IMPLEMENTATION OF SGD

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [2]:

```
from sklearn.datasets import load_boston
dataset= load_boston()
```

In [3]:

```
dataset.data.shape
```

Out[3]:

```
(506, 13)
```

In [4]:

```
dataset.feature_names
```

Out[4]:

```
array(['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
       'TAX', 'PTRATIO', 'B', 'LSTAT'], dtype='<U7')
```

In [5]:

```
import pandas as pd
df = pd.DataFrame(dataset.data, columns = dataset.feature_names)
df.head()
```

Out[5]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33

In [6]:

```
df.describe()
```

Out[6]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTR
count	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.00
mean	3.613524	11.363636	11.136779	0.069170	0.554695	6.284634	68.574901	3.795043	9.549407	408.237154	18.45
std	8.601545	23.322453	6.860353	0.253994	0.115878	0.702617	28.148861	2.105710	8.707259	168.537116	2.16
min	0.006320	0.000000	0.460000	0.000000	0.385000	3.561000	2.900000	1.129600	1.000000	187.000000	12.60
25%	0.082045	0.000000	5.190000	0.000000	0.449000	5.885500	45.025000	2.100175	4.000000	279.000000	17.40

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTR
50%	0.256510	0.000000	9.690000	0.000000	0.538000	6.208500	77.500000	3.207450	5.000000	330.000000	19.05
75%	3.677083	12.500000	18.100000	0.000000	0.624000	6.623500	94.075000	5.188425	24.000000	666.000000	20.20
max	88.976200	100.000000	27.740000	1.000000	0.871000	8.780000	100.000000	12.126500	24.000000	711.000000	22.00

In [7]:

```
df['price'] = dataset.target
```

In [8]:

```
X = df.drop('price', axis=1)
y = df['price']
```

In [10]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train_1, y_test_1 = train_test_split(X, y, test_size = 0.3, random_state = 42)
print(X_train.shape)
print(X_test.shape)
print(y_train_1.shape)
print(y_test_1.shape)
```

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

In [11]:

```
#Standardize the values
from sklearn.preprocessing import StandardScaler
sc_X_1 = StandardScaler()
X_train_1 = sc_X_1.fit_transform(X_train)
X_test_1 = sc_X_1.transform(X_test)
```

In [13]:

```
print(X_train_1.shape)
print(y_train_1.shape)
```

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

In [14]:

```
X_train_1
```

Out[14]:

```
array([[-0.41425879, -0.50512499, -1.29214218, ...,  0.18727079,
         0.39651419, -1.01531611],
       [-0.40200818, -0.50512499, -0.16208345, ..., -0.21208981,
         0.3870674 , -0.05366252],
       [-0.39721053, -0.50512499, -0.60948856, ..., -0.16771641,
         0.42854113, -0.31132373],
       ...,
       [-0.41604586,  3.03838247, -1.3166773 , ..., -0.56707702,
         0.35987906, -0.90549329],
       [ 0.92611293, -0.50512499,  1.00549958, ...,  0.8528718 ,
        -2.87841346,  1.52750437],
       [-0.39030549, -0.50512499, -0.37135358, ...,  1.16348561,
        -3.32828832, -0.25218837]])
```

1. By Sklearn

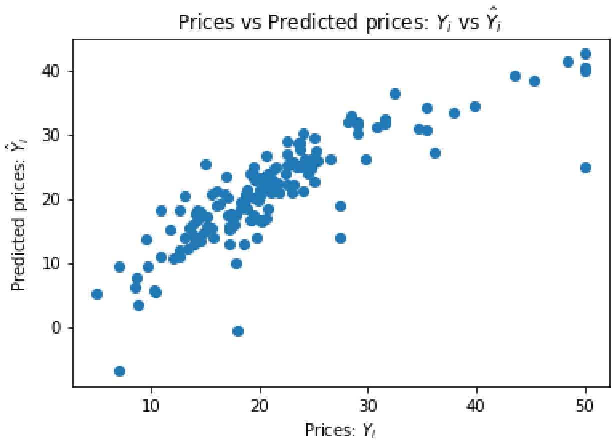
In [15]:

```
# code source:https://medium.com/@haydar_ai/learning-data-science-day-9-linear-regression-on-bosto
n-housing-dataset-cd62a80775ef
from sklearn.linear_model import LinearRegression

lm = LinearRegression()
lm.fit(X_train_1, y_train_1)

y_pred = lm.predict(X_test_1)

plt.scatter(y_test_1, 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()
```



2. From scratch

In [16]:

```
X
```

Out[16]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33
...	...	...	...	...	...	...	...	...	...	...	...	...	...
501	0.06263	0.0	11.93	0.0	0.573	6.593	69.1	2.4786	1.0	273.0	21.0	391.99	9.67
502	0.04527	0.0	11.93	0.0	0.573	6.120	76.7	2.2875	1.0	273.0	21.0	396.90	9.08
503	0.06076	0.0	11.93	0.0	0.573	6.976	91.0	2.1675	1.0	273.0	21.0	396.90	5.64
504	0.10959	0.0	11.93	0.0	0.573	6.794	89.3	2.3889	1.0	273.0	21.0	393.45	6.48
505	0.04741	0.0	11.93	0.0	0.573	6.030	80.8	2.5050	1.0	273.0	21.0	396.90	7.88

506 rows × 13 columns

In [18]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train_2, y_test_2 = train_test_split(X, y, test_size = 0.3, random_state = 42)
print(X_train.shape)
print(X_test.shape)
print(y_train_2.shape)
print(y_test_2.shape)
```

```
print(y_test_2.shape)
```

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

In [19]:

```
X_train.head(2)
```

Out[19]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
5	0.02985	0.0	2.18	0.0	0.458	6.430	58.7	6.0622	3.0	222.0	18.7	394.12	5.21
116	0.13158	0.0	10.01	0.0	0.547	6.176	72.5	2.7301	6.0	432.0	17.8	393.30	12.04

In [20]:

```
X_train.index
```

Out[20]:

```
Int64Index([  5, 116,  45,  16, 468, 360,   3, 405, 185,  60,
            ...
            121, 505,  20, 188,  71, 106, 270, 348, 435, 102],
           dtype='int64', length=354)
```

In [22]:

```
#Standardizing
from sklearn.preprocessing import StandardScaler
sc_X_2 = StandardScaler()
X_train_2 = sc_X_2.fit_transform(X_train)
X_test_2 = sc_X_2.transform(X_test)
```

In [23]:

```
X_train_2 = pd.DataFrame(X_train_2, columns=dataset.feature_names, index= X_train.index)
X_train_2.head(3)
```

Out[23]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
5	-0.414259	-0.505125	-1.292142	-0.281546	-0.851085	0.145264	-0.365584	1.081628	-0.746179	-1.112790	0.187271	0.396514	-1.015316
116	-0.402008	-0.505125	-0.162083	-0.281546	-0.087967	-0.208401	0.133941	-0.487876	-0.398464	0.150088	-0.212090	0.387067	-0.053663
45	-0.397211	-0.505125	-0.609489	-0.281546	-0.936828	-0.896237	-1.266900	0.628596	-0.746179	-1.046639	-0.167716	0.428541	-0.311324

In [25]:

```
import warnings
warnings.filterwarnings('ignore')

training_data_2 = X_train_2
training_data_2['price'] = y_train_2
training_data_2.head(5)
```

Out[25]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
5	-0.414259	-0.505125	-1.292142	-0.281546	-0.851085	0.145264	-0.365584	1.081628	-0.746179	-1.112790	0.187271	0.396514	-1.015316

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
116	0.402008	0.505125	0.162083	0.281546	0.087967	0.208401	0.133941	0.487876	0.398464	0.150088	0.212090	0.387067	0.053663
45	-0.397211	-0.505125	-0.609489	-0.281546	-0.936828	-0.896237	-1.266900	0.628596	-0.746179	-1.046639	-0.167716	0.428541	-0.311324
16	-0.290936	-0.505125	-0.431970	-0.281546	-0.165136	-0.543965	-1.429789	0.345133	-0.630274	-0.601625	1.207859	0.312760	-0.822422
468	1.457816	-0.505125	1.005500	-0.281546	0.194987	-0.556496	0.079645	-0.403892	1.687825	1.557294	0.852872	0.104124	0.803800

In [26]:

```
def cost_function(weights, bias, features, target):
  totalError = 0
  for i in range(len(features)):
    x = features
    y = target
    totalError += (y[:,1] - np.dot(x[i], weights) + bias)**2
    return totalError/len(x)
```

In [27]:

```
#https://github.com/premvardhan/Stochastic-Gradient-descent-in-
python/blob/master/LinearRegression_on_bostan_house_price_using_SGD_reopen.ipynb
def ImplementSGD(w0, b0, training_data, X_test, y_test, learning_rate, iterations, m):
    loss_train = []
    loss_test = []
    grad_W = 0
    grad_b = 0

    for iter in range(iterations):

        #training batch
        train_sample = training_data.sample(m)
        y = np.asmatrix(train_sample['price'])
        x = np.asmatrix(train_sample.drop(['price'], axis=1))

        for i in range(len(x)):
            grad_W += np.dot(-2*x[i].T , (y[:,i] - np.dot(x[i] , w0) + b0))
            grad_b += -2*(y[:,i] - (np.dot(x[i] , w0) + b0))

            w1 = w0 - learning_rate * grad_W
            b1 = b0 - learning_rate * grad_b

        if (w0==w1).all():
            break

        else:
            w0 = w1
            b0 = b1
            learning_rate = learning_rate/2

        error_train = cost_function(w0, b0, x, y)
        loss_train.append(error_train)
        error_test = cost_function(w0, b0, np.asmatrix(X_test), np.asmatrix(y_test))
        loss_test.append(error_test)

    return w0, b0, loss_train, loss_test
```

In [531]:

```
#w0 = np.asmatrix(np.random.rand(13)).T
#b0 = np.random.rand()
w0 = np.asmatrix(np.zeros(13)).T
b0 = 0
W,b, loss_train, loss_test = ImplementSGD(w0, b0, training_data_2, X_test_2, y_test_2, 0.001 , 2500
, 177)
```

In [532]:

```
print(W)
print(b)
```

```
[[ 0.39757704]
 [ 0.49149552]
 [-0.14612561]
 [ 0.80366253]
 [ 0.39242645]
 [ 3.08664273]
 [-0.2078443 ]
 [-1.17380315]
 [ 0.83002523]
 [ 0.35558206]
 [-0.93041063]
 [ 1.73416789]
 [-4.00053788]]
[[23.18309227]]
```

Predict the test data using Implemented SGD Weights and bias

In [30]:

```
def predict(testing_data, weights , bias):
    y_pred = []
    for i in range(testing_data.shape[0]):
        x = np.asmatrix(testing_data)
        y = (np.dot(x[i] , weights) + bias)
        #print(y.shape)
        y_pred.append(y)

    return np.array(y_pred)
```

In [533]:

```
y_pred_test = predict(X_test_2, W,b)
```

In [534]:

```
y_pred_test = y_pred_test.reshape(-1,1)
```

Comparing both the results

In [34]:

```
# RMSE for Sklearn library predictions
from sklearn.metrics import mean_squared_error
#from math import sqrt
MSE_1 = mean_squared_error(y_test_1, y_pred)
print('Mean Squared Error:', MSE_1)
```

```
Mean Squared Error: 21.51744423117721
```

In [424]:

```
#RMSE for our own implementations of SGD
from sklearn.metrics import mean_squared_error
#from math import sqrt
MSE_2 = mean_squared_error(y_test_2, y_pred_test)
print('Mean Squared Error:', MSE_2)
```

```
Mean Squared Error: 25.360046548960746
```

Note:

- I can't reduce much more of MSE_2 even after i changed different iterations, learning rate and epochs.

In [37]:

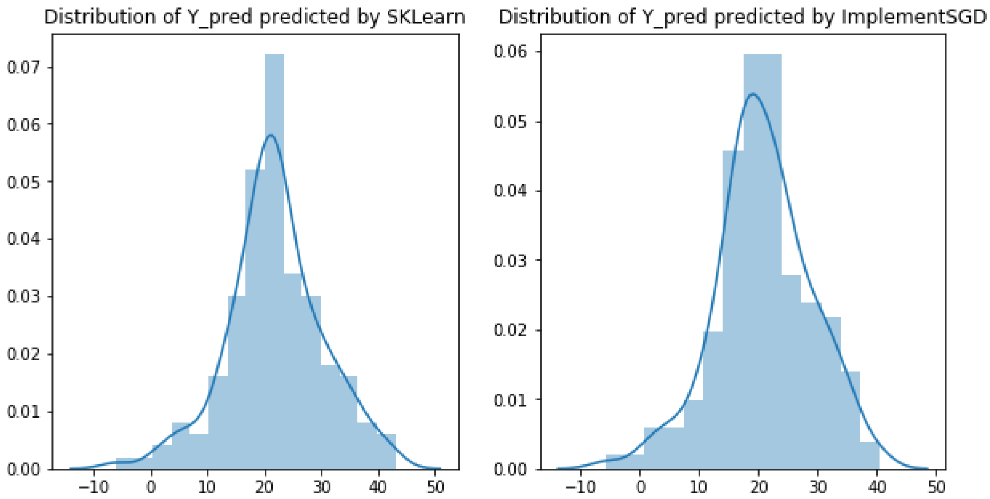
In [37]:

```
fig = plt.figure(figsize=(10,5))
ax1 = fig.add_subplot(121)
sns.distplot(y_pred)
plt.title('Distribution of Y_pred predicted by SKLearn')

ax2 = fig.add_subplot(122)
sns.distplot(y_pred_test)
plt.title('Distribution of Y_pred predicted by ImplementSGD')
```

Out[37]:

```
Text(0.5, 1.0, 'Distribution of Y_pred predicted by ImplementSGD')
```



Summary:

```
- It looks like the distribution of both the data are in almost similar and their mean is a
lso at around 20 for both of them
```

Conclusion:

In [425]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ['Model', 'Root Mean Squared Error']
x.add_row(['Sklearn', str('%4f'%MSE_1)])
x.add_row(['SGD from scratch', str('%4f'%MSE_2)])
print(x)
```

```
+------------------+-------------------------+
|      Model       | Root Mean Squared Error |
+------------------+-------------------------+
|     Sklearn      |        21.517444        |
| SGD from scratch |        25.360046        |
+------------------+-------------------------+
```

- We can see that the RMSE for Sklearn prediction is: 21.51 and RMSE for our own implemented SGD is 25.36 and since it almost close to each other we can say that our SGD implementation working good