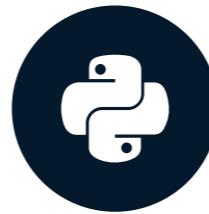


Timeseries kinds and applications

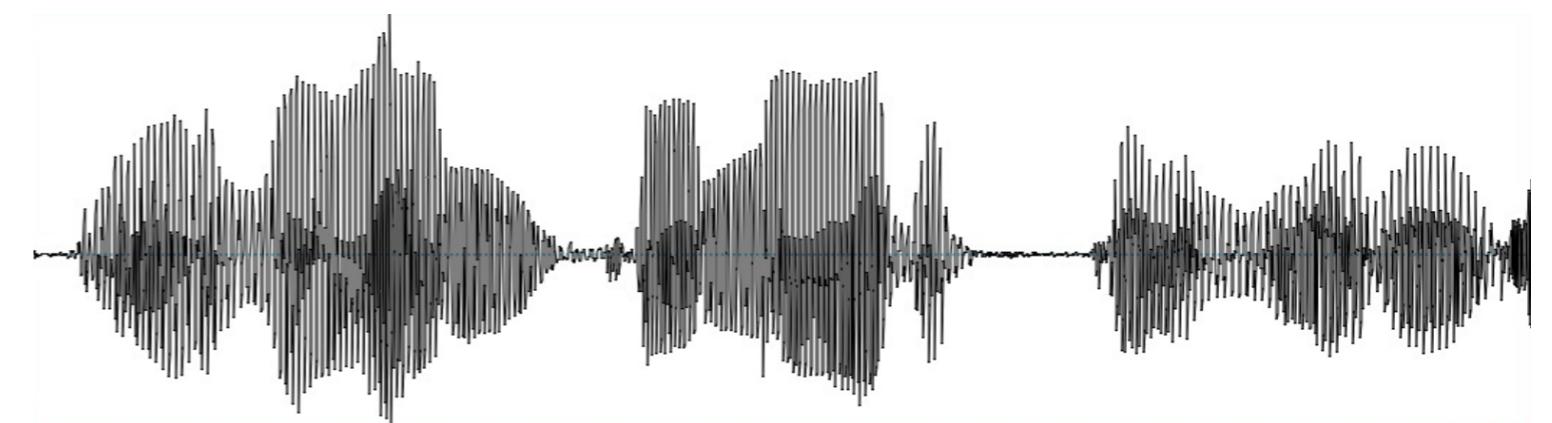
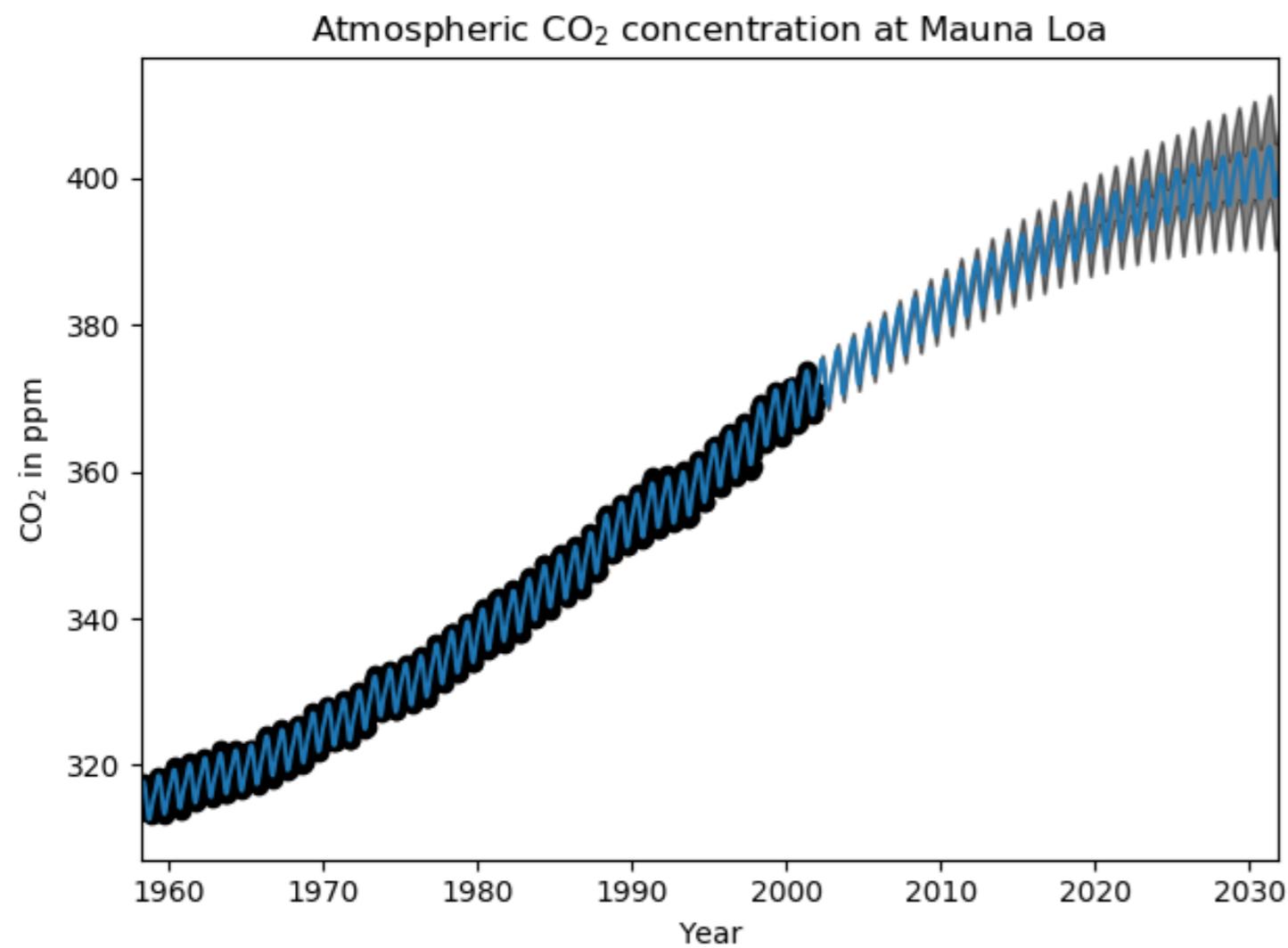
MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON



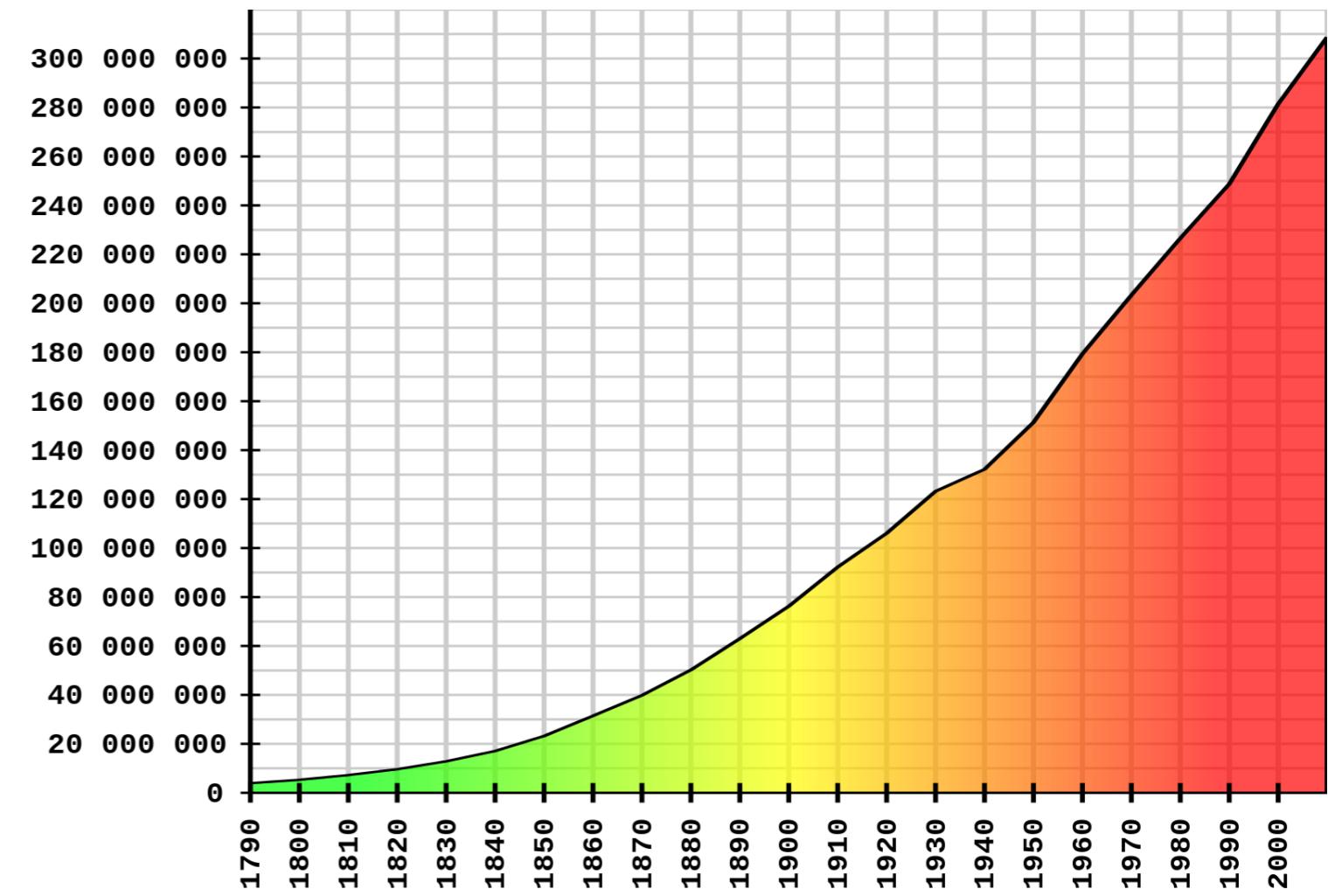
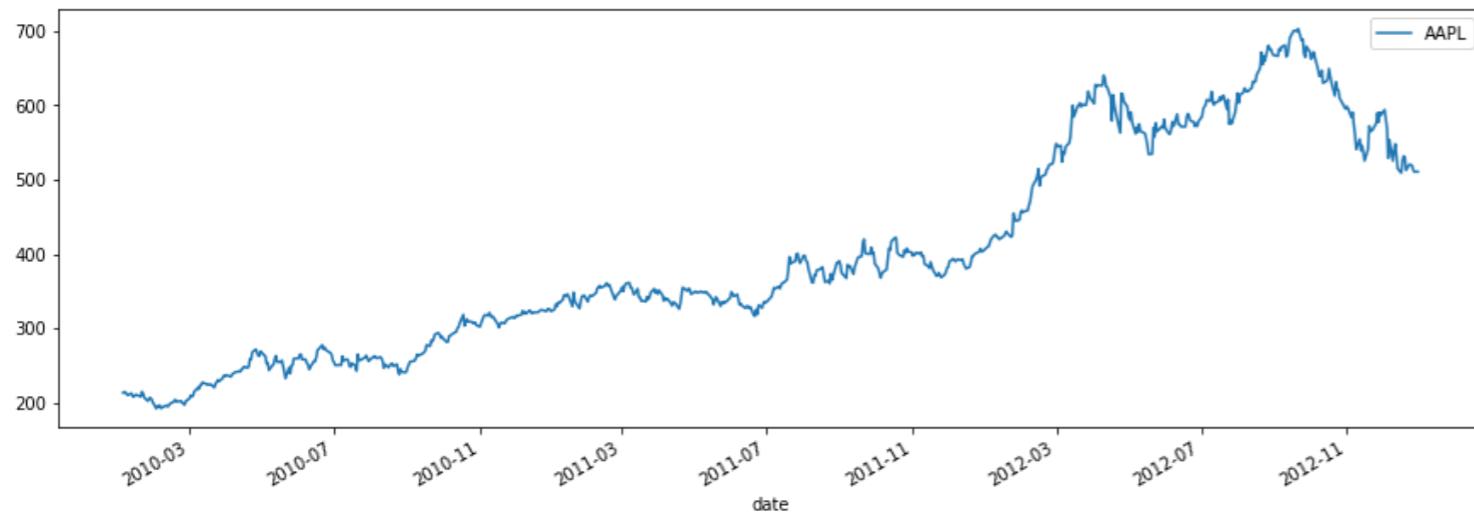
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Time Series



Time Series



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

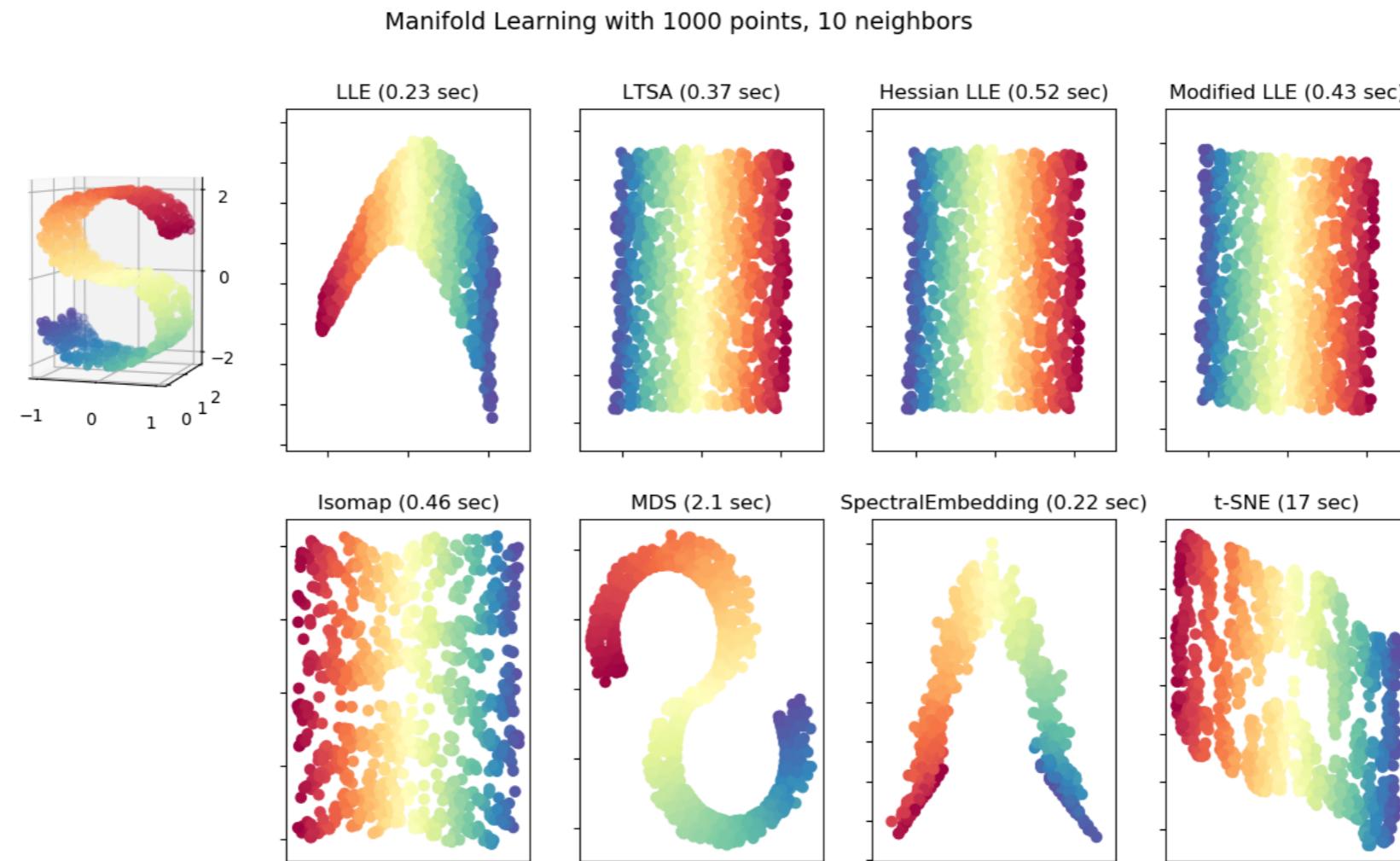
```
import matplotlib.pyplot as plt  
  
fig, ax = plt.subplots(figsize=(12, 6))  
data.plot('date', 'close', ax=ax)  
ax.set(title="AAPL daily closing price")
```

A timeseries plot



Why machine learning?

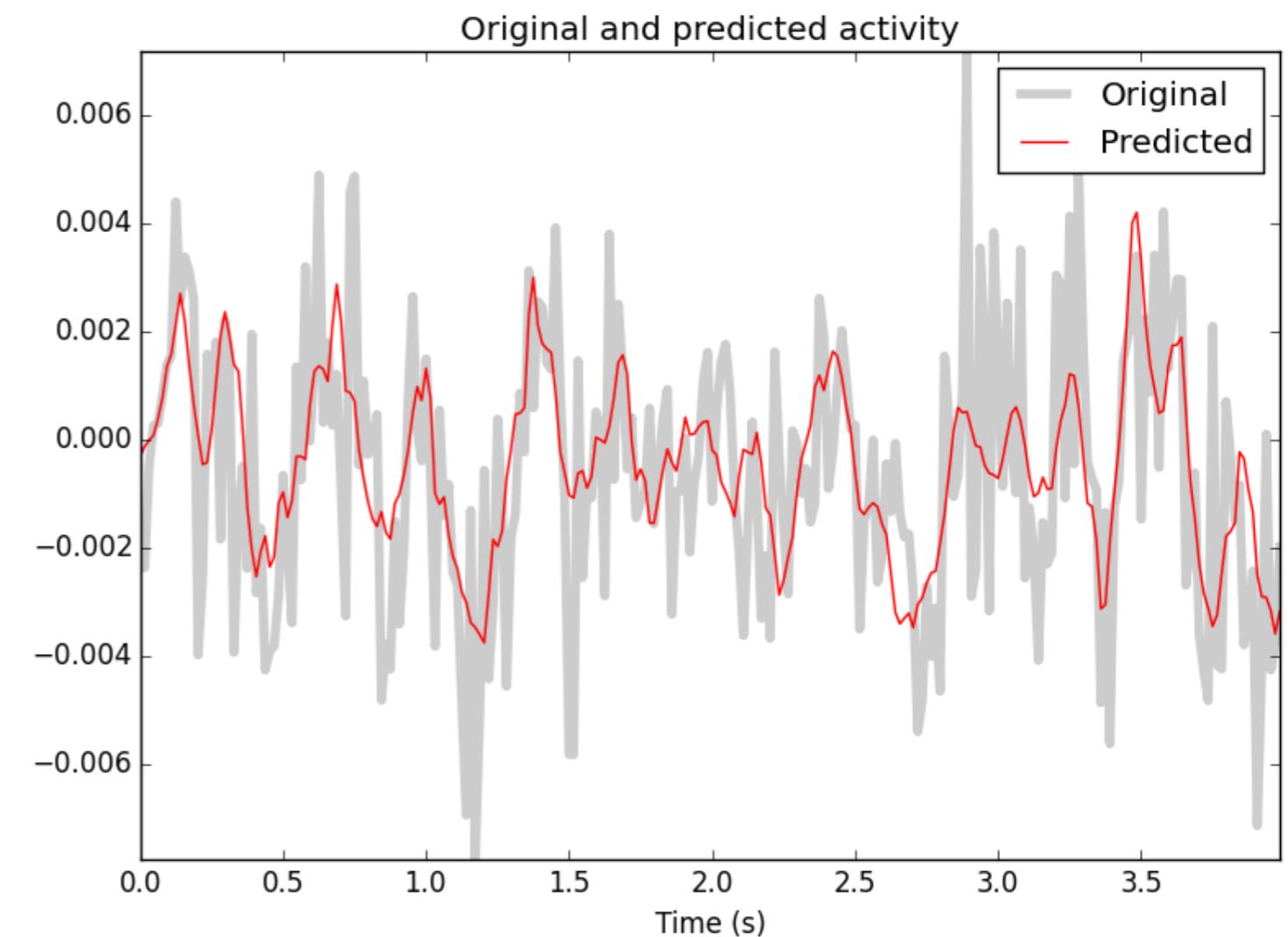
We can use really big data and really complicated data



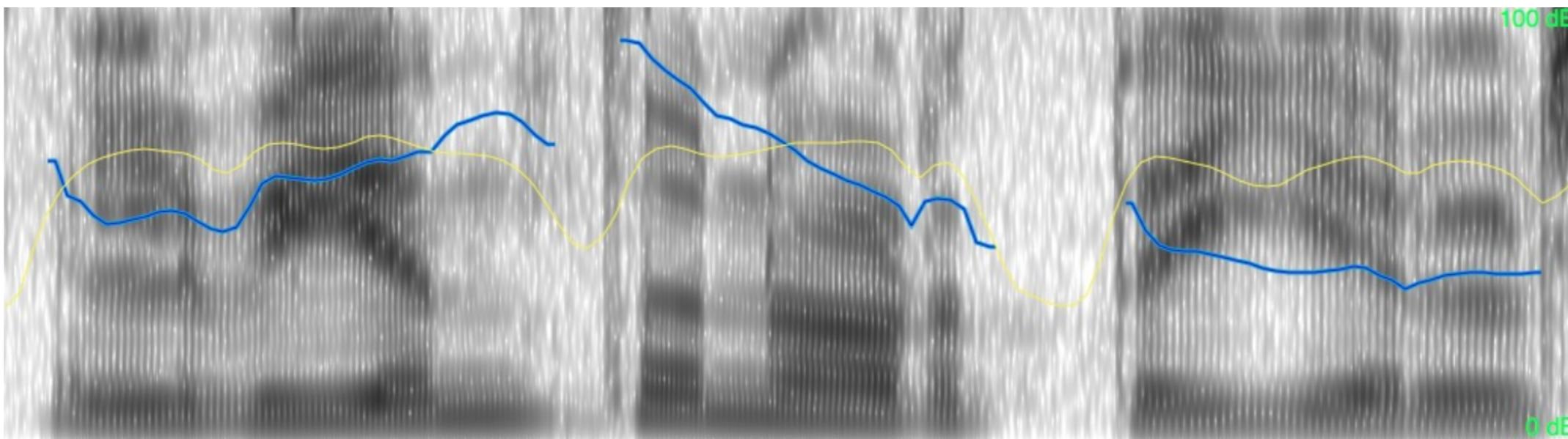
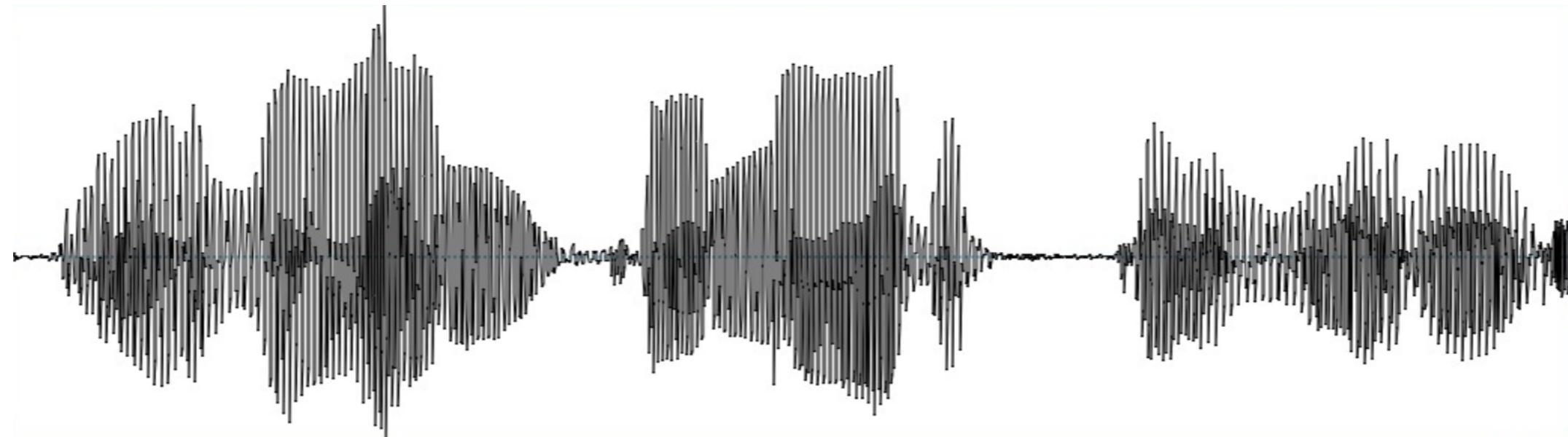
Why machine learning?

We can...

- Predict the future
- Automate this process



Why combine these two?



A machine learning pipeline

- Feature extraction
- Model fitting
- Prediction and validation

Let's practice!

MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON

Machine learning basics

MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON



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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)
```

Let's practice

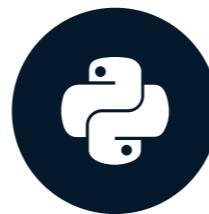
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Combining timeseries data with machine learning

MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON

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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.wav')

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 -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]
```

Let's practice!

MACHINE LEARNING FOR TIME SERIES DATA IN PYTHON