data from CSVs

- With CSV files, all you need is a single line to load in the data:

```
df = pd.read_csv('dataset.csv')
```

	Unnamed: 0	apples	oranges
0	Ahmad	3	0
1	Ali	2	3
2	Rashed	0	7
3	Hamza	1	2

- CSVs don't have indexes like our DataFrames, so all we need to do is just designate the **`index_col`** when reading:

```
df = pd.read_csv('dataset.csv', index_col=0)
```

- *Note: here we're setting the index to be column zero.*

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

Reading data from JSON

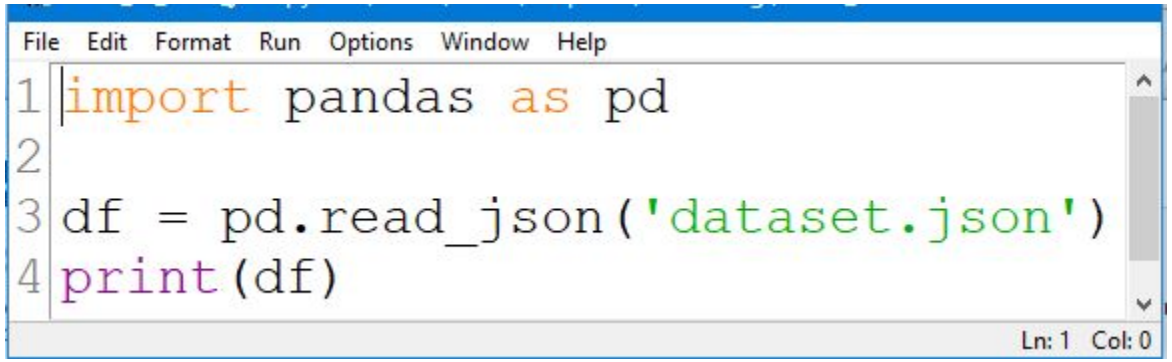
- If you have a JSON file — which is essentially a stored Python dict — pandas can read this just as easily:

```
df = pd.read_json('dataset.json')
```

- Notice this time our index came with us correctly since using JSON allowed indexes to work through nesting.
- Pandas will try to figure out how to create a DataFrame by analyzing structure of your JSON, and sometimes it doesn't get it right.
- Often you'll need to set the `orient` keyword argument depending on the structure

Example #1:Reading data from JSON

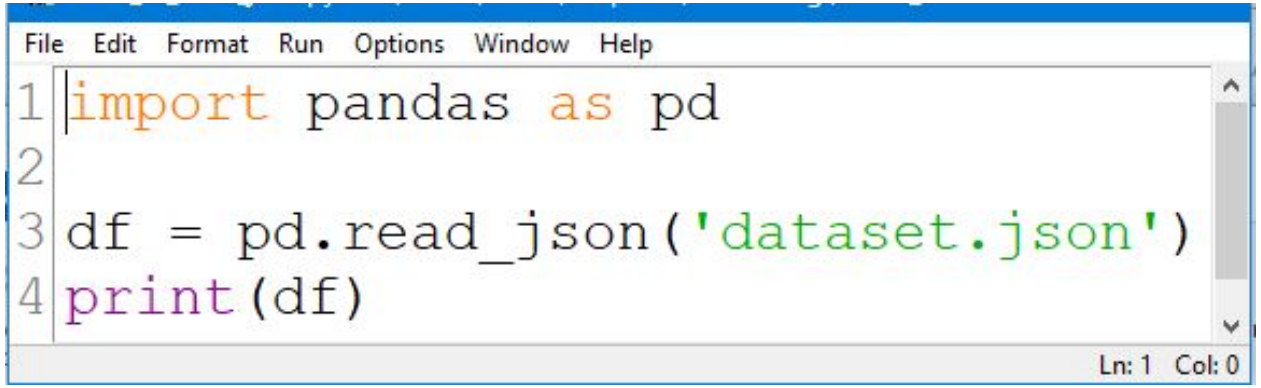
```
{
   "apples" :{"Ahmad":3,"Ali":2,"Rashed":0, "Hamza":1},
   "oranges":{"Ahmad":0,"Ali":3,"Rashed":7, "Hamza":2}
}
```



	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

Example #2: Reading data from JSON

```json
{
   "Ahmad"   : {"apples":3,"oranges":0},
   "Ali"     : {"apples":2,"oranges":3},
   "Rashed"  : {"apples":0,"oranges":7},
   "Hamza"   : {"apples":1,"oranges":2}
}
```



	Ahmad	Ali	Rashed	Hamza
apples	3	2	0	1
oranges	0	3	7	2

Example #3: Reading data from JSON

```
{
   "Ahmad"   : {"apples":3,"oranges":0},
   "Ali"     : {"apples":2,"oranges":3},
   "Rashed"  : {"apples":0,"oranges":7},
   "Hamza"   : {"apples":1,"oranges":2}
}
```

```
File  Edit  Format  Run  Options  Window  Help
1 import pandas as pd
2
3 df = pd.read_json('dataset.json',
4                   orient='column')
5 print(df)
                                   Ln: 6  Col: 0
```

	Ahmad	Ali	Rashed	Hamza
apples	3	2	0	1
oranges	0	3	7	2

```
File  Edit  Format  Run  Options  Window  Help
1 import pandas as pd
2
3 df = pd.read_json('dataset.json',
4                   orient='index')
5 print(df)
                                   Ln: 6  Col: 0
```

	apples	oranges
Ahmad	3	0
Ali	2	3
Rashed	0	7
Hamza	1	2

Converting back to a CSV or JSON

- So after extensive work on cleaning your data, you're now ready to save it as a file of your choice. Similar to the ways we read in data, pandas provides intuitive commands to save it:

```
df.to_csv('new_dataset.csv')

df.to_json('new_dataset.json')
```

- When we save JSON and CSV files, all we have to input into those functions is our desired filename with the appropriate file extension.

Reference: https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.to_json.html

Most important DataFrame operations

- DataFrames possess hundreds of methods and other operations that are crucial to any analysis.
- As a beginner, you should know the operations that:
  - that perform simple transformations of your data and those
  - that provide fundamental statistical analysis on your data.

Loading dataset

- We're loading this dataset from a CSV and designating the movie titles to be our index.

```
movies_df = pd.read_csv("movies.csv", index_col="title")
```

https://grouplens.org/datasets/movielens/

Viewing your data

- The first thing to do when opening a new dataset is print out a few rows to keep as a visual reference. We accomplish this with `.head()`:

```
movies_df.head()
```

- .head() outputs the first five rows of your DataFrame by default, but we could also pass a number as well: `movies_df.head(10)` would output the top ten rows, for example.

- To see the last five rows use `.tail()` that also accepts a number, and in this case we printing the bottom two rows.:

```
movies_df.tail(2)
```

Getting info about your data

- `.info()` should be one of the very first commands you run after loading your data
- `.info()` provides the essential details about your dataset, such as the number of rows and columns, the number of non-null values, what type of data is in each column, and how much memory your DataFrame is using.

```
movies_df.info()
```

```
OUT:

<class 'pandas.core.frame.DataFrame'>
Index: 1000 entries, Guardians of the Galaxy to Nine Lives
Data columns (total 11 columns):
Rank                    1000 non-null int64
Genre                   1000 non-null object
Description             1000 non-null object
Director                1000 non-null object
Actors                  1000 non-null object
Year                    1000 non-null int64
Runtime (Minutes)       1000 non-null int64
Rating                  1000 non-null float64
Votes                   1000 non-null int64
Revenue (Millions)      872 non-null float64
Metascore               936 non-null float64
dtypes: float64(3), int64(4), object(4)
memory usage: 93.8+ KB
```

```
movies_df.shape
```

```
OUT:

(1000, 11)
```

Handling duplicates

- This dataset does not have duplicate rows, but it is always important to verify you aren't aggregating duplicate rows.
- To demonstrate, let's simply just double up our movies DataFrame by appending it to itself:
- Using `append()` will return a copy without affecting the original DataFrame. We are capturing this copy in **temp** so we aren't working with the real data.
- Notice call `.shape` quickly proves our DataFrame rows have doubled.

```
temp_df = movies_df.append(movies_df)
temp_df.shape
```

OUT:

```
(2000, 11)
```

Now we can try dropping duplicates:

```
temp_df = temp_df.drop_duplicates()
temp_df.shape
```

OUT:

```
(1000, 11)
```

Handling duplicates

- Just like **`append()`**, the **`drop_duplicates()`** method will also return a copy of your DataFrame, but this time with duplicates removed. Calling **`.shape`** confirms we're back to the 1000 rows of our original dataset.
- It's a little verbose to keep assigning DataFrames to the same variable like in this example. For this reason, pandas has the inplace keyword argument on many of its methods. Using **`inplace=True`** will modify the DataFrame object in place:

```
temp_df.drop_duplicates(inplace=True)
```

- Another important argument for **`drop_duplicates()`** is keep, which has three possible options:
  - **first**: (default) Drop duplicates except for the first occurrence.
  - **last**: Drop duplicates except for the last occurrence.
  - **False**: Drop all duplicates.

https://www.learndatasci.com/tutorials/python-pandas-tutorial-complete-introduction-for-beginners/

Understanding your variables

- Using `.describe()` on an entire DataFrame we can get a summary of the distribution of continuous variables:

```
movies_df.describe()
```

OUT:

	rank	year	runtime	rating	
count	1000.000000	1000.000000	1000.000000	1000.000000	1.0(
mean	500.500000	2012.783000	113.172000	6.723200	1.6(
std	288.819436	3.205962	18.810908	0.945429	1.8(
min	1.000000	2006.000000	66.000000	1.900000	6.1(
25%	250.750000	2010.000000	100.000000	6.200000	3.6
50%	500.500000	2014.000000	111.000000	6.800000	1.10
75%	750.250000	2016.000000	123.000000	7.400000	2.3
max	1000.000000	2016.000000	191.000000	9.000000	1.7(

- `.describe()` can also be used on a categorical variable to get the count of rows, unique count of categories, top category, and freq of top category:

```
movies_df['genre'].describe()
```

OUT:

```
count                          1000
unique                          207
top       Action,Adventure,Sci-Fi
freq                             50
Name: genre, dtype: object
```

- This tells us that the genre column has 207 unique values, the top value is Action/Adventure/Sci-Fi, which shows up 50 times (freq).

More Examples

```
import pandas as pd
data = [1,2,3,10,20,30]
df = pd.DataFrame(data)
print(df)
```

	0
0	1
1	2
2	3
3	10
4	20
5	30

```
import pandas as pd
data = {'Name' : ['AA', 'BB'], 'Age': [30,45]}
df = pd.DataFrame(data)
print(df)
```

	Name	Age
0	AA	30
1	BB	45

More Examples

```
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]
df = pd.DataFrame(data)
print(df)
```

```
   a   b     c
0  1   2   NaN
1  5  10  20.0
```

```
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]
df = pd.DataFrame(data, index=['first', 'second'])
print(df)
```

```
        a   b     c
first   1   2   NaN
second  5  10  20.0
```

More Examples

E.g. This shows how to create a DataFrame with a list of dictionaries, row indices, and column indices.

```
import pandas as pd
data = [{'a': 1, 'b': 2},{'a': 5, 'b': 10, 'c': 20}]

#With two column indices, values same as dictionary keys
df1 = pd.DataFrame(data,index=['first','second'],columns=['a','b'])

#With two column indices with one index with other name
df2 = pd.DataFrame(data,index=['first','second'],columns=['a','b1'])

print(df1)
print('............')
print(df2)
```

```
        a   b
first   1   2
second  5  10
............
        a  b1
first   1 NaN
second  5 NaN
```

More Examples:
Create a DataFrame from Dict of Series

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3]   , index=['a', 'b', 'c']),
     'two' : pd.Series([1,2, 3, 4], index=['a', 'b', 'c', 'd'])
    }
df = pd.DataFrame(d)
print(df)
```

```
   one  two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4
```

More Examples: Column Addition

```
import pandas as pd
d = {'one':pd.Series([1,2,3],   index=['a','b','c']),
     'two':pd.Series([1,2,3,4], index=['a','b','c','d'])
    }
df = pd.DataFrame(d)
# Adding a new column to an existing DataFrame object
# with column label by passing new series

print("Adding a new column by passing as Series:")
df['three'] = pd.Series([10,20,30],index=['a','b','c'])
print(df)

print("Adding a column using an existing columns in
DataFrame:")
df['four'] = df['one']+df['three']
print(df)
```

Adding a column using Series:

	one	two	three
a	1.0	1	10.0
b	2.0	2	20.0
c	3.0	3	30.0
d	NaN	4	NaN

Adding a column using columns:

	one	two	three	four
a	1.0	1	10.0	11.0
b	2.0	2	20.0	22.0
c	3.0	3	30.0	33.0
d	NaN	4	NaN	NaN

More Examples: Column Deletion

```
# Using the previous DataFrame, we will delete a column
# using del function
import pandas as pd
d = {'one'   : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two'   : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c', 'd']),
     'three' : pd.Series([10,20,30],   index=['a','b','c'])
    }
df = pd.DataFrame(d)
print ("Our dataframe is:")
print(df)

# using del function
print("Deleting the first column using DEL function:")
del df['one']
print(df)

# using pop function
print("Deleting another column using POP function:")
df.pop('two')
print(df)
```

```
Our dataframe is:
   one  two  three
a  1.0    1   10.0
b  2.0    2   20.0
c  3.0    3   30.0
d  NaN    4    NaN

Deleting the first column:
    two  three
a     1   10.0
b     2   20.0
c     3   30.0
d     4    NaN

Deleting another column:
a   10.0
b   20.0
c   30.0
d    NaN
```

More Examples: Slicing in DataFrames

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two' : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c','d'])
    }
df = pd.DataFrame(d)
print(df[2:4])
```

```
   one     two
c  3.0     3
d  NaN     4
```

More Examples: Addition of rows

```
import pandas as pd
d = {'one' : pd.Series([1, 2, 3],    index=['a', 'b', 'c']),
     'two' : pd.Series([1, 2, 3, 4], index=['a', 'b', 'c','d'])
    }
df = pd.DataFrame(d)
print(df)

df2 = pd.DataFrame([[5,6], [7,8]], columns = ['a', 'b'])
df = df.append(df2 )
print(df)
```

```
   one   two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4


   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
0  NaN  NaN  5.0  6.0
1  NaN  NaN  7.0  8.0
```

More Examples: Deletion of rows

```
import pandas as pd
d = {'one':pd.Series([1, 2, 3],    index=['a','b','c']),
     'two':pd.Series([1, 2, 3, 4], index=['a','b','c','d'])
    }
df = pd.DataFrame(d)
print(df)

df2 = pd.DataFrame([[5,6], [7,8]], columns = ['a', 'b'])
df = df.append(df2 )
print(df)

df = df.drop(0)
print(df)
```

```
   one  two
a  1.0    1
b  2.0    2
c  3.0    3
d  NaN    4

   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
0  NaN  NaN  5.0  6.0
1  NaN  NaN  7.0  8.0

   one  two    a    b
a  1.0  1.0  NaN  NaN
b  2.0  2.0  NaN  NaN
c  3.0  3.0  NaN  NaN
d  NaN  4.0  NaN  NaN
1  NaN  NaN  7.0  8.0
```

More Examples: Reindexing

```
import pandas as pd
# Creating the first dataframe
df1 = pd.DataFrame({"A":[1, 5, 3, 4, 2],
                    "B":[3, 2, 4, 3, 4],
                    "C":[2, 2, 7, 3, 4],
                    "D":[4, 3, 6, 12, 7]},
                    index =["A1", "A2", "A3", "A4", "A5"])

# Creating the second dataframe
df2 = pd.DataFrame({"A":[10, 11, 7, 8, 5],
                    "B":[21, 5, 32, 4, 6],
                    "C":[11, 21, 23, 7, 9],
                    "D":[1, 5, 3, 8, 6]},
                    index =["A1", "A3", "A4", "A7", "A8"])

# Print the first dataframe
print(df1)
print(df2)
# find matching indexes
df1.reindex_like(df2)
```

- Pandas **`dataframe.reindex_like()`** function return an object with matching indices to myself.
- Any non-matching indexes are filled with NaN values.

Out[72]:

	A	B	C	D
A1	1.0	3.0	2.0	4.0
A3	3.0	4.0	7.0	6.0
A4	4.0	3.0	3.0	12.0
A7	NaN	NaN	NaN	NaN
A8	NaN	NaN	NaN	NaN

More Examples:
Concatenating Objects (Data Frames)

```
import pandas as pd
df1 = pd.DataFrame({'Name':['A','B'], 'SSN':[10,20], 'marks':[90, 95] })
df2 = pd.DataFrame({'Name':['B','C'], 'SSN':[25,30], 'marks':[80, 97] })
df3 = pd.concat([df1, df2])
df3
```

Handling categorical data

- There are many data that are repetitive for example gender , country , and codes are always repetitive .
- Categorical variables can take on only a limited
- The categorical data type is useful in the following cases –
- A string variable consisting of only a few different values. Converting such a string variable to a categorical variable will save some memory.
- The lexical order of a variable is not the same as the logical order (“one”, “two”, “three”).
    - By converting to a categorical and specifying an order on the categories, sorting and min/max will use the logical order instead of the lexical order.
- As a signal to other python libraries that this column should be treated as a categorical variable (e.g. to use suitable statistical methods or plot types).

Examples

```
import pandas as pd
cat = pd.Categorical(['a', 'b', 'c', 'a', 'b', 'c'])
print(cat)
```

```
import pandas as pd
import numpy as np
cat = pd.Categorical(["a", "c", "c", np.nan], categories=["b", "a", "c"])
df = pd.DataFrame({"cat": cat, "s":["a", "c", "c", np.nan]})
print(df.describe())
print(df["cat"].describe())
```

Reading data from a SQL database

- f you’re working with data from a SQL database you need to first establish a connection using an appropriate Python library, then pass a query to pandas. Here we'll use SQLite to demonstrate.
- First, we need pysqlite3 installed, so run this command in your terminal:
  - pip install pysqlite3
  - Or run this cell if you're in a notebook: !pip install pysqlite3
- sqlite3 is used to create a connection to a database which we can then use to generate a DataFrame through a SELECT query.
  - So first we'll make a connection to a SQLite database file:

```
import sqlite3
con = sqlite3.connect("database.db")
```

  - In this SQLite database we have a table called purchases, and our index is in a column called "index".
  - By passing a SELECT query and our con, we can read from the purchases table:

```
df = pd.read_sql_query("SELECT * FROM purchases", con)
```

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OUT:

	index	apples	oranges
0	June	3	0
1	Robert	2	3
2	Lily	0	7
3	David	1	2

- Just like with CSVs, we could pass index_col='index', but we can also set an index after-the-fact:
  - In fact, we could use set_index() on any DataFrame using any column at any time. Indexing Series and DataFrames is a very common task, and the different ways of doing it is worth remembering.

```
df = df.set_index('index')
```

OUT:

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index		
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References

- pandas documentation
  - https://pandas.pydata.org/pandas-docs/stable/index.html
- pandas: Input/output
  - https://pandas.pydata.org/pandas-docs/stable/reference/io.html
- pandas: DataFrame
  - https://pandas.pydata.org/pandas-docs/stable/reference/frame.html
- pandas: Series
  - https://pandas.pydata.org/pandas-docs/stable/reference/series.html
- pandas: Plotting
  - https://pandas.pydata.org/pandas-docs/stable/reference/plotting.html