practical4

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Practical 4 : Data Analytics 1

Create a Linear Regression Model using Python/R to predict home prices using Boston Housing Dataset (https://www.kaggle.com/c/boston-housing). The Boston Housing dataset contains information about various houses in Boston through different parameters. There are 506 samplesand 14 feature variables in this dataset. The objective is to predict the value of prices of the house using the given features.

IMPORT LIBRARIES AND LOAD DATASET

[1]:
```
from google.colab import drive
from google.colab import files
files.upload()
```

```
<IPython.core.display.HTML object>
```

```
Saving boston.csv to boston.csv
```

[1]:
```
{'boston.csv': b'CRIM,ZN,INDUS,CHAS,NOX,RM,AGE,DIS,RAD,TAX,PTRATIO,B,LSTAT,MEDV\
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2.4699,4,437.0,21.20,388.69,15.03,18.40\n0.97617,0.00,21.890,0,0.6240,5.7570,98.
40,2.3460,4,437.0,21.20,262.76,17.31,15.60\n0.55778,0.00,21.890,0,0.6240,6.3350,
98.20,2.1107,4,437.0,21.20,394.67,16.96,18.10\n0.32264,0.00,21.890,0,0.6240,5.94
20,93.50,1.9669,4,437.0,21.20,378.25,16.90,17.40\n0.35233,0.00,21.890,0,0.6240,6
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00,18.100,0,0.6930,5.5310,85.40,1.6074,24,666.0,20.20,329.46,27.38,8.50\n67.9208
0,0.00,18.100,0,0.6930,5.6830,100.00,1.4254,24,666.0,20.20,384.97,22.98,5.00\n20
.71620,0.00,18.100,0,0.6590,4.1380,100.00,1.1781,24,666.0,20.20,370.22,23.34,11.
90\n11.95110,0.00,18.100,0,0.6590,5.6080,100.00,1.2852,24,666.0,20.20,332.09,12.
13,27.90\n7.40389,0.00,18.100,0,0.5970,5.6170,97.90,1.4547,24,666.0,20.20,314.64
,26.40,17.20\n14.43830,0.00,18.100,0,0.5970,6.8520,100.00,1.4655,24,666.0,20.20,
179.36,19.78,27.50\n51.13580,0.00,18.100,0,0.5970,5.7570,100.00,1.4130,24,666.0,
20.20,2.60,10.11,15.00\n14.05070,0.00,18.100,0,0.5970,6.6570,100.00,1.5275,24,66
6.0,20.20,35.05,21.22,17.20\n18.81100,0.00,18.100,0,0.5970,4.6280,100.00,1.5539,
24,666.0,20.20,28.79,34.37,17.90\n28.65580,0.00,18.100,0,0.5970,5.1550,100.00,1.
5894,24,666.0,20.20,210.97,20.08,16.30\n45.74610,0.00,18.100,0,0.6930,4.5190,100
.00,1.6582,24,666.0,20.20,88.27,36.98,7.00\n18.08460,0.00,18.100,0,0.6790,6.4340
,100.00,1.8347,24,666.0,20.20,27.25,29.05,7.20\n10.83420,0.00,18.100,0,0.6790,6.
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,5.3040,89.10,1.6475,24,666.0,20.20,127.36,26.64,10.40\n73.53410,0.00,18.100,0,0
.6790,5.9570,100.00,1.8026,24,666.0,20.20,16.45,20.62,8.80\n11.81230,0.00,18.100
,0,0.7180,6.8240,76.50,1.7940,24,666.0,20.20,48.45,22.74,8.40\n11.08740,0.00,18.
100,0,0.7180,6.4110,100.00,1.8589,24,666.0,20.20,318.75,15.02,16.70\n7.02259,0.0
0,18.100,0,0.7180,6.0060,95.30,1.8746,24,666.0,20.20,319.98,15.70,14.20\n12.0482
0,0.00,18.100,0,0.6140,5.6480,87.60,1.9512,24,666.0,20.20,291.55,14.10,20.80\n7.
05042,0.00,18.100,0,0.6140,6.1030,85.10,2.0218,24,666.0,20.20,2.52,23.29,13.40\n
8.79212,0.00,18.100,0,0.5840,5.5650,70.60,2.0635,24,666.0,20.20,3.65,17.16,11.70
\n15.86030,0.00,18.100,0,0.6790,5.8960,95.40,1.9096,24,666.0,20.20,7.68,24.39,8.
30\n12.24720,0.00,18.100,0,0.5840,5.8370,59.70,1.9976,24,666.0,20.20,24.65,15.69
,10.20\n37.66190,0.00,18.100,0,0.6790,6.2020,78.70,1.8629,24,666.0,20.20,18.82,1
4.52,10.90\n7.36711,0.00,18.100,0,0.6790,6.1930,78.10,1.9356,24,666.0,20.20,96.7

3,21.52,11.00\n9.33889,0.00,18.100,0,0.6790,6.3800,95.60,1.9682,24,666.0,20.20,6
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,83.45,17.64,14.50\n10.06230,0.00,18.100,0,0.5840,6.8330,94.30,2.0882,24,666.0,2
0.20,81.33,19.69,14.10\n6.44405,0.00,18.100,0,0.5840,6.4250,74.80,2.2004,24,666.
0,20.20,97.95,12.03,16.10\n5.58107,0.00,18.100,0,0.7130,6.4360,87.90,2.3158,24,6
66.0,20.20,100.19,16.22,14.30\n13.91340,0.00,18.100,0,0.7130,6.2080,95.00,2.2222
,24,666.0,20.20,100.63,15.17,11.70\n11.16040,0.00,18.100,0,0.7400,6.6290,94.60,2
.1247,24,666.0,20.20,109.85,23.27,13.40\n14.42080,0.00,18.100,0,0.7400,6.4610,93
.30,2.0026,24,666.0,20.20,27.49,18.05,9.60\n15.17720,0.00,18.100,0,0.7400,6.1520
,100.00,1.9142,24,666.0,20.20,9.32,26.45,8.70\n13.67810,0.00,18.100,0,0.7400,5.9
350,87.90,1.8206,24,666.0,20.20,68.95,34.02,8.40\n9.39063,0.00,18.100,0,0.7400,5
.6270,93.90,1.8172,24,666.0,20.20,396.90,22.88,12.80\n22.05110,0.00,18.100,0,0.7
400,5.8180,92.40,1.8662,24,666.0,20.20,391.45,22.11,10.50\n9.72418,0.00,18.100,0
,0.7400,6.4060,97.20,2.0651,24,666.0,20.20,385.96,19.52,17.10\n5.66637,0.00,18.1
00,0,0.7400,6.2190,100.00,2.0048,24,666.0,20.20,395.69,16.59,18.40\n9.96654,0.00
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.67180,0.00,18.100,0,0.7400,6.4590,94.80,1.9879,24,666.0,20.20,43.06,23.98,11.80
\n6.28807,0.00,18.100,0,0.7400,6.3410,96.40,2.0720,24,666.0,20.20,318.01,17.79,1
4.90\n9.92485,0.00,18.100,0,0.7400,6.2510,96.60,2.1980,24,666.0,20.20,388.52,16.
44,12.60\n9.32909,0.00,18.100,0,0.7130,6.1850,98.70,2.2616,24,666.0,20.20,396.90
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.20,355.29,17.73,15.20\n5.09017,0.00,18.100,0,0.7130,6.2970,91.80,2.3682,24,666.
0,20.20,385.09,17.27,16.10\n8.24809,0.00,18.100,0,0.7130,7.3930,99.30,2.4527,24,
666.0,20.20,375.87,16.74,17.80\n9.51363,0.00,18.100,0,0.7130,6.7280,94.10,2.4961
,24,666.0,20.20,6.68,18.71,14.90\n4.75237,0.00,18.100,0,0.7130,6.5250,86.50,2.43
58,24,666.0,20.20,50.92,18.13,14.10\n4.66883,0.00,18.100,0,0.7130,5.9760,87.90,2
.5806,24,666.0,20.20,10.48,19.01,12.70\n8.20058,0.00,18.100,0,0.7130,5.9360,80.3
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.70,2.7831,24,666.0,20.20,272.21,16.23,14.90\n6.80117,0.00,18.100,0,0.7130,6.081
0,84.40,2.7175,24,666.0,20.20,396.90,14.70,20.00\n4.81213,0.00,18.100,0,0.7130,6
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0,0,0.7130,6.5130,89.90,2.8016,24,666.0,20.20,393.82,10.29,20.20\n7.83932,0.00,1
8.100,0,0.6550,6.2090,65.40,2.9634,24,666.0,20.20,396.90,13.22,21.40\n3.16360,0.
00,18.100,0,0.6550,5.7590,48.20,3.0665,24,666.0,20.20,334.40,14.13,19.90\n3.7749
8,0.00,18.100,0,0.6550,5.9520,84.70,2.8715,24,666.0,20.20,22.01,17.15,19.00\n4.4
2228,0.00,18.100,0,0.5840,6.0030,94.50,2.5403,24,666.0,20.20,331.29,21.32,19.10\
n15.57570,0.00,18.100,0,0.5800,5.9260,71.00,2.9084,24,666.0,20.20,368.74,18.13,1
9.10\n13.07510,0.00,18.100,0,0.5800,5.7130,56.70,2.8237,24,666.0,20.20,396.90,14
.76,20.10\n4.34879,0.00,18.100,0,0.5800,6.1670,84.00,3.0334,24,666.0,20.20,396.9
0,16.29,19.90\n4.03841,0.00,18.100,0,0.5320,6.2290,90.70,3.0993,24,666.0,20.20,3
95.33,12.87,19.60\n3.56868,0.00,18.100,0,0.5800,6.4370,75.00,2.8965,24,666.0,20.
20,393.37,14.36,23.20\n4.64689,0.00,18.100,0,0.6140,6.9800,67.60,2.5329,24,666.0

```
,20.20,374.68,11.66,29.80\n8.05579,0.00,18.100,0,0.5840,5.4270,95.40,2.4298,24,6
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053,24,666.0,20.20,396.21,18.68,16.70\n15.02340,0.00,18.100,0,0.6140,5.3040,97.3
0,2.1007,24,666.0,20.20,349.48,24.91,12.00\n10.23300,0.00,18.100,0,0.6140,6.1850
,96.70,2.1705,24,666.0,20.20,379.70,18.03,14.60\n14.33370,0.00,18.100,0,0.6140,6
.2290,88.00,1.9512,24,666.0,20.20,383.32,13.11,21.40\n5.82401,0.00,18.100,0,0.53
20,6.2420,64.70,3.4242,24,666.0,20.20,396.90,10.74,23.00\n5.70818,0.00,18.100,0,
0.5320,6.7500,74.90,3.3317,24,666.0,20.20,393.07,7.74,23.70\n5.73116,0.00,18.100
,0,0.5320,7.0610,77.00,3.4106,24,666.0,20.20,395.28,7.01,25.00\n2.81838,0.00,18.
100,0,0.5320,5.7620,40.30,4.0983,24,666.0,20.20,392.92,10.42,21.80\n2.37857,0.00
,18.100,0,0.5830,5.8710,41.90,3.7240,24,666.0,20.20,370.73,13.34,20.60\n3.67367,
0.00,18.100,0,0.5830,6.3120,51.90,3.9917,24,666.0,20.20,388.62,10.58,21.20\n5.69
175,0.00,18.100,0,0.5830,6.1140,79.80,3.5459,24,666.0,20.20,392.68,14.98,19.10\n
4.83567,0.00,18.100,0,0.5830,5.9050,53.20,3.1523,24,666.0,20.20,388.22,11.45,20.
60\n0.15086,0.00,27.740,0,0.6090,5.4540,92.70,1.8209,4,711.0,20.10,395.09,18.06,
15.20\n0.18337,0.00,27.740,0,0.6090,5.4140,98.30,1.7554,4,711.0,20.10,344.05,23.
97,7.00\n0.20746,0.00,27.740,0,0.6090,5.0930,98.00,1.8226,4,711.0,20.10,318.43,2
9.68,8.10\n0.10574,0.00,27.740,0,0.6090,5.9830,98.80,1.8681,4,711.0,20.10,390.11
,18.07,13.60\n0.11132,0.00,27.740,0,0.6090,5.9830,83.50,2.1099,4,711.0,20.10,396
.90,13.35,20.10\n0.17331,0.00,9.690,0,0.5850,5.7070,54.00,2.3817,6,391.0,19.20,3
96.90,12.01,21.80\n0.27957,0.00,9.690,0,0.5850,5.9260,42.60,2.3817,6,391.0,19.20
,396.90,13.59,24.50\n0.17899,0.00,9.690,0,0.5850,5.6700,28.80,2.7986,6,391.0,19.
20,393.29,17.60,23.10\n0.28960,0.00,9.690,0,0.5850,5.3900,72.90,2.7986,6,391.0,1
9.20,396.90,21.14,19.70\n0.26838,0.00,9.690,0,0.5850,5.7940,70.60,2.8927,6,391.0
,19.20,396.90,14.10,18.30\n0.23912,0.00,9.690,0,0.5850,6.0190,65.30,2.4091,6,391
.0,19.20,396.90,12.92,21.20\n0.17783,0.00,9.690,0,0.5850,5.5690,73.50,2.3999,6,3
91.0,19.20,395.77,15.10,17.50\n0.22438,0.00,9.690,0,0.5850,6.0270,79.70,2.4982,6
,391.0,19.20,396.90,14.33,16.80\n0.06263,0.00,11.930,0,0.5730,6.5930,69.10,2.478
6,1,273.0,21.00,391.99,9.67,22.40\n0.04527,0.00,11.930,0,0.5730,6.1200,76.70,2.2
875,1,273.0,21.00,396.90,9.08,20.60\n0.06076,0.00,11.930,0,0.5730,6.9760,91.00,2
.1675,1,273.0,21.00,396.90,5.64,23.90\n0.10959,0.00,11.930,0,0.5730,6.7940,89.30
,2.3889,1,273.0,21.00,393.45,6.48,22.00\n0.04741,0.00,11.930,0,0.5730,6.0300,80.
80,2.5050,1,273.0,21.00,396.90,7.88,11.90\n'}
```

[2]:
```
import pandas as pd
import numpy as np
```

[3]:
```
df = pd.read_csv("/content/boston.csv")
```

[4]:
```
df
```

[4]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	\
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296.0	
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242.0	
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242.0	
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222.0	

```
4    0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222.0
..       …   …    …   …    …    …   …      …  …    …
501  0.06263   0.0  11.93     0  0.573  6.593  69.1  2.4786    1  273.0
502  0.04527   0.0  11.93     0  0.573  6.120  76.7  2.2875    1  273.0
503  0.06076   0.0  11.93     0  0.573  6.976  91.0  2.1675    1  273.0
504  0.10959   0.0  11.93     0  0.573  6.794  89.3  2.3889    1  273.0
505  0.04741   0.0  11.93     0  0.573  6.030  80.8  2.5050    1  273.0

     PTRATIO       B  LSTAT  MEDV
0       15.3  396.90   4.98  24.0
1       17.8  396.90   9.14  21.6
2       17.8  392.83   4.03  34.7
3       18.7  394.63   2.94  33.4
4       18.7  396.90   5.33  36.2
..       …     …    …   …
501     21.0  391.99   9.67  22.4
502     21.0  396.90   9.08  20.6
503     21.0  396.90   5.64  23.9
504     21.0  393.45   6.48  22.0
505     21.0  396.90   7.88  11.9

[506 rows x 14 columns]
```

DATA PREPROCESSING

[5]:
```
df.head()
```

[5]:
```
      CRIM    ZN  INDUS  CHAS    NOX     RM   AGE     DIS  RAD    TAX  \
0  0.00632  18.0   2.31     0  0.538  6.575  65.2  4.0900    1  296.0
1  0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242.0
2  0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242.0
3  0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222.0
4  0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222.0

   PTRATIO       B  LSTAT  MEDV
0     15.3  396.90   4.98  24.0
1     17.8  396.90   9.14  21.6
2     17.8  392.83   4.03  34.7
3     18.7  394.63   2.94  33.4
4     18.7  396.90   5.33  36.2
```

[6]:
```
df.tail()
```

[6]:
```
        CRIM   ZN  INDUS  CHAS    NOX     RM   AGE     DIS  RAD    TAX  \
501  0.06263  0.0  11.93     0  0.573  6.593  69.1  2.4786    1  273.0
502  0.04527  0.0  11.93     0  0.573  6.120  76.7  2.2875    1  273.0
503  0.06076  0.0  11.93     0  0.573  6.976  91.0  2.1675    1  273.0
```

```
504  0.10959  0.0  11.93     0  0.573  6.794  89.3  2.3889    1  273.0
505  0.04741  0.0  11.93     0  0.573  6.030  80.8  2.5050    1  273.0

     PTRATIO       B  LSTAT  MEDV
501     21.0  391.99   9.67  22.4
502     21.0  396.90   9.08  20.6
503     21.0  396.90   5.64  23.9
504     21.0  393.45   6.48  22.0
505     21.0  396.90   7.88  11.9
```

[7]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 506 entries, 0 to 505
Data columns (total 14 columns):
 #   Column   Non-Null Count  Dtype
---  ------   --------------  -----
 0   CRIM     506 non-null    float64
 1   ZN       506 non-null    float64
 2   INDUS    506 non-null    float64
 3   CHAS     506 non-null    int64
 4   NOX      506 non-null    float64
 5   RM       506 non-null    float64
 6   AGE      506 non-null    float64
 7   DIS      506 non-null    float64
 8   RAD      506 non-null    int64
 9   TAX      506 non-null    float64
 10  PTRATIO  506 non-null    float64
 11  B        506 non-null    float64
 12  LSTAT    506 non-null    float64
 13  MEDV     506 non-null    float64
dtypes: float64(12), int64(2)
memory usage: 55.5 KB
```

[8]:
```
df.describe(include="all")
```

[8]:
```
              CRIM          ZN       INDUS        CHAS         NOX          RM  \
count  506.000000  506.000000  506.000000  506.000000  506.000000  506.000000
mean     3.613524   11.363636   11.136779    0.069170    0.554695    6.284634
std      8.601545   23.322453    6.860353    0.253994    0.115878    0.702617
min      0.006320    0.000000    0.460000    0.000000    0.385000    3.561000
25%      0.082045    0.000000    5.190000    0.000000    0.449000    5.885500
50%      0.256510    0.000000    9.690000    0.000000    0.538000    6.208500
75%      3.677083   12.500000   18.100000    0.000000    0.624000    6.623500
max     88.976200  100.000000   27.740000    1.000000    0.871000    8.780000

              AGE         DIS         RAD         TAX     PTRATIO           B  \
```

```
count  506.000000  506.000000  506.000000  506.000000  506.000000  506.000000
mean    68.574901    3.795043    9.549407  408.237154   18.455534  356.674032
std     28.148861    2.105710    8.707259  168.537116    2.164946   91.294864
min      2.900000    1.129600    1.000000  187.000000   12.600000    0.320000
25%     45.025000    2.100175    4.000000  279.000000   17.400000  375.377500
50%     77.500000    3.207450    5.000000  330.000000   19.050000  391.440000
75%     94.075000    5.188425   24.000000  666.000000   20.200000  396.225000
max    100.000000   12.126500   24.000000  711.000000   22.000000  396.900000

            LSTAT        MEDV
count  506.000000  506.000000
mean    12.653063   22.532806
std      7.141062    9.197104
min      1.730000    5.000000
25%      6.950000   17.025000
50%     11.360000   21.200000
75%     16.955000   25.000000
max     37.970000   50.000000
```

CHECK FOR NULL VALUES

[9]:
```
df.isna()
```

[9]:
```
       CRIM     ZN  INDUS   CHAS    NOX     RM    AGE    DIS    RAD    TAX  \
0     False  False  False  False  False  False  False  False  False  False
1     False  False  False  False  False  False  False  False  False  False
2     False  False  False  False  False  False  False  False  False  False
3     False  False  False  False  False  False  False  False  False  False
4     False  False  False  False  False  False  False  False  False  False
..      …      …      …      …      …      …      …      …      …      …
501   False  False  False  False  False  False  False  False  False  False
502   False  False  False  False  False  False  False  False  False  False
503   False  False  False  False  False  False  False  False  False  False
504   False  False  False  False  False  False  False  False  False  False
505   False  False  False  False  False  False  False  False  False  False

     PTRATIO      B  LSTAT   MEDV
0      False  False  False  False
1      False  False  False  False
2      False  False  False  False
3      False  False  False  False
4      False  False  False  False
..       …      …      …      …
501    False  False  False  False
502    False  False  False  False
503    False  False  False  False
504    False  False  False  False
```

```
505    False  False  False  False

[506 rows x 14 columns]
```

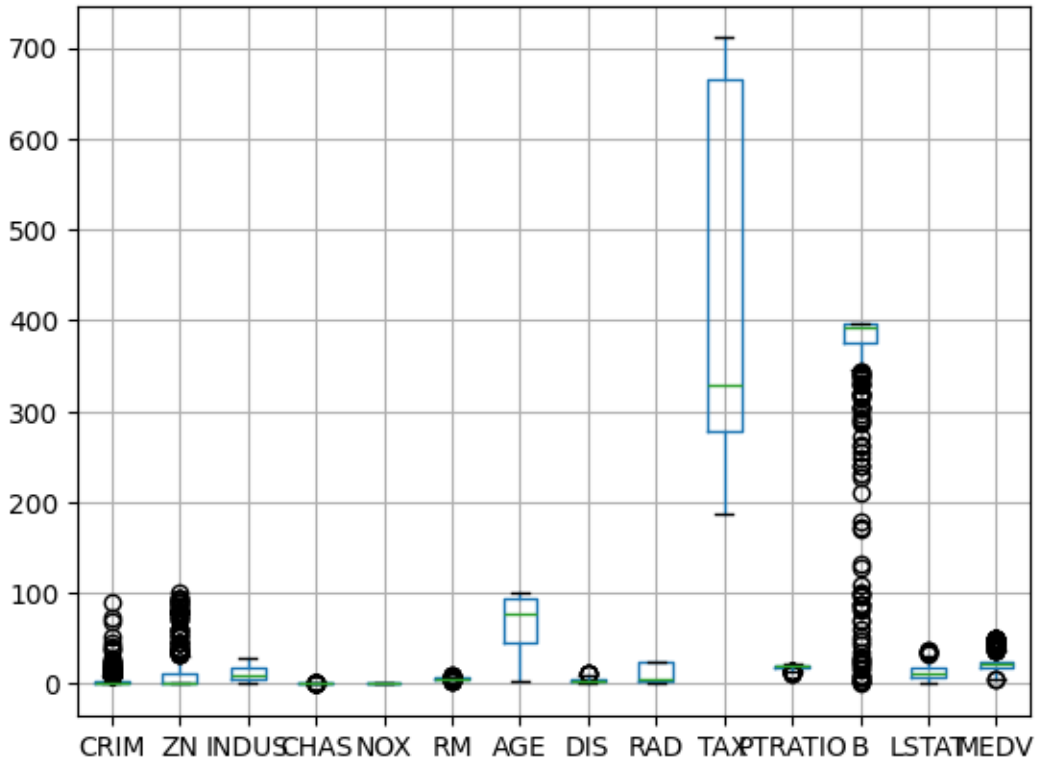
[10]:
```
df.isna().sum()
```

[10]:
```
CRIM       0
ZN         0
INDUS      0
CHAS       0
NOX        0
RM         0
AGE        0
DIS        0
RAD        0
TAX        0
PTRATIO    0
B          0
LSTAT      0
MEDV       0
dtype: int64
```

CHECK FOR OUTLIERS - USING INTERQUARTILE RANGE

[11]:
```
import seaborn as sns
import matplotlib.pyplot as plt
df.boxplot()
```

[11]:
```
<Axes: >
```



[12]:
```
Q1 = df['MEDV'].quantile(0.25)
Q3 = df['MEDV'].quantile(0.75)
IQR = Q3 - Q1
Lower_limit = Q1 - 1.5 * IQR
Upper_limit = Q3 + 1.5 * IQR
print(f'Q1 = {Q1}, Q3 = {Q3}, IQR = {IQR}, Lower_limit =␣
  ↪{Lower_limit},Upper_limit = {Upper_limit}')
```

```
Q1 = 17.025, Q3 = 25.0, IQR = 7.975000000000001, Lower_limit =
5.0624999999999964,Upper_limit = 36.962500000000006
```

[13]:
```
outliers_medv=[]
for i in df.MEDV:
  if i<Lower_limit or i>Upper_limit:
    outliers_medv.append(i)
    print("outliers are",outliers_medv)
```

```
outliers are [38.7]
outliers are [38.7, 43.8]
outliers are [38.7, 43.8, 41.3]
outliers are [38.7, 43.8, 41.3, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0]
```

```
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
```

```
50.0, 43.1, 48.8, 50.0, 43.5, 45.4]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0, 50.0, 50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0, 50.0, 50.0,
50.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0, 50.0, 50.0,
50.0, 5.0]
outliers are [38.7, 43.8, 41.3, 50.0, 50.0, 50.0, 50.0, 37.2, 39.8, 37.9, 50.0,
37.0, 50.0, 42.3, 48.5, 50.0, 44.8, 50.0, 37.6, 46.7, 41.7, 48.3, 42.8, 44.0,
50.0, 43.1, 48.8, 50.0, 43.5, 45.4, 46.0, 50.0, 37.3, 50.0, 50.0, 50.0, 50.0,
50.0, 5.0, 5.0]
```

DIVIDING THE DATASET INTO TEST AND TRAINING

[14]:
```
df[df.MEDV<Lower_limit].index
```

[14]:
```
Index([398, 405], dtype='int64')
```

[15]:
```
X = df.drop(['MEDV'], axis = 1)
Y = df['MEDV']
```

[16]:
```
X
```

[16]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	\
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296.0	

```
1    0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242.0
2    0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242.0
3    0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222.0
4    0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222.0
..       …   …    …   …    …    …   …      …  …     …
501  0.06263   0.0  11.93     0  0.573  6.593  69.1  2.4786    1  273.0
502  0.04527   0.0  11.93     0  0.573  6.120  76.7  2.2875    1  273.0
503  0.06076   0.0  11.93     0  0.573  6.976  91.0  2.1675    1  273.0
504  0.10959   0.0  11.93     0  0.573  6.794  89.3  2.3889    1  273.0
505  0.04741   0.0  11.93     0  0.573  6.030  80.8  2.5050    1  273.0

     PTRATIO       B  LSTAT
0       15.3  396.90   4.98
1       17.8  396.90   9.14
2       17.8  392.83   4.03
3       18.7  394.63   2.94
4       18.7  396.90   5.33
..       …     …    …
501     21.0  391.99   9.67
502     21.0  396.90   9.08
503     21.0  396.90   5.64
504     21.0  393.45   6.48
505     21.0  396.90   7.88

[506 rows x 13 columns]
```

[17]:
```
Y
```

[17]:
```
0      24.0
1      21.6
2      34.7
3      33.4
4      36.2
       …
501    22.4
502    20.6
503    23.9
504    22.0
505    11.9
Name: MEDV, Length: 506, dtype: float64
```

[18]:
```
from sklearn.model_selection import train_test_split
xtrain, xtest, ytrain, ytest = train_test_split( X,  Y, test_size =0.
 ↪2,random_state = 0)
```

[19]:
```
import sklearn
from sklearn.linear_model import LinearRegression
```

```
lm = LinearRegression()
```

[20]:
```
model=lm.fit(xtrain, ytrain)
```

IMPORT FOR LINEAR REGRESSION MODEL

[21]:
```
model
```

[21]:
```
LinearRegression()
```

[22]:
```
ytrain_pred = lm.predict(xtrain)
ytest_pred = lm.predict(xtest)
ytrain_pred
```

[22]:
```
array([32.55692655, 21.92709478, 27.54382573, 23.60318829,  6.57190962,
       14.94183849, 22.2234359 , 29.16492082, 33.24362083, 13.14592261,
       20.25607099, 20.69823381, 12.65147525, 23.36451045,  5.04647867,
       19.82921197,  9.41949932, 44.64390988, 30.78308135, 12.51377155,
       17.7083025 , 21.40137495, 23.63206936, 20.43451195, 35.01471208,
       13.84093827, 21.04977584, 35.15299117, 19.43031106, 13.17488144,
       14.10200042, 23.10677783, 14.38600111, 31.24428679, 25.30231549,
       15.41257398, 24.21291852,  9.40801187, 14.94526286, 20.83029825,
       32.74172958, 27.96372521, 25.60836003, 15.56419667, 31.11934684,
       27.96958264, 13.99703059,  7.63346533, 28.4388332 , 25.33766463,
        4.52504654, 28.38514306, 17.1896917 , 29.74225124, 20.45365104,
       15.92613078, 17.88247152, 12.73233004,  8.75151422, 19.2087374 ,
       34.49694507, 32.94684483, 23.67278817, 19.55243904, 22.8357545 ,
       26.87133257, 21.80817968, 17.06379885, 32.05027982, 10.92397211,
       19.43423447, 32.4854791 , 18.83330461, 15.95730389, 18.64348601,
       14.44808929, 24.60654801, 24.2966726 , 16.64095381, 13.32850391,
       20.20307548, 25.12819701, 17.18033172, 24.71277155, 22.55275499,
       27.95373582, 35.65590799, 16.64554264, 11.83311357, 34.84466464,
       30.84970933, 20.7296176 , 39.5623948 , 28.93322544, 29.14486603,
       17.37121002, 26.82268232, 40.00777296, 28.73960914, 16.44453732,
       37.45185446, 35.50108073, 13.44578945, 29.15098204, 21.60750842,
       24.3179916 , 21.41700241, 23.69538029, 27.763419  , 29.66227826,
       14.17302558, 26.07579718, 23.29927812, 12.80163317, 13.72880538,
       25.27684715, 19.3372779 , 30.54665354, 10.97447089, 23.60361618,
       16.97107603, 16.94075184, 22.59508311, 21.66478168, 11.77477027,
       25.21624705, 28.69690945, 20.17018883, 12.57893016, 25.48767672,
       25.94576428, 25.07919075, 23.5616099 , 26.7499689 , 16.61402974,
       21.79867747, 36.15143711, 21.00423145, 35.88524905, 25.69352037,
       21.5263148 , 15.87068763, 31.29616772, 21.21153127, 27.77524582,
       14.8263031 , 32.22158358, 13.99145209,  1.72558788, 19.37012454,
       14.26927105, 37.54465846, 15.72768892, 14.42603011, 27.31195528,
       23.24522425, 18.47439387, 30.56792527, 27.27498194, 27.27933163,
       24.82223745, 24.16626145, 23.72500963, 11.15226922, 20.76322385,
```

```
13.54743953, 17.16753222, 12.72059151, 28.36113417, 14.93078086,
16.28718393, 28.70785889, 14.89693976, 21.24395164, 12.83793534,
13.8967354 , 22.63435472, 21.22168525, 14.71193886, 20.93690941,
16.89161444, 24.57078637, 12.55171427, 34.77581569, 12.04428697,
43.13783582, 31.24743877, 35.27489214, 21.44652404, 15.75342369,
26.54541539, 29.48749252, 14.09267258, 26.55382087, 37.06264306,
17.64994791, 10.60033751, 34.12962592, 35.60893841, 18.29850589,
22.55033558, 17.99336763, 24.37931178, 19.51737003, 27.30545421,
-4.3921497 , 20.5694959 , 35.24711794, 36.62936652, 25.08667454,
27.21318383, 20.76260072, 20.62207277, 15.87527321, 20.67111164,
20.55222254, 27.90614562, 19.6623801 ,  7.40663904, 16.40149348,
32.41751592, 35.22532239, 17.48615135, 18.73060335, 23.40379308,
 6.90428516, 21.44745461, 24.02200142, 16.46784691, 18.38505179,
21.90096579, 27.59158204, 25.48139462, 37.02340322, 15.43332269,
28.60694794, 25.833241  , 22.27537004, 38.70334609, 20.83802332,
23.4287209 , 22.86380935, 12.48755328, 20.30380995, 33.59657861,
24.79674983, 18.00283472, 33.54517371, 21.63038303, 28.34884771,
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19.69986884, 18.54092642, 40.99282958, 25.1228036 , 19.49495107,
```

```
       33.32636427, 23.79620777, 18.45835276, 23.24918114])
```

[23]:
```
ytrain
```

[23]:
```
220    26.7
71     21.7
240    22.0
6      22.9
417    10.4
       …
323    18.5
192    36.4
117    19.2
47     16.6
172    23.1
Name: MEDV, Length: 404, dtype: float64
```

DISPLAY ALL THE STATISTICS FOR THE TRAINING AND TESTING DATASETS

[24]:
```
import numpy as np
import sklearn.metrics
from sklearn.metrics import mean_absolute_error

# Model evaluation for training set
mse = sklearn.metrics.mean_squared_error(ytrain, ytrain_pred)
mae = mean_absolute_error(ytrain, ytrain_pred)
rmse = np.sqrt(mse)
r2 = sklearn.metrics.r2_score(ytrain, ytrain_pred)

print("The model performance for training set")
print("--------------------------------------")
print('MAE is {}'.format(mae))
print('MSE is {}'.format(mse))
print('RMSE is {}'.format(rmse))
print('R2 score is {}'.format(r2))
print("\n")

# Model evaluation for testing set
mse = sklearn.metrics.mean_squared_error(ytest, ytest_pred)
mae = mean_absolute_error(ytest, ytest_pred)
rmse = np.sqrt(mse)
r2 = sklearn.metrics.r2_score(ytest, ytest_pred)

print("The model performance for testing set")
print("--------------------------------------")
print('MAE is {}'.format(mae))
print('MSE is {}'.format(mse))
```

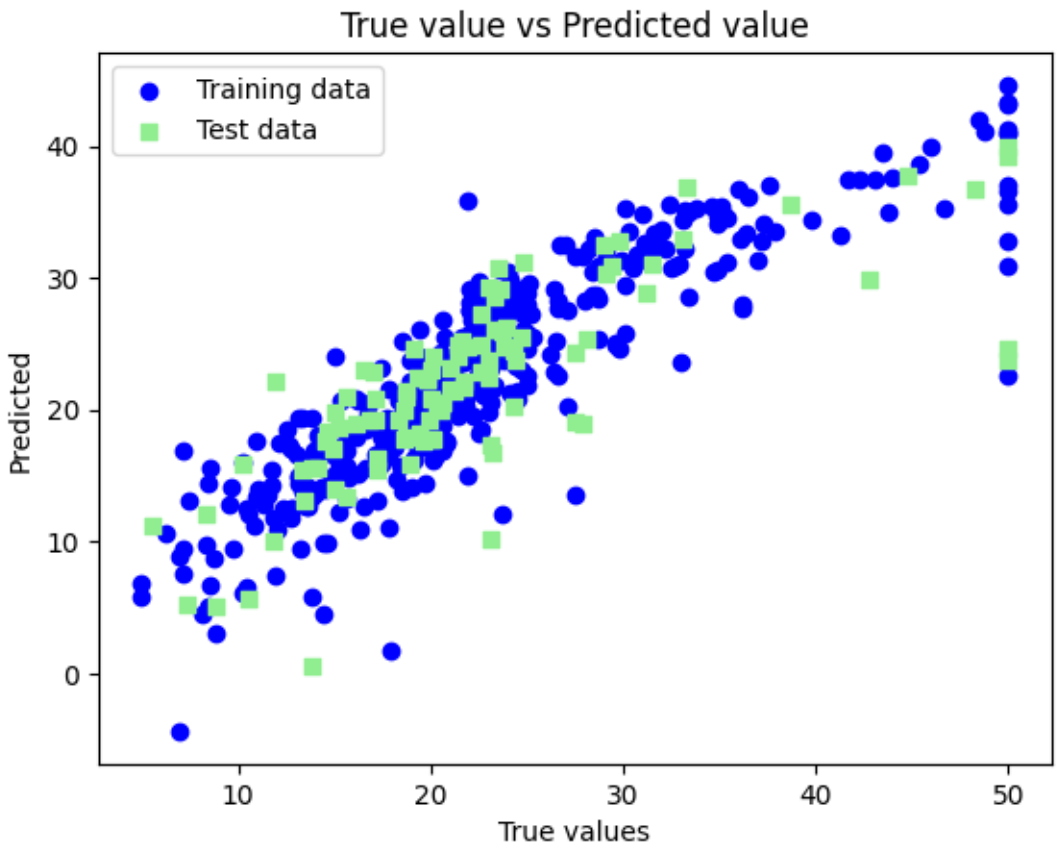
```
print('RMSE is {}'.format(rmse))
print('R2 score is {}'.format(r2))
```

```
The model performance for training set
--------------------------------------
MAE is 3.1031563965794335
MSE is 19.326470203585725
RMSE is 4.396188144698282
R2 score is 0.7730135569264234

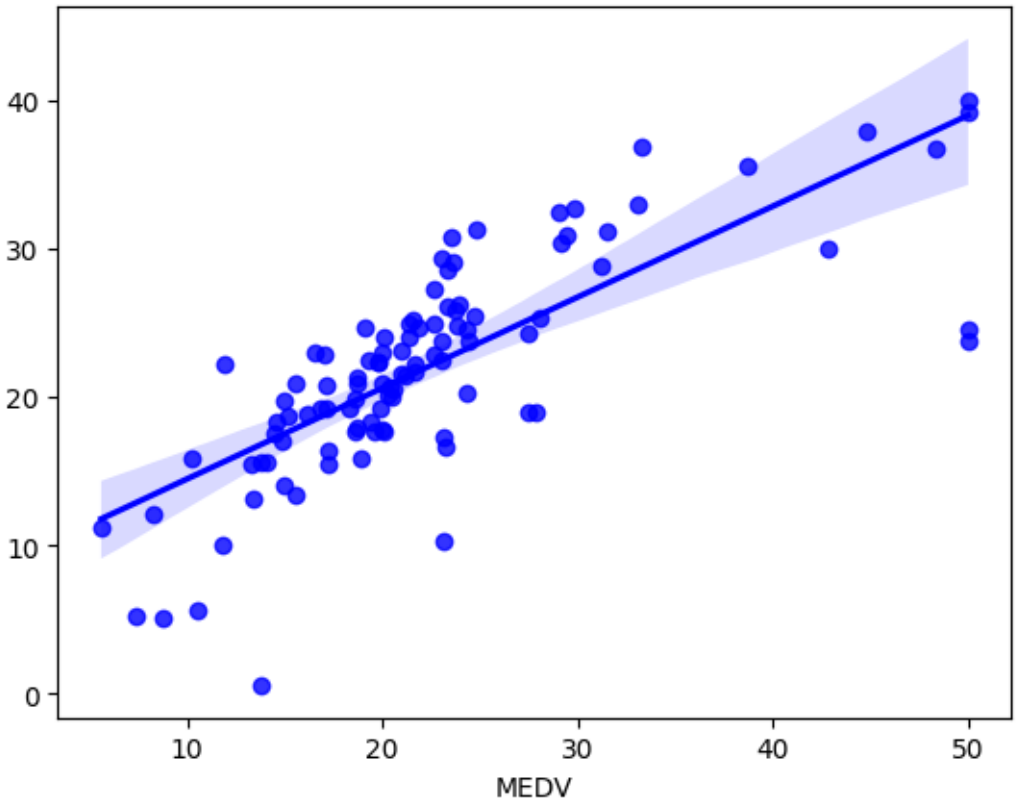

The model performance for testing set
--------------------------------------
MAE is 3.8429092204444983
MSE is 33.44897999767639
RMSE is 5.783509315085123
R2 score is 0.5892223849182525
```

PLOTTING THE LINEAR REGRESSION

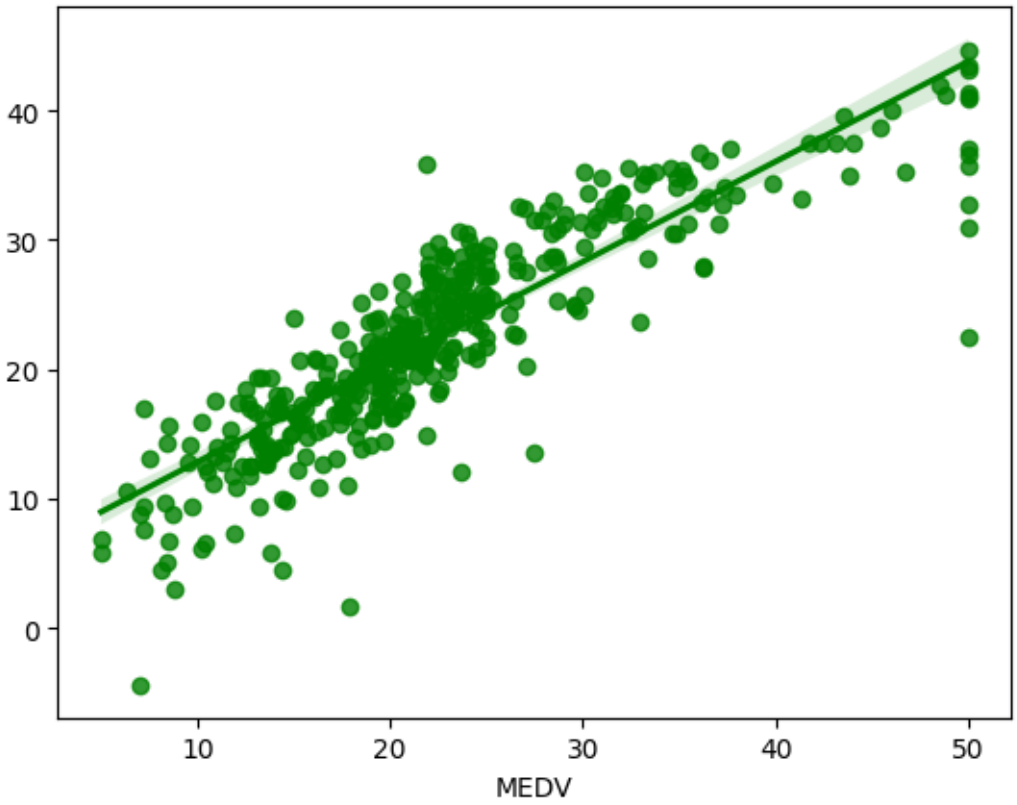
[25]:
```
plt.scatter(ytrain ,ytrain_pred,c='blue',marker='o',label='Training data')
plt.scatter(ytest,ytest_pred ,c='lightgreen',marker='s',label='Test data')
plt.xlabel('True values')
plt.ylabel('Predicted')
plt.title("True value vs Predicted value")
plt.legend(loc= 'upper left')
#plt.hlines(y=0,xmin=0,xmax=50)
plt.plot()
plt.show()
```



[26]:
```
sns.regplot(x=ytest, y=ytest_pred, color='blue')
plt.show()
```



[27]:
```
sns.regplot(x=ytrain, y=ytrain_pred, color='green')
plt.show()
```



Conclusion

In this way we have done data analysis using linear regression for Boston Dataset and predict the price of houses using the features of the Boston Dataset