

Deep Learning Practical Assignment 1

April 30, 2023

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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