

Intro to Machine Learning and Time Series Analysis

FinTech
Lesson 10.1



Class objectives

By the end of today's class you will understand:



Intro to Machine Learning



Time Series Fundamentals



Time Series Decomposition



Hodrick-Prescott Filter

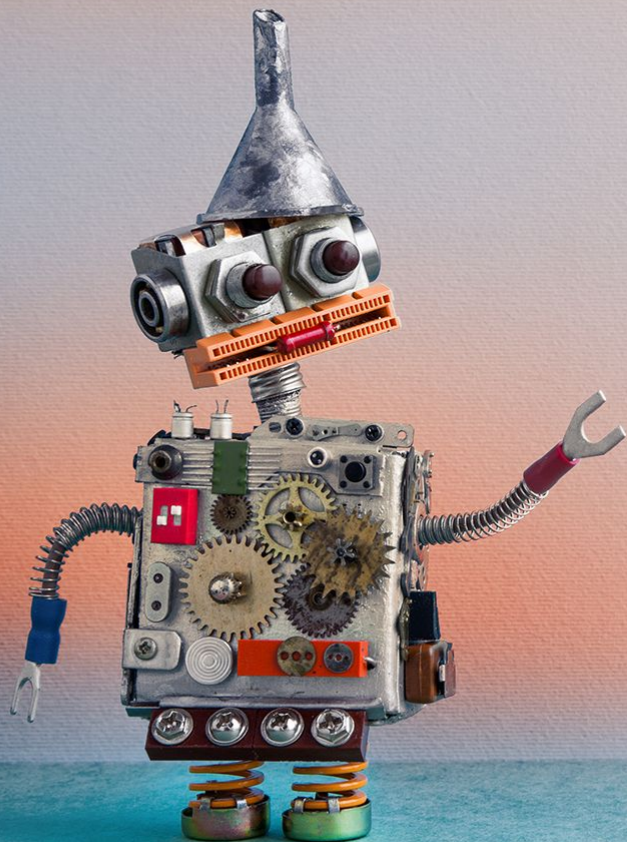


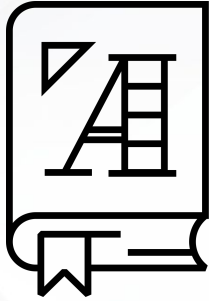
Autocorrelation and Partial Autocorrelation Analysis

Mysticism of Machine Learning



So It Begins...





Machine learning is a programming approach allowing applications to learn from their inputs and make adjustments based on their outputs.

In a nutshell, **machine learning**, is developing statistical models that can make predictions or decisions on new data automatically.

Mysticism of Machine Learning

Machine Learning is used to predict:



Loan eligibility, foreclosure rates, and fraud.



Disease diagnosis and prognosis.



Consumer segmentation and clustering.



Presidential election results.



Natural disaster and planetary climate impacts.

Mysticism of Machine Learning

Machine Learning Models

01

Libraries

Models for machine learning are provided in libraries, just like other code we've used.

02

Pipelines

All machine learning pipelines use a **Model -> Fit-> Predict** paradigm. Once the model is fit, it can be used to make predictions.

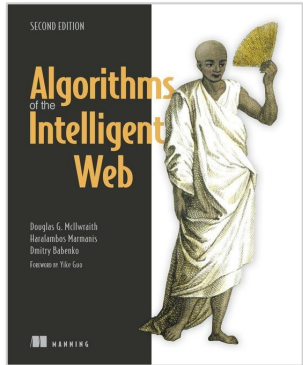
Mysticism of Machine Learning



Intelligent algorithms are ones that use data to modify its behavior. Intelligent algorithms differ in that they can change their behavior as they run, often resulting in a user experience that many would say is intelligent.



—*Algorithms of the Intelligent Web, Second Edition*



Algorithms of the Intelligent Web, Second Edition

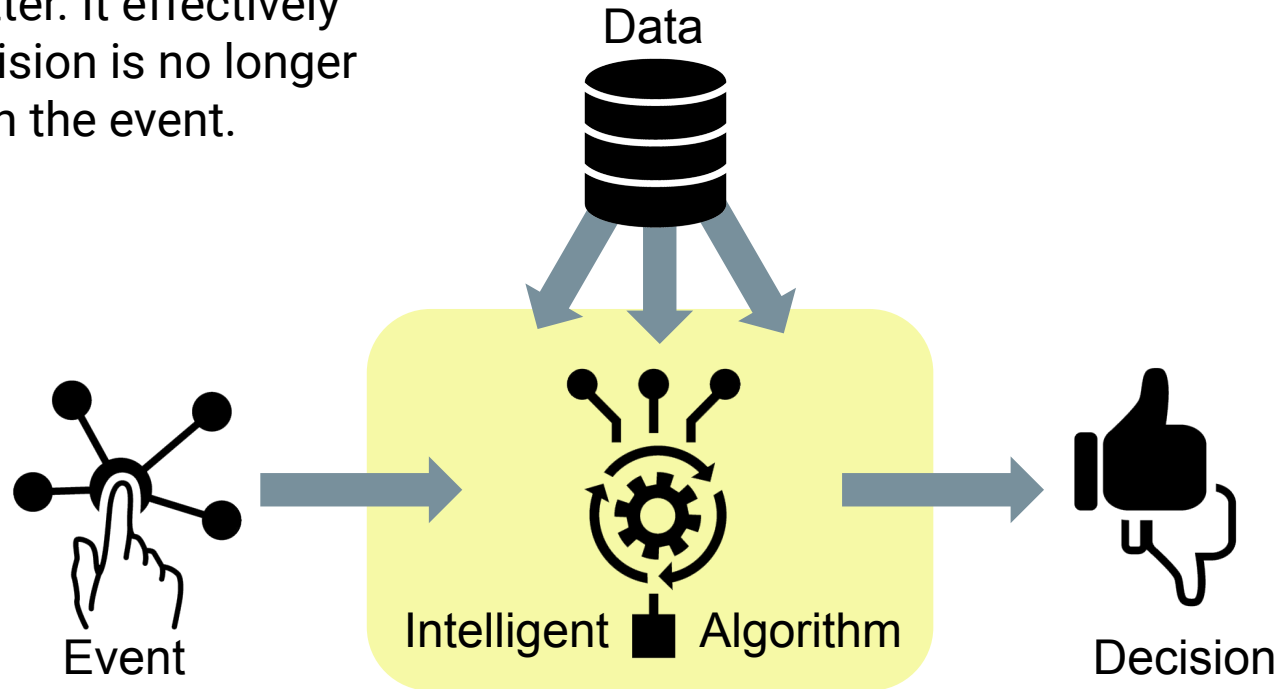
by Douglas G. McIlwraith Haralambos Marmanis Dmitry Babenko

Publisher: Manning Publications

Release Date: August 2016

Mysticism of Machine Learning

Intelligent algorithms are ones that respond to data such that the algorithm gets better. It effectively “evolves.” The decision is no longer deterministic given the event.



Mysticism of Machine Learning

Machine Learning

Capability of software to generalize phenomena (past or future) based on past experience



Predictive Analytics

Capability of software to predict future outcomes based on historical data



Artificial Intelligence

Software (and machines) that have a series of options to achieve a particular goal



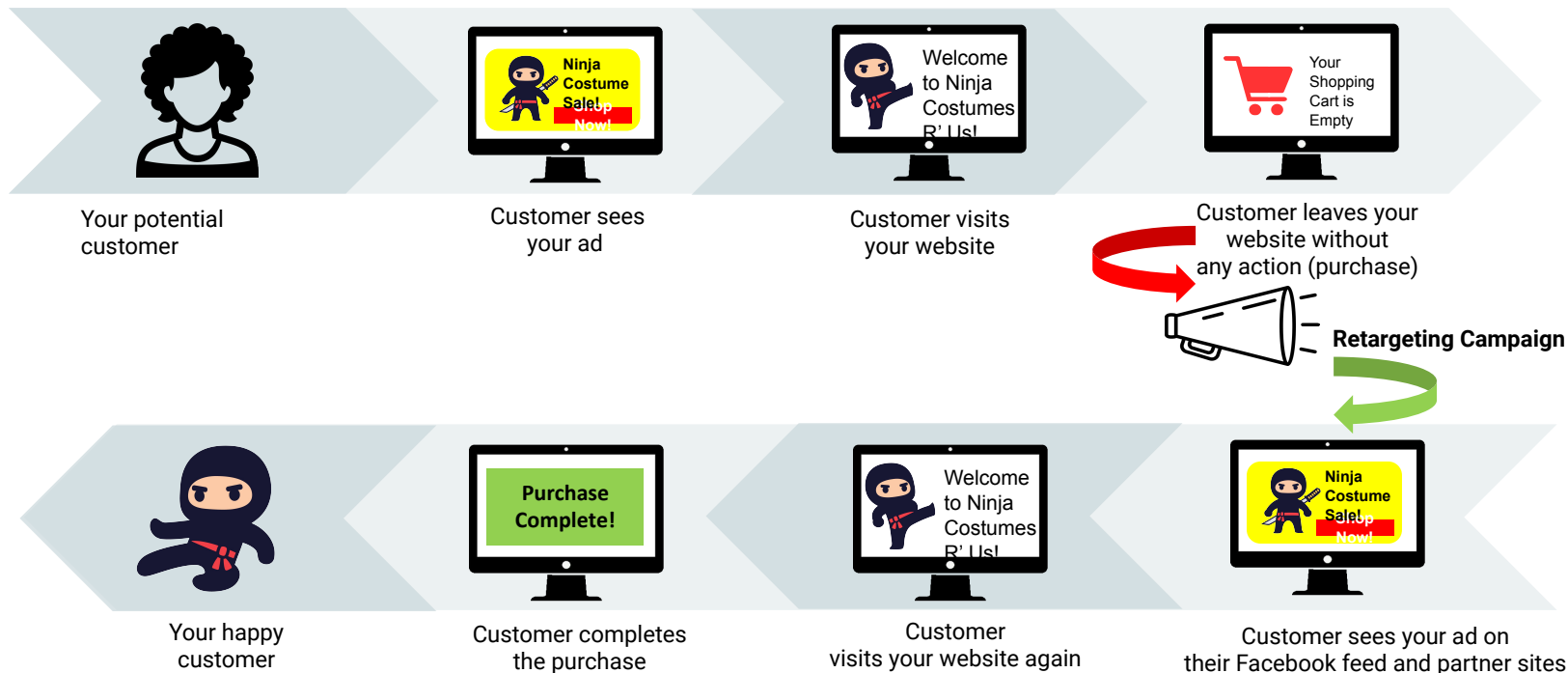
Mysticism of Machine Learning

Artificial Intelligence

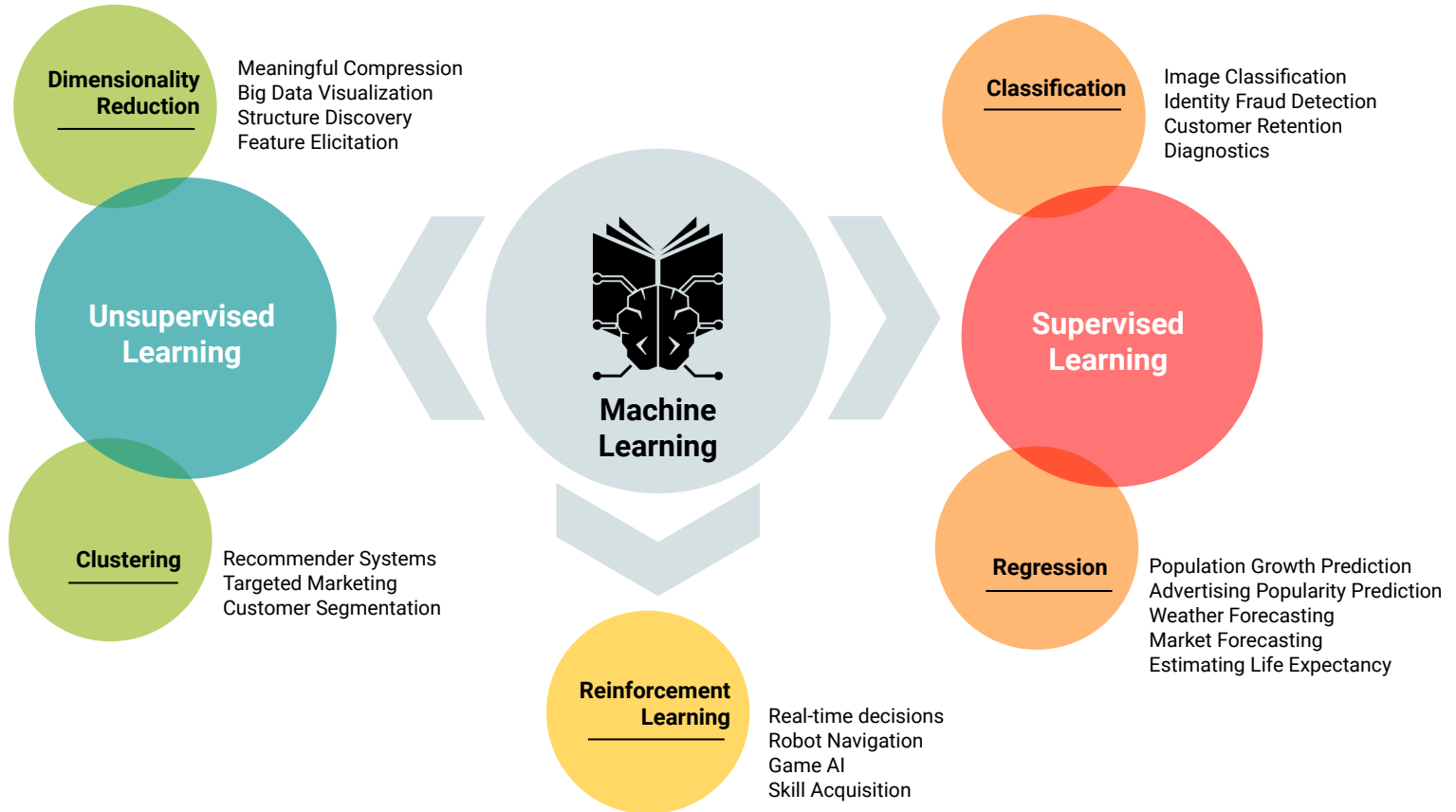


Mysticism of Machine Learning

Predictive Analytics



Mysticism of Machine Learning





Instructor Demonstration

Review Homework

Time Series Basics

Time Series Basics

Working with time series data requires a return to the basics

Data needs to be sliced and diced at various time frequencies in order to analyze data points as a time series

E.g. day, week, month, year



Pandas DateTimeIndex index can be used to help with this

```
df.loc[2019]
```


Time Series Basics

The Pandas resample function can also be used to slice and dice data, once a DateTimeIndex has been created

```
weekly = df['Close'].resample('W').mean()
```



Instructor Demonstration

Time Series Basics



Activity: Time Series Basics

In this activity, you will practice the basics of time series manipulation in pandas.

Instructions sent via Slack.

Suggested Time:
15 minutes

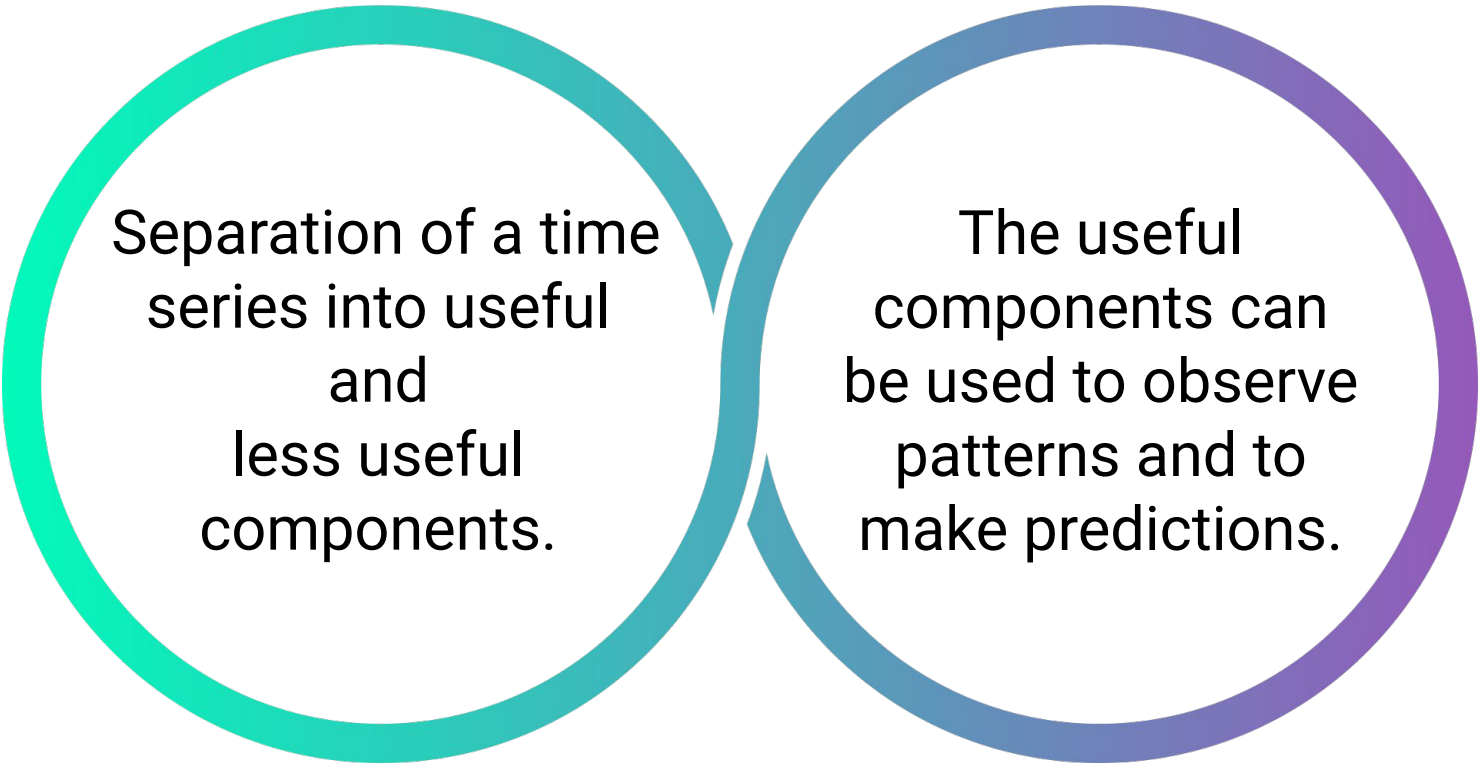




Time's Up! Let's Review.

Time Series Decomposition

Time Series Decomposition



Separation of a time series into useful and less useful components.

The useful components can be used to observe patterns and to make predictions.

Time Series Decomposition

Components

01

Level: What is the average value of the series?

02

Trend: Is there an overall direction of movement?

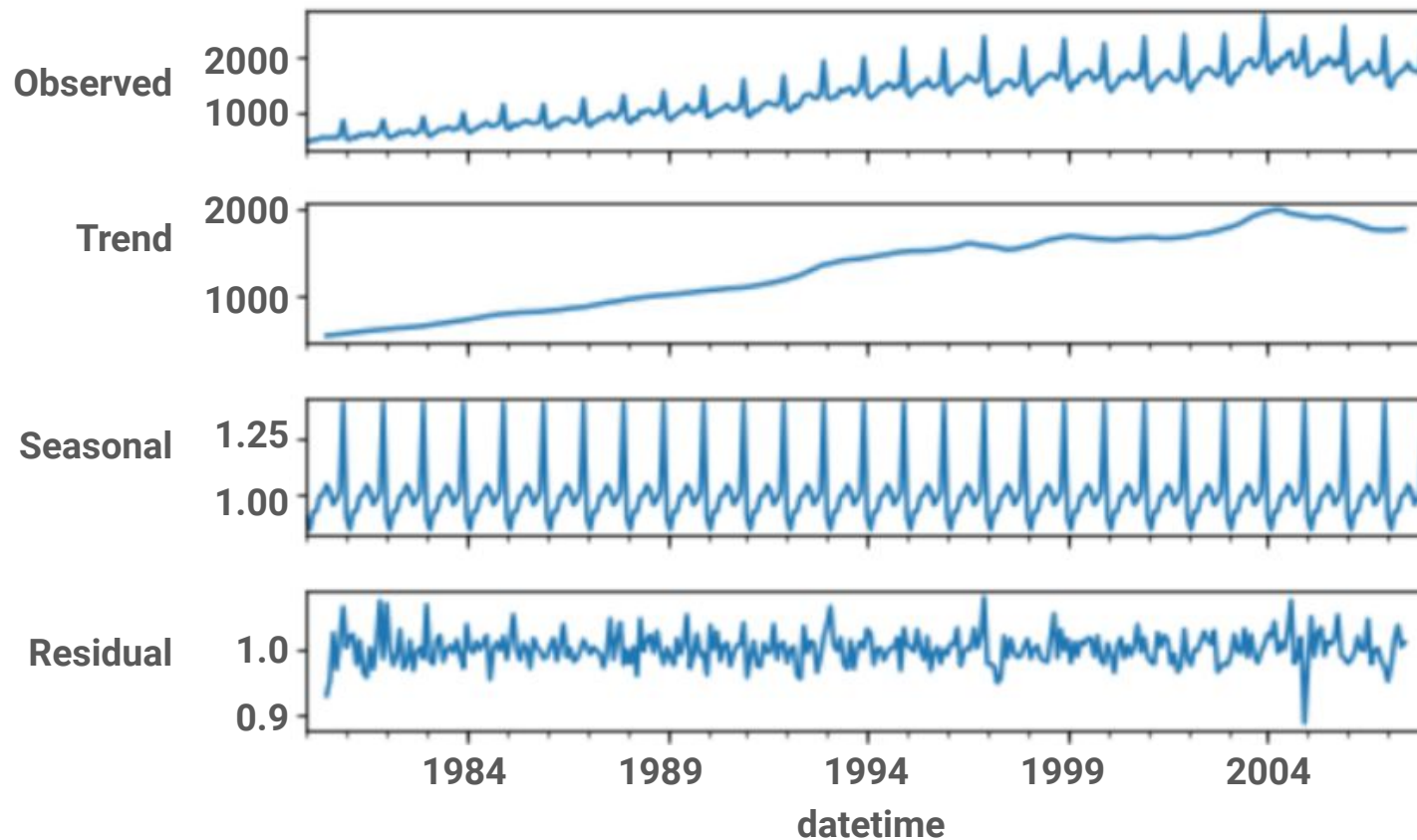
03

Periodicity: Do patterns occur in cycles?

04

Residual: How much noise exists in the data?

Time Series Decomposition



Time Series Decomposition



The `observed data` panel is decomposed into the next three elements.



An upward trend is observed in the data.



A seasonality is also observed.



The residual components are the leftovers when trend and seasonality are removed.



Instructor Demonstration

Time Series Decomposition



Exponentially-Weighted Moving Average

Exponentially Weighted Moving Average (EWMA)

EWMA is an approach used to “denoise” or “smooth” out time series data so that trends and predictions can be made

01

EWMA involves calculating the average of the last n prices

02

Weights are added to the averages based on the recency of the data

- Recent data is weighted more heavily
- Weighting decreases exponentially for previous prices/time periods

03

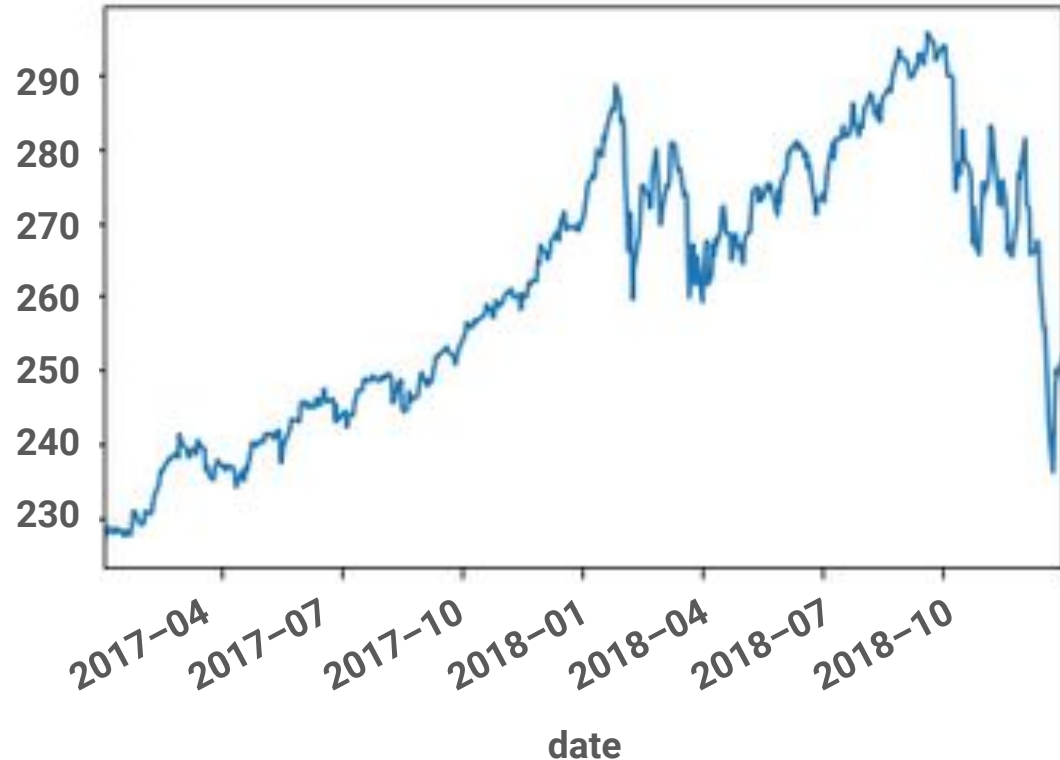
Requires past average values to be stored in memory

Exponentially Weighted Moving Average (EWMA)

EWMA is used to highlight trends and illustrate the price trajectory for an investment



In which direction
is the price moving?



Hodrick-Prescott Filter



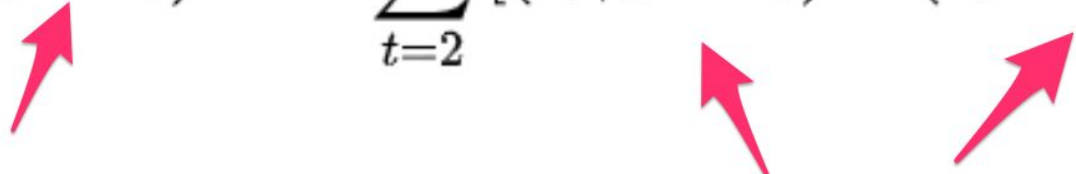
Hodrick-Prescott Filter: A mathematical function that separates a time series into trend and non-trend components.

Hodrick-Prescott Filter

Filters out short-term
fluctuations



Hodrick-Prescott Filter

$$\min_{\tau} \left(\sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \right)$$


**time series value - trend =
cyclic element**

**Difference in trend
over time = volatility**



Instructor Demonstration

EWMA and Hodrick-Prescott Filter



Activity: You've got a FRED

In this activity, you will use the Hodrick-Prescott filter to identify macroeconomic trends in the United States in the period from 2004 to 2010. Instructions sent via Slack.

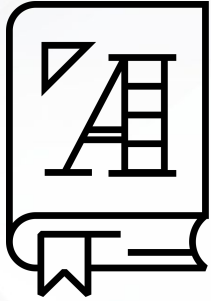
Suggested Time:
15 minutes





Time's Up! Let's Review.

Autocorrelation

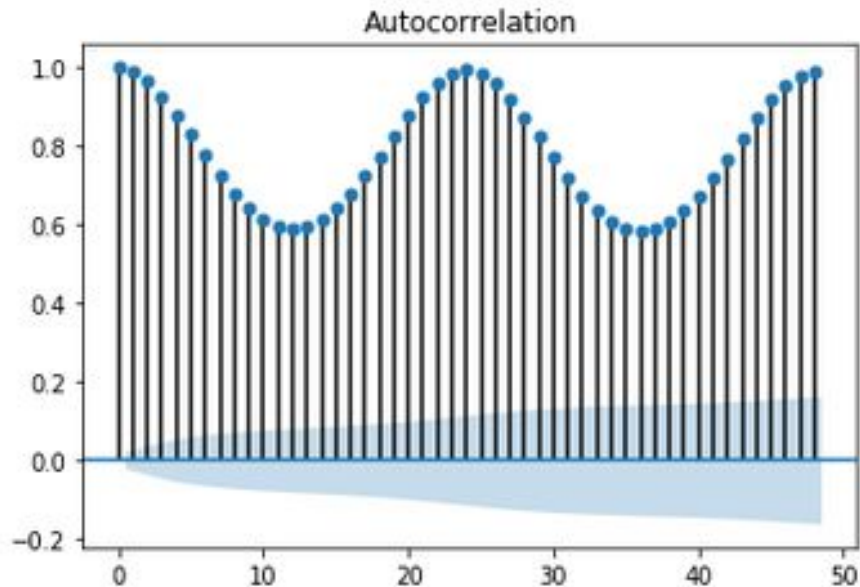
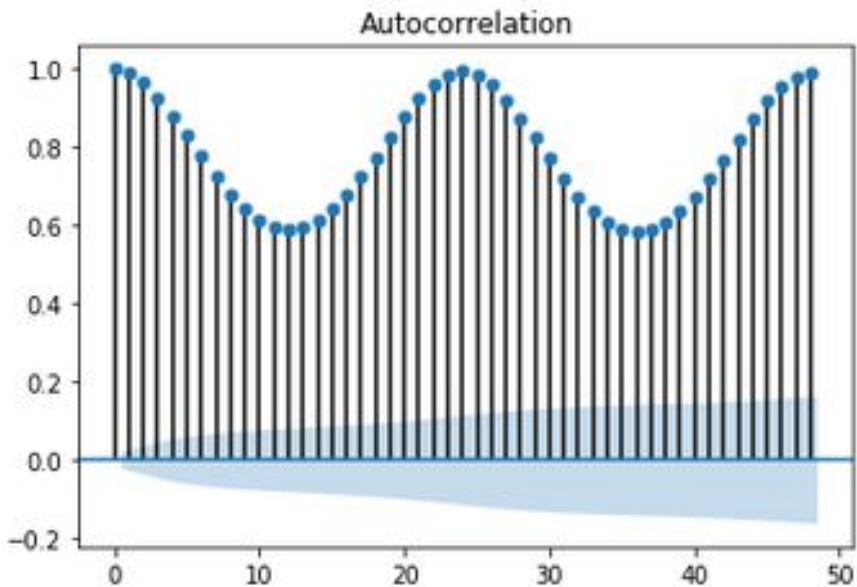


Autocorrelation is a measure of how closely current values correlate with past values

For example, **autocorrelation** is used to determine to what extent today's prices correlate with yesterday's prices

Autocorrelation

```
df.Temperature.autocorr(lag=1)  
sm.graphics.tsaplots.plot_acf(df.Temperature,  
                                1, 49)
```





Instructor Demonstration

Autocorrelation



Activity: Euro ETFs

In this activity, you will examine a time series of bid-ask spreads of an ETF for autocorrelation.

Instructions sent via Slack.

Suggested Time:
15 minutes





Time's Up! Let's Review.



Questions?