MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON

Timeseries kinds and applications

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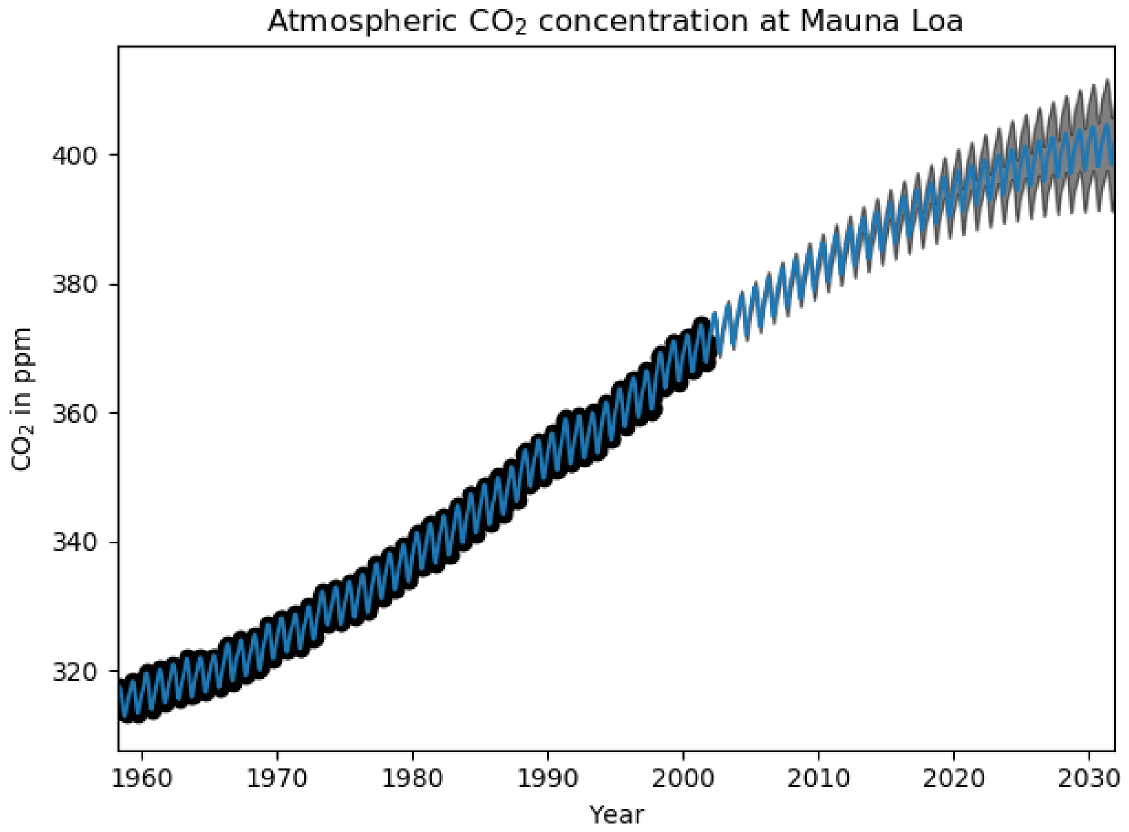
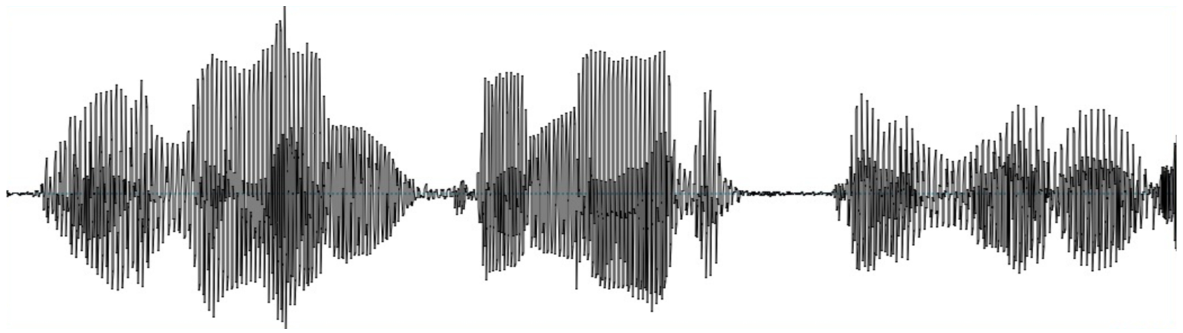
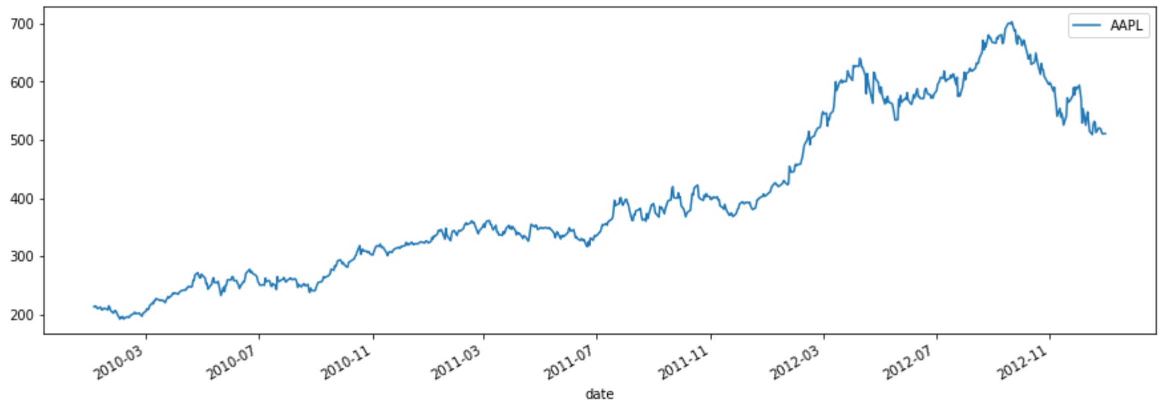
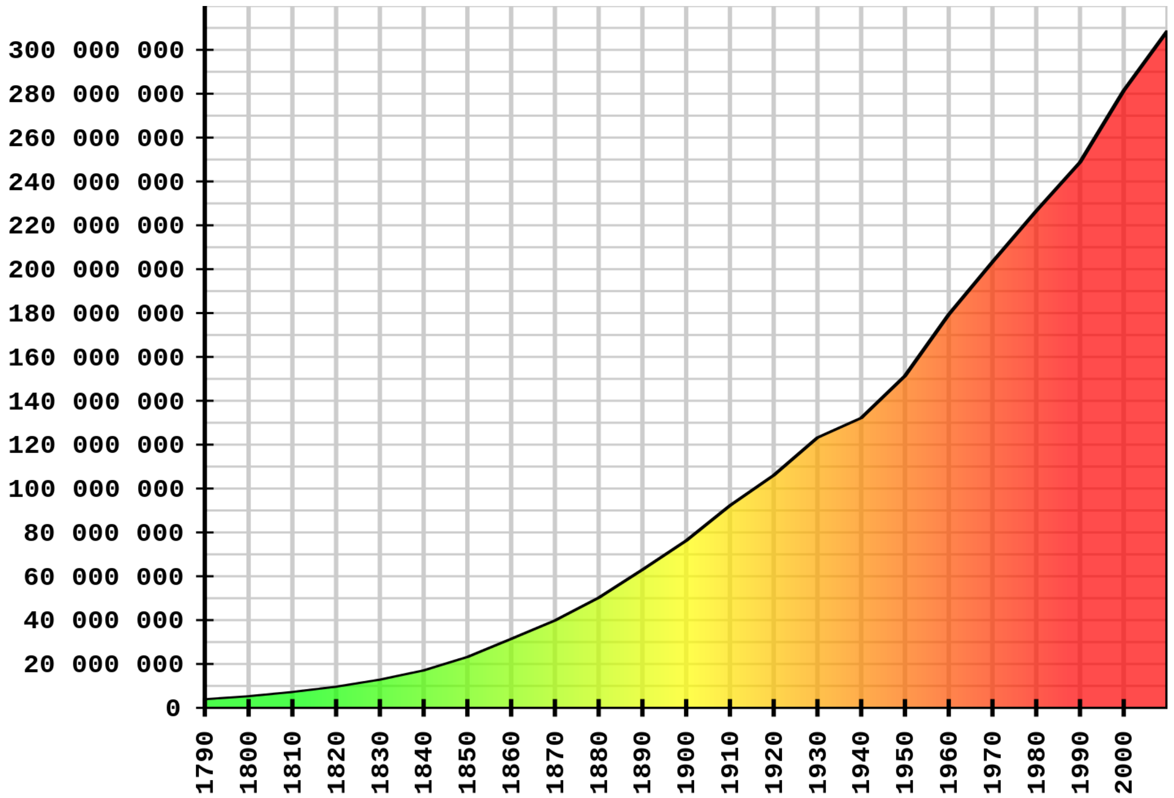
Time Series


Atmospheric CO_2 concentration at Mauna Loa
CO_2 in ppm
320
340
360
380
400
1960
1970
1980
1990
2000
2010
2020
2030
Year



Time Series


AAPL
700
600
500
400
300
200
2010-03
2010-07
2010-11
2011-03
2011-07
2011-11
2012-03
2012-07
2012-11
date


300 000 000
280 000 000
260 000 000
240 000 000
220 000 000
200 000 000
180 000 000
160 000 000
140 000 000
120 000 000
100 000 000
80 000 000
60 000 000
40 000 000
20 000 000
0
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

What makes a time series?

Datapoint	Datapoint	Datapoint	Datapoint	Datapoint	Datapoint
1	34	12	54	76	40

Timepoint	Timepoint	Timepoint	Timepoint	Timepoint	Timepoint
2:00	2:01	2:02	2:03	2:04	2:05

Timepoint	Timepoint	Timepoint	Timepoint	Timepoint	Timepoint
Jan	Feb	March	April	May	Jun

Timepoint	Timepoint	Timepoint	Timepoint	Timepoint	Timepoint
1e-9	2e-9	3e-9	4e-9	5e-9	6e-9

Reading in a time series with Pandas

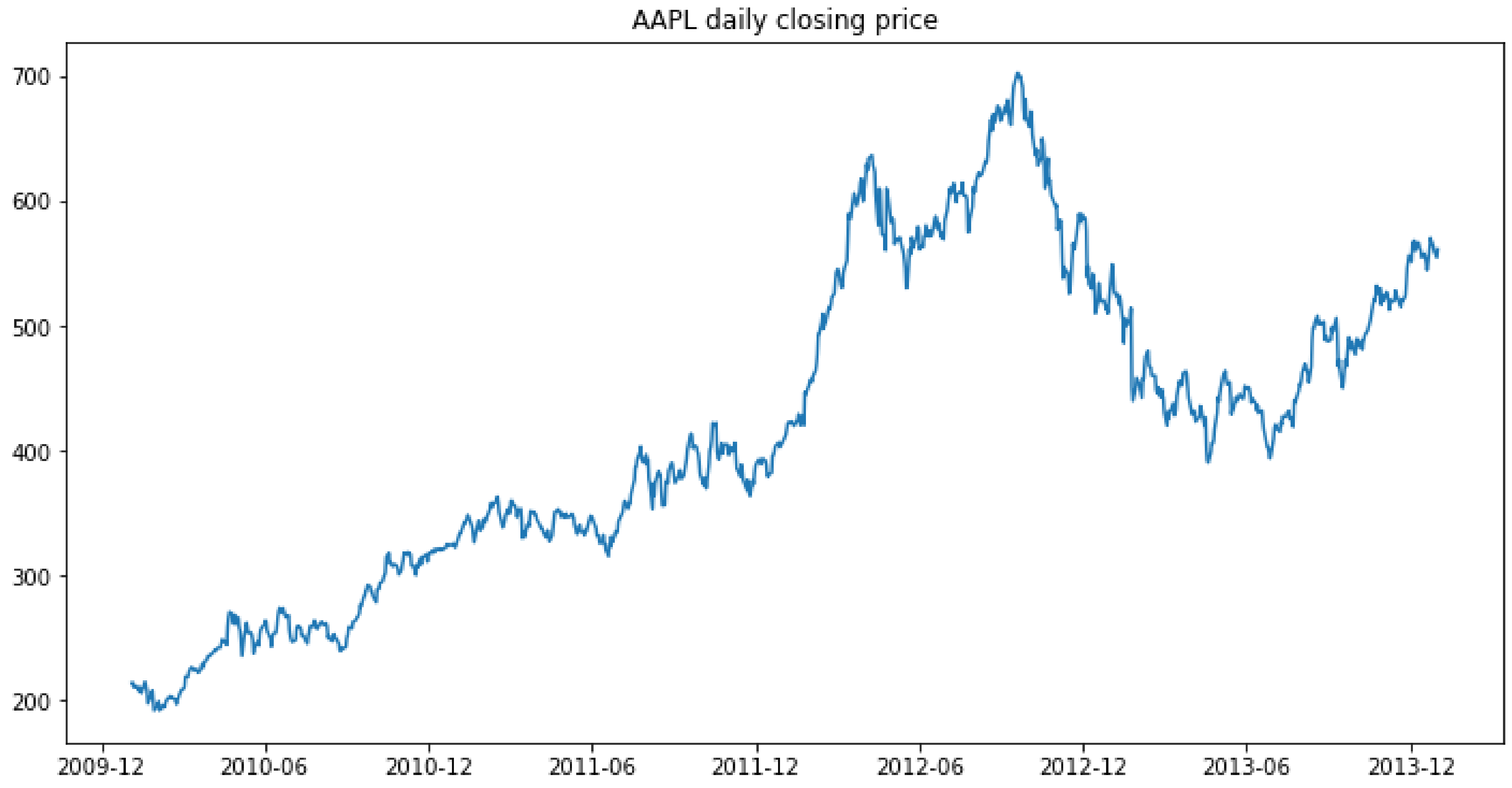
```
import pandas as pd
import matplotlib.pyplot as plt
data = pd.read_csv('data.csv')
data.head()

          date symbol       close       volume
0   2010-01-04   AAPL  214.009998  123432400.0
46  2010-01-05   AAPL  214.379993  150476200.0
92  2010-01-06   AAPL  210.969995  138040000.0
138 2010-01-07   AAPL  210.580000  119282800.0
184 2010-01-08   AAPL  211.980005  111902700.0
```

Plotting a pandas timeseries

```
import matplotlib.pyplot as plt
fig, ax = plt.subplots(figsize=(12, 6))
data.plot('date', 'close', ax=ax)
ax.set(title="AAPL daily closing price")
```

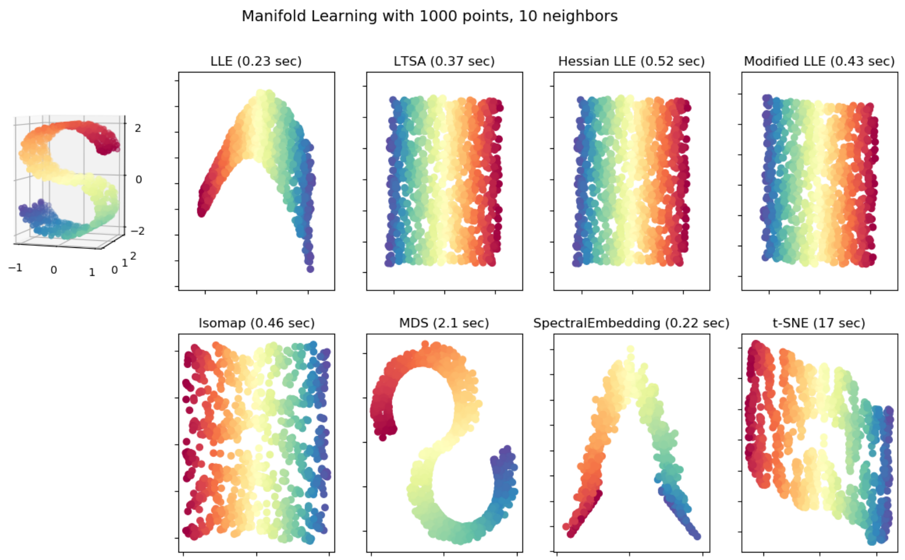
A timeseries plot



Why machine learning?

We can...

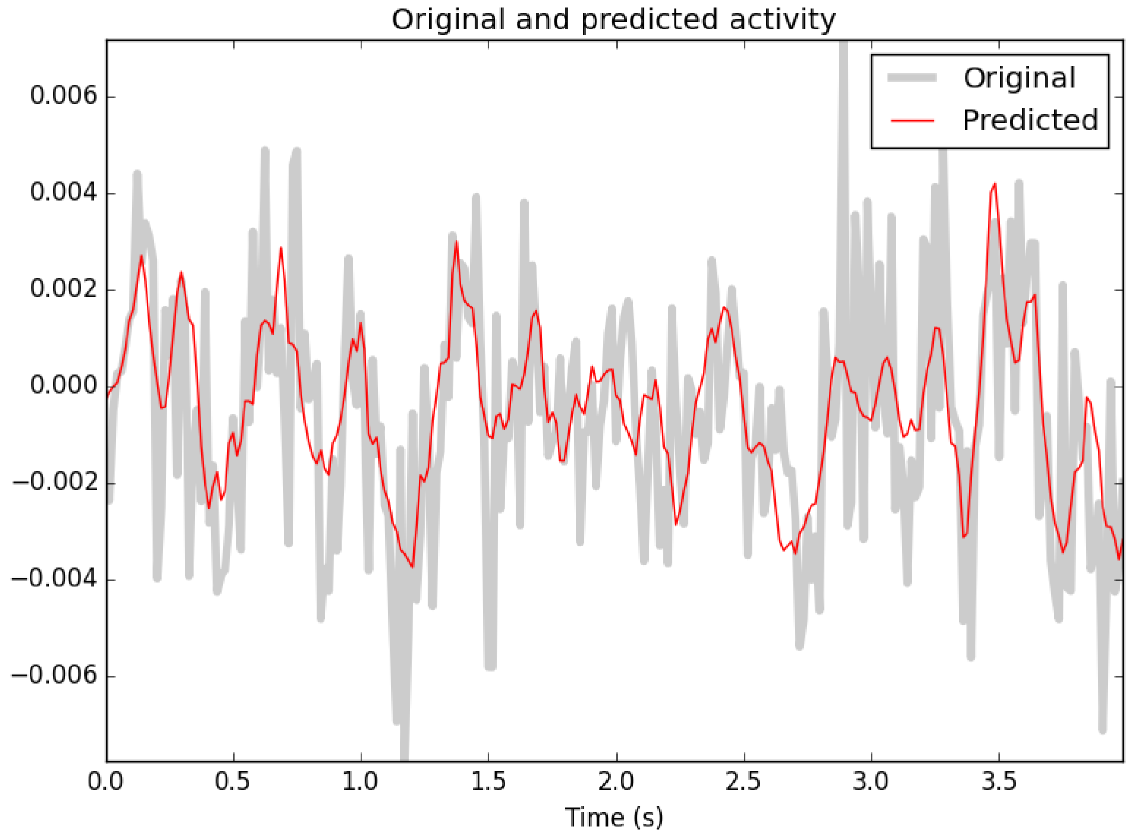
- Use really big data
- Use really complicated data



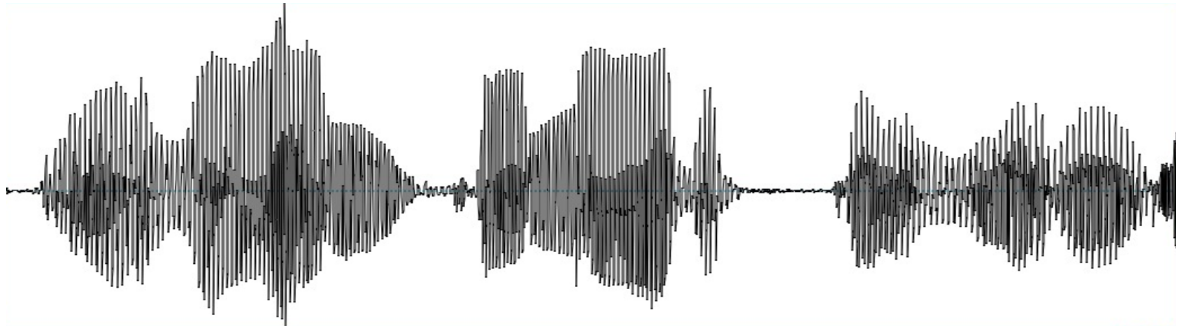
Why machine learning?

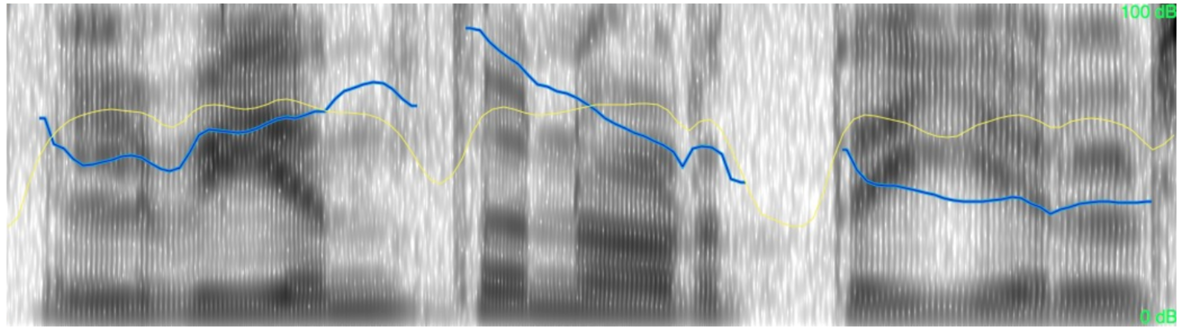
We can...

- Predict the future
- Automate this process



Why combine these two?





A machine learning pipeline

- Feature extraction
- Model fitting
- Prediction and validation

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Let's practice!

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Machine learning basics

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Always begin by looking at your data

```
array.shape
(10, 5)

array[:3]
array([[ 0.735528  ,  1.00122818, -0.28315978],
       [-0.94478393,  0.18658748, -0.00241224],
       [-0.74822942, -1.46636618,  0.69835096]])
```

Always begin by looking at your data

```
df.head()

       col1      col2      col3
0  0.735528  1.001228 -0.283160
1 -0.944784  0.186587 -0.002412
2 -0.748229 -1.466366  0.698351
3  1.038589 -0.171248  0.831457
4 -0.161904  0.003972 -0.321933
```

Always visualize your data

Make sure it looks the way you'd expect.

```
# Using matplotlib
fig, ax = plt.subplots()
ax.plot(...)

# Using pandas
fig, ax = plt.subplots()
df.plot(..., ax=ax)
```

Scikit-learn

Scikit-learn is the most popular machine learning library in Python

```
from sklearn.svm import LinearSVC
```

Preparing data for scikit-learn

- `scikit-learn` expects a particular structure of data:

`(SAMPLES, FEATURES)`

- Make sure that your data is *at least two-dimensional*
- Make sure the first dimension is *samples*

If your data is not shaped properly

- If the axes are swapped:

```
array.T.shape
(10, 3)
```

If your data is not shaped properly

- If we're missing an axis, use `.reshape()`:

```
array.shape
(10,)

array.reshape([-1, 1]).shape
(10, 1)
```

- `-1` will automatically fill that axis with remaining values

Fitting a model with scikit-learn

```
# Import a support vector classifier
from sklearn.svm import LinearSVC

# Instantiate this model
model = LinearSVC()

# Fit the model on some data
model.fit(X, y)
```

It is common for `y` to be of shape `(samples, 1)`

Investigating the model

```
# There is one coefficient per input feature
model.coef_
array([[ 0.69417875, -0.5289162 ]])
```

Predicting with a fit model

```
# Generate predictions
predictions = model.predict(X_test)
```

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Combining timeseries data with machine learning

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Getting to know our data

- The datasets that we'll use in this course are all freely-available online
- There are many datasets available to download on the web, the ones we'll use come from Kaggle

The Heartbeat Acoustic Data

- Many recordings of heart sounds from different patients
- Some had normally-functioning hearts, others had abnormalities
- Data comes in the form of audio files + labels for each file
- Can we find the "abnormal" heart beats?

Loading auditory data

```
from glob import glob
files = glob('data/heartbeat-sounds/files/*.wav')

print(files)

['data/heartbeat-sounds/proc/files/murmur__201101051104.wav',
 ...
 'data/heartbeat-sounds/proc/files/murmur__201101051114.wav']
```

Reading in auditory data

```
import librosa as lr
# `load` accepts a path to an audio file
audio, sfreq = lr.load('data/heartbeat-sounds/proc/files/murmur__201101051104.wa

print(sfreq)
2205
```

In this case, the sampling frequency is `2205`, meaning there are `2205` samples per second

Inferring time from samples

- If we know the sampling rate of a timeseries, then we know the timestamp of each datapoint *relative to the first datapoint*
- Note: this assumes the sampling rate is fixed and no data points are lost

Creating a time array (I)

- Create an array of indices, one for each sample, and divide by the sampling frequency

```
indices = np.arange(0, len(audio))
time = indices / sfreq
```

Creating a time array (II)

- Find the time stamp for the *N-1*th data point. Then use `linspace()` to interpolate from zero to that time

```
final_time = (len(audio) - 1) / sfreq
time = np.linspace(0, final_time, sfreq)
```

The New York Stock Exchange dataset

- This dataset consists of company stock values for 10 years
- Can we detect any patterns in historical records that allow us to predict the value of companies in the future?

Looking at the data

```
data = pd.read_csv('path/to/data.csv')

data.columns
Index(['date', 'symbol', 'close', 'volume'], dtype='object')

data.head()

         date symbol       close       volume
0  2010-01-04   AAPL  214.009998  123432400.0
1  2010-01-04    ABT   54.459951   10829000.0
2  2010-01-04    AIG   29.889999    7750900.0
3  2010-01-04   AMAT   14.300000   18615100.0
4  2010-01-04   ARNC   16.650013   11512100.0
```

Timeseries with Pandas DataFrames

- We can investigate the object type of each column by accessing the `dtypes` attribute

```
df['date'].dtypes

0     object
1     object
2     object
dtype: object
```

Converting a column to a time series

- To ensure that a column within a DataFrame is treated as time series, use the `to_datetime()` function

```
df['date'] = pd.to_datetime(df['date'])

df['date']

0   2017-01-01
1   2017-01-02
2   2017-01-03
Name: date, dtype: datetime64[ns]
```

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Let's practice!