dl-1

April 29, 2024

[ ]:
```
import tensorflow as tf
from tensorflow.keras.datasets import boston_housing
from sklearn import preprocessing
import plotly.graph_objects as go
import matplotlib.pyplot as plt
```

[ ]:
```
(train_x,train_y),(test_x,test_y)=boston_housing.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/boston_housing.npz
57026/57026 [==============================] - 0s 0us/step
```

[ ]:
```
print("Train Shape :",train_x.shape)
print("Test Shape :",test_x.shape)
print("Training Sample :",train_x[0])
print("Training Target Sample :",train_y[0])
```

```
Train Shape : (404, 13)
Test Shape : (102, 13)
Training Sample : [  1.23247   0.        8.14      0.        0.538     6.142
91.7
   3.9769    4.      307.       21.      396.9      18.72    ]
Training Target Sample : 15.2
```

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

[ ]:
```
train_x=(train_x-mean)/std
test_x=(test_x-mean)/std
```

[ ]:
```
train_x[0]
```

[ ]:
```
array([-0.27224633, -0.48361547, -0.43576161, -0.25683275, -0.1652266 ,
       -0.1764426 ,  0.81306188,  0.1166983 , -0.62624905, -0.59517003,
        1.14850044,  0.44807713,  0.8252202 ])
```

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

[ ]:
```python
def HousePricePredictionModel():
  model=Sequential()
  model.add(Dense(128,activation='relu',input_shape=(train_x[0].
 ↪shape),name='dense_1')) #128 Neurons
  model.add(Dense(64,activation='relu',name='dense_2')) #64 Neurons
  model.add(Dense(1,activation='linear',name='dense_output')) #1 Neuron
  model.compile(optimizer='adam', loss='mse', metrics=['mae'])
  model.summary()
  return model
```

[ ]:
```python
model=HousePricePredictionModel()
history=model.
 ↪fit(x=train_x,y=train_y,epochs=100,batch_size=1,verbose=1,validation_data=(test_x,test_y))
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_1 (Dense)             (None, 128)               1792

 dense_2 (Dense)             (None, 64)                8256

 dense_output (Dense)        (None, 1)                 65

=================================================================
Total params: 10113 (39.50 KB)
Trainable params: 10113 (39.50 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/100
404/404 [==============================] - 2s 2ms/step - loss: 105.1573 - mae:
6.8544 - val_loss: 26.4772 - val_mae: 3.8849
Epoch 2/100
404/404 [==============================] - 1s 2ms/step - loss: 18.3881 - mae:
2.8920 - val_loss: 19.2604 - val_mae: 3.1217
Epoch 3/100
404/404 [==============================] - 1s 2ms/step - loss: 13.4310 - mae:
2.5604 - val_loss: 24.2789 - val_mae: 3.4730
Epoch 4/100
404/404 [==============================] - 1s 2ms/step - loss: 12.8564 - mae:
2.6224 - val_loss: 20.7704 - val_mae: 3.0387
Epoch 5/100
404/404 [==============================] - 1s 2ms/step - loss: 11.6064 - mae:
2.4140 - val_loss: 29.3337 - val_mae: 3.4136
Epoch 6/100
404/404 [==============================] - 1s 2ms/step - loss: 10.6591 - mae:
2.3145 - val_loss: 22.0202 - val_mae: 3.0515
```

```
Epoch 7/100
404/404 [==============================] - 1s 2ms/step - loss: 10.1933 - mae:
2.2966 - val_loss: 24.7855 - val_mae: 3.2647
Epoch 8/100
404/404 [==============================] - 1s 3ms/step - loss: 10.4488 - mae:
2.3890 - val_loss: 25.4460 - val_mae: 3.3251
Epoch 9/100
404/404 [==============================] - 1s 2ms/step - loss: 10.6721 - mae:
2.4288 - val_loss: 18.5491 - val_mae: 2.8343
Epoch 10/100
404/404 [==============================] - 1s 2ms/step - loss: 9.7626 - mae:
2.2443 - val_loss: 18.2872 - val_mae: 2.6382
Epoch 11/100
404/404 [==============================] - 1s 2ms/step - loss: 9.1896 - mae:
2.1740 - val_loss: 18.5864 - val_mae: 2.8444
Epoch 12/100
404/404 [==============================] - 1s 2ms/step - loss: 8.8790 - mae:
2.2036 - val_loss: 28.1095 - val_mae: 3.1375
Epoch 13/100
404/404 [==============================] - 1s 2ms/step - loss: 9.3221 - mae:
2.1735 - val_loss: 22.1057 - val_mae: 3.0095
Epoch 14/100
404/404 [==============================] - 1s 2ms/step - loss: 8.2503 - mae:
2.0313 - val_loss: 24.7198 - val_mae: 3.4032
Epoch 15/100
404/404 [==============================] - 1s 2ms/step - loss: 8.4433 - mae:
2.1097 - val_loss: 15.9679 - val_mae: 2.5888
Epoch 16/100
404/404 [==============================] - 1s 2ms/step - loss: 7.6300 - mae:
1.9993 - val_loss: 25.3262 - val_mae: 3.2867
Epoch 17/100
404/404 [==============================] - 1s 2ms/step - loss: 7.7940 - mae:
2.0479 - val_loss: 21.6699 - val_mae: 2.8441
Epoch 18/100
404/404 [==============================] - 1s 2ms/step - loss: 8.0377 - mae:
2.1155 - val_loss: 17.5582 - val_mae: 2.7240
Epoch 19/100
404/404 [==============================] - 1s 2ms/step - loss: 7.6533 - mae:
1.9698 - val_loss: 22.1726 - val_mae: 2.8663
Epoch 20/100
404/404 [==============================] - 1s 2ms/step - loss: 7.2967 - mae:
2.0140 - val_loss: 17.1870 - val_mae: 2.5850
Epoch 21/100
404/404 [==============================] - 1s 2ms/step - loss: 7.2439 - mae:
1.9163 - val_loss: 23.1554 - val_mae: 3.4150
Epoch 22/100
404/404 [==============================] - 1s 2ms/step - loss: 7.4597 - mae:
1.9605 - val_loss: 16.7647 - val_mae: 2.6188
```

```
Epoch 23/100
404/404 [==============================] - 1s 3ms/step - loss: 6.9768 - mae:
1.9094 - val_loss: 16.2485 - val_mae: 2.5095
Epoch 24/100
404/404 [==============================] - 1s 3ms/step - loss: 6.7483 - mae:
1.9080 - val_loss: 15.7093 - val_mae: 2.4118
Epoch 25/100
404/404 [==============================] - 1s 2ms/step - loss: 6.5852 - mae:
1.9051 - val_loss: 18.5611 - val_mae: 2.8629
Epoch 26/100
404/404 [==============================] - 1s 2ms/step - loss: 6.3442 - mae:
1.8239 - val_loss: 26.4514 - val_mae: 3.6140
Epoch 27/100
404/404 [==============================] - 1s 2ms/step - loss: 6.2976 - mae:
1.8907 - val_loss: 15.0086 - val_mae: 2.5578
Epoch 28/100
404/404 [==============================] - 1s 2ms/step - loss: 6.9503 - mae:
1.8301 - val_loss: 13.2839 - val_mae: 2.4152
Epoch 29/100
404/404 [==============================] - 1s 2ms/step - loss: 6.0646 - mae:
1.7846 - val_loss: 15.3856 - val_mae: 2.6119
Epoch 30/100
404/404 [==============================] - 1s 2ms/step - loss: 5.7989 - mae:
1.7069 - val_loss: 18.0060 - val_mae: 2.8778
Epoch 31/100
404/404 [==============================] - 1s 2ms/step - loss: 6.0475 - mae:
1.8021 - val_loss: 16.6499 - val_mae: 2.6627
Epoch 32/100
404/404 [==============================] - 1s 2ms/step - loss: 5.8567 - mae:
1.7396 - val_loss: 17.2037 - val_mae: 2.6207
Epoch 33/100
404/404 [==============================] - 1s 2ms/step - loss: 5.1385 - mae:
1.6382 - val_loss: 14.1261 - val_mae: 2.5173
Epoch 34/100
404/404 [==============================] - 1s 2ms/step - loss: 5.1634 - mae:
1.6509 - val_loss: 15.4182 - val_mae: 2.7163
Epoch 35/100
404/404 [==============================] - 1s 2ms/step - loss: 5.1827 - mae:
1.6745 - val_loss: 12.3262 - val_mae: 2.4387
Epoch 36/100
404/404 [==============================] - 1s 2ms/step - loss: 5.2793 - mae:
1.6889 - val_loss: 14.7611 - val_mae: 2.5378
Epoch 37/100
404/404 [==============================] - 1s 2ms/step - loss: 4.8950 - mae:
1.6091 - val_loss: 16.0123 - val_mae: 2.8206
Epoch 38/100
404/404 [==============================] - 1s 3ms/step - loss: 4.8833 - mae:
1.6337 - val_loss: 12.4893 - val_mae: 2.4050
```

```
Epoch 39/100
404/404 [==============================] - 1s 3ms/step - loss: 5.0984 - mae:
1.6248 - val_loss: 20.8809 - val_mae: 3.2139
Epoch 40/100
404/404 [==============================] - 1s 2ms/step - loss: 5.0947 - mae:
1.6796 - val_loss: 12.3559 - val_mae: 2.4427
Epoch 41/100
404/404 [==============================] - 1s 2ms/step - loss: 4.4485 - mae:
1.5859 - val_loss: 15.3846 - val_mae: 2.6266
Epoch 42/100
404/404 [==============================] - 1s 2ms/step - loss: 4.5939 - mae:
1.6122 - val_loss: 12.8935 - val_mae: 2.3894
Epoch 43/100
404/404 [==============================] - 1s 2ms/step - loss: 4.2662 - mae:
1.5401 - val_loss: 12.2845 - val_mae: 2.4129
Epoch 44/100
404/404 [==============================] - 1s 2ms/step - loss: 4.7105 - mae:
1.6177 - val_loss: 14.2689 - val_mae: 2.6281
Epoch 45/100
404/404 [==============================] - 1s 2ms/step - loss: 4.5994 - mae:
1.5842 - val_loss: 14.2848 - val_mae: 2.5043
Epoch 46/100
404/404 [==============================] - 1s 2ms/step - loss: 4.4333 - mae:
1.5611 - val_loss: 11.5462 - val_mae: 2.3556
Epoch 47/100
404/404 [==============================] - 1s 2ms/step - loss: 4.2940 - mae:
1.5434 - val_loss: 12.6742 - val_mae: 2.4254
Epoch 48/100
404/404 [==============================] - 1s 2ms/step - loss: 4.0240 - mae:
1.5248 - val_loss: 16.4655 - val_mae: 2.8389
Epoch 49/100
404/404 [==============================] - 1s 2ms/step - loss: 4.3081 - mae:
1.5938 - val_loss: 11.4510 - val_mae: 2.3695
Epoch 50/100
404/404 [==============================] - 1s 2ms/step - loss: 4.3096 - mae:
1.4866 - val_loss: 11.3599 - val_mae: 2.4598
Epoch 51/100
404/404 [==============================] - 1s 2ms/step - loss: 4.0515 - mae:
1.5247 - val_loss: 10.3315 - val_mae: 2.2088
Epoch 52/100
404/404 [==============================] - 1s 2ms/step - loss: 3.8136 - mae:
1.5065 - val_loss: 11.3532 - val_mae: 2.3254
Epoch 53/100
404/404 [==============================] - 1s 3ms/step - loss: 3.7243 - mae:
1.4665 - val_loss: 11.8015 - val_mae: 2.3003
Epoch 54/100
404/404 [==============================] - 1s 3ms/step - loss: 3.5960 - mae:
1.3987 - val_loss: 13.9809 - val_mae: 2.7377
```

```
Epoch 55/100
404/404 [==============================] - 1s 2ms/step - loss: 3.8490 - mae:
1.4272 - val_loss: 14.3588 - val_mae: 2.5282
Epoch 56/100
404/404 [==============================] - 1s 2ms/step - loss: 3.5555 - mae:
1.4167 - val_loss: 12.6394 - val_mae: 2.7418
Epoch 57/100
404/404 [==============================] - 1s 2ms/step - loss: 3.4271 - mae:
1.3750 - val_loss: 11.1096 - val_mae: 2.3214
Epoch 58/100
404/404 [==============================] - 1s 2ms/step - loss: 4.1104 - mae:
1.4757 - val_loss: 11.7369 - val_mae: 2.3626
Epoch 59/100
404/404 [==============================] - 1s 2ms/step - loss: 3.6114 - mae:
1.4427 - val_loss: 12.9964 - val_mae: 2.5940
Epoch 60/100
404/404 [==============================] - 1s 2ms/step - loss: 3.5348 - mae:
1.3758 - val_loss: 13.6081 - val_mae: 2.5208
Epoch 61/100
404/404 [==============================] - 1s 2ms/step - loss: 3.2124 - mae:
1.3755 - val_loss: 11.9123 - val_mae: 2.4916
Epoch 62/100
404/404 [==============================] - 1s 2ms/step - loss: 3.5122 - mae:
1.4140 - val_loss: 11.8553 - val_mae: 2.2961
Epoch 63/100
404/404 [==============================] - 1s 2ms/step - loss: 3.7293 - mae:
1.4459 - val_loss: 12.0564 - val_mae: 2.4176
Epoch 64/100
404/404 [==============================] - 1s 2ms/step - loss: 3.6262 - mae:
1.3715 - val_loss: 11.1579 - val_mae: 2.4052
Epoch 65/100
404/404 [==============================] - 1s 2ms/step - loss: 3.3068 - mae:
1.3710 - val_loss: 11.8275 - val_mae: 2.4355
Epoch 66/100
404/404 [==============================] - 1s 2ms/step - loss: 3.1584 - mae:
1.3386 - val_loss: 11.5528 - val_mae: 2.4786
Epoch 67/100
404/404 [==============================] - 1s 2ms/step - loss: 3.4774 - mae:
1.3936 - val_loss: 14.7788 - val_mae: 2.7532
Epoch 68/100
404/404 [==============================] - 1s 3ms/step - loss: 4.1086 - mae:
1.4673 - val_loss: 14.4449 - val_mae: 2.5285
Epoch 69/100
404/404 [==============================] - 1s 3ms/step - loss: 3.2298 - mae:
1.3702 - val_loss: 11.8227 - val_mae: 2.3093
Epoch 70/100
404/404 [==============================] - 1s 2ms/step - loss: 2.9833 - mae:
1.2939 - val_loss: 12.3480 - val_mae: 2.4865
```

```
Epoch 71/100
404/404 [==============================] - 1s 2ms/step - loss: 2.9305 - mae:
1.2804 - val_loss: 14.4785 - val_mae: 2.7044
Epoch 72/100
404/404 [==============================] - 1s 2ms/step - loss: 2.8462 - mae:
1.2547 - val_loss: 14.0953 - val_mae: 2.8615
Epoch 73/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6504 - mae:
1.2090 - val_loss: 11.4618 - val_mae: 2.4959
Epoch 74/100
404/404 [==============================] - 1s 2ms/step - loss: 3.4273 - mae:
1.4065 - val_loss: 10.6010 - val_mae: 2.2548
Epoch 75/100
404/404 [==============================] - 1s 2ms/step - loss: 3.1637 - mae:
1.3618 - val_loss: 10.2108 - val_mae: 2.2965
Epoch 76/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0426 - mae:
1.3034 - val_loss: 12.3665 - val_mae: 2.5695
Epoch 77/100
404/404 [==============================] - 1s 2ms/step - loss: 3.1790 - mae:
1.3291 - val_loss: 11.5152 - val_mae: 2.3948
Epoch 78/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6106 - mae:
1.2086 - val_loss: 12.7598 - val_mae: 2.4383
Epoch 79/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0004 - mae:
1.3143 - val_loss: 11.6451 - val_mae: 2.4104
Epoch 80/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0962 - mae:
1.2924 - val_loss: 11.0637 - val_mae: 2.3769
Epoch 81/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5358 - mae:
1.2066 - val_loss: 11.1246 - val_mae: 2.5179
Epoch 82/100
404/404 [==============================] - 1s 2ms/step - loss: 2.7736 - mae:
1.2301 - val_loss: 11.0412 - val_mae: 2.4354
Epoch 83/100
404/404 [==============================] - 1s 3ms/step - loss: 3.0967 - mae:
1.2953 - val_loss: 13.1144 - val_mae: 2.5434
Epoch 84/100
404/404 [==============================] - 1s 3ms/step - loss: 2.9094 - mae:
1.2476 - val_loss: 10.3407 - val_mae: 2.3168
Epoch 85/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3655 - mae:
1.1455 - val_loss: 12.0468 - val_mae: 2.3457
Epoch 86/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6953 - mae:
1.2196 - val_loss: 11.7692 - val_mae: 2.4890
```

```
Epoch 87/100
404/404 [==============================] - 1s 2ms/step - loss: 2.5780 - mae:
1.1963 - val_loss: 12.1750 - val_mae: 2.3008
Epoch 88/100
404/404 [==============================] - 1s 2ms/step - loss: 3.0786 - mae:
1.3137 - val_loss: 10.8993 - val_mae: 2.3241
Epoch 89/100
404/404 [==============================] - 1s 2ms/step - loss: 2.2300 - mae:
1.0989 - val_loss: 11.0223 - val_mae: 2.3422
Epoch 90/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4482 - mae:
1.1902 - val_loss: 11.3606 - val_mae: 2.4105
Epoch 91/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3593 - mae:
1.1642 - val_loss: 10.3123 - val_mae: 2.3654
Epoch 92/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3273 - mae:
1.1181 - val_loss: 10.1262 - val_mae: 2.2096
Epoch 93/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4862 - mae:
1.1905 - val_loss: 12.5619 - val_mae: 2.4429
Epoch 94/100
404/404 [==============================] - 1s 2ms/step - loss: 2.6926 - mae:
1.2653 - val_loss: 9.8133 - val_mae: 2.2528
Epoch 95/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4357 - mae:
1.1561 - val_loss: 10.3101 - val_mae: 2.2520
Epoch 96/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4437 - mae:
1.1551 - val_loss: 11.7081 - val_mae: 2.3610
Epoch 97/100
404/404 [==============================] - 1s 2ms/step - loss: 2.3008 - mae:
1.1241 - val_loss: 11.3845 - val_mae: 2.3941
Epoch 98/100
404/404 [==============================] - 1s 3ms/step - loss: 2.2561 - mae:
1.1368 - val_loss: 9.9193 - val_mae: 2.2567
Epoch 99/100
404/404 [==============================] - 1s 3ms/step - loss: 2.5401 - mae:
1.2102 - val_loss: 10.0739 - val_mae: 2.2588
Epoch 100/100
404/404 [==============================] - 1s 2ms/step - loss: 2.4294 - mae:
1.1355 - val_loss: 10.3713 - val_mae: 2.3987
```

[ ]:
```
test_x[8]
```

[ ]:
```
array([-0.39570978, -0.48361547,  2.13815109, -0.25683275,  0.20183093,
       -0.43176465,  0.85606329, -0.81539201, -0.85646254, -1.31131055,
```

```
         0.28394328,  0.24795926,  0.71618792])
```

```
[ ]: test_input=[[-0.39570978, -0.48361547,  2.13815109, -0.25683275,  0.20183093,
            -0.43176465,  0.85606329, -0.81539201, -0.85646254, -1.31131055,
             0.28394328,  0.24795926,  0.71618792]]
     print("Actual Output :",test_y[8])
     print("Predicted Output :",model.predict(test_input))
```

```
Actual Output : 20.5
1/1 [==============================] - 0s 112ms/step
Predicted Output : [[17.897112]]
```

```
[ ]: fig = go.Figure()
     fig.add_trace(go.Scattergl(y=history.history['loss'],name='Train'))
     fig.add_trace(go.Scattergl(y=history.history['val_loss'],name='Valid'))
     fig.update_layout(height=500, width=700,xaxis_title='Epoch',yaxis_title='Loss')
     fig.show()
```

```
[ ]: fig = go.Figure()
     fig.add_trace(go.Scattergl(y=history.history['mae'],name='Train'))
     fig.add_trace(go.Scattergl(y=history.history['val_mae'],name='Valid'))
     fig.update_layout(height=500, width=700,xaxis_title='Epoch',yaxis_title='Mean␣
      ↪Absolute Error')
     fig.show()
```

```
[ ]: mse_nn,mae_nn=model.evaluate(test_x,test_y)
```

```
4/4 [==============================] - 0s 4ms/step - loss: 10.3713 - mae: 2.3987
```

```
[ ]: print('Mean squared error on test data :',mse_nn)
     print('Mean absolute error on test data :',mae_nn)
```

```
Mean squared error on test data : 10.371269226074219
Mean absolute error on test data : 2.398691415786743
```

```
[ ]: from sklearn.metrics import r2_score
     y_dl=model.predict(test_x)
     r2=r2_score(test_y,y_dl)
     print('R2 Score :',r2)
```

```
4/4 [==============================] - 0s 6ms/step
R2 Score : 0.87541098462976
```

```
[ ]: from sklearn.linear_model import LinearRegression
     from sklearn.metrics import mean_squared_error,mean_absolute_error,r2_score
```

```
[ ]: lr_model=LinearRegression()
     lr_model.fit(train_x,train_y)
```

[ ]: LinearRegression()

[ ]:
```
y_pred=lr_model.predict(test_x)
```

[ ]:
```
mse_lr=mean_squared_error(test_y,y_pred)
mae_lr=mean_absolute_error(test_y,y_pred)
r2=r2_score(test_y,y_pred)
print('Mean squared error on test data :',mse_lr)
print('Mean absolute error on test data :',mae_lr)
print('R2 Score :',r2)
```

```
Mean squared error on test data : 23.19559925642298
Mean absolute error on test data : 3.4641858124067175
R2 Score : 0.7213535934621552
```