ARIMA Modeling



Learning Objectives

- Describe the purpose of the autoregressive and moving average components.
- Define hyperparameters p, d, and q.
- Describe AIC.
- Find the right value of p and q using AIC.
- Find the right value of d using the augmented Dickey-Fuller test.
- Complete a manual GridSearch.
- Fit an ARIMA model.



We have multiple approaches to work with time series data.

Linear Models ARIMA Models Exponential Smoothing Methods Recurrent Neural Networks (RNNs)

Note: This is not an exhaustive list of models, but lists the most common ones!



Why ARIMA?

- Among the most common approaches to time series modeling.
- Highly flexible; it can model time series with varying characteristics.
 - It takes information from both long-term trends and sudden shocks!
- Can easily be extended into more advanced models.

- Tends to perform well with moderate amounts of data.
 - It can be hard to get lots of time series data!



Downsides of ARIMA Models

- ARIMA models are best suited for short-term forecasts, but very quickly will start predicting the mean.
 - Some extensions to ARIMA models can handle this better.



What is an ARIMA model?

ARIMA



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ARIMA

Autoregressive Integrated Moving Average



What do you think the word "autoregressive" means?



What do you think the word "autoregressive" means?

- Autocorrelation is the correlation of one variable with itself.
- An autobiography is a book written by a person, about that same person.
- An autotransplant is a surgical procedure in which an organ is transplanted from a person to that same person.
- Autoregressive means we regress a variable on itself.
 - We'll regress newer values on older values.



AR(p): An autoregressive model of order p

$$Y_t = eta_0 + eta_1 Y_{t-1} + eta_2 Y_{t-2} + \cdots + eta_p Y_{t-p}$$
 $= eta_0 + \sum_{k=1}^p eta_p Y_{t-p}$



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$$= eta_0 + \sum_{k=1}^p eta_p Y_{t-p}$$

Purpose: An autoregressive model explains long-term trends in our data.

Hyperparameter: p, the number of previous values of Y to put into our model.



We'll **GridSearch** to find this value!



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ARIMA

Autoregressive Integrated Moving Average



Moving Average Models

- A moving average model takes previous error terms as inputs.
- The goal is to predict future values based on recent forecasting errors.
 - This isn't identical to boosting, but is similar in that fitting is driven by errors.
- Annoying: this isn't the same thing as moving average smoothing.



MA(q): A moving average model of order q

$$egin{aligned} Y_t &= \mu + w_1 arepsilon_{t-1} + w_2 arepsilon_{t-2} + \cdots + w_p arepsilon_{t-q} \ &= \mu + \sum_{k=1}^q w_q arepsilon_{t-q} \end{aligned}$$

$$MA(1) \Rightarrow Yt = \mu + w_1^*e_t-1$$

MA(q): A moving average model of order q

$$egin{aligned} Y_t &= \mu + w_1 arepsilon_{t-1} + w_2 arepsilon_{t-2} + \cdots + w_p arepsilon_{t-q} \ &= \mu + \sum_{k=1}^q w_q arepsilon_{t-q} \end{aligned}$$

Purpose: A moving average model explains sudden shocks in our data.

Hyperparameter: q, the number of previous errors ε to put into our model.



We'll **GridSearch** to find this value!



How do we GridSearch to find the best values of p and q?

- Because we're working in statsmodels, we will **manually GridSearch** values of p and q to see which gives us the **lowest AIC**.
- AIC, or Akaike Information Criterion, is a common way to evaluate time series models. (AIC is an attribute in statsmodels.)
- Remember that a model is a simplification of reality?
 - AIC attempts to measure how much information we lose when we simplify reality with a model.

$$AIC = 2 \times [\text{\# of model parameters}] - 2 \times \log(\text{likelihood})$$



What is an ARIMA model?

ARIMA

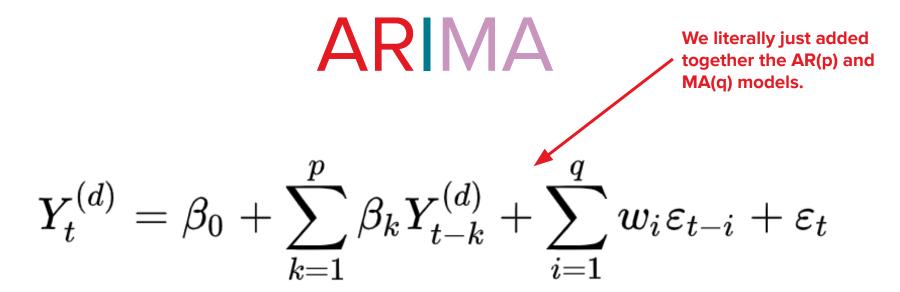
Autoregressive Integrated Moving Average



At this point, it's helpful to see what an ARIMA model is.

$$Y_t^{(d)} = eta_0 + \sum_{k=1}^p eta_k Y_{t-k}^{(d)} + \sum_{i=1}^q w_i arepsilon_{t-i} + arepsilon_t$$

At this point, it's helpful to see what an ARIMA model is.



Autoregressive Integrated Moving Average



What is that $Y_t^{(d)}$?

Onto the notebook!

...but first!



ARIMA Cheat Sheet

	AR		MA
Stands for:	Autoregressive	Integrated	Moving Average
Summary:	Regress future values on past values .	Differences our Y variable.	Regress future values on past errors.
Looks Like:	$igg eta_0 + \sum_{k=1}^p eta_k Y_{t-k}^{(d)}$	$Y_t^{(d)}$	$egin{aligned} eta_0 + \sum_{i=1}^q w_i arepsilon_{t-i} + arepsilon_t \end{aligned}$
Purpose:	Long-term trends.	Ensure stationarity.	Sudden shocks.
Hyperparameter:	р	d	q
Find good value of hyperparameter by:	GridSearch	Augmented Dickey-Fuller Test	GridSearch