

ML5-sLR-Excercise-E5-1b

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1 # Simple Linear Regression (sLR) With scikit-learn (Example from lesson ML05)

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Following ideas from: “Linear Regression in Python” by Mirko Stojiljkovic, 28.4.2020 (see details: <https://realpython.com/linear-regression-in-python/#what-is-regression>)

The example is from Lecture: “ML_Concept&Algorithm” (WS2020); Chapter ML5, Exercise E5.1-b “Exam Results”

Let’s start with the simplest case, which is simple linear regression. There are five basic steps when you’re implementing linear regression:

1. Import the packages and classes you need.
2. Provide data to work with and eventually do appropriate transformations.
3. Create a regression model and fit it with existing data.
4. Check the results of model fitting to know whether the model is satisfactory.
5. Apply the model for predictions. These steps are more or less general for most of the regression approaches and implementations.

2 Step 1: Import packages and classes

The first step is to import the package numpy and the class LinearRegression from sklearn.linear_model:

```
[1]: print_
      ↪ ("*****")
print ("*** The picture shows the 10 students s1...s10 as points in (x,y)-plane_
      ↪****")
print ("***** X-axis --> hours of effort for homework; Y-axis -->score-points_
      ↪****")
print_
      ↪ ("*****")

from IPython.display import Image

Image('test.jpg')
```

```
# Step 1: Import packages and classes

import numpy as np
from sklearn.linear_model import LinearRegression

# import time module
import time
```

```
*****
*** The picture shows the 10 students s1...s10 as points in (x,y)-plane *****
***** X-axis --> hours of effort for homework; Y-axis -->score-points *****
*****
```

Now, you have all the functionalities you need to implement linear regression.

The fundamental data type of NumPy is the array type called `numpy.ndarray`. The rest of this article uses the term array to refer to instances of the type `numpy.ndarray`.

The class `sklearn.linear_model.LinearRegression` will be used to perform linear and polynomial regression and make predictions accordingly.

3 Step 2: Provide data

The second step is defining data to work with. The inputs (regressors,) and output (predictor,) should be arrays (the instances of the class `numpy.ndarray`) or similar objects. This is the simplest way of providing data for regression:

```
[2]: # Step 2: Provide data

x = np.array([ 5, 4, 5, 3, 9, 8, 10, 5, 3, 3]).reshape((-1, 1))
y = np.array([41,27,35,26,48,45,46, 27,29,19])
```

Now, you have two arrays: the input `x` and output `y`. You should call `.reshape()` on `x` because this array is required to be two-dimensional, or to be more precise, to have one column and as many rows as necessary. That's exactly what the argument `(-1, 1)` of `.reshape()` specifies.

```
[3]: print ("This is how x and y look now:")
      print("x=",x)
      print("y=",y)
```

This is how `x` and `y` look now:

```
x= [[ 5]
     [ 4]
     [ 5]
     [ 3]
     [ 9]
     [ 8]
```

```
[10]
[ 5]
[ 3]
[ 3]]
y= [41 27 35 26 48 45 46 27 29 19]
```

As you can see, `x` has two dimensions, and `x.shape` is `(10, 1)`, while `y` has only a single dimension, and `y.shape` is `(10,)`.

4 Step 3: Create a model and fit it

The next step is to create a linear regression model and fit it using the existing data. Let's create an instance of the class `LinearRegression`, which will represent the regression model:

```
[4]: model = LinearRegression()
```

This statement creates the variable `model` as the instance of `LinearRegression`. You can provide several optional parameters to `LinearRegression`:

—> `fit_intercept` is a Boolean (True by default) that decides whether to calculate the intercept (True) or consider it equal to zero (False).

—> `normalize` is a Boolean (False by default) that decides whether to normalize the input variables (True) or not (False).

—> `copy_X` is a Boolean (True by default) that decides whether to copy (True) or overwrite the input variables (False).

—> `n_jobs` is an integer or None (default) and represents the number of jobs used in parallel computation. None usually means one job and -1 to use all processors.

This example uses the default values of all parameters.

It's time to start using the model. First, you need to call `.fit()` on `model`:

```
[5]: model.fit(x, y)
```

```
[6]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

With `.fit()`, you calculate the optimal values of the weights `w` and `b`, using the existing input and output (`x` and `y`) as the arguments. In other words, `.fit()` fits the model. It returns `self`, which is the variable `model` itself. That's why you can replace the last two statements with this one:

```
[6]: # model = LinearRegression().fit(x, y)
```

This statement does the same thing as the previous two. It's just shorter.

5 Step 4: Get results

Once you have your model fitted, you can get the results to check whether the model works satisfactorily and interpret it.

You can obtain the coefficient of determination (r^2) with `.score()` called on model:

```
r_sq = model.score(x, y) print('coefficient of determination:', r_sq)
```

When you're applying `.score()`, the arguments are also the predictor `x` and regressor `y`, and the return value is r^2 .

The attributes of model are `.intercept_`, which represents the coefficient, and `.coef_`, which represents `slope`:

```
[7]: print('intercept:', model.intercept_)
      print('slope:', model.coef_)
```

```
intercept: 15.163636363636353
slope: [3.47933884]
```

The code above illustrates how to get `intercept` and `slope`. You can notice that `.intercept_` is a scalar, while `.coef_` is an array.

The value `intercept` = 15.1636 (approximately) illustrates that your model predicts the response 15.1636 when `x` is zero. The value `slope` = 3.4793 means that the predicted response rises by 3.4793 when `x` is increased by one.

You should notice that you can provide `y` as a two-dimensional array as well. In this case, you'll get a similar result. This is how it might look:

```
[8]: new_model = LinearRegression().fit(x, y.reshape((-1, 1)))
      print('intercept:', new_model.intercept_)
      print('slope:', new_model.coef_)
```

```
intercept: [15.16363636]
slope: [[3.47933884]]
```

As you can see, this example is very similar to the previous one, but in this case, `.intercept_` is a one-dimensional array with the single element `intercept`, and `.coef_` is a two-dimensional array with the single element `slope`.

6 Step 5: Predict response

Once there is a satisfactory model, you can use it for predictions with either existing or new data.

To obtain the predicted response, use `.predict()`:

When applying `.predict()`, you pass the regressor as the argument and get the corresponding predicted response.

This is a nearly identical way to predict the response:

In this case, you multiply each element of `x` with `model.coef_` and add `model.intercept_` to the product.

The output here differs from the previous example only in dimensions. The predicted response is now a two-dimensional array, while in the previous case, it had one dimension.

If you reduce the number of dimensions of `x` to one, these two approaches will yield the same result. You can do this by replacing `x` with `x.reshape(-1)`, `x.flatten()`, or `x.ravel()` when multiplying it with `model.coef_`.

In practice, regression models are often applied for forecasts. This means that you can use fitted models to calculate the outputs based on some other, new inputs:

```
x_new = np.arange(5).reshape((-1, 1)) print(x_new) y_new = model.predict(x_new)
print(y_new)
```

Here `.predict()` is applied to the new regressor `x_new` and yields the response `y_new`. This example conveniently uses `arange()` from numpy to generate an array with the elements from 0 (inclusive) to 5 (exclusive), that is 0, 1, 2, 3, and 4.

You can find more information about `LinearRegression` on the official documentation page.

```
[13]: # print current date and time
print("***** current date and time *****")
print("date and time:",time.strftime("%d.%m.%Y %H:%M:%S"))
print ("end")
```

```
***** current date and time *****
date and time: 29.08.2020 22:23:35
end
```