06linearregression

July 14, 2019

```
In [2]: import warnings
        warnings.filterwarnings("ignore")
        from sklearn.datasets import load_boston
        from random import seed
        from random import randrange
        from csv import reader
        from math import sqrt
        from sklearn import preprocessing
        import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        from prettytable import PrettyTable
        from sklearn import preprocessing
        from sklearn.metrics import mean_squared_error
        import seaborn as sns
        from sklearn.linear_model import SGDRegressor
        from sklearn.linear_model import LinearRegression
        import sklearn.cross_validation
```

```
In [24]: boston = load_boston()
         print(boston.data.shape)
         print(boston.target.shape)
```

```
(506, 13)
(506,)
```

```
In [4]: print(boston.feature_names)
```

```
['CRIM' 'ZN' 'INDUS' 'CHAS' 'NOX' 'RM' 'AGE' 'DIS' 'RAD' 'TAX' 'PTRATIO'
 'B' 'LSTAT']
```

```
In [74]: X = boston.data
         Y = boston.target
         print(X)
         print("--"*50)
         print(Y)
```

```
[[6.3200e-03 1.8000e+01 2.3100e+00 ... 1.5300e+01 3.9690e+02 4.9800e+00]
 [2.7310e-02 0.0000e+00 7.0700e+00 ... 1.7800e+01 3.9690e+02 9.1400e+00]
 [2.7290e-02 0.0000e+00 7.0700e+00 ... 1.7800e+01 3.9283e+02 4.0300e+00]
 ...
 [6.0760e-02 0.0000e+00 1.1930e+01 ... 2.1000e+01 3.9690e+02 5.6400e+00]
 [1.0959e-01 0.0000e+00 1.1930e+01 ... 2.1000e+01 3.9345e+02 6.4800e+00]
 [4.7410e-02 0.0000e+00 1.1930e+01 ... 2.1000e+01 3.9690e+02 7.8800e+00]]
-------------------------------------------------------------------------------------------
[24.  21.6 34.7 33.4 36.2 28.7 22.9 27.1 16.5 18.9 15.  18.9 21.7 20.4
 18.2 19.9 23.1 17.5 20.2 18.2 13.6 19.6 15.2 14.5 15.6 13.9 16.6 14.8
 18.4 21.  12.7 14.5 13.2 13.1 13.5 18.9 20.  21.  24.7 30.8 34.9 26.6
 25.3 24.7 21.2 19.3 20.  16.6 14.4 19.4 19.7 20.5 25.  23.4 18.9 35.4
 24.7 31.6 23.3 19.6 18.7 16.  22.2 25.  33.  23.5 19.4 22.  17.4 20.9
 24.2 21.7 22.8 23.4 24.1 21.4 20.  20.8 21.2 20.3 28.  23.9 24.8 22.9
 23.9 26.6 22.5 22.2 23.6 28.7 22.6 22.  22.9 25.  20.6 28.4 21.4 38.7
 43.8 33.2 27.5 26.5 18.6 19.3 20.1 19.5 19.5 20.4 19.8 19.4 21.7 22.8
 18.8 18.7 18.5 18.3 21.2 19.2 20.4 19.3 22.  20.3 20.5 17.3 18.8 21.4
 15.7 16.2 18.  14.3 19.2 19.6 23.  18.4 15.6 18.1 17.4 17.1 13.3 17.8
 14.  14.4 13.4 15.6 11.8 13.8 15.6 14.6 17.8 15.4 21.5 19.6 15.3 19.4
 17.  15.6 13.1 41.3 24.3 23.3 27.  50.  50.  50.  22.7 25.  50.  23.8
 23.8 22.3 17.4 19.1 23.1 23.6 22.6 29.4 23.2 24.6 29.9 37.2 39.8 36.2
 37.9 32.5 26.4 29.6 50.  32.  29.8 34.9 37.  30.5 36.4 31.1 29.1 50.
 33.3 30.3 34.6 34.9 32.9 24.1 42.3 48.5 50.  22.6 24.4 22.5 24.4 20.
 21.7 19.3 22.4 28.1 23.7 25.  23.3 28.7 21.5 23.  26.7 21.7 27.5 30.1
 44.8 50.  37.6 31.6 46.7 31.5 24.3 31.7 41.7 48.3 29.  24.  25.1 31.5
 23.7 23.3 22.  20.1 22.2 23.7 17.6 18.5 24.3 20.5 24.5 26.2 24.4 24.8
 29.6 42.8 21.9 20.9 44.  50.  36.  30.1 33.8 43.1 48.8 31.  36.5 22.8
 30.7 50.  43.5 20.7 21.1 25.2 24.4 35.2 32.4 32.  33.2 33.1 29.1 35.1
 45.4 35.4 46.  50.  32.2 22.  20.1 23.2 22.3 24.8 28.5 37.3 27.9 23.9
 21.7 28.6 27.1 20.3 22.5 29.  24.8 22.  26.4 33.1 36.1 28.4 33.4 28.2
 22.8 20.3 16.1 22.1 19.4 21.6 23.8 16.2 17.8 19.8 23.1 21.  23.8 23.1
 20.4 18.5 25.  24.6 23.  22.2 19.3 22.6 19.8 17.1 19.4 22.2 20.7 21.1
 19.5 18.5 20.6 19.  18.7 32.7 16.5 23.9 31.2 17.5 17.2 23.1 24.5 26.6
 22.9 24.1 18.6 30.1 18.2 20.6 17.8 21.7 22.7 22.6 25.  19.9 20.8 16.8
 21.9 27.5 21.9 23.1 50.  50.  50.  50.  50.  13.8 13.8 15.  13.9 13.3
 13.1 10.2 10.4 10.9 11.3 12.3  8.8  7.2 10.5  7.4 10.2 11.5 15.1 23.2
  9.7 13.8 12.7 13.1 12.5  8.5  5.   6.3  5.6  7.2 12.1  8.3  8.5  5.
 11.9 27.9 17.2 27.5 15.  17.2 17.9 16.3  7.   7.2  7.5 10.4  8.8  8.4
 16.7 14.2 20.8 13.4 11.7  8.3 10.2 10.9 11.   9.5 14.5 14.1 16.1 14.3
 11.7 13.4  9.6  8.7  8.4 12.8 10.5 17.1 18.4 15.4 10.8 11.8 14.9 12.6
 14.1 13.  13.4 15.2 16.1 17.8 14.9 14.1 12.7 13.5 14.9 20.  16.4 17.7
 19.5 20.2 21.4 19.9 19.  19.1 19.1 20.1 19.9 19.6 23.2 29.8 13.8 13.3
 16.7 12.  14.6 21.4 23.  23.7 25.  21.8 20.6 21.2 19.1 20.6 15.2  7.
  8.1 13.6 20.1 21.8 24.5 23.1 19.7 18.3 21.2 17.5 16.8 22.4 20.6 23.9
 22.  11.9]
```

```
In [75]: df=pd.DataFrame(X)
```

```
X=df.as_matrix()
df.head()
```

Out[75]:

```
         0     1     2    3      4      5     6       7    8      9    10  \
0  0.00632  18.0  2.31  0.0  0.538  6.575  65.2  4.0900  1.0  296.0  15.3
1  0.02731   0.0  7.07  0.0  0.469  6.421  78.9  4.9671  2.0  242.0  17.8
2  0.02729   0.0  7.07  0.0  0.469  7.185  61.1  4.9671  2.0  242.0  17.8
3  0.03237   0.0  2.18  0.0  0.458  6.998  45.8  6.0622  3.0  222.0  18.7
4  0.06905   0.0  2.18  0.0  0.458  7.147  54.2  6.0622  3.0  222.0  18.7

       11    12
0  396.90  4.98
1  396.90  9.14
2  392.83  4.03
3  394.63  2.94
4  396.90  5.33
```

In [76]:

```
X_train, X_test, Y_train, Y_test = sklearn.cross_validation.train_test_split(X, Y, tes
print(X_train.shape)
print(X_test.shape)
print(Y_train.shape)
print(Y_test.shape)
```

```
(354, 13)
(152, 13)
(354,)
(152,)
```

In [77]:

```
scaler  = preprocessing.StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test  = scaler.transform(X_test)
```

In [78]:

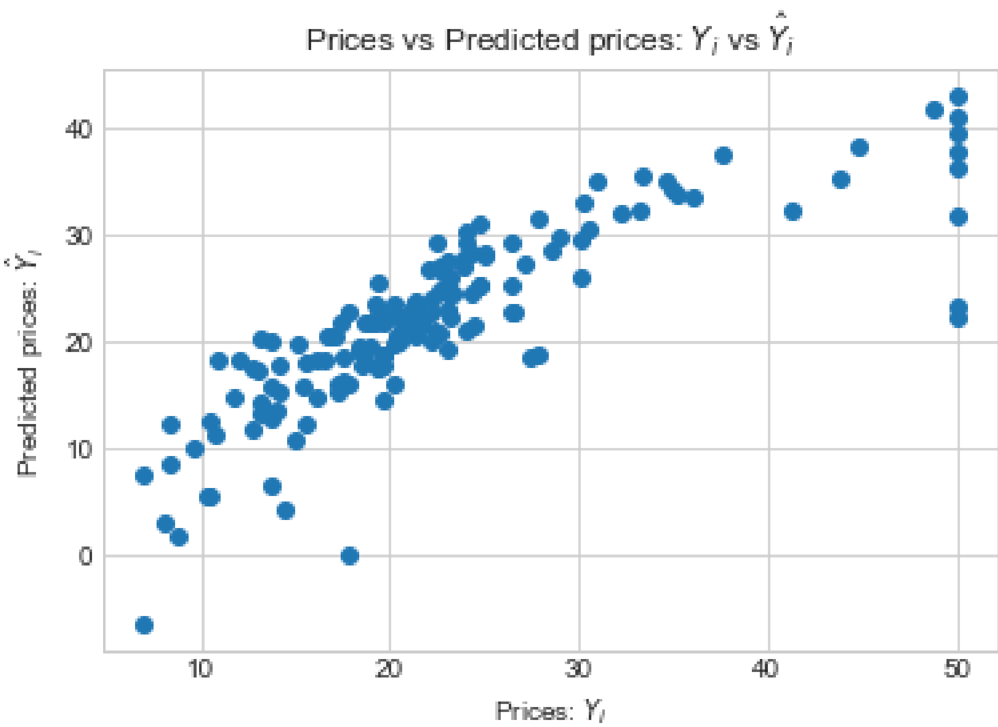
```
df_train=pd.DataFrame(X_train)
df_train['PRICE']=Y_train

df_train.head()
```

Out[78]:

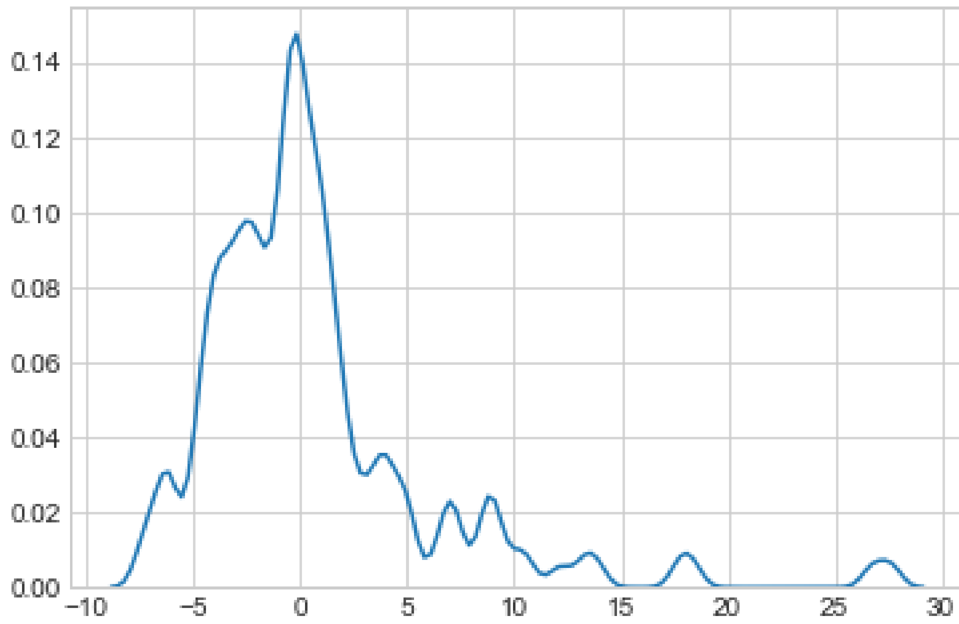
```
          0         1         2         3         4         5         6  \
0 -0.334330 -0.499618  1.069608 -0.251124  1.645428  0.233772  0.969882
1  0.478536 -0.499618  1.069608 -0.251124  1.113435 -0.149715  0.383159
2  0.277128 -0.499618  1.069608 -0.251124 -0.168580  0.653301  0.270733
3 -0.414300  3.445319 -1.442682 -0.251124 -1.293614  1.372699 -1.591321
4 -0.397576 -0.499618  2.504352 -0.251124  0.502952 -1.215116  0.896102

          7         8         9        10        11        12  PRICE
0 -0.900522  1.654486  1.538813  0.810913 -3.463820  1.611369   11.8
1 -0.926152  1.654486  1.538813  0.810913 -2.872888  1.265636   11.0
2 -0.241993  1.654486  1.538813  0.810913  0.389957 -0.671032   23.7
```

```
3  2.387078 -0.527917 -1.061095 -0.265106  0.421447 -1.082820   35.4
4 -0.982361 -0.642780  1.804713  0.764129  0.412198  0.779361   15.2
```

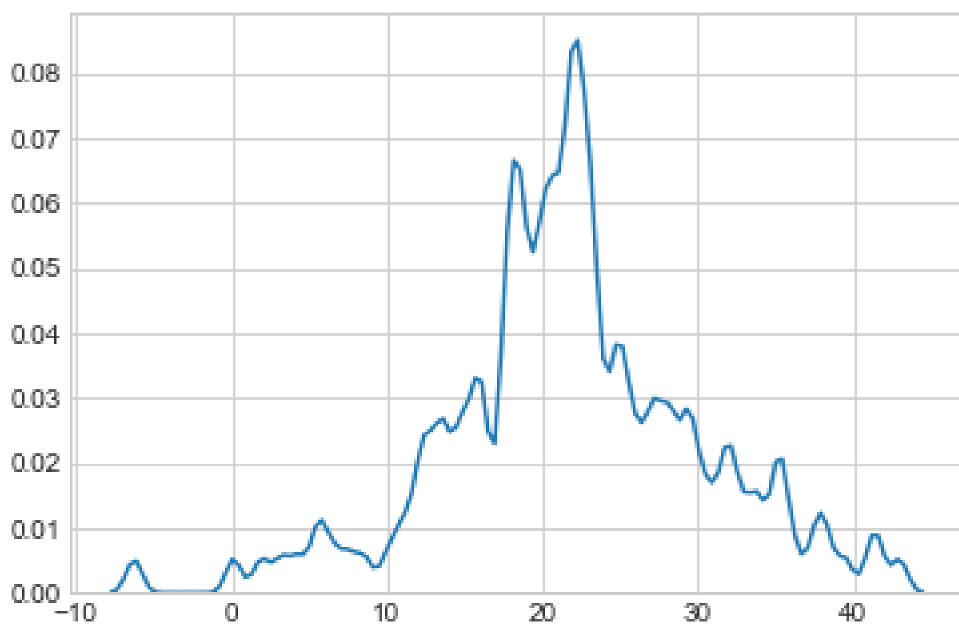
In [79]:
```
# code source:https://medium.com/@haydar_ai/learning-data-science-day-9-linear-regres

lm = LinearRegression()
lm.fit(X_train, Y_train)

Y_pred = lm.predict(X_test)

plt.scatter(Y_test, Y_pred)
plt.xlabel("Prices: $Y_i$")
plt.ylabel("Predicted prices: $\hat{Y}_i$")
plt.title("Prices vs Predicted prices: $Y_i$ vs $\hat{Y}_i$")
plt.show()
```



In [80]:
```
delta_y = Y_test - Y_pred;

sns.set_style('whitegrid')
sns.kdeplot(np.array(delta_y), bw=0.5)
plt.show()
```




```
In [81]: sns.set_style('whitegrid')
         sns.kdeplot(np.array(Y_pred), bw=0.5)
         plt.show()
```



In [82]:
```
#SGD implementation for linear regression

W,B,iteration,rate,k = np.zeros(shape=(1,13)),0,700,0.1,25 #intialise W and B to zero


while iteration>=0 :
    w,b,delta_w,delta_b = W,B,np.zeros(shape=(1,13)),0
    data = df_train.sample(25)                  #sampling random k=batch size=20 data
    x = np.array(data.drop('PRICE',axis=1))
    y = np.array(data['PRICE'])

    for i in range(25):
        delta_w += (-2)*x[i]*(y[i]-(np.dot(w,x[i])+b))   #partial differentiation wrt
        delta_b += (-2)*(y[i]-(np.dot(w,x[i])+b))        #partial differentiation wrt

    W=(w-rate*(delta_w)/k)
    B=(b-rate*(delta_b)/k)

    rate = rate/1.01
    iteration-=1


print(W)
print(B)
```

```
[[-1.2487875   0.87689079 -0.45965487  0.20235369 -1.42100563  2.61437601
  -0.22784103 -2.70649964  2.22489369 -1.38188117 -2.10348261  1.15048756
  -3.46084742]]
[22.50079696]
```

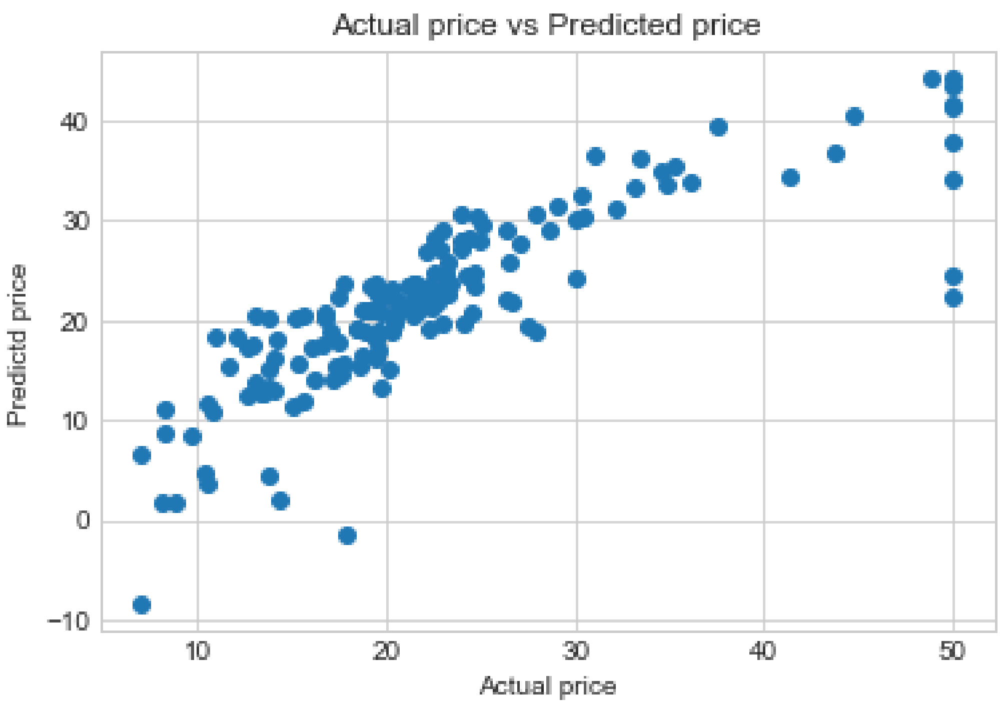
In [83]:
```
#prediction on x_test
#https://www.geeksforgeeks.org/numpy-asscalar-in-python/
y_predic=[]
for i in range(len(X_test)):
    val=np.dot(W,X_test[i])+B  #val= wTx+b
    y_predic.append(np.asscalar(val))
```

In [84]:
```
#Scatter plot of actual price vs predicted price

plt.scatter(Y_test,y_predic)
plt.xlabel('Actual price')
plt.ylabel('Predictd price')
plt.title('Actual price vs Predicted price')
plt.show()
```


```
In [85]: MSE_lr=mean_squared_error(Y_test,y_predic)
         print('mean squared error =',MSE_lr)
```

```
mean squared error = 30.78503402128002
```

```
In [86]: #SGD regression sklearn implementation

         model=SGDRegressor(learning_rate='constant',eta0=0.01,penalty=None,n_iter=100,max_ite
         model.fit(X_train,Y_train)
         Y_pred_sgd=model.predict(X_test)

         #Scatter plot of actual price vs predicted price

         plt.scatter(Y_test,Y_pred_sgd)
         plt.xlabel('Actual price')
         plt.ylabel('Predictd price')
         plt.title('Actual price vs Predicted price')
         plt.show()
```




```
In [89]: MSE_sgd=mean_squared_error(Y_test,Y_pred_sgd)
         print('mean squared error =',MSE_sgd)

mean squared error = 29.958075584142815


In [88]: #Comparison between weights obtained from own implementation and weights obtained fro
         from prettytable import PrettyTable
         x = PrettyTable()
         x.field_names=['Weight vector manual','Weight vector SGD sklearn']
         weight_sgd=model.coef_
         for i in range(13):
             x.add_row([W[0][i],weight_sgd[i]])
         print(x)

+----------------------+---------------------------+
| Weight vector manual | Weight vector SGD sklearn |
+----------------------+---------------------------+
| -1.2487875005565663  |     -1.367634066486797    |
|  0.8768907910707392  |     0.6232126548856614    |
| -0.45965487392711285 |   -0.034321602974485256   |
| 0.20235368792480632  |     0.40482018147864196   |
| -1.4210056337505508  |    -1.4762829533157247    |
|  2.6143760112285666  |     3.3679058605944086    |
| -0.22784103355767868 |    -0.22049142711468647   |
```

```
| -2.7064996405269692  |     -3.008014875734558    |
|  2.2248936947136384  |     2.912155404513144     |
| -1.3818811742142798  |    -2.1673612468913763    |
| -2.1034826093058006  |    -2.3343970840414117    |
|  1.1504875571567152  |     0.9213535450650273    |
| -3.4608474150234865  |    -3.7125274213122017    |
+----------------------+---------------------------+
```

0.0.1 Conclusions

Weight vectors and MSE values are almost same in Custom SGD implementation and Sklearn implementation