Time Series Forecasting with Python 7-Day Mini-Course

by **Jason Brownlee** on March 22, 2017 in **Time Series**

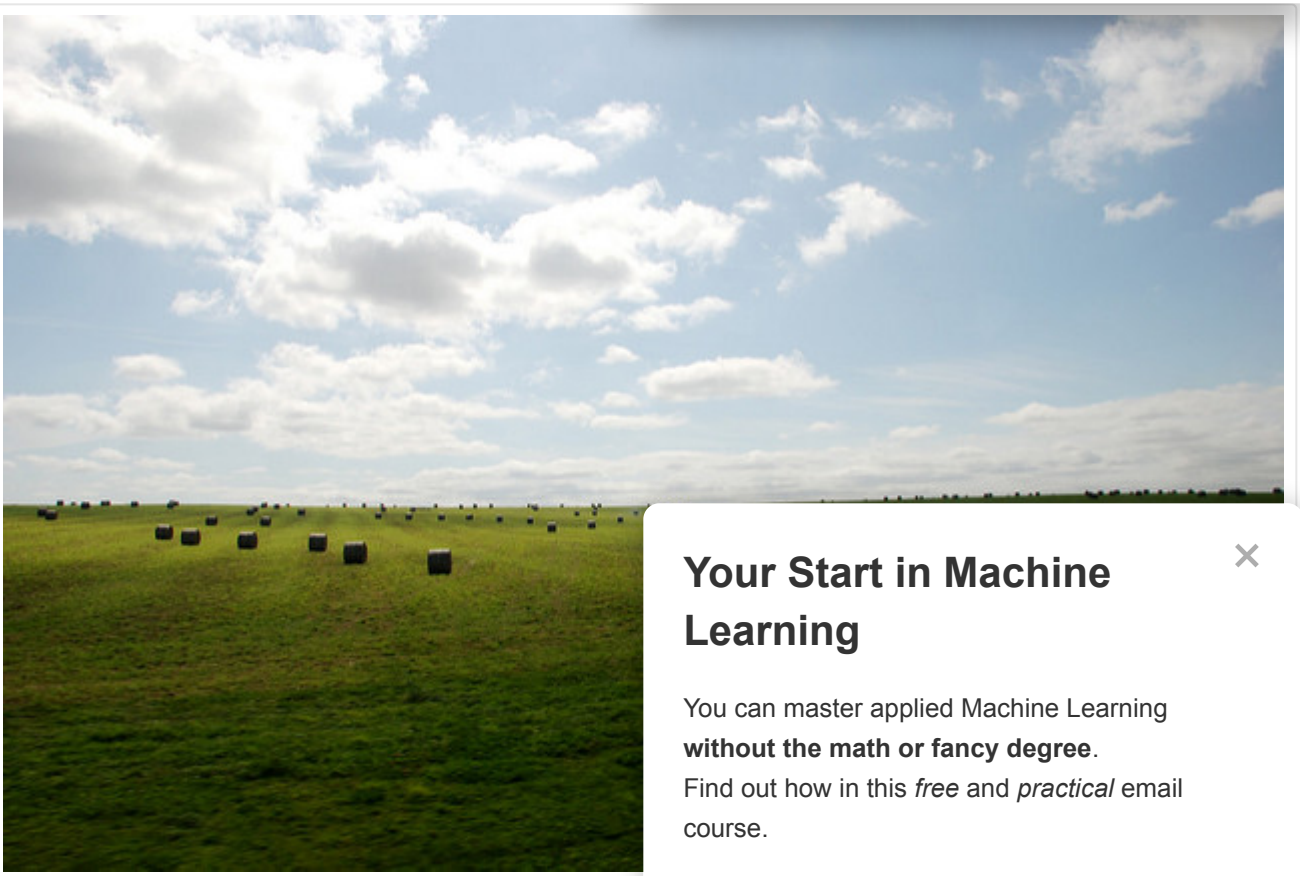
From Developer to Time Series Forecaster in 7 Days.

Python is one of the fastest-growing platforms for applied machine learning.

In this mini-course, you will discover how you can get started, build accurate models and confidently complete predictive modeling time series forecasting projects using Python in 7 days.

This is a big and important post. You might want to bookmark it.

Let's get started.



Time Series Forecasting wit
Photo by Raquel M, s

Who Is This Mini-Course For?

Before we get started, let's make sure you are in the right place.

The list below provides some general guidelines as to who this course was designed for.

Don't panic if you don't match these points exactly, you might just need to brush up in one area or another to keep up.

- **You're a Developer**: This is a course for developers. You are a developer of some sort. You know how to read and write code. You know how to develop and debug a program.
- **You know Python**: This is a course for Python people. You know the Python programming language, or you're a skilled enough developer that you can pick it up as you go along.
- **You know some Machine Learning**: This is a course for novice machine learning practitioners. You know some basic practical machine learning, or you can figure it out quickly.

This mini-course is neither a textbook on Python or a textbook on time series forecasting.

It will take you from a developer that knows a little machine learning to a developer who can get time series forecasting results using the Python ecosystem, the rising platform for professional machine learning.

Note: This mini-course assumes you have a working P nPy, Pandas, scikit-learn and statsmodels installed.

Mini-Course Overview

This mini-course is broken down into 7 lessons.

You could complete one lesson per day (*recommended*) or complete all of the lessons in one day (*hardcore*). It really depends on the time you have available and your level of enthusiasm.

Below are 7 lessons that will get you started and productive with machine learning in Python:

- **Lesson 01**: Time Series as Supervised Learning.
- **Lesson 02**: Load Time Series Data.
- **Lesson 03**: Data Visualization.
- **Lesson 04**: Persistence Forecast Model.
- **Lesson 05**: Autoregressive Forecast Model.
- **Lesson 06**: ARIMA Forecast Model.
- **Lesson 07**: Hello World End-to-End Project.

Each lesson could take you 60 seconds or up to 30 m t your own pace. Ask questions and even post results i

The lessons expect you to go off and find out how to c of each lesson is to force you to learn where to go to loo e series (hint, I have all of the answers directly on this b

I do provide more help in the early lessons because I

Post your results in the comments, I'll cheer you on!

Hang in there, don't give up.

Lesson 01: Time Series as Supervised Learning

Time series problems are different to traditional prediction problems

Your Start in Machine Learning

The addition of time adds an order to observations that both must be preserved and can provide additional information for learning algorithms.

A time series dataset may look like the following:

```
Time, Observation
day1, obs1
day2, obs2
day3, obs3
```

We can reframe this data as a supervised learning problem with inputs and outputs to be predicted. For example:

```
Input,  Output
?,      obs1
obs1,   obs2
obs2,   obs3
obs3,   ?
```

You can see that the reframing means we have to disc

Once it is reframed, we can then apply all of our favori nd Random Forest.

For more help, see the post:

- Time Series Forecasting as Supervised Learning

Lesson 02: Load Time Series D

Before you can develop forecast models, you must load and work with your time series data.

Pandas provides tools to load data in CSV format.

In this lesson, you will download a standard time series dataset, load it in Pandas and explore it.

Download the daily female births dataset from DataMarket in CSV format and save it with the filename "*daily-births.csv*".

You can load a time series dataset as a Pandas Series and specify the header row at line zero, as follows:

```
from pandas import Series
series = Series.from_csv('daily-births.csv', header=0)
```

Get used to exploring loaded time series data in Python:

- Print the first few rows using the *head()* function.
- Print the dimensions of the dataset using the *size* attribute.
- Query the dataset using a date-time string.
- Print summary statistics of the observations.

For more help, see the post:

- How to Load and Explore Time Series Data in Python

Lesson 03: Data Visualization

Data visualization is a big part of time series forecasting.

Line plots of observations over time are popular, but there is a suite of other plots that you can use to learn more about your problem.

In this lesson, you must download a standard time series dataset and create 6 different types of plots.

Download the monthly shampoo sales dataset from D
filename "*shampoo-sales.csv*".

Now create the following 6 types of plots:

1. Line Plots.
2. Histograms and Density Plots.
3. Box and Whisker Plots by year or quarter.
4. Heat Maps.
5. Lag Plots or Scatter Plots.
6. Autocorrelation Plots.

Below is an example of a simple line plot to get you st


```
1 from pandas import Series
2 from matplotlib import pyplot
3 series = Series.from_csv('shampoo-sales.csv', header=0)
4 series.plot()
5 pyplot.show()
```

For more help, see the post:

- Time Series Data Visualization with Python

Lesson 04: Persistence Forecast Model

It is important to establish a baseline forecast.

The simplest forecast you can make is to use the current observation (t) to predict the observation at the next time step (t+1).

This is called the naive forecast or the persistence forecast and may be the best possible model on some time series forecast problems.

In this lesson, you will make a persistence forecast for

Download the daily female births dataset from DataMarket in CSV format and save it with the filename "*daily-births.csv*".

You can implement the persistence forecast as a single line function, as follows:

```
# persistence model
def model_persistence(x):
    return x
```

Write code to load the dataset and use the persistence forecast to make a prediction for each time step in the dataset. Note, that you will not be able to make a forecast for the first time step in the dataset as there is no previous observation to use.

Store all of the predictions in a list. You can calculate a
predictions compared to the actual observations as fo

```
from sklearn.metrics import mean_squared_error
from math import sqrt
predictions = []
actual = series.values[1:]
rmse = sqrt(mean_squared_error(actual, predict
```

For more help, see the post:

- How to Make Baseline Predictions for Time Serie

Lesson 05: Autoregressive For

Autoregression means developing a linear model that ct observations at future time step ("auto" means self in ancient Greek).

Autoregression is a quick and powerful time series forecasting method.

The statsmodels Python library provides the autoregression model in the AR class.

In this lesson, you will develop an autoregressive forecast model for a standard time series dataset.

Download the monthly shampoo sales dataset from DataMarket in CSV format and save it with the filename "*shampoo-sales.csv*".

You can fit an AR model as follows:

```
model = AR(dataset)
model_fit = model.fit()
```

You can predict the next out of sample observation with a fit AR model as follows:

```
prediction = model_fit.predict(start=len(dataset), end=len(dataset))
```

You may want to experiment by fitting the model on half of the dataset and predicting one or more of the second half of the series, then compare the prediction

For more help, see the post:

- Autoregression Models for Time Series Forecasting With Python

Lesson 06: ARIMA Forecast Model

The ARIMA is a classical linear model for time series forecasting.

It combines the autoregressive model (AR), differencing to remove trends and seasonality, called integrated (I) and the moving average model (MA) which is an old name given to a model that forecasts the error, used to correct predictions.

The statsmodels Python library provides the ARIMA c

In this lesson, you will develop an ARIMA model for a

Download the monthly shampoo sales dataset from D
filename "*shampoo-sales.csv*".

The ARIMA class requires an order(p,d,q) that is comp gs,
number of differences and MA lags.

You can fit an ARIMA model as follows:

```
model = ARIMA(dataset, order=(0,1,0))
model_fit = model.fit()
```

You can make a one-step out-of-sample forecast for a fit ARIMA model as follows:

```
outcome = model_fit.forecast()[0]
```

The shampoo dataset has a trend so I'd recommend a d value of 1. Experiment with different p and q values and evaluate the predictions from resulting models.

For more help, see the post:

- How to Create an ARIMA Model for Time Series Forecasting with Python

Lesson 07: Hello World End-to-End Project

You now have the tools to work through a time series problem and develop a simple forecast model.

In this lesson, you will use the skills learned from all of the prior lessons to work through a new time series forecasting problem.

Download the quarterly S&P 500 index, 1900-1996 dataset from DataMarket in CSV format and save it with the filename "*sp500.csv*".

Split the data, perhaps extract the last 4 or 8 quarters to a separate file. Work through the problem and develop forecasts for the missing data, including:

1. Load and explore the dataset.
2. Visualize the dataset.
3. Develop a persistence model.
4. Develop an autoregressive model.
5. Develop an ARIMA model.
6. Visualize forecasts and summarize forecast error.

For an example of working through a project, see the post:

- Time Series Forecast Study with Python: Monthly

The End!
(Look How Far You Have Come)

You made it. Well done!

Take a moment and look back at how far you have co

You discovered:

- How to frame a time series forecasting problem a
- How to load and explore time series data with Pa
- How to plot and visualize time series data a numb
- How to develop a naive forecast called the persistence model as a baseline.
- How to develop an autoregressive forecast model using lagged observations.
- How to develop an ARIMA model including autoregression, integration and moving average elements.
- How to pull all of these elements together into an end-to-end project.

Don't make light of this, you have come a long way in a short amount of time.

This is just the beginning of your time series forecasting journey with Python. Keep practicing and developing your skills.

Summary

How Did You Go With The Mini-Course?
Did you enjoy this mini-course?

Do you have any questions? Were there any sticking points?
Let me know. Leave a comment below.

About Jason Brownlee

Jason Brownlee, Ph.D. is a machine learni
with modern machine learning methods via
View all posts by Jason Brownlee →

‹ How to Handle Missing Data with Python

How to Make Out-of-Sample Forecasts with ARIMA in Python ›

11 Responses to *Time Series Forecasting with Python 7-Day Mini-Course*

Luca May 5, 2017 at 2:29 am #

REPLY

Hi

Thanks for so many articles in your blog. Really appreciate.

I have a question that I see sometimes we use a fixed-parameter model (e.g. parameters in ARIMA model is always fixed), while other times use an iterative way to determine the model parameters in each iteration of a test data sample. Are there any differences or reasons behind that? and when fixed model is useful and when to use an iterative way?

my understanding from the examples are: iterative way of modeling ARIMA seems more appropriate to seasonal and trending dataset, right?

Thanks a lot

Jason Brownlee May 5, 2017 at 7:32 am #

REPLY

In general, I would suggest evaluating a suite of different models for a problem and see what works best.

Gururaj August 13, 2017 at 12:21 pm #

Thanks Jason for these helpful articles. I have
number of sensors, are there simpler methods to mode
own time series data?

If we have some intuition that we may find groups of se
method to cluster them and validate, given the individu

Jason Brownlee August 14, 2017 at 6:23 am

Good question Gururaj, sorry I have not w
expert advice.

joseph September 10, 2017 at 4:02 pm #

REPLY

Thanks for the course.
I intend on doing the course
I would like to know:
do you have anomaly detection course?
are hidden markov models and recurrent nn fit this area(time series)?
thanks
joseph

Jason Brownlee September 11, 2017 at 12:05 pm #

REPLY

Not at this stage, perhaps in the future.

Prashant Gupta June 5, 2018 at 4:16 pm #

REPLY

Yes, LSTM (a type of rnn) has been using for a while for time series problems

Johnny Castro September 25, 2018 at 8:20 pm #

REPLY

Hi Jason, I am really enjoying the course. You make it easy to learn ML faster than via other curricula.
I wanted to ask where/if you have the answers to these lessons (using the same datsets).
Specifically I am having trouble with “Lesson 03” (box plots and on) in grouping by year and quarter the data from “shampoo sales”.
The function “TimeGrouper” has been deprecated. I ar
results.

Jason Brownlee September 26, 2018 at 6:15

I have blog posts on each, you can use th
https://machinelearningmastery.com/start-here/#tir

Mia Cloe September 27, 2018 at 9:04 pm #

Hello. Thank you for creating this time series mini-course, I am learning a lot of things.
One thing that I’m wondering is that how hard it is if someone tries to code ARIMA computation without using APIs such as statsmodel. Do people usually use APIs in time series forecasting?

Jason Brownlee September 28, 2018 at 6:14 am #

REPLY

Yes, people usually use APIs. Coding from scratch is only a good idea if you want to learn how it works in more detail or you have special operational requirements.

Leave a Reply

Your Start in Machine Learning

Name (required)

Email (will not be published) (requ

Website

SUBMIT COMMENT

Welcome to Machine Learning Mastery!

Hi, I'm Jason Brownlee, Ph.D.
My goal is to make developers like *YOU*

Read More

Time Series Forecasting with Python
Explore time series data and predict the future.

Click to Get Started Now!

POPULAR

How to Develop a Deep Learning Photo Caption Ge
NOVEMBER 27, 2017

How to Develop a Neural Machine Translation Syst
JANUARY 10, 2018

How to Develop an Encoder-Decoder Model for Sequence-to-Sequence Prediction in Keras
NOVEMBER 2, 2017

How to Develop a Word-Level Neural Language Model and Use it to Generate Text
NOVEMBER 10, 2017

Difference Between Classification and Regression in Machine Learning
DECEMBER 11, 2017

How to Develop an N-gram Multichannel Convolutional Neural Network for Sentiment Analysis
JANUARY 12, 2018

So, You are Working on a Machine Learning Problem…
APRIL 4, 2018

You might also like…

- How to Install Python for Machine Learning

Your Start in Machine Learning

- Your First Machine Learning Project in Python
- Your First Neural Network in Python
- Your First Classifier in Weka
- Your First Time Series Forecasting Project

Your Start in Machine Learning