Assignment 6

1.1 importing necessary packages

In [1]:

```
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.linear_model import SGDRegressor
from sklearn import preprocessing
from sklearn.metrics import mean_squared_error
```

1.2 Loading dataset

adding a new feature for feature engineering which is feature 13

In [2]:

```
X = load_boston().data
Y = load_boston().target
df=pd.DataFrame(X)
# adding a new feature because feauture 10 represents the Med
ian value of owner-occupied homes in $1000's and feature 12 r
epresents he proportion of blacks by town
df[13]=df[10]//df[12]  #here we set a column 13 such that df[
13]=Boston_data['Medv']//Boston_data['B']
X=df.as_matrix()
df.head()
```

Out[2]:

	0	1	2	3	4	5	6	7	
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.

In [17]:

```
# Standardizing all numerical features
```

In [3]:

```
#Splitting whole data into train and test
```

```python
#https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDRegressor.html
from sklearn.model_selection  import train_test_split
X_train, X_test, y_train, y_test=train_test_split(X, Y, test_size=0.33, random_state=7)

# applying column standardization on train and test data

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

df_train=pd.DataFrame(X_train)
df_train['price']=y_train
df_train.head()
```

Out[3]:

	0	1	2	3	4	5	6	
0	-0.434509	2.569022	-1.267370	-0.282166	-1.340054	0.102435	-1.751328	1.935397
1	-0.435461	-0.477752	-1.235724	-0.282166	-0.564048	0.980322	-0.382070	-0.4
2	1.455745	-0.477752	1.014046	-0.282166	1.658151	-0.464389	0.672580	-0.930124
3	-0.436571	0.436280	-0.778290	-0.282166	-0.996142	-0.377292	-1.704852	1.4
4	0.766851	-0.477752	1.014046	-0.282166	1.243693	0.276630	1.062264	-0.975393

1.3 SGD implementation for linear regression

- function having parameter X_train,y_train,no of iteration,learning rate r
- intialising no of iteration=1000,learning rate =0.01
- batch size=32

In [5]:

```
# batch_size should be selected as a multiple of 2 for good results



W,B,iteration,lr_rate,k=np.random.randn(1,14),0,1000,0.01,32
#intialise W to random no and B to zero

while iteration>=0:
    w,b,temp_vectors,temp_intercept=W,B,np.zeros(shape=(1,14)),0
    data=df_train.sample(32) #sampling random k=batch size=32 data
    x=np.array(data.drop('price',axis=1))
    y=np.array(data['price'])

    for i in range(k):
        temp_vectors+=(-2)*x[i]*(y[i]-(np.dot(w,x[i])+b))#partial differentiation wrt w dl/dw=1/k(-2x)*(y-wTx-b)
        temp_intercept+=(-2)*(y[i]-(np.dot(w,x[i])+b))#partial differentiation wrt b dl/db=1/k(-2)*(y-wTx-b)

    W=(w-lr_rate*(temp_vectors)/k)
    B=(b-lr_rate*(temp_intercept)/k)
```

```
    iteration-=1



print(W)
print(B)
```

```
[[-1.06376104  0.31049954 -0.29369134  0.54904
567 -1.67674344  2.97486592
   0.06973423 -2.60088026  1.787087   -1.12082
982 -2.46390053  0.67676598
  -0.63292549  3.23570847]]
[22.59734909]
```

In [6]:

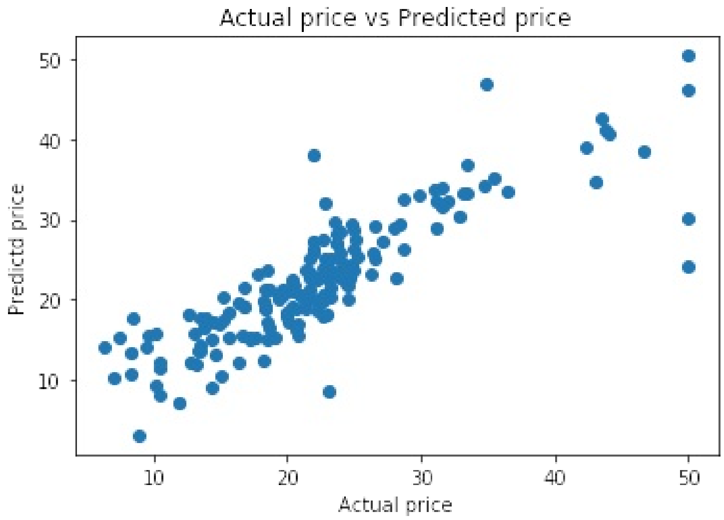
```
#prediction on x_test
#https://www.geeksforgeeks.org/numpy-asscalar-in-python/
y_predic_lr=[]
for i in range(len(X_test)):
    val=np.dot(W,X_test[i])+B  #val= wTx+b
    y_predic_lr.append(np.asscalar(val))
```

Scatter plot of manual SGD implementation

In [7]:

```
#Scatter plot of actual price vs predicted price

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



In [8]:

```
MSE_lr=mean_squared_error(y_test,y_predic_lr)
print('mean squared error =',MSE_lr)
```

mean squared error = 20.290469323888228

1.5 Scatterplot of sklearn SGD

In [11]:

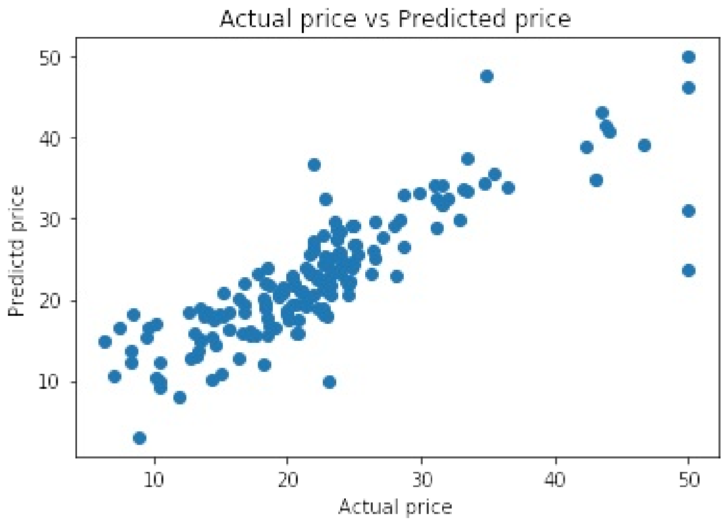
```
#SGD regression sklearn implementation

#intialising no of iteration=1000,eta0=1
#taking t=2 and power_t=1 such that for each iteration eta0=e
ta0/pow(2,1) ,it means half each times

model=SGDRegressor(learning_rate='constant',eta0=0.01,penalty=
None,max_iter=1000)
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()
```


Actual price vs Predicted price
Predictd price
Actual price
10
20
30
40
50
10
20
30
40
50

Explanation

- We observe the scatterplots of both manual implemention as well as sklearn SGD give almost similar plots
- It implies manual implementation is almost correct

In [12]:

```
MSE_sgd=mean_squared_error(y_test,y_pred_sgd)
print('mean squared error =',MSE_sgd)
```

```
mean squared error = 20.874879169535497
```

In [25]:

```
# Comparing weights of two implementations
from prettytable import PrettyTable
x = PrettyTable()
x.field_names=['Weight vector of  manual SGD','Weight vector
of SGD sklearn']
weight_sgd=model.coef_
for i in range(13):
    x.add_row([W[0][i],weight_sgd[i]])
print(x)
```

```
+-------------------------------+--------------
----------------+
| Weight vector of  manual SGD | Weight vector
 of SGD sklearn |
+-------------------------------+--------------
----------------+
|     -1.0637610418383168      |     -1.210266
9406105764      |
|      0.3104995415747905      |     0.1649296
```

```
5830786752      |
|     -0.29369133922081336     |     -0.315221
9947428299      |
|      0.549045666598545       |     0.2800612
8032896843      |
|     -1.6767434379586952      |     -1.718226
9873531635      |
|      2.974865920224037       |      2.794507
7844582427      |
|     0.06973422979094325      |    9.29813537
1791543e-05     |
|      -2.600880260417682      |      -2.69116
1025332599      |
|      1.7870869985271018      |      2.075230
9264734548      |
|     -1.1208298245761101      |      -1.41252
292288952       |
|     -2.4639005262277456      |      -2.60158
3342104059      |
|      0.6767659847794245      |     0.4728539
6370479016      |
|     -0.6329254893449336      |     -0.286260
3629565815      |
+------------------------------+-------------
----------------+
```

In [24]:

```python
#comparison between MSE of own implementation and SGD sklearn
 implementation
print('Mean Square error of manual implementation = ',MSE_lr)
print('-'*50)
print('Mean square error of SGD sklearn implementation = ',MS
E_sgd)
```

```
Mean Square error of manual implementation =
20.290469323888228
----------------------------------------------
```

```
----
Mean square error of SGD sklearn implementatio
n =  20.874879169535497
```

In [16]:

```
z= PrettyTable()
z.field_names=['MSE of manual implementation',"MSE of SGD skl
earn"]
z.add_row([20.29,20.87])
print(z)
```

```
+-----------------------------+-------------
------+
| MSE of manual implementation | MSE of SGD sk
learn |
+-----------------------------+-------------
------+
|            20.29             |       20.87
      |
+-----------------------------+-------------
------+
```

Conclusion

- We observe that weight vectors of manual implementation and sklearns SGD implementation nearly give same values for the Boston dataset
- MSE of manual implementation was 20.29 and that of Sklearn was 20.87