

Timeseries II

Learning Goals

By the end of the lecture you should be able to:

Understand Autocorrelation

Understand Partial Autocorrelation

Interpret timeseries

Interpret Autocorrelation plots

Interpret Partial Autocorrelation plots

Use ACF and PACF and the timeseries plot to
select optimal parameter values

Understand how timeseries models work

Fit ARMA models

Fit ARIMA models

Fit SARIMA models

Fit SARIMAX models

Generate forecasts from timeseries models

Generate Confidence Intervals for forecasts

Validate a timeseries model

Concept Review

Explain to your partner

What is stationarity?

How do you check for stationarity?

How do you interpret the output of the Dickey-Fuller test?

How do you make your data stationary?

What does 'validation' mean at a high level/abstract level?

Steps to modeling time series data

1. Visualize the time series



```
graph TD; A[1. Visualize the time series] --> B[2. Stationarize the series]; B --> C[3. Plot ACF/PACF charts and find optimal parameters]; C --> D[4. Build the ARIMA model]; D --> E[5. Make Predictions];
```

The diagram is a vertical flowchart with five steps, each in a colored box. The boxes are arranged from top to bottom, with each subsequent box shifted further to the right. The colors transition from light green at the top to dark purple at the bottom. Downward-pointing arrows connect each box to the next one below it.

2. Stationarize the series

3. Plot ACF/PACF charts and find optimal parameters

4. Build the ARIMA model

5. Make Predictions

Autocorrelation

Autocorrelation

Correlation of the lag of our timeseries with the original

The lag acts as a predictor of the current value

DEMO

NOW IT'S YOUR TIME

Are you ready?!

Partial Autocorrelation

Partial Autocorrelation

Correlation of the lags of our timeseries with the original values AFTER we have controlled for the autocorrelation of previous lags

Moving Average have strong connection with this values

DEMO

NOW IT'S YOUR TIME

Are you ready?!

ARMA

AutoRegressive

Moving Average

Models

The Differencing Rules

Logic

Orders of diff meaning for the original timeseries:

0 = stationary

1 = constant average trend

2 = time-varying trend

Visual process

ACF Shows:

- Sequence of + \rightarrow Add diff
- All small w/o pattern \rightarrow Leave it
- Lag-1 $\leq 0 \rightarrow$ Leave it
- Lag-1 $\leq -.5 \rightarrow$ Reduce diff

BEWARE OF OVERDIFFERENCING

Quantitative process

Select the degree of diff that leads to the lowest std

Although, AR or MA terms can help with small differencing issues too

DEMO

NOW IT'S YOUR TIME

Are you ready?!

ARMA

AutoRegressive

Moving Average

Models

The ARMA Rules

PACF of diffed series:

- sharp cutoff / lag-1 $> 0 \rightarrow$ Add AR
- Optimal AR = term after sharp cutoff

ACF of diffed series:

- sharp cutoff / lag-1 $> 0 \rightarrow$ Add MA
- Optimal MA = term after sharp cutoff

AR could cancel MA

Try making it work with less terms

If long term forecast erratic or unstable:

- Try trading off AR for diff
- Try decreasing both AR and MA

**BEWARE OF MULTIPLE AR & MA
TERMS IN THE SAME MODEL**

DEMO

NOW IT'S YOUR TIME

Are you ready?!

The Seasonality Rules

If seasonal pattern \rightarrow Seasonal diff = 1

Note: Regular diff + Seasonal diff ≤ 2

ACF off diffed series at S:

- Positive \rightarrow Add seasonal AR
- Negative \rightarrow Add seasonal MA

Note: Seasonal AR + Seasonal MA ≤ 2

DEMO

NOW IT'S YOUR TIME

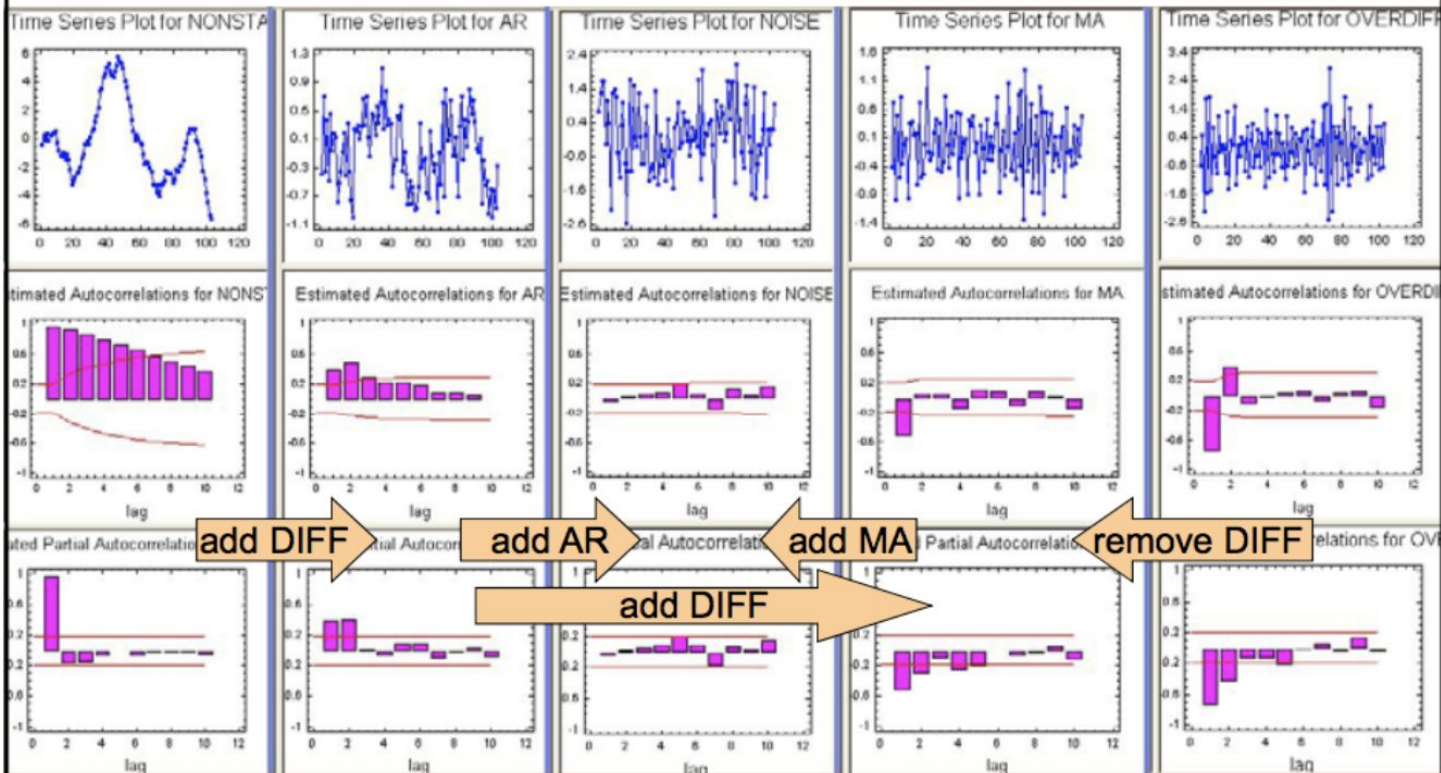
Are you ready?!

The autocorrelation spectrum

← Positive autocorrelation

No autocorrelation

Negative autocorrelation →



Nonstationary

Auto-Regressive

White Noise

Moving-Average

Overdifferenced

