Deep Learning Practical Assignment 1

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Importing Dataset & Libraries

[64]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
```

[65]:
```
df = pd.read_csv('D:\DL Practical\BostonHousingData.csv')
```

[66]:
```
df
```

[66]:
```
         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
1     0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242
2     0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242
3     0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222
4     0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222
..        …    …     …     …      …    …     …   …   …    …
501   0.06263   0.0  11.93     0  0.573  6.593  69.1  2.4786    1  273
502   0.04527   0.0  11.93     0  0.573  6.120  76.7  2.2875    1  273
503   0.06076   0.0  11.93     0  0.573  6.976  91.0  2.1675    1  273
504   0.10959   0.0  11.93     0  0.573  6.794  89.3  2.3889    1  273
505   0.04741   0.0  11.93     0  0.573  6.030  80.8  2.5050    1  273

     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]
```

[67]:
```
x = df.drop("MEDV", axis=1).values
y = df["MEDV"].values
```

[68]:
```
x.shape
```

[68]: (506, 13)

[69]:
```
y.shape
```

[69]: (506,)

[70]:
```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2)
```

[71]:
```
def shape():
   print("x_train Shape :",x_train.shape)
   print("x_test Shape :",x_test.shape)
   print("y_train shape :",y_train.shape)
   print("y_test shape :",y_test.shape)
shape()
```

```
x_train Shape : (404, 13)
x_test Shape : (102, 13)
y_train shape : (404,)
y_test shape : (102,)
```

Data Preprocessing

[72]:
```
mean=x_train.mean(axis=0)
std=x_train.std(axis=0)

x_train=(x_train-mean)/std
x_test=(x_test-mean)/std
```

[76]:
```
x_train[0]
```

[76]:
```
array([-0.41806237, -0.50156705, -0.76370333, -0.25683275, -0.47105102,
       -0.47810275,  0.00600064, -0.21826774, -0.53353005, -0.79042967,
        0.32551634,  0.44829015, -0.42781533])
```

[77]:
```
y_train[0]
```

[77]: 18.9

Building our Model

[78]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
```

[79]:
```
model=Sequential()
model.add(Dense(128,activation='relu',input_shape=(x_train[0].shape)))
model.add(Dense(64,activation='relu'))
model.add(Dense(1,activation='linear'))
model.compile(optimizer='adam', loss='mse', metrics=['mae'])
model.summary()
```

```
Model: "sequential_3"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_9 (Dense)             (None, 128)               1792

 dense_10 (Dense)            (None, 64)                8256

 dense_11 (Dense)            (None, 1)                 65

=================================================================
Total params: 10,113
Trainable params: 10,113
Non-trainable params: 0
_________________________________________________________________
```

Training our Model

[80]:
```
model.fit(x_train, y_train, epochs=100, batch_size=1, verbose=1,␣
↪validation_data=(x_test, y_test))
```

```
Epoch 1/100
404/404 [==============================] - 2s 2ms/step - loss: 122.7514 - mae:
7.8024 - val_loss: 18.8983 - val_mae: 3.2053
Epoch 2/100
404/404 [==============================] - 1s 2ms/step - loss: 20.5720 - mae:
3.0962 - val_loss: 14.2718 - val_mae: 2.8681
Epoch 3/100
404/404 [==============================] - 1s 2ms/step - loss: 17.1919 - mae:
2.9065 - val_loss: 13.6511 - val_mae: 2.7763
Epoch 4/100
404/404 [==============================] - 1s 2ms/step - loss: 14.8424 - mae:
2.6261 - val_loss: 14.0540 - val_mae: 2.7540
Epoch 5/100
404/404 [==============================] - 1s 2ms/step - loss: 14.4971 - mae:
2.6557 - val_loss: 10.0695 - val_mae: 2.3094
Epoch 6/100
404/404 [==============================] - 1s 2ms/step - loss: 12.5962 - mae:
2.4777 - val_loss: 11.6453 - val_mae: 2.5423
Epoch 7/100
404/404 [==============================] - 1s 2ms/step - loss: 12.9367 - mae:
2.4549 - val_loss: 10.0990 - val_mae: 2.3056
```

```
Epoch 8/100
404/404 [==============================] - 1s 2ms/step - loss: 11.7447 - mae:
2.3959 - val_loss: 9.0170 - val_mae: 2.3507
Epoch 9/100
404/404 [==============================] - 1s 2ms/step - loss: 11.3679 - mae:
2.4240 - val_loss: 9.5588 - val_mae: 2.2564
Epoch 10/100
404/404 [==============================] - 1s 2ms/step - loss: 10.8914 - mae:
2.3683 - val_loss: 10.2646 - val_mae: 2.4917
Epoch 11/100
404/404 [==============================] - 1s 2ms/step - loss: 10.1724 - mae:
2.3232 - val_loss: 11.0658 - val_mae: 2.3995
Epoch 12/100
404/404 [==============================] - 1s 2ms/step - loss: 9.9657 - mae:
2.2338 - val_loss: 9.0501 - val_mae: 2.4146
Epoch 13/100
404/404 [==============================] - 1s 2ms/step - loss: 10.1195 - mae:
2.2879 - val_loss: 9.5007 - val_mae: 2.2463
Epoch 14/100
404/404 [==============================] - 1s 2ms/step - loss: 9.9409 - mae:
2.2706 - val_loss: 8.6730 - val_mae: 2.2380
Epoch 15/100
404/404 [==============================] - 1s 2ms/step - loss: 8.8228 - mae:
2.1003 - val_loss: 9.7525 - val_mae: 2.3487
Epoch 16/100
404/404 [==============================] - 1s 2ms/step - loss: 8.6597 - mae:
2.1386 - val_loss: 8.6737 - val_mae: 2.1562
Epoch 17/100
404/404 [==============================] - 1s 2ms/step - loss: 8.8402 - mae:
2.1490 - val_loss: 8.9486 - val_mae: 2.3652
Epoch 18/100
404/404 [==============================] - 1s 2ms/step - loss: 8.1009 - mae:
2.0873 - val_loss: 6.9322 - val_mae: 1.9848
Epoch 19/100
404/404 [==============================] - 1s 2ms/step - loss: 8.8403 - mae:
2.1454 - val_loss: 11.6595 - val_mae: 2.7453
Epoch 20/100
404/404 [==============================] - 1s 2ms/step - loss: 7.8556 - mae:
2.0820 - val_loss: 7.8804 - val_mae: 2.1459
Epoch 21/100
404/404 [==============================] - 1s 2ms/step - loss: 7.4412 - mae:
1.9469 - val_loss: 7.3990 - val_mae: 1.9677
Epoch 22/100
404/404 [==============================] - 1s 2ms/step - loss: 7.0529 - mae:
1.9630 - val_loss: 8.2771 - val_mae: 2.2583
Epoch 23/100
404/404 [==============================] - 1s 2ms/step - loss: 6.8204 - mae:
1.9124 - val_loss: 7.6218 - val_mae: 2.0653
```

```
Epoch 24/100
404/404 [==============================] - 1s 2ms/step - loss: 7.1741 - mae:
1.9978 - val_loss: 9.6626 - val_mae: 2.3492
Epoch 25/100
404/404 [==============================] - 1s 2ms/step - loss: 6.9984 - mae:
1.9229 - val_loss: 7.7421 - val_mae: 2.0834
Epoch 26/100
404/404 [==============================] - 1s 2ms/step - loss: 6.5634 - mae:
1.8941 - val_loss: 7.4726 - val_mae: 2.1338
Epoch 27/100
404/404 [==============================] - 1s 2ms/step - loss: 6.9132 - mae:
1.9152 - val_loss: 11.1166 - val_mae: 2.4918
Epoch 28/100
404/404 [==============================] - 1s 2ms/step - loss: 6.5505 - mae:
1.8701 - val_loss: 7.4778 - val_mae: 2.0639
Epoch 29/100
404/404 [==============================] - 1s 2ms/step - loss: 6.1217 - mae:
1.8127 - val_loss: 6.7181 - val_mae: 2.0006
Epoch 30/100
404/404 [==============================] - 1s 2ms/step - loss: 6.4757 - mae:
1.9208 - val_loss: 8.2838 - val_mae: 2.2482
Epoch 31/100
404/404 [==============================] - 1s 2ms/step - loss: 6.0748 - mae:
1.7736 - val_loss: 8.5714 - val_mae: 2.2959
Epoch 32/100
404/404 [==============================] - 1s 3ms/step - loss: 5.7130 - mae:
1.7284 - val_loss: 8.3215 - val_mae: 2.0364
Epoch 33/100
404/404 [==============================] - 1s 2ms/step - loss: 5.7975 - mae:
1.8326 - val_loss: 7.5580 - val_mae: 2.1304
Epoch 34/100
404/404 [==============================] - 1s 2ms/step - loss: 5.6768 - mae:
1.7565 - val_loss: 7.1233 - val_mae: 2.0700
Epoch 35/100
404/404 [==============================] - 1s 2ms/step - loss: 5.3299 - mae:
1.7184 - val_loss: 7.2935 - val_mae: 2.0338
Epoch 36/100
404/404 [==============================] - 1s 2ms/step - loss: 5.7728 - mae:
1.8134 - val_loss: 8.1987 - val_mae: 2.1687
Epoch 37/100
404/404 [==============================] - 1s 2ms/step - loss: 5.1892 - mae:
1.6861 - val_loss: 7.7175 - val_mae: 2.0636
Epoch 38/100
404/404 [==============================] - 1s 2ms/step - loss: 4.7822 - mae:
1.6326 - val_loss: 8.0454 - val_mae: 2.1404
Epoch 39/100
404/404 [==============================] - 1s 3ms/step - loss: 5.1292 - mae:
1.6347 - val_loss: 7.0536 - val_mae: 1.9274
```

```
Epoch 40/100
404/404 [==============================] - 1s 2ms/step - loss: 4.8543 - mae:
1.6360 - val_loss: 10.1126 - val_mae: 2.1864
Epoch 41/100
404/404 [==============================] - 1s 2ms/step - loss: 4.7250 - mae:
1.6366 - val_loss: 9.2308 - val_mae: 2.1742
Epoch 42/100
404/404 [==============================] - 1s 2ms/step - loss: 4.4224 - mae:
1.5896 - val_loss: 7.1169 - val_mae: 1.9416
Epoch 43/100
404/404 [==============================] - 1s 2ms/step - loss: 4.5178 - mae:
1.6147 - val_loss: 6.9689 - val_mae: 1.9456
Epoch 44/100
404/404 [==============================] - 1s 2ms/step - loss: 4.1405 - mae:
1.5204 - val_loss: 7.5730 - val_mae: 2.0373
Epoch 45/100
404/404 [==============================] - 1s 2ms/step - loss: 4.6359 - mae:
1.6717 - val_loss: 9.4077 - val_mae: 2.0370
Epoch 46/100
404/404 [==============================] - 1s 2ms/step - loss: 4.5242 - mae:
1.6365 - val_loss: 11.0532 - val_mae: 2.5320
Epoch 47/100
404/404 [==============================] - 1s 2ms/step - loss: 4.6404 - mae:
1.6174 - val_loss: 6.9241 - val_mae: 1.9694
Epoch 48/100
404/404 [==============================] - 1s 2ms/step - loss: 4.1196 - mae:
1.5094 - val_loss: 7.3821 - val_mae: 1.9150
Epoch 49/100
404/404 [==============================] - 1s 2ms/step - loss: 4.0190 - mae:
1.4781 - val_loss: 9.3261 - val_mae: 2.2589
Epoch 50/100
404/404 [==============================] - 1s 2ms/step - loss: 3.9047 - mae:
1.4925 - val_loss: 12.1854 - val_mae: 2.6621
Epoch 51/100
404/404 [==============================] - 1s 2ms/step - loss: 3.7529 - mae:
1.4609 - val_loss: 8.1296 - val_mae: 2.1177
Epoch 52/100
404/404 [==============================] - 1s 2ms/step - loss: 3.7580 - mae:
1.4777 - val_loss: 6.6428 - val_mae: 1.9362
Epoch 53/100
404/404 [==============================] - 1s 2ms/step - loss: 3.6003 - mae:
1.4320 - val_loss: 7.0106 - val_mae: 1.9055
Epoch 54/100
404/404 [==============================] - 1s 2ms/step - loss: 3.6284 - mae:
1.4497 - val_loss: 9.0336 - val_mae: 2.2230
Epoch 55/100
404/404 [==============================] - 1s 2ms/step - loss: 3.2737 - mae:
1.3521 - val_loss: 9.1390 - val_mae: 2.1304
```

```
Epoch 56/100
404/404 [==============================] - 1s 2ms/step - loss: 3.7795 - mae:
1.4707 - val_loss: 7.4339 - val_mae: 2.0537
Epoch 57/100
404/404 [==============================] - 1s 2ms/step - loss: 3.4772 - mae:
1.4111 - val_loss: 6.8302 - val_mae: 1.9363
Epoch 58/100
404/404 [==============================] - 1s 2ms/step - loss: 3.2055 - mae:
1.3511 - val_loss: 16.6738 - val_mae: 3.0904
Epoch 59/100
404/404 [==============================] - 1s 2ms/step - loss: 4.3952 - mae:
1.5588 - val_loss: 11.2270 - val_mae: 2.4112
Epoch 60/100
404/404 [==============================] - 1s 2ms/step - loss: 3.3435 - mae:
1.3791 - val_loss: 9.4940 - val_mae: 2.1624
Epoch 61/100
404/404 [==============================] - 1s 2ms/step - loss: 3.1103 - mae:
1.3210 - val_loss: 6.3960 - val_mae: 1.8606
Epoch 62/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0923 - mae:
1.3436 - val_loss: 8.5034 - val_mae: 2.1727
Epoch 63/100
404/404 [==============================] - 1s 2ms/step - loss: 3.2414 - mae:
1.3262 - val_loss: 9.0952 - val_mae: 2.0883
Epoch 64/100
404/404 [==============================] - 1s 2ms/step - loss: 3.4099 - mae:
1.3948 - val_loss: 10.8434 - val_mae: 2.2867
Epoch 65/100
404/404 [==============================] - 1s 2ms/step - loss: 3.6054 - mae:
1.3899 - val_loss: 7.3336 - val_mae: 1.9164
Epoch 66/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0011 - mae:
1.3181 - val_loss: 7.6100 - val_mae: 2.0637
Epoch 67/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0930 - mae:
1.2935 - val_loss: 9.7658 - val_mae: 2.2539
Epoch 68/100
404/404 [==============================] - 1s 2ms/step - loss: 2.8484 - mae:
1.2830 - val_loss: 6.7758 - val_mae: 1.8566
Epoch 69/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5743 - mae:
1.2306 - val_loss: 7.3128 - val_mae: 2.0353
Epoch 70/100
404/404 [==============================] - 1s 2ms/step - loss: 2.9784 - mae:
1.3139 - val_loss: 8.1831 - val_mae: 2.0943
Epoch 71/100
404/404 [==============================] - 1s 2ms/step - loss: 2.9735 - mae:
1.3460 - val_loss: 9.7729 - val_mae: 2.2778
```

```
Epoch 72/100
404/404 [==============================] - 1s 2ms/step - loss: 2.7244 - mae:
1.2531 - val_loss: 7.7489 - val_mae: 1.9240
Epoch 73/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4394 - mae:
1.2029 - val_loss: 8.6421 - val_mae: 1.9805
Epoch 74/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5418 - mae:
1.1975 - val_loss: 9.0166 - val_mae: 2.1990
Epoch 75/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5346 - mae:
1.2040 - val_loss: 11.2391 - val_mae: 2.4369
Epoch 76/100
404/404 [==============================] - 1s 2ms/step - loss: 3.1394 - mae:
1.3106 - val_loss: 7.8039 - val_mae: 1.8776
Epoch 77/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4538 - mae:
1.2166 - val_loss: 7.2163 - val_mae: 1.9423
Epoch 78/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3804 - mae:
1.1864 - val_loss: 6.7784 - val_mae: 1.9715
Epoch 79/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5266 - mae:
1.1626 - val_loss: 9.3545 - val_mae: 2.0531
Epoch 80/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6632 - mae:
1.2185 - val_loss: 7.1447 - val_mae: 2.0475
Epoch 81/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3866 - mae:
1.1644 - val_loss: 8.8078 - val_mae: 2.2285
Epoch 82/100
404/404 [==============================] - 1s 2ms/step - loss: 1.8928 - mae:
1.0645 - val_loss: 8.2891 - val_mae: 2.0856
Epoch 83/100
404/404 [==============================] - 1s 2ms/step - loss: 2.1163 - mae:
1.1055 - val_loss: 7.7154 - val_mae: 2.0273
Epoch 84/100
404/404 [==============================] - 1s 2ms/step - loss: 1.9812 - mae:
1.0874 - val_loss: 7.7378 - val_mae: 1.9539
Epoch 85/100
404/404 [==============================] - 1s 2ms/step - loss: 2.1178 - mae:
1.1094 - val_loss: 8.9278 - val_mae: 2.0563
Epoch 86/100
404/404 [==============================] - 1s 2ms/step - loss: 2.1890 - mae:
1.1285 - val_loss: 8.5106 - val_mae: 2.1917
Epoch 87/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5184 - mae:
1.2007 - val_loss: 6.4885 - val_mae: 1.8473
```

```
Epoch 88/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4276 - mae:
1.1467 - val_loss: 6.9221 - val_mae: 1.9069
Epoch 89/100
404/404 [==============================] - 1s 2ms/step - loss: 1.9468 - mae:
1.0529 - val_loss: 6.8869 - val_mae: 1.9088
Epoch 90/100
404/404 [==============================] - 1s 2ms/step - loss: 2.2542 - mae:
1.1150 - val_loss: 6.6561 - val_mae: 1.8672
Epoch 91/100
404/404 [==============================] - 1s 2ms/step - loss: 2.1123 - mae:
1.0798 - val_loss: 8.9416 - val_mae: 2.1173
Epoch 92/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6635 - mae:
1.1923 - val_loss: 8.1389 - val_mae: 2.1324
Epoch 93/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4089 - mae:
1.1399 - val_loss: 8.7985 - val_mae: 2.1074
Epoch 94/100
404/404 [==============================] - 1s 2ms/step - loss: 1.8803 - mae:
1.0292 - val_loss: 7.0289 - val_mae: 1.9118
Epoch 95/100
404/404 [==============================] - 1s 2ms/step - loss: 1.7914 - mae:
1.0158 - val_loss: 6.8045 - val_mae: 1.9054
Epoch 96/100
404/404 [==============================] - 1s 2ms/step - loss: 2.0587 - mae:
1.0679 - val_loss: 6.6291 - val_mae: 1.9192
Epoch 97/100
404/404 [==============================] - 1s 2ms/step - loss: 1.7034 - mae:
0.9980 - val_loss: 6.5601 - val_mae: 1.9169
Epoch 98/100
404/404 [==============================] - 1s 2ms/step - loss: 1.9610 - mae:
1.0595 - val_loss: 9.0730 - val_mae: 2.3027
Epoch 99/100
404/404 [==============================] - 1s 2ms/step - loss: 2.0075 - mae:
1.0775 - val_loss: 8.3617 - val_mae: 2.2196
Epoch 100/100
404/404 [==============================] - 1s 2ms/step - loss: 2.2916 - mae:
1.1874 - val_loss: 6.8608 - val_mae: 1.8924
```

[80]:
```
<keras.callbacks.History at 0x1b7b7c194c0>
```

[81]:
```
x_test[8]
```

[81]:
```
array([-0.42101827, -0.50156705, -1.13081973, -0.25683275, -0.55572682,
        0.19758953,  0.20684755, -0.34272202, -0.87422469, -0.84336666,
       -0.32505625,  0.41244772, -0.63500406])
```

Testing our Model

[84]:
```
test_input=[[-0.42101827, -0.50156705, -1.13081973, -0.25683275, -0.55572682,
        0.19758953,  0.20684755, -0.34272202, -0.87422469, -0.84336666,
       -0.32505625,  0.41244772, -0.63500406]]
print("Actual Output :",y_test[8])
print("Predicted Output :",model.predict(test_input))
```

```
Actual Output : 22.0
1/1 [==============================] - 0s 85ms/step
Predicted Output : [[21.148806]]
```

Evaluating our Model

[87]:
```
mse_nn,mae_nn=model.evaluate(x_test,y_test)
print('Mean squared error on test data :',mse_nn)
print('Mean absolute error on test data :',mae_nn)

from sklearn.metrics import r2_score
y_dl=model.predict(x_test)
r2=r2_score(y_test,y_dl)
print('R2 Score :',r2)
```

```
4/4 [==============================] - 0s 0s/step - loss: 6.8608 - mae: 1.8924
Mean squared error on test data : 6.860829830169678
Mean absolute error on test data : 1.8923770189285278
4/4 [==============================] - 0s 0s/step
R2 Score : 0.9268583351666828
```