Introduction to Pandas

"*Pandas is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language*"

https://pandas.pydata.org

How to get started?

In [1]:
```
import pandas as pd
```

In [2]:
```
pd.__version__
```

Out[2]:
```
'1.1.1'
```

Make sure you have the file "hour.csv" in the current directory. If not copy it here or go work there!

In [3]:
```
ls
```

```
 Volume in drive C is Windows
 Volume Serial Number is 5259-21A3

 Directory of C:\Users\catia\Dropbox (UFL)\Teaching\2020 Fall\EEE 4773 Fundamentals of M
achine Learning\GitHub\Lectures\Lecture 4a - Feature Engineering & Pandas

09/08/2020  09:38 AM    <DIR>          .
09/08/2020  09:38 AM    <DIR>          ..
09/07/2020  10:48 PM    <DIR>          .ipynb_checkpoints
09/07/2020  11:08 PM            12,836 Feature Engineering.ipynb
01/16/2020  11:24 AM         1,156,736 hour.csv
09/08/2020  09:29 AM           740,569 Introduction to Pandas - prep.ipynb
09/08/2020  09:38 AM            10,899 Introduction to Pandas.ipynb
               4 File(s)      1,921,040 bytes
               3 Dir(s)  801,972,359,168 bytes free
```

Now let's read the data from the CSV file into a dataframe:

In [4]:
```

```

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

What is a dataframe?

A dataframe is like an Excel spreadsheet within Python:

In [5]:
```
df
```

Out[5]:

	instant	dteday	season	yr	mnth	hr	holiday	weekday	workingday	weathersit	temp	atem
0	1	2011-01-01	1	0	1	0	0	6	0	1	0.24	0.287
1	2	2011-01-01	1	0	1	1	0	6	0	1	0.22	0.272
2	3	2011-01-01	1	0	1	2	0	6	0	1	0.22	0.272
3	4	2011-01-01	1	0	1	3	0	6	0	1	0.24	0.287
4	5	2011-01-01	1	0	1	4	0	6	0	1	0.24	0.287
...	...	...	...	...	...	...	...	...	...	...	...	
17374	17375	2012-12-31	1	1	12	19	0	1	1	2	0.26	0.257
17375	17376	2012-12-31	1	1	12	20	0	1	1	2	0.26	0.257
17376	17377	2012-12-31	1	1	12	21	0	1	1	1	0.26	0.257
17377	17378	2012-12-31	1	1	12	22	0	1	1	1	0.26	0.272
17378	17379	2012-12-31	1	1	12	23	0	1	1	1	0.26	0.272

17379 rows × 17 columns

It is a two-dimensional set of data, where the rows and columns can have labels. We can retrieve the data using these labels:

In [6]:
```
df['weekday']
```

Out[6]:
```
0        6
1        6
2        6
3        6
4        6
        ..
17374    1
17375    1
```

```
17376    1
17377    1
17378    1
Name: weekday, Length: 17379, dtype: int64
```

Note that a colum of a dataframe is returned as a pandas series:

In [7]:
```
type(df['weekday'])
```

Out[7]:
```
pandas.core.series.Series
```

A Pandas series is a one-dimensional data object with row labels.

When you import from a CSV file, the column labels are imported, but the row labels are just the numbers of the data rows:

In [8]:
```
df.loc[1,:]
```

Out[8]:
```
instant               2
dteday       2011-01-01
season                1
yr                    0
mnth                  1
hr                    1
holiday               0
weekday               6
workingday            0
weathersit            1
temp               0.22
atemp            0.2727
hum                 0.8
windspeed             0
casual                8
registered           32
cnt                  40
Name: 1, dtype: object
```

It is often convenient to use the values in one of the columns as the labels of the rows. We call these the *index* for the rows:

In [9]:
```
df.set_index('weekday')
```

Out[9]:

weekday	instant	dteday	season	yr	mnth	hr	holiday	workingday	weathersit	temp	atemp	hum
6	1	2011-01-01	1	0	1	0	0	0	1	0.24	0.2879	0.81
6	2	2011-01-01	1	0	1	1	0	0	1	0.22	0.2727	0.80
6	3	2011-01-01	1	0	1	2	0	0	1	0.22	0.2727	0.80
6	4	2011-01-01	1	0	1	3	0	0	1	0.24	0.2879	0.75

	instant	dteday	season	yr	mnth	hr	holiday	workingday	weathersit	temp	atemp	hum
weekday												
6	5	2011-01-01	1	0	1	4	0	0	1	0.24	0.2879	0.75
...	...	...	...	...	...	...	...	...	...	...	...	..
1	17375	2012-12-31	1	1	12	19	0	1	2	0.26	0.2576	0.60
1	17376	2012-12-31	1	1	12	20	0	1	2	0.26	0.2576	0.60
1	17377	2012-12-31	1	1	12	21	0	1	1	0.26	0.2576	0.60
1	17378	2012-12-31	1	1	12	22	0	1	1	0.26	0.2727	0.56
1	17379	2012-12-31	1	1	12	23	0	1	1	0.26	0.2727	0.65

17379 rows × 16 columns

Note that that is actually returning a new dataframe and the original dataframe is unchanged:

In [10]:
```
df
```

Out[10]:

	instant	dteday	season	yr	mnth	hr	holiday	weekday	workingday	weathersit	temp	atem
0	1	2011-01-01	1	0	1	0	0	6	0	1	0.24	0.28
1	2	2011-01-01	1	0	1	1	0	6	0	1	0.22	0.27
2	3	2011-01-01	1	0	1	2	0	6	0	1	0.22	0.27
3	4	2011-01-01	1	0	1	3	0	6	0	1	0.24	0.28
4	5	2011-01-01	1	0	1	4	0	6	0	1	0.24	0.28
...	...	...	...	...	...	...	...	...	...	...	...	
17374	17375	2012-12-31	1	1	12	19	0	1	1	2	0.26	0.25
17375	17376	2012-12-31	1	1	12	20	0	1	1	2	0.26	0.25
17376	17377	2012-12-31	1	1	12	21	0	1	1	1	0.26	0.25
17377	17378	2012-12-31	1	1	12	22	0	1	1	1	0.26	0.27

	instant	dteday	season	yr	mnth	hr	holiday	weekday	workingday	weathersit	temp	atem
17378	17379	2012-12-31	1	1	12	23	0	1	1	1	0.26	0.27

17379 rows × 17 columns

If we wish to work with the original one, we have to replace it

In [11]:
```
df2 = df.set_index('weekday')
```

This makes indexing much easier

In [12]:
```
df2.loc[1,:]
```

Out[12]:

weekday	instant	dteday	season	yr	mnth	hr	holiday	workingday	weathersit	temp	atemp	hum
1	48	2011-01-03	1	0	1	0	0	1	1	0.22	0.1970	0.44
1	49	2011-01-03	1	0	1	1	0	1	1	0.20	0.1667	0.44
1	50	2011-01-03	1	0	1	4	0	1	1	0.16	0.1364	0.47
1	51	2011-01-03	1	0	1	5	0	1	1	0.16	0.1364	0.47
1	52	2011-01-03	1	0	1	6	0	1	1	0.14	0.1061	0.50
...	...	...	...	...	...	...	...	...	...	...	...	..
1	17375	2012-12-31	1	1	12	19	0	1	2	0.26	0.2576	0.60
1	17376	2012-12-31	1	1	12	20	0	1	2	0.26	0.2576	0.60
1	17377	2012-12-31	1	1	12	21	0	1	1	0.26	0.2576	0.60
1	17378	2012-12-31	1	1	12	22	0	1	1	0.26	0.2727	0.56
1	17379	2012-12-31	1	1	12	23	0	1	1	0.26	0.2727	0.65

2479 rows × 16 columns

Note that the row labels carry over to the Pandas series that is returned by indexing a particular column of the dataframe:

In [13]:
```
df2['temp']
```

Out[13]:
```
weekday
6    0.24
6    0.22
6    0.22
6    0.24
6    0.24
     ...
1    0.26
1    0.26
1    0.26
1    0.26
1    0.26
Name: temp, Length: 17379, dtype: float64
```

In [14]:
```
df2['temp'][6]
```

Out[14]:
```
weekday
6    0.24
6    0.22
6    0.22
6    0.24
6    0.24
     ...
6    0.30
6    0.30
6    0.28
6    0.26
6    0.26
Name: temp, Length: 2512, dtype: float64
```

If all we want is the numerical values in the data series, we can convert it to a `numpy` array:

In [15]:
```
df2['temp'].to_numpy()
```

Out[15]:
```
array([0.24, 0.22, 0.22, ..., 0.26, 0.26, 0.26])
```

Creating new Dataframes

From existent ones

Suppose that we want to create a dataframe with the columns: "temp", "atemp", "hum", "windspeed", "casual", "registered" and "cnt". We can create it this way:

In [16]:
```
D = df[['temp','atemp','hum','windspeed','casual','registered','cnt']]
```

In [17]:
```
D
```

Out[17]:

	temp	atemp	hum	windspeed	casual	registered	cnt
0	0.24	0.2879	0.81	0.0000	3	13	16
1	0.22	0.2727	0.80	0.0000	8	32	40

	temp	atemp	hum	windspeed	casual	registered	cnt
2	0.22	0.2727	0.80	0.0000	5	27	32
3	0.24	0.2879	0.75	0.0000	3	10	13
4	0.24	0.2879	0.75	0.0000	0	1	1
...	...	...	...	...	...	...	...
17374	0.26	0.2576	0.60	0.1642	11	108	119
17375	0.26	0.2576	0.60	0.1642	8	81	89
17376	0.26	0.2576	0.60	0.1642	7	83	90
17377	0.26	0.2727	0.56	0.1343	13	48	61
17378	0.26	0.2727	0.65	0.1343	12	37	49

17379 rows × 7 columns

In [18]:
```
D.head(10)
```

Out[18]:

	temp	atemp	hum	windspeed	casual	registered	cnt
0	0.24	0.2879	0.81	0.0000	3	13	16
1	0.22	0.2727	0.80	0.0000	8	32	40
2	0.22	0.2727	0.80	0.0000	5	27	32
3	0.24	0.2879	0.75	0.0000	3	10	13
4	0.24	0.2879	0.75	0.0000	0	1	1
5	0.24	0.2576	0.75	0.0896	0	1	1
6	0.22	0.2727	0.80	0.0000	2	0	2
7	0.20	0.2576	0.86	0.0000	1	2	3
8	0.24	0.2879	0.75	0.0000	1	7	8
9	0.32	0.3485	0.76	0.0000	8	6	14

From numerical values

In [19]:
```
import numpy as np

x = np.linspace(0,1,20)
y = np.sin(2*np.pi*x)
z = np.cos(2*np.pi*x)
t = np.tan(2*np.pi*x)
```

In [20]:
```
list_of_tuples = list(zip(x,y,z))
list_of_tuples
```

Out[20]:
```
[(0.0, 0.0, 1.0),
 (0.05263157894736842, 0.32469946920468346, 0.9458172417006346),
```

```
(0.10526315789473684, 0.6142127126896678, 0.7891405093963936),
(0.15789473684210525, 0.8371664782625285, 0.5469481581224269),
(0.21052631578947367, 0.9694002659393304, 0.24548548714079924),
(0.2631578947368421, 0.9965844930066698, -0.08257934547233227),
(0.3157894736842105, 0.9157733266550575, -0.40169542465296926),
(0.3684210526315789, 0.7357239106731317, -0.6772815716257409),
(0.42105263157894735, 0.4759473930370737, -0.879473751206489),
(0.47368421052631576, 0.16459459028073403, -0.9863613034027223),
(0.5263157894736842, -0.16459459028073378, -0.9863613034027224),
(0.5789473684210527, -0.47594739303707345, -0.8794737512064891),
(0.631578947368421, -0.7357239106731313, -0.6772815716257414),
(0.6842105263157894, -0.9157733266550573, -0.40169542465296987),
(0.7368421052631579, -0.9965844930066698, -0.08257934547233274),
(0.7894736842105263, -0.9694002659393305, 0.2454854871407988),
(0.8421052631578947, -0.8371664782625288, 0.5469481581224266),
(0.894736842105263, -0.6142127126896688, 0.7891405093963929),
(0.9473684210526315, -0.32469946920468373, 0.9458172417006346),
(1.0, -2.4492935982947064e-16, 1.0)]
```

In [21]:

```
C = pd.DataFrame(list_of_tuples, columns=['Input','Sine','Cosine'])
C
```

Out[21]:

	Input	Sine	Cosine
0	0.000000	0.000000e+00	1.000000
1	0.052632	3.246995e-01	0.945817
2	0.105263	6.142127e-01	0.789141
3	0.157895	8.371665e-01	0.546948
4	0.210526	9.694003e-01	0.245485
5	0.263158	9.965845e-01	-0.082579
6	0.315789	9.157733e-01	-0.401695
7	0.368421	7.357239e-01	-0.677282
8	0.421053	4.759474e-01	-0.879474
9	0.473684	1.645946e-01	-0.986361
10	0.526316	-1.645946e-01	-0.986361
11	0.578947	-4.759474e-01	-0.879474
12	0.631579	-7.357239e-01	-0.677282
13	0.684211	-9.157733e-01	-0.401695
14	0.736842	-9.965845e-01	-0.082579
15	0.789474	-9.694003e-01	0.245485
16	0.842105	-8.371665e-01	0.546948
17	0.894737	-6.142127e-01	0.789141
18	0.947368	-3.246995e-01	0.945817
19	1.000000	-2.449294e-16	1.000000

In [22]:
```
C.insert(3,'Tangent',t)
```

In [23]:
```
C
```

Out[23]:

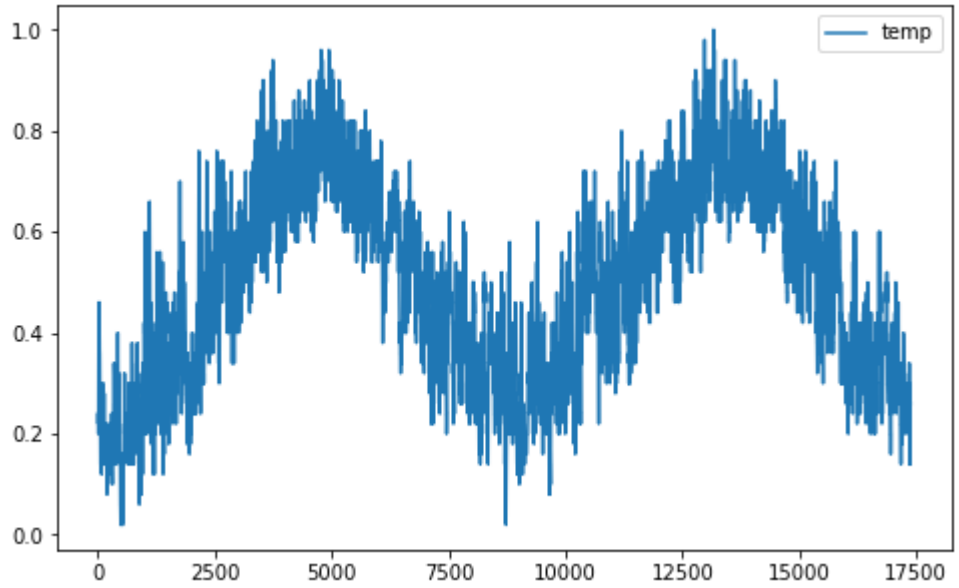
	Input	Sine	Cosine	Tangent
0	0.000000	0.000000e+00	1.000000	0.000000e+00
1	0.052632	3.246995e-01	0.945817	3.433004e-01
2	0.105263	6.142127e-01	0.789141	7.783312e-01
3	0.157895	8.371665e-01	0.546948	1.530614e+00
4	0.210526	9.694003e-01	0.245485	3.948911e+00
5	0.263158	9.965845e-01	-0.082579	-1.206821e+01
6	0.315789	9.157733e-01	-0.401695	-2.279770e+00
7	0.368421	7.357239e-01	-0.677282	-1.086290e+00
8	0.421053	4.759474e-01	-0.879474	-5.411729e-01
9	0.473684	1.645946e-01	-0.986361	-1.668705e-01
10	0.526316	-1.645946e-01	-0.986361	1.668705e-01
11	0.578947	-4.759474e-01	-0.879474	5.411729e-01
12	0.631579	-7.357239e-01	-0.677282	1.086290e+00
13	0.684211	-9.157733e-01	-0.401695	2.279770e+00
14	0.736842	-9.965845e-01	-0.082579	1.206821e+01
15	0.789474	-9.694003e-01	0.245485	-3.948911e+00
16	0.842105	-8.371665e-01	0.546948	-1.530614e+00
17	0.894737	-6.142127e-01	0.789141	-7.783312e-01
18	0.947368	-3.246995e-01	0.945817	-3.433004e-01
19	1.000000	-2.449294e-16	1.000000	-2.449294e-16

Visualization

`pandas` offers a wide range of plotting functions provided by the `matplotlib` library.

For example, to plot the feature "temp", you can:

In [24]:
```
D['temp'].plot(figsize=(8,5), legend=True);
```

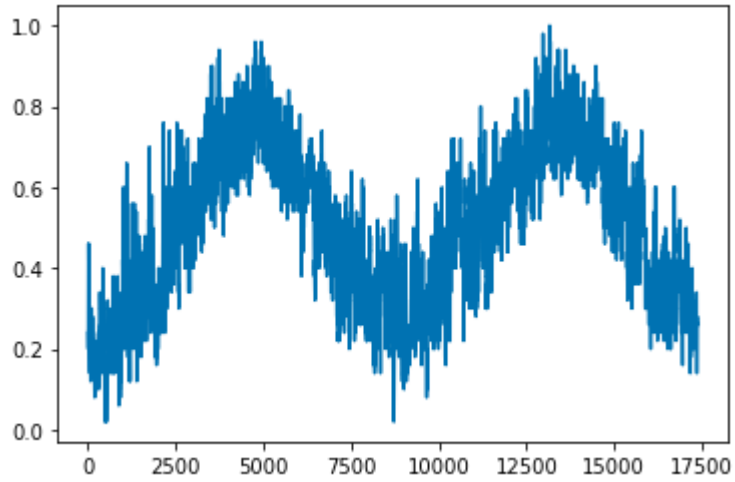


Alternatively, you can pass it directly to `matplotlib` functions:

In [25]:
```
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-colorblind')
```

In [26]:
```
plt.plot(D['temp'])
```

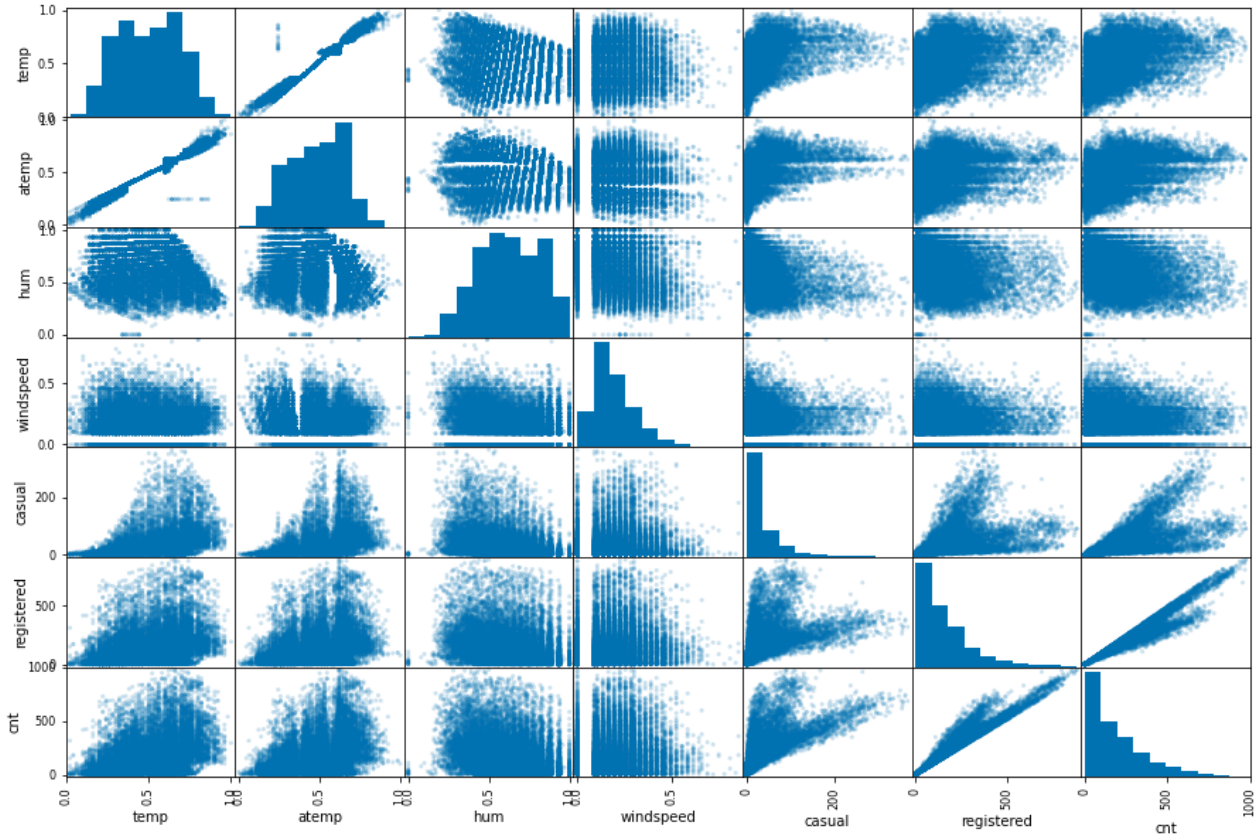
Out[26]:
```
[<matplotlib.lines.Line2D at 0x18174317148>]
```



`pandas` also includes a plotting module:

In [27]:
```
import pandas.plotting as pplt
```

In [28]:
```
pplt.scatter_matrix(D, alpha=0.2, figsize=(15,10));
```



Summary Statistics

In [29]:
```
D.mean()
```

Out[29]:
```
temp            0.496987
atemp           0.475775
hum             0.627229
windspeed       0.190098
casual         35.676218
registered    153.786869
cnt           189.463088
dtype: float64
```

In [30]:
```
D['temp'].median()
```

Out[30]:
```
0.5
```

In [31]:
```
D[['temp','hum']].std()
```

Out[31]:
```
temp    0.192556
hum     0.192930
dtype: float64
```

In [32]:
```
D.describe()
```

Out[32]:

	temp	atemp	hum	windspeed	casual	registered	cn
count	17379.000000	17379.000000	17379.000000	17379.000000	17379.000000	17379.000000	17379.00000

	temp	atemp	hum	windspeed	casual	registered	cn
mean	0.496987	0.475775	0.627229	0.190098	35.676218	153.786869	189.46308
std	0.192556	0.171850	0.192930	0.122340	49.305030	151.357286	181.38759
min	0.020000	0.000000	0.000000	0.000000	0.000000	0.000000	1.00000
25%	0.340000	0.333300	0.480000	0.104500	4.000000	34.000000	40.00000
50%	0.500000	0.484800	0.630000	0.194000	17.000000	115.000000	142.00000
75%	0.660000	0.621200	0.780000	0.253700	48.000000	220.000000	281.00000
max	1.000000	1.000000	1.000000	0.850700	367.000000	886.000000	977.00000

In [33]:
```
D.corr()
```

Out[33]:

	temp	atemp	hum	windspeed	casual	registered	cnt
temp	1.000000	0.987672	-0.069881	-0.023125	0.459616	0.335361	0.404772
atemp	0.987672	1.000000	-0.051918	-0.062336	0.454080	0.332559	0.400929
hum	-0.069881	-0.051918	1.000000	-0.290105	-0.347028	-0.273933	-0.322911
windspeed	-0.023125	-0.062336	-0.290105	1.000000	0.090287	0.082321	0.093234
casual	0.459616	0.454080	-0.347028	0.090287	1.000000	0.506618	0.694564
registered	0.335361	0.332559	-0.273933	0.082321	0.506618	1.000000	0.972151
cnt	0.404772	0.400929	-0.322911	0.093234	0.694564	0.972151	1.000000

This covers some basics of working with Pandas dataframes and series, we can begin to work with real data in the next class.

More Resources

- Read chapter 3 "Data Manipulation with Pandas" from the book *Python Data Science Handbook* by Jake VanderPlas.
- Watch the video "pandas in 10 minutes" from the pandas *getting started* website
- Read "10 minutes to pandas" tutorial series provided in the User Guide documentation website
- Pandas cheat sheet: https://pandas.pydata.org/Pandas_Cheat_Sheet.pdf

In [ ]:
```
```