Topic : Neural Network for Simple Linear Regression

Objective for this template:

1. Introduce participants to fundamental concepts of simple linear regression
2. Use tensorflow to build a simple sequential neural network regression model
3. Demonstrate the process of training the model and evaluating its performance
4. Allow participants to practice normalizing the dataset to improve the performance of the dataset

Designed By: *Rodolfo C. Raga Jr.*

Step 1: load the tensorflow library and other helper libraries using the import keyword

```
import tensorflow as tf
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.metrics import r2_score

print("Done with library declaration. Current version of Tensorflow is :", tf.__version__)
```

```
Done with library declaration. Current version of Tensorflow is : 2.7.0
```

Step 2: Load a sample data into a numpy array. Here, the market_budget attribute serves as the feature attribute while the subscribers_gained attribute serves as the target attribute.

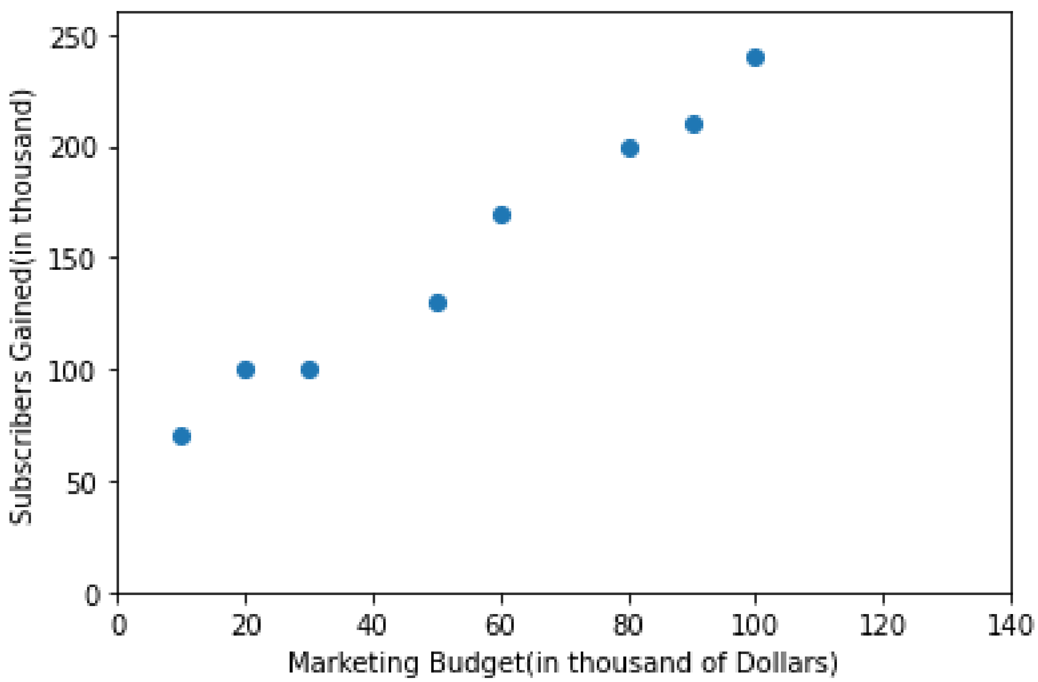
```
market_budget  = np.array([60,80,100,30,50,20,90,10,],  dtype=float)
subscribers_gained = np.array([170,200,240,100,130,100,210,70], dtype=float)
#market_budget  = np.array([50, 69,  85  , 83, 74, 81, 97,  92, 114, 85],  dtype=float)
#subscribers_gained = np.array([90, 125, 140, 160, 130, 180, 150, 140, 200, 130],  dtype=float)

print("marketing budget data :", market_budget)
print("# of subscribers gained :", subscribers_gained)
print("Done with loading data to dataframes...")
```

```
marketing budget data : [ 60.  80. 100.  30.  50.  20.  90.  10.]
# of subscribers gained : [170. 200. 240. 100. 130. 100. 210.  70.]
Done with loading data to dataframes...
```

Step 3: Analyze the relationship between the two attributes by visualizing the correlation using a scatter chart.

```
plt.scatter(market_budget, subscribers_gained)
plt.xlim(0,140)
plt.ylim(0,260)
plt.xlabel('Marketing Budget(in thousand of Dollars)')
plt.ylabel('Subscribers Gained(in thousand)')
plt.show()
print("Done with displaying scatter chart...")
```




```
Done with displaying scatter chart...
```

Step 3.1: Optionally, apply Normalization to the dataset using MinMaxScaler

```
from sklearn.preprocessing import MinMaxScaler
import pandas as pd
scaler = MinMaxScaler(feature_range=(0, 1))
rescaledMB = scaler.fit_transform(market_budget.reshape(-1, 1))
rescaledMBDF = pd.DataFrame(rescaledMB)

rescaledSG = scaler.fit_transform(subscribers_gained.reshape(-1, 1))
rescaledSGDF = pd.DataFrame(rescaledSG)

print("marketing budget data :", rescaledMBDF.head())
print("\n# of subscribers gained :", rescaledSGDF.head())
```

```
marketing budget data :           0
0  0.555556
1  0.777778
2  1.000000
3  0.222222
4  0.444444

# of subscribers gained :           0
0  0.588235
1  0.764706
2  1.000000
3  0.176471
4  0.352941
```

Step 4 : Separate the data into distinct training and testing datasets. Separating the dataset returns four NumPy arrays:

1. The X_train and y_train_labels arrays are the training set—the data the model uses to learn.
2. The X_test and y_test labels arrays are the data used to test the model performance.

```
#X_train, X_test, y_train, y_test = 
train_test_split(rescaledMBDF,rescaledSGDF,random_state=42, 
test_size=0.3)
X_train, X_test, y_train, y_test = 
train_test_split(market_budget,subscribers_gained,random_state=42, 
test_size=0.3)
print("Done with data separation...") #rescaledMBDF,rescaledSGDF
```

```
Done with data separation...
```

Step 5 : We start building the neural network by using the Sequential API to define a Sequential model object named model. This type of model takes a list of layers (Input, Hidden, Output) as arguments and implicitly assumes the order of the calculation from the input layer to the output layer based on the sequence of layer definitions.

```
model = tf.keras.Sequential()
print("Done with declaring Sequential model object...")
```

```
Done with declaring Sequential model object...
```

Step 6 : Then we start defining the layers using the Dense class. Dense implements the operation: output = activation(dot(input, kernel) + bias) where activation is the element-wise activation function passed as the activation argument, kernel is a weights matrix created by the layer, and bias is a bias vector created by the layer (only applicable if use_bias is True)

```
layer_0 = tf.keras.layers.Dense(units=40, input_shape=[1])
layer_1 = tf.keras.layers.Dense(units=20)
layer_2 = tf.keras.layers.Dense(units=10)
layer_3 = tf.keras.layers.Dense(units=1)
```

```
print("Done with defining layer properties...")
```

```
Done with defining layer properties...
```

Step 7 : After that, we insert the dense layer into our sequential model.

```
#model = tf.keras.Sequential([layer_0,layer_1,layer_2,layer_3])
model.add(layer_0)
model.add(layer_1)
model.add(layer_2)
model.add(layer_3)

#print the model architecture for inspection
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 dense_20 (Dense)            (None, 40)                80        
                                                                 
 dense_21 (Dense)            (None, 20)                820       
                                                                 
 dense_22 (Dense)            (None, 10)                210       
                                                                 
 dense_23 (Dense)            (None, 1)                 11        
                                                                 
=================================================================
Total params: 1,121
Trainable params: 1,121
Non-trainable params: 0
_________________________________________________________________
```

Step 8 : Compile the built model architecture. The compilation configures the learning process by defining an optimizer, a loss function, and other useful training parameters.

```
model.compile(loss='mean_squared_error',
              optimizer=tf.keras.optimizers.Adam(lr = 0.001),
metrics=['mse'])
print("Done with model compilation")
```

```
Done with model compilation

C:\Users\Jen\anaconda3\lib\site-packages\keras\optimizer_v2\
adam.py:105: UserWarning: The `lr` argument is deprecated, use
`learning_rate` instead.
  super(Adam, self).__init__(name, **kwargs)
```

Step 9 : Train the model by using the set training data

```
trained_model = model.fit(X_train, y_train, epochs=500, batch_size=32,
verbose=1)
print("Done with model training")
```

```
Epoch 1/500
1/1 [==============================] - 1s 735ms/step - loss:
33250.1016 - mse: 33250.1016
Epoch 2/500
1/1 [==============================] - 0s 4ms/step - loss: 32133.1602
- mse: 32133.1602
Epoch 3/500
1/1 [==============================] - 0s 19ms/step - loss: 31042.8633
- mse: 31042.8633
Epoch 4/500
1/1 [==============================] - 0s 5ms/step - loss: 29978.0566
- mse: 29978.0566
Epoch 5/500
1/1 [==============================] - 0s 14ms/step - loss: 28937.2500
- mse: 28937.2500
Epoch 6/500
1/1 [==============================] - 0s 10ms/step - loss: 27918.9883
- mse: 27918.9883
Epoch 7/500
1/1 [==============================] - 0s 12ms/step - loss: 26921.8281
- mse: 26921.8281
Epoch 8/500
1/1 [==============================] - 0s 12ms/step - loss: 25944.2852
- mse: 25944.2852
Epoch 9/500
1/1 [==============================] - 0s 8ms/step - loss: 24984.8848
- mse: 24984.8848
Epoch 10/500
1/1 [==============================] - 0s 15ms/step - loss: 24042.3320
- mse: 24042.3320
Epoch 11/500
1/1 [==============================] - 0s 10ms/step - loss: 23115.5215
- mse: 23115.5215
Epoch 12/500
1/1 [==============================] - 0s 10ms/step - loss: 22203.5273
- mse: 22203.5273
Epoch 13/500
1/1 [==============================] - 0s 14ms/step - loss: 21305.5645
- mse: 21305.5645
Epoch 14/500
1/1 [==============================] - 0s 4ms/step - loss: 20421.0059
- mse: 20421.0059
Epoch 15/500
1/1 [==============================] - 0s 12ms/step - loss: 19549.3945
- mse: 19549.3945
Epoch 16/500
```

```
1/1 [==============================] - 0s 10ms/step - loss: 18690.4102
- mse: 18690.4102
Epoch 17/500
1/1 [==============================] - 0s 10ms/step - loss: 17843.8867
- mse: 17843.8867
Epoch 18/500
1/1 [==============================] - 0s 5ms/step - loss: 17009.7695
- mse: 17009.7695
Epoch 19/500
1/1 [==============================] - 0s 12ms/step - loss: 16188.1328
- mse: 16188.1328
Epoch 20/500
1/1 [==============================] - 0s 12ms/step - loss: 15379.1484
- mse: 15379.1484
Epoch 21/500
1/1 [==============================] - 0s 15ms/step - loss: 14583.0938
- mse: 14583.0938
Epoch 22/500
1/1 [==============================] - 0s 6ms/step - loss: 13800.3379
- mse: 13800.3379
Epoch 23/500
1/1 [==============================] - 0s 12ms/step - loss: 13031.3506
- mse: 13031.3506
Epoch 24/500
1/1 [==============================] - 0s 8ms/step - loss: 12276.6953
- mse: 12276.6953
Epoch 25/500
1/1 [==============================] - 0s 6ms/step - loss: 11537.0225
- mse: 11537.0225
Epoch 26/500
1/1 [==============================] - 0s 11ms/step - loss: 10813.0732
- mse: 10813.0732
Epoch 27/500
1/1 [==============================] - 0s 6ms/step - loss: 10105.6699
- mse: 10105.6699
Epoch 28/500
1/1 [==============================] - 0s 13ms/step - loss: 9415.7197
- mse: 9415.7197
Epoch 29/500
1/1 [==============================] - 0s 12ms/step - loss: 8744.2051
- mse: 8744.2051
Epoch 30/500
1/1 [==============================] - 0s 6ms/step - loss: 8092.1772 -
mse: 8092.1772
Epoch 31/500
1/1 [==============================] - 0s 9ms/step - loss: 7460.7515 -
mse: 7460.7515
Epoch 32/500
1/1 [==============================] - 0s 13ms/step - loss: 6851.0889
- mse: 6851.0889
```

```
Epoch 33/500
1/1 [==============================] - 0s 5ms/step - loss: 6264.3965 -
mse: 6264.3965
Epoch 34/500
1/1 [==============================] - 0s 6ms/step - loss: 5701.8994 -
mse: 5701.8994
Epoch 35/500
1/1 [==============================] - 0s 7ms/step - loss: 5164.8213 -
mse: 5164.8213
Epoch 36/500
1/1 [==============================] - 0s 7ms/step - loss: 4654.3804 -
mse: 4654.3804
Epoch 37/500
1/1 [==============================] - 0s 8ms/step - loss: 4171.7490 -
mse: 4171.7490
Epoch 38/500
1/1 [==============================] - 0s 6ms/step - loss: 3718.0317 -
mse: 3718.0317
Epoch 39/500
1/1 [==============================] - 0s 7ms/step - loss: 3294.2422 -
mse: 3294.2422
Epoch 40/500
1/1 [==============================] - 0s 9ms/step - loss: 2901.2703 -
mse: 2901.2703
Epoch 41/500
1/1 [==============================] - 0s 9ms/step - loss: 2539.8464 -
mse: 2539.8464
Epoch 42/500
1/1 [==============================] - 0s 10ms/step - loss: 2210.5110
- mse: 2210.5110
Epoch 43/500
1/1 [==============================] - 0s 6ms/step - loss: 1913.5778 -
mse: 1913.5778
Epoch 44/500
1/1 [==============================] - 0s 10ms/step - loss: 1649.1000
- mse: 1649.1000
Epoch 45/500
1/1 [==============================] - 0s 11ms/step - loss: 1416.8418
- mse: 1416.8418
Epoch 46/500
1/1 [==============================] - 0s 8ms/step - loss: 1216.2419 -
mse: 1216.2419
Epoch 47/500
1/1 [==============================] - 0s 7ms/step - loss: 1046.4001 -
mse: 1046.4001
Epoch 48/500
1/1 [==============================] - 0s 6ms/step - loss: 906.0581 -
mse: 906.0581
Epoch 49/500
1/1 [==============================] - 0s 6ms/step - loss: 793.5976 -
```

```
mse: 793.5976
Epoch 50/500
1/1 [==============================] - 0s 10ms/step - loss: 707.0497 -
mse: 707.0497
Epoch 51/500
1/1 [==============================] - 0s 8ms/step - loss: 644.1174 -
mse: 644.1174
Epoch 52/500
1/1 [==============================] - 0s 8ms/step - loss: 602.2180 -
mse: 602.2180
Epoch 53/500
1/1 [==============================] - 0s 6ms/step - loss: 578.5372 -
mse: 578.5372
Epoch 54/500
1/1 [==============================] - 0s 11ms/step - loss: 570.1015 -
mse: 570.1015
Epoch 55/500
1/1 [==============================] - 0s 5ms/step - loss: 573.8622 -
mse: 573.8622
Epoch 56/500
1/1 [==============================] - 0s 7ms/step - loss: 586.7892 -
mse: 586.7892
Epoch 57/500
1/1 [==============================] - 0s 9ms/step - loss: 605.9681 -
mse: 605.9681
Epoch 58/500
1/1 [==============================] - 0s 9ms/step - loss: 628.6969 -
mse: 628.6969
Epoch 59/500
1/1 [==============================] - 0s 7ms/step - loss: 652.5670 -
mse: 652.5670
Epoch 60/500
1/1 [==============================] - 0s 7ms/step - loss: 675.5366 -
mse: 675.5366
Epoch 61/500
1/1 [==============================] - 0s 8ms/step - loss: 695.9764 -
mse: 695.9764
Epoch 62/500
1/1 [==============================] - 0s 7ms/step - loss: 712.6917 -
mse: 712.6917
Epoch 63/500
1/1 [==============================] - 0s 7ms/step - loss: 724.9162 -
mse: 724.9162
Epoch 64/500
1/1 [==============================] - 0s 10ms/step - loss: 732.2888 -
mse: 732.2888
Epoch 65/500
1/1 [==============================] - 0s 7ms/step - loss: 734.8013 -
mse: 734.8013
Epoch 66/500
```

```
1/1 [==============================] - 0s 7ms/step - loss: 732.7421 -
mse: 732.7421
Epoch 67/500
1/1 [==============================] - 0s 6ms/step - loss: 726.6248 -
mse: 726.6248
Epoch 68/500
1/1 [==============================] - 0s 12ms/step - loss: 717.1198 -
mse: 717.1198
Epoch 69/500
1/1 [==============================] - 0s 9ms/step - loss: 704.9871 -
mse: 704.9871
Epoch 70/500
1/1 [==============================] - 0s 7ms/step - loss: 691.0145 -
mse: 691.0145
Epoch 71/500
1/1 [==============================] - 0s 9ms/step - loss: 675.9698 -
mse: 675.9698
Epoch 72/500
1/1 [==============================] - 0s 6ms/step - loss: 660.5606 -
mse: 660.5606
Epoch 73/500
1/1 [==============================] - 0s 7ms/step - loss: 645.4027 -
mse: 645.4027
Epoch 74/500
1/1 [==============================] - 0s 9ms/step - loss: 631.0065 -
mse: 631.0065
Epoch 75/500
1/1 [==============================] - 0s 11ms/step - loss: 617.7659 -
mse: 617.7659
Epoch 76/500
1/1 [==============================] - 0s 6ms/step - loss: 605.9598 -
mse: 605.9598
Epoch 77/500
1/1 [==============================] - 0s 7ms/step - loss: 595.7565 -
mse: 595.7565
Epoch 78/500
1/1 [==============================] - 0s 11ms/step - loss: 587.2275 -
mse: 587.2275
Epoch 79/500
1/1 [==============================] - 0s 16ms/step - loss: 580.3586 -
mse: 580.3586
Epoch 80/500
1/1 [==============================] - 0s 9ms/step - loss: 575.0679 -
mse: 575.0679
Epoch 81/500
1/1 [==============================] - 0s 6ms/step - loss: 571.2201 -
mse: 571.2201
Epoch 82/500
1/1 [==============================] - 0s 10ms/step - loss: 568.6442 -
```

```
mse: 568.6442
Epoch 83/500

1/1 [==============================] - 0s 10ms/step - loss: 567.1464 -
mse: 567.1464
Epoch 84/500
1/1 [==============================] - 0s 9ms/step - loss: 566.5245 -
mse: 566.5245
Epoch 85/500
1/1 [==============================] - 0s 8ms/step - loss: 566.5774 -
mse: 566.5774
Epoch 86/500
1/1 [==============================] - 0s 6ms/step - loss: 567.1149 -
mse: 567.1149
Epoch 87/500
1/1 [==============================] - 0s 8ms/step - loss: 567.9626 -
mse: 567.9626
Epoch 88/500
1/1 [==============================] - 0s 8ms/step - loss: 568.9698 -
mse: 568.9698
Epoch 89/500
1/1 [==============================] - 0s 5ms/step - loss: 570.0083 -
mse: 570.0083
Epoch 90/500
1/1 [==============================] - 0s 8ms/step - loss: 570.9765 -
mse: 570.9765
Epoch 91/500
1/1 [==============================] - 0s 9ms/step - loss: 571.7980 -
mse: 571.7980
Epoch 92/500
1/1 [==============================] - 0s 8ms/step - loss: 572.4203 -
mse: 572.4203
Epoch 93/500
1/1 [==============================] - 0s 6ms/step - loss: 572.8134 -
mse: 572.8134
Epoch 94/500
1/1 [==============================] - 0s 6ms/step - loss: 572.9658 -
mse: 572.9658
Epoch 95/500
1/1 [==============================] - 0s 8ms/step - loss: 572.8832 -
mse: 572.8832
Epoch 96/500
1/1 [==============================] - 0s 9ms/step - loss: 572.5831 -
mse: 572.5831
Epoch 97/500
1/1 [==============================] - 0s 8ms/step - loss: 572.0936 -
mse: 572.0936
Epoch 98/500
1/1 [==============================] - 0s 7ms/step - loss: 571.4486 -
mse: 571.4486
```

```
Epoch 99/500
1/1 [==============================] - 0s 4ms/step - loss: 570.6857 -
mse: 570.6857
Epoch 100/500
1/1 [==============================] - 0s 8ms/step - loss: 569.8429 -
mse: 569.8429
Epoch 101/500
1/1 [==============================] - 0s 5ms/step - loss: 568.9581 -
mse: 568.9581
Epoch 102/500
1/1 [==============================] - 0s 6ms/step - loss: 568.0653 -
mse: 568.0653
Epoch 103/500
1/1 [==============================] - 0s 10ms/step - loss: 567.1940 -
mse: 567.1940
Epoch 104/500
1/1 [==============================] - 0s 9ms/step - loss: 566.3693 -
mse: 566.3693
Epoch 105/500
1/1 [==============================] - 0s 8ms/step - loss: 565.6099 -
mse: 565.6099
Epoch 106/500
1/1 [==============================] - 0s 8ms/step - loss: 564.9289 -
mse: 564.9289
Epoch 107/500
1/1 [==============================] - 0s 8ms/step - loss: 564.3336 -
mse: 564.3336
Epoch 108/500
1/1 [==============================] - 0s 11ms/step - loss: 563.8265 -
mse: 563.8265
Epoch 109/500
1/1 [==============================] - 0s 7ms/step - loss: 563.4053 -
mse: 563.4053
Epoch 110/500
1/1 [==============================] - 0s 6ms/step - loss: 563.0640 -
mse: 563.0640
Epoch 111/500
1/1 [==============================] - 0s 16ms/step - loss: 562.7936 -
mse: 562.7936
Epoch 112/500
1/1 [==============================] - 0s 8ms/step - loss: 562.5845 -
mse: 562.5845
Epoch 113/500
1/1 [==============================] - 0s 11ms/step - loss: 562.4237 -
mse: 562.4237
Epoch 114/500
1/1 [==============================] - 0s 7ms/step - loss: 562.2998 -
mse: 562.2998
Epoch 115/500
1/1 [==============================] - 0s 10ms/step - loss: 562.2009 -
```

```
mse: 562.2009
Epoch 116/500
1/1 [==============================] - 0s 9ms/step - loss: 562.1166 -
mse: 562.1166
Epoch 117/500
1/1 [==============================] - 0s 8ms/step - loss: 562.0370 -
mse: 562.0370
Epoch 118/500
1/1 [==============================] - 0s 6ms/step - loss: 561.9547 -
mse: 561.9547
Epoch 119/500
1/1 [==============================] - 0s 6ms/step - loss: 561.8633 -
mse: 561.8633
Epoch 120/500
1/1 [==============================] - 0s 8ms/step - loss: 561.7592 -
mse: 561.7592
Epoch 121/500
1/1 [==============================] - 0s 9ms/step - loss: 561.6390 -
mse: 561.6390
Epoch 122/500
1/1 [==============================] - 0s 9ms/step - loss: 561.5021 -
mse: 561.5021
Epoch 123/500
1/1 [==============================] - 0s 7ms/step - loss: 561.3489 -
mse: 561.3489
Epoch 124/500
1/1 [==============================] - 0s 11ms/step - loss: 561.1802 -
mse: 561.1802
Epoch 125/500
1/1 [==============================] - 0s 10ms/step - loss: 560.9987 -
mse: 560.9987
Epoch 126/500
1/1 [==============================] - 0s 10ms/step - loss: 560.8068 -
mse: 560.8068
Epoch 127/500
1/1 [==============================] - 0s 9ms/step - loss: 560.6073 -
mse: 560.6073
Epoch 128/500
1/1 [==============================] - 0s 8ms/step - loss: 560.4031 -
mse: 560.4031
Epoch 129/500
1/1 [==============================] - 0s 6ms/step - loss: 560.1970 -
mse: 560.1970
Epoch 130/500
1/1 [==============================] - 0s 5ms/step - loss: 559.9911 -
mse: 559.9911
Epoch 131/500
1/1 [==============================] - 0s 6ms/step - loss: 559.7877 -
mse: 559.7877
Epoch 132/500
```

```
1/1 [==============================] - 0s 6ms/step - loss: 559.5884 -
mse: 559.5884
Epoch 133/500
1/1 [==============================] - 0s 9ms/step - loss: 559.3938 -
mse: 559.3938
Epoch 134/500
1/1 [==============================] - 0s 11ms/step - loss: 559.2049 -
mse: 559.2049
Epoch 135/500
1/1 [==============================] - 0s 10ms/step - loss: 559.0215 -
mse: 559.0215
Epoch 136/500
1/1 [==============================] - 0s 7ms/step - loss: 558.8439 -
mse: 558.8439
Epoch 137/500
1/1 [==============================] - 0s 12ms/step - loss: 558.6712 -
mse: 558.6712
Epoch 138/500
1/1 [==============================] - 0s 11ms/step - loss: 558.5027 -
mse: 558.5027
Epoch 139/500
1/1 [==============================] - 0s 16ms/step - loss: 558.3376 -
mse: 558.3376
Epoch 140/500
1/1 [==============================] - 0s 12ms/step - loss: 558.1749 -
mse: 558.1749
Epoch 141/500
1/1 [==============================] - 0s 8ms/step - loss: 558.0140 -
mse: 558.0140
Epoch 142/500
1/1 [==============================] - 0s 7ms/step - loss: 557.8537 -
mse: 557.8537
Epoch 143/500
1/1 [==============================] - 0s 12ms/step - loss: 557.6933 -
mse: 557.6933
Epoch 144/500
1/1 [==============================] - 0s 5ms/step - loss: 557.5323 -
mse: 557.5323
Epoch 145/500
1/1 [==============================] - 0s 10ms/step - loss: 557.3704 -
mse: 557.3704
Epoch 146/500
1/1 [==============================] - 0s 12ms/step - loss: 557.2072 -
mse: 557.2072
Epoch 147/500
1/1 [==============================] - 0s 14ms/step - loss: 557.0419 -
mse: 557.0419
Epoch 148/500
1/1 [==============================] - 0s 8ms/step - loss: 556.8754 -
mse: 556.8754
```

```
Epoch 149/500
1/1 [==============================] - 0s 11ms/step - loss: 556.7066 -
mse: 556.7066
Epoch 150/500
1/1 [==============================] - 0s 7ms/step - loss: 556.5367 -
mse: 556.5367
Epoch 151/500
1/1 [==============================] - 0s 6ms/step - loss: 556.3652 -
mse: 556.3652
Epoch 152/500
1/1 [==============================] - 0s 7ms/step - loss: 556.1926 -
mse: 556.1926
Epoch 153/500
1/1 [==============================] - 0s 7ms/step - loss: 556.0193 -
mse: 556.0193
Epoch 154/500
1/1 [==============================] - 0s 14ms/step - loss: 555.8452 -
mse: 555.8452
Epoch 155/500
1/1 [==============================] - 0s 6ms/step - loss: 555.6705 -
mse: 555.6705
Epoch 156/500
1/1 [==============================] - 0s 6ms/step - loss: 555.4955 -
mse: 555.4955
Epoch 157/500
1/1 [==============================] - 0s 9ms/step - loss: 555.3204 -
mse: 555.3204
Epoch 158/500
1/1 [==============================] - 0s 12ms/step - loss: 555.1452 -
mse: 555.1452
Epoch 159/500
1/1 [==============================] - 0s 10ms/step - loss: 554.9703 -
mse: 554.9703
Epoch 160/500
1/1 [==============================] - 0s 7ms/step - loss: 554.7953 -
mse: 554.7953
Epoch 161/500
1/1 [==============================] - 0s 9ms/step - loss: 554.6201 -
mse: 554.6201
Epoch 162/500
1/1 [==============================] - 0s 10ms/step - loss: 554.4452 -
mse: 554.4452
Epoch 163/500
1/1 [==============================] - 0s 6ms/step - loss: 554.2701 -
mse: 554.2701
Epoch 164/500
1/1 [==============================] - 0s 6ms/step - loss: 554.0951 -
mse: 554.0951
Epoch 165/500
1/1 [==============================] - 0s 10ms/step - loss: 553.9198 -
```

```
mse: 553.9198
Epoch 166/500

1/1 [==============================] - 0s 8ms/step - loss: 553.7440 -
mse: 553.7440
Epoch 167/500
1/1 [==============================] - 0s 8ms/step - loss: 553.5682 -
mse: 553.5682
Epoch 168/500
1/1 [==============================] - 0s 11ms/step - loss: 553.3917 -
mse: 553.3917
Epoch 169/500
1/1 [==============================] - 0s 5ms/step - loss: 553.2150 -
mse: 553.2150
Epoch 170/500
1/1 [==============================] - 0s 8ms/step - loss: 553.0377 -
mse: 553.0377
Epoch 171/500
1/1 [==============================] - 0s 7ms/step - loss: 552.8597 -
mse: 552.8597
Epoch 172/500
1/1 [==============================] - 0s 8ms/step - loss: 552.6816 -
mse: 552.6816
Epoch 173/500
1/1 [==============================] - 0s 8ms/step - loss: 552.5028 -
mse: 552.5028
Epoch 174/500
1/1 [==============================] - 0s 8ms/step - loss: 552.3234 -
mse: 552.3234
Epoch 175/500
1/1 [==============================] - 0s 10ms/step - loss: 552.1434 -
mse: 552.1434
Epoch 176/500
1/1 [==============================] - 0s 8ms/step - loss: 551.9633 -
mse: 551.9633
Epoch 177/500
1/1 [==============================] - 0s 5ms/step - loss: 551.7825 -
mse: 551.7825
Epoch 178/500
1/1 [==============================] - 0s 11ms/step - loss: 551.6010 -
mse: 551.6010
Epoch 179/500
1/1 [==============================] - 0s 8ms/step - loss: 551.4195 -
mse: 551.4195
Epoch 180/500
1/1 [==============================] - 0s 6ms/step - loss: 551.2373 -
mse: 551.2373
Epoch 181/500
1/1 [==============================] - 0s 5ms/step - loss: 551.0552 -
mse: 551.0552
```

```
Epoch 182/500
1/1 [==============================] - 0s 9ms/step - loss: 550.8723 -
mse: 550.8723
Epoch 183/500
1/1 [==============================] - 0s 9ms/step - loss: 550.6893 -
mse: 550.6893
Epoch 184/500
1/1 [==============================] - 0s 11ms/step - loss: 550.5057 -
mse: 550.5057
Epoch 185/500
1/1 [==============================] - 0s 6ms/step - loss: 550.3217 -
mse: 550.3217
Epoch 186/500
1/1 [==============================] - 0s 15ms/step - loss: 550.1377 -
mse: 550.1377
Epoch 187/500
1/1 [==============================] - 0s 9ms/step - loss: 549.9531 -
mse: 549.9531
Epoch 188/500
1/1 [==============================] - 0s 10ms/step - loss: 549.7682 -
mse: 549.7682
Epoch 189/500
1/1 [==============================] - 0s 7ms/step - loss: 549.5832 -
mse: 549.5832
Epoch 190/500
1/1 [==============================] - 0s 6ms/step - loss: 549.3973 -
mse: 549.3973
Epoch 191/500
1/1 [==============================] - 0s 19ms/step - loss: 549.2112 -
mse: 549.2112
Epoch 192/500
1/1 [==============================] - 0s 12ms/step - loss: 549.0250 -
mse: 549.0250
Epoch 193/500
1/1 [==============================] - 0s 7ms/step - loss: 548.8382 -
mse: 548.8382
Epoch 194/500
1/1 [==============================] - 0s 4ms/step - loss: 548.6509 -
mse: 548.6509
Epoch 195/500
1/1 [==============================] - 0s 6ms/step - loss: 548.4633 -
mse: 548.4633
Epoch 196/500
1/1 [==============================] - 0s 11ms/step - loss: 548.2754 -
mse: 548.2754
Epoch 197/500
1/1 [==============================] - 0s 10ms/step - loss: 548.0870 -
mse: 548.0870
Epoch 198/500
1/1 [==============================] - 0s 6ms/step - loss: 547.8983 -
```

```
mse: 547.8983
Epoch 199/500
1/1 [==============================] - 0s 8ms/step - loss: 547.7093 -
mse: 547.7093
Epoch 200/500
1/1 [==============================] - 0s 10ms/step - loss: 547.5198 -
mse: 547.5198
Epoch 201/500
1/1 [==============================] - 0s 10ms/step - loss: 547.3302 -
mse: 547.3302
Epoch 202/500
1/1 [==============================] - 0s 11ms/step - loss: 547.1396 -
mse: 547.1396
Epoch 203/500
1/1 [==============================] - 0s 5ms/step - loss: 546.9491 -
mse: 546.9491
Epoch 204/500
1/1 [==============================] - 0s 8ms/step - loss: 546.7581 -
mse: 546.7581
Epoch 205/500
1/1 [==============================] - 0s 7ms/step - loss: 546.5667 -
mse: 546.5667
Epoch 206/500
1/1 [==============================] - 0s 9ms/step - loss: 546.3751 -
mse: 546.3751
Epoch 207/500
1/1 [==============================] - 0s 6ms/step - loss: 546.1831 -
mse: 546.1831
Epoch 208/500
1/1 [==============================] - 0s 9ms/step - loss: 545.9910 -
mse: 545.9910
Epoch 209/500
1/1 [==============================] - 0s 12ms/step - loss: 545.7982 -
mse: 545.7982
Epoch 210/500
1/1 [==============================] - 0s 8ms/step - loss: 545.6052 -
mse: 545.6052
Epoch 211/500
1/1 [==============================] - 0s 7ms/step - loss: 545.4117 -
mse: 545.4117
Epoch 212/500
1/1 [==============================] - 0s 13ms/step - loss: 545.2179 -
mse: 545.2179
Epoch 213/500
1/1 [==============================] - 0s 10ms/step - loss: 545.0238 -
mse: 545.0238
Epoch 214/500
1/1 [==============================] - 0s 6ms/step - loss: 544.8292 -
mse: 544.8292
Epoch 215/500
```

```
1/1 [==============================] - 0s 5ms/step - loss: 544.6344 -
mse: 544.6344
Epoch 216/500
1/1 [==============================] - 0s 10ms/step - loss: 544.4393 -
mse: 544.4393
Epoch 217/500
1/1 [==============================] - 0s 998us/step - loss: 544.2437
- mse: 544.2437
Epoch 218/500
1/1 [==============================] - 0s 7ms/step - loss: 544.0478 -
mse: 544.0478
Epoch 219/500
1/1 [==============================] - 0s 4ms/step - loss: 543.8516 -
mse: 543.8516
Epoch 220/500
1/1 [==============================] - 0s 16ms/step - loss: 543.6550 -
mse: 543.6550
Epoch 221/500
1/1 [==============================] - 0s 6ms/step - loss: 543.4581 -
mse: 543.4581
Epoch 222/500
1/1 [==============================] - 0s 8ms/step - loss: 543.2610 -
mse: 543.2610
Epoch 223/500
1/1 [==============================] - 0s 8ms/step - loss: 543.0634 -
mse: 543.0634
Epoch 224/500
1/1 [==============================] - 0s 8ms/step - loss: 542.8656 -
mse: 542.8656
Epoch 225/500
1/1 [==============================] - 0s 14ms/step - loss: 542.6670 -
mse: 542.6670
Epoch 226/500
1/1 [==============================] - 0s 11ms/step - loss: 542.4684 -
mse: 542.4684
Epoch 227/500
1/1 [==============================] - 0s 11ms/step - loss: 542.2695 -
mse: 542.2695
Epoch 228/500
1/1 [==============================] - 0s 11ms/step - loss: 542.0704 -
mse: 542.0704
Epoch 229/500
1/1 [==============================] - 0s 9ms/step - loss: 541.8706 -
mse: 541.8706
Epoch 230/500
1/1 [==============================] - 0s 10ms/step - loss: 541.6705 -
mse: 541.6705
Epoch 231/500
1/1 [==============================] - 0s 8ms/step - loss: 541.4704 -
mse: 541.4704
```

```
Epoch 232/500
1/1 [==============================] - 0s 9ms/step - loss: 541.2698 -
mse: 541.2698
Epoch 233/500
1/1 [==============================] - 0s 17ms/step - loss: 541.0690 -
mse: 541.0690
Epoch 234/500
1/1 [==============================] - 0s 6ms/step - loss: 540.8677 -
mse: 540.8677
Epoch 235/500
1/1 [==============================] - 0s 5ms/step - loss: 540.6659 -
mse: 540.6659
Epoch 236/500
1/1 [==============================] - 0s 9ms/step - loss: 540.4642 -
mse: 540.4642
Epoch 237/500
1/1 [==============================] - 0s 7ms/step - loss: 540.2617 -
mse: 540.2617
Epoch 238/500
1/1 [==============================] - 0s 9ms/step - loss: 540.0593 -
mse: 540.0593
Epoch 239/500
1/1 [==============================] - 0s 7ms/step - loss: 539.8563 -
mse: 539.8563
Epoch 240/500
1/1 [==============================] - 0s 7ms/step - loss: 539.6532 -
mse: 539.6532
Epoch 241/500
1/1 [==============================] - 0s 10ms/step - loss: 539.4496 -
mse: 539.4496
Epoch 242/500
1/1 [==============================] - 0s 7ms/step - loss: 539.2460 -
mse: 539.2460
Epoch 243/500
1/1 [==============================] - 0s 11ms/step - loss: 539.0416 -
mse: 539.0416
Epoch 244/500
1/1 [==============================] - 0s 10ms/step - loss: 538.8372 -
mse: 538.8372
Epoch 245/500
1/1 [==============================] - 0s 9ms/step - loss: 538.6324 -
mse: 538.6324
Epoch 246/500
1/1 [==============================] - 0s 7ms/step - loss: 538.4271 -
mse: 538.4271
Epoch 247/500
1/1 [==============================] - 0s 10ms/step - loss: 538.2219 -
mse: 538.2219
Epoch 248/500
1/1 [==============================] - 0s 9ms/step - loss: 538.0160 -
```

```
mse: 538.0160
Epoch 249/500

1/1 [==============================] - 0s 6ms/step - loss: 537.8099 -
mse: 537.8099
Epoch 250/500
1/1 [==============================] - 0s 7ms/step - loss: 537.6034 -
mse: 537.6034
Epoch 251/500
1/1 [==============================] - 0s 11ms/step - loss: 537.3969 -
mse: 537.3969
Epoch 252/500
1/1 [==============================] - 0s 5ms/step - loss: 537.1898 -
mse: 537.1898
Epoch 253/500
1/1 [==============================] - 0s 9ms/step - loss: 536.9824 -
mse: 536.9824
Epoch 254/500
1/1 [==============================] - 0s 6ms/step - loss: 536.7746 -
mse: 536.7746
Epoch 255/500
1/1 [==============================] - 0s 7ms/step - loss: 536.5670 -
mse: 536.5670
Epoch 256/500
1/1 [==============================] - 0s 6ms/step - loss: 536.3588 -
mse: 536.3588
Epoch 257/500
1/1 [==============================] - 0s 7ms/step - loss: 536.1498 -
mse: 536.1498
Epoch 258/500
1/1 [==============================] - 0s 13ms/step - loss: 535.9410 -
mse: 535.9410
Epoch 259/500
1/1 [==============================] - 0s 7ms/step - loss: 535.7321 -
mse: 535.7321
Epoch 260/500
1/1 [==============================] - 0s 10ms/step - loss: 535.5225 -
mse: 535.5225
Epoch 261/500
1/1 [==============================] - 0s 6ms/step - loss: 535.3127 -
mse: 535.3127
Epoch 262/500
1/1 [==============================] - 0s 8ms/step - loss: 535.1027 -
mse: 535.1027
Epoch 263/500
1/1 [==============================] - 0s 8ms/step - loss: 534.8923 -
mse: 534.8923
Epoch 264/500
1/1 [==============================] - 0s 6ms/step - loss: 534.6817 -
mse: 534.6817
```

```
Epoch 265/500
1/1 [==============================] - 0s 14ms/step - loss: 534.4706 -
mse: 534.4706
Epoch 266/500
1/1 [==============================] - 0s 11ms/step - loss: 534.2593 -
mse: 534.2593
Epoch 267/500
1/1 [==============================] - 0s 13ms/step - loss: 534.0479 -
mse: 534.0479
Epoch 268/500
1/1 [==============================] - 0s 8ms/step - loss: 533.8359 -
mse: 533.8359
Epoch 269/500
1/1 [==============================] - 0s 6ms/step - loss: 533.6237 -
mse: 533.6237
Epoch 270/500
1/1 [==============================] - 0s 5ms/step - loss: 533.4108 -
mse: 533.4108
Epoch 271/500
1/1 [==============================] - 0s 6ms/step - loss: 533.1984 -
mse: 533.1984
Epoch 272/500
1/1 [==============================] - 0s 6ms/step - loss: 532.9854 -
mse: 532.9854
Epoch 273/500
1/1 [==============================] - 0s 8ms/step - loss: 532.7721 -
mse: 532.7721
Epoch 274/500
1/1 [==============================] - 0s 9ms/step - loss: 532.5582 -
mse: 532.5582
Epoch 275/500
1/1 [==============================] - 0s 12ms/step - loss: 532.3442 -
mse: 532.3442
Epoch 276/500
1/1 [==============================] - 0s 5ms/step - loss: 532.1300 -
mse: 532.1300
Epoch 277/500
1/1 [==============================] - 0s 10ms/step - loss: 531.9156 -
mse: 531.9156
Epoch 278/500
1/1 [==============================] - 0s 7ms/step - loss: 531.7007 -
mse: 531.7007
Epoch 279/500
1/1 [==============================] - 0s 9ms/step - loss: 531.4855 -
mse: 531.4855
Epoch 280/500
1/1 [==============================] - 0s 6ms/step - loss: 531.2701 -
mse: 531.2701
Epoch 281/500
1/1 [==============================] - 0s 6ms/step - loss: 531.0543 -
```

```
mse: 531.0543
Epoch 282/500
1/1 [==============================] - 0s 8ms/step - loss: 530.8385 -
mse: 530.8385
Epoch 283/500
1/1 [==============================] - 0s 6ms/step - loss: 530.6222 -
mse: 530.6222
Epoch 284/500
1/1 [==============================] - 0s 8ms/step - loss: 530.4056 -
mse: 530.4056
Epoch 285/500
1/1 [==============================] - 0s 7ms/step - loss: 530.1886 -
mse: 530.1886
Epoch 286/500
1/1 [==============================] - 0s 12ms/step - loss: 529.9715 -
mse: 529.9715
Epoch 287/500
1/1 [==============================] - 0s 7ms/step - loss: 529.7540 -
mse: 529.7540
Epoch 288/500
1/1 [==============================] - 0s 6ms/step - loss: 529.5363 -
mse: 529.5363
Epoch 289/500
1/1 [==============================] - 0s 7ms/step - loss: 529.3184 -
mse: 529.3184
Epoch 290/500
1/1 [==============================] - 0s 5ms/step - loss: 529.0999 -
mse: 529.0999
Epoch 291/500
1/1 [==============================] - 0s 6ms/step - loss: 528.8815 -
mse: 528.8815
Epoch 292/500
1/1 [==============================] - 0s 8ms/step - loss: 528.6625 -
mse: 528.6625
Epoch 293/500
1/1 [==============================] - 0s 8ms/step - loss: 528.4435 -
mse: 528.4435
Epoch 294/500
1/1 [==============================] - 0s 8ms/step - loss: 528.2240 -
mse: 528.2240
Epoch 295/500
1/1 [==============================] - 0s 8ms/step - loss: 528.0045 -
mse: 528.0045
Epoch 296/500
1/1 [==============================] - ETA: 0s - loss: 527.7843 - mse:
527.784 - 0s 8ms/step - loss: 527.7843 - mse: 527.7843
Epoch 297/500
1/1 [==============================] - 0s 10ms/step - loss: 527.5641 -
mse: 527.5641
Epoch 298/500
```

```
1/1 [==============================] - 0s 8ms/step - loss: 527.3434 -
mse: 527.3434
Epoch 299/500
1/1 [==============================] - 0s 7ms/step - loss: 527.1227 -
mse: 527.1227
Epoch 300/500
1/1 [==============================] - 0s 7ms/step - loss: 526.9016 -
mse: 526.9016
Epoch 301/500
1/1 [==============================] - 0s 9ms/step - loss: 526.6801 -
mse: 526.6801
Epoch 302/500
1/1 [==============================] - 0s 15ms/step - loss: 526.4584 -
mse: 526.4584
Epoch 303/500
1/1 [==============================] - 0s 7ms/step - loss: 526.2365 -
mse: 526.2365
Epoch 304/500
1/1 [==============================] - 0s 8ms/step - loss: 526.0141 -
mse: 526.0141
Epoch 305/500
1/1 [==============================] - 0s 8ms/step - loss: 525.7916 -
mse: 525.7916
Epoch 306/500
1/1 [==============================] - 0s 8ms/step - loss: 525.5688 -
mse: 525.5688
Epoch 307/500
1/1 [==============================] - 0s 19ms/step - loss: 525.3459 -
mse: 525.3459
Epoch 308/500
1/1 [==============================] - 0s 14ms/step - loss: 525.1224 -
mse: 525.1224
Epoch 309/500
1/1 [==============================] - 0s 5ms/step - loss: 524.8987 -
mse: 524.8987
Epoch 310/500
1/1 [==============================] - 0s 11ms/step - loss: 524.6750 -
mse: 524.6750
Epoch 311/500
1/1 [==============================] - 0s 15ms/step - loss: 524.4508 -
mse: 524.4508
Epoch 312/500
1/1 [==============================] - 0s 6ms/step - loss: 524.2264 -
mse: 524.2264
Epoch 313/500
1/1 [==============================] - 0s 7ms/step - loss: 524.0016 -
mse: 524.0016
Epoch 314/500
1/1 [==============================] - 0s 10ms/step - loss: 523.7766 -
mse: 523.7766
```

```
Epoch 315/500
1/1 [==============================] - 0s 10ms/step - loss: 523.5515 -
mse: 523.5515
Epoch 316/500
1/1 [==============================] - 0s 9ms/step - loss: 523.3260 -
mse: 523.3260
Epoch 317/500
1/1 [==============================] - 0s 10ms/step - loss: 523.1002 -
mse: 523.1002
Epoch 318/500
1/1 [==============================] - 0s 20ms/step - loss: 522.8739 -
mse: 522.8739
Epoch 319/500
1/1 [==============================] - 0s 10ms/step - loss: 522.6476 -
mse: 522.6476
Epoch 320/500
1/1 [==============================] - 0s 9ms/step - loss: 522.4209 -
mse: 522.4209
Epoch 321/500
1/1 [==============================] - 0s 15ms/step - loss: 522.1940 -
mse: 522.1940
Epoch 322/500
1/1 [==============================] - 0s 8ms/step - loss: 521.9670 -
mse: 521.9670
Epoch 323/500
1/1 [==============================] - 0s 9ms/step - loss: 521.7394 -
mse: 521.7394
Epoch 324/500
1/1 [==============================] - 0s 9ms/step - loss: 521.5117 -
mse: 521.5117
Epoch 325/500
1/1 [==============================] - 0s 12ms/step - loss: 521.2838 -
mse: 521.2838
Epoch 326/500
1/1 [==============================] - 0s 9ms/step - loss: 521.0553 -
mse: 521.0553
Epoch 327/500
1/1 [==============================] - 0s 8ms/step - loss: 520.8270 -
mse: 520.8270
Epoch 328/500
1/1 [==============================] - 0s 7ms/step - loss: 520.5981 -
mse: 520.5981
Epoch 329/500
1/1 [==============================] - 0s 6ms/step - loss: 520.3694 -
mse: 520.3694
Epoch 330/500
1/1 [==============================] - 0s 20ms/step - loss: 520.1397 -
mse: 520.1397
Epoch 331/500
1/1 [==============================] - 0s 6ms/step - loss: 519.9103 -
```

```
mse: 519.9103
Epoch 332/500

1/1 [==============================] - 0s 8ms/step - loss: 519.6802 -
mse: 519.6802
Epoch 333/500
1/1 [==============================] - 0s 8ms/step - loss: 519.4501 -
mse: 519.4501
Epoch 334/500
1/1 [==============================] - 0s 7ms/step - loss: 519.2196 -
mse: 519.2196
Epoch 335/500
1/1 [==============================] - 0s 10ms/step - loss: 518.9891 -
mse: 518.9891
Epoch 336/500
1/1 [==============================] - 0s 7ms/step - loss: 518.7582 -
mse: 518.7582
Epoch 337/500
1/1 [==============================] - 0s 8ms/step - loss: 518.5270 -
mse: 518.5270
Epoch 338/500
1/1 [==============================] - 0s 7ms/step - loss: 518.2955 -
mse: 518.2955
Epoch 339/500
1/1 [==============================] - 0s 7ms/step - loss: 518.0638 -
mse: 518.0638
Epoch 340/500
1/1 [==============================] - 0s 7ms/step - loss: 517.8318 -
mse: 517.8318
Epoch 341/500
1/1 [==============================] - 0s 14ms/step - loss: 517.5997 -
mse: 517.5997
Epoch 342/500
1/1 [==============================] - 0s 11ms/step - loss: 517.3668 -
mse: 517.3668
Epoch 343/500
1/1 [==============================] - 0s 9ms/step - loss: 517.1343 -
mse: 517.1343
Epoch 344/500
1/1 [==============================] - 0s 13ms/step - loss: 516.9012 -
mse: 516.9012
Epoch 345/500
1/1 [==============================] - 0s 12ms/step - loss: 516.6679 -
mse: 516.6679
Epoch 346/500
1/1 [==============================] - 0s 10ms/step - loss: 516.4342 -
mse: 516.4342
Epoch 347/500
1/1 [==============================] - 0s 3ms/step - loss: 516.2006 -
mse: 516.2006
```

```
Epoch 348/500
1/1 [==============================] - 0s 10ms/step - loss: 515.9664 -
mse: 515.9664
Epoch 349/500
1/1 [==============================] - 0s 19ms/step - loss: 515.7321 -
mse: 515.7321
Epoch 350/500
1/1 [==============================] - 0s 15ms/step - loss: 515.4972 -
mse: 515.4972
Epoch 351/500
1/1 [==============================] - 0s 9ms/step - loss: 515.2626 -
mse: 515.2626
Epoch 352/500
1/1 [==============================] - 0s 9ms/step - loss: 515.0271 -
mse: 515.0271
Epoch 353/500
1/1 [==============================] - 0s 13ms/step - loss: 514.7918 -
mse: 514.7918
Epoch 354/500
1/1 [==============================] - 0s 18ms/step - loss: 514.5562 -
mse: 514.5562
Epoch 355/500
1/1 [==============================] - 0s 10ms/step - loss: 514.3202 -
mse: 514.3202
Epoch 356/500
1/1 [==============================] - 0s 7ms/step - loss: 514.0839 -
mse: 514.0839
Epoch 357/500
1/1 [==============================] - 0s 10ms/step - loss: 513.8475 -
mse: 513.8475
Epoch 358/500
1/1 [==============================] - 0s 13ms/step - loss: 513.6110 -
mse: 513.6110
Epoch 359/500
1/1 [==============================] - 0s 12ms/step - loss: 513.3738 -
mse: 513.3738
Epoch 360/500
1/1 [==============================] - 0s 9ms/step - loss: 513.1366 -
mse: 513.1366
Epoch 361/500
1/1 [==============================] - 0s 10ms/step - loss: 512.8989 -
mse: 512.8989
Epoch 362/500
1/1 [==============================] - 0s 11ms/step - loss: 512.6611 -
mse: 512.6611
Epoch 363/500
1/1 [==============================] - 0s 6ms/step - loss: 512.4233 -
mse: 512.4233
Epoch 364/500
1/1 [==============================] - 0s 16ms/step - loss: 512.1846 -
```

```
mse: 512.1846
Epoch 365/500
1/1 [==============================] - 0s 8ms/step - loss: 511.9461 -
mse: 511.9461
Epoch 366/500
1/1 [==============================] - 0s 8ms/step - loss: 511.7075 -
mse: 511.7075
Epoch 367/500
1/1 [==============================] - 0s 7ms/step - loss: 511.4681 -
mse: 511.4681
Epoch 368/500
1/1 [==============================] - 0s 5ms/step - loss: 511.2289 -
mse: 511.2289
Epoch 369/500
1/1 [==============================] - 0s 9ms/step - loss: 510.9893 -
mse: 510.9893
Epoch 370/500
1/1 [==============================] - 0s 9ms/step - loss: 510.7494 -
mse: 510.7494
Epoch 371/500
1/1 [==============================] - 0s 7ms/step - loss: 510.5092 -
mse: 510.5092
Epoch 372/500
1/1 [==============================] - 0s 15ms/step - loss: 510.2689 -
mse: 510.2689
Epoch 373/500
1/1 [==============================] - 0s 13ms/step - loss: 510.0284 -
mse: 510.0284
Epoch 374/500
1/1 [==============================] - 0s 20ms/step - loss: 509.7872 -
mse: 509.7872
Epoch 375/500
1/1 [==============================] - 0s 7ms/step - loss: 509.5459 -
mse: 509.5459
Epoch 376/500
1/1 [==============================] - 0s 15ms/step - loss: 509.3046 -
mse: 509.3046
Epoch 377/500
1/1 [==============================] - 0s 11ms/step - loss: 509.0629 -
mse: 509.0629
Epoch 378/500
1/1 [==============================] - 0s 21ms/step - loss: 508.8209 -
mse: 508.8209
Epoch 379/500
1/1 [==============================] - 0s 15ms/step - loss: 508.5786 -
mse: 508.5786
Epoch 380/500
1/1 [==============================] - 0s 9ms/step - loss: 508.3359 -
mse: 508.3359
Epoch 381/500
```

```
1/1 [==============================] - 0s 14ms/step - loss: 508.0934 -
mse: 508.0934
Epoch 382/500
1/1 [==============================] - 0s 11ms/step - loss: 507.8503 -
mse: 507.8503
Epoch 383/500
1/1 [==============================] - 0s 18ms/step - loss: 507.6071 -
mse: 507.6071
Epoch 384/500
1/1 [==============================] - 0s 12ms/step - loss: 507.3634 -
mse: 507.3634
Epoch 385/500
1/1 [==============================] - 0s 9ms/step - loss: 507.1197 -
mse: 507.1197
Epoch 386/500
1/1 [==============================] - 0s 12ms/step - loss: 506.8756 -
mse: 506.8756
Epoch 387/500
1/1 [==============================] - 0s 10ms/step - loss: 506.6314 -
mse: 506.6314
Epoch 388/500
1/1 [==============================] - ETA: 0s - loss: 506.3868 - mse:
506.386 - 0s 6ms/step - loss: 506.3868 - mse: 506.3868
Epoch 389/500
1/1 [==============================] - 0s 9ms/step - loss: 506.1419 -
mse: 506.1419
Epoch 390/500
1/1 [==============================] - 0s 8ms/step - loss: 505.8970 -
mse: 505.8970
Epoch 391/500
1/1 [==============================] - 0s 6ms/step - loss: 505.6516 -
mse: 505.6516
Epoch 392/500
1/1 [==============================] - 0s 12ms/step - loss: 505.4059 -
mse: 505.4059
Epoch 393/500
1/1 [==============================] - ETA: 0s - loss: 505.1599 - mse:
505.159 - 0s 7ms/step - loss: 505.1599 - mse: 505.1599
Epoch 394/500
1/1 [==============================] - 0s 15ms/step - loss: 504.9138 -
mse: 504.9138
Epoch 395/500
1/1 [==============================] - 0s 6ms/step - loss: 504.6672 -
mse: 504.6672
Epoch 396/500
1/1 [==============================] - 0s 13ms/step - loss: 504.4205 -
mse: 504.4205
Epoch 397/500
1/1 [==============================] - 0s 13ms/step - loss: 504.1738 -
mse: 504.1738
```

```
Epoch 398/500
1/1 [==============================] - 0s 5ms/step - loss: 503.9267 -
mse: 503.9267
Epoch 399/500
1/1 [==============================] - 0s 6ms/step - loss: 503.6790 -
mse: 503.6790
Epoch 400/500
1/1 [==============================] - 0s 5ms/step - loss: 503.4312 -
mse: 503.4312
Epoch 401/500
1/1 [==============================] - 0s 6ms/step - loss: 503.1833 -
mse: 503.1833
Epoch 402/500
1/1 [==============================] - 0s 21ms/step - loss: 502.9351 -
mse: 502.9351
Epoch 403/500
1/1 [==============================] - 0s 9ms/step - loss: 502.6867 -
mse: 502.6867
Epoch 404/500
1/1 [==============================] - 0s 9ms/step - loss: 502.4378 -
mse: 502.4378
Epoch 405/500
1/1 [==============================] - 0s 6ms/step - loss: 502.1887 -
mse: 502.1887
Epoch 406/500
1/1 [==============================] - 0s 7ms/step - loss: 501.9394 -
mse: 501.9394
Epoch 407/500
1/1 [==============================] - 0s 10ms/step - loss: 501.6901 -
mse: 501.6901
Epoch 408/500
1/1 [==============================] - 0s 14ms/step - loss: 501.4400 -
mse: 501.4400
Epoch 409/500
1/1 [==============================] - 0s 4ms/step - loss: 501.1901 -
mse: 501.1901
Epoch 410/500
1/1 [==============================] - 0s 8ms/step - loss: 500.9397 -
mse: 500.9397
Epoch 411/500
1/1 [==============================] - 0s 8ms/step - loss: 500.6891 -
mse: 500.6891
Epoch 412/500
1/1 [==============================] - 0s 11ms/step - loss: 500.4384 -
mse: 500.4384
Epoch 413/500
1/1 [==============================] - 0s 11ms/step - loss: 500.1872 -
mse: 500.1872
Epoch 414/500
```

```
1/1 [==============================] - 0s 15ms/step - loss: 499.9357 -
mse: 499.9357
Epoch 415/500
1/1 [==============================] - 0s 8ms/step - loss: 499.6840 -
mse: 499.6840
Epoch 416/500
1/1 [==============================] - 0s 13ms/step - loss: 499.4322 -
mse: 499.4322
Epoch 417/500
1/1 [==============================] - 0s 7ms/step - loss: 499.1800 -
mse: 499.1800
Epoch 418/500
1/1 [==============================] - 0s 8ms/step - loss: 498.9274 -
mse: 498.9274
Epoch 419/500
1/1 [==============================] - 0s 8ms/step - loss: 498.6749 -
mse: 498.6749
Epoch 420/500
1/1 [==============================] - 0s 17ms/step - loss: 498.4217 -
mse: 498.4217
Epoch 421/500
1/1 [==============================] - 0s 10ms/step - loss: 498.1685 -
mse: 498.1685
Epoch 422/500
1/1 [==============================] - 0s 7ms/step - loss: 497.9150 -
mse: 497.9150
Epoch 423/500
1/1 [==============================] - 0s 8ms/step - loss: 497.6613 -
mse: 497.6613
Epoch 424/500
1/1 [==============================] - 0s 12ms/step - loss: 497.4070 -
mse: 497.4070
Epoch 425/500
1/1 [==============================] - 0s 8ms/step - loss: 497.1528 -
mse: 497.1528
Epoch 426/500
1/1 [==============================] - 0s 11ms/step - loss: 496.8984 -
mse: 496.8984
Epoch 427/500
1/1 [==============================] - 0s 6ms/step - loss: 496.6435 -
mse: 496.6435
Epoch 428/500
1/1 [==============================] - 0s 9ms/step - loss: 496.3883 -
mse: 496.3883
Epoch 429/500
1/1 [==============================] - 0s 14ms/step - loss: 496.1329 -
mse: 496.1329
Epoch 430/500
1/1 [==============================] - 0s 8ms/step - loss: 495.8774 -
mse: 495.8774
```

```
Epoch 431/500
1/1 [==============================] - 0s 11ms/step - loss: 495.6213 -
mse: 495.6213
Epoch 432/500
1/1 [==============================] - 0s 6ms/step - loss: 495.3651 -
mse: 495.3651
Epoch 433/500
1/1 [==============================] - 0s 9ms/step - loss: 495.1087 -
mse: 495.1087
Epoch 434/500
1/1 [==============================] - 0s 8ms/step - loss: 494.8521 -
mse: 494.8521
Epoch 435/500
1/1 [==============================] - 0s 8ms/step - loss: 494.5953 -
mse: 494.5953
Epoch 436/500
1/1 [==============================] - 0s 8ms/step - loss: 494.3379 -
mse: 494.3379
Epoch 437/500
1/1 [==============================] - 0s 6ms/step - loss: 494.0803 -
mse: 494.0803
Epoch 438/500
1/1 [==============================] - 0s 10ms/step - loss: 493.8224 -
mse: 493.8224
Epoch 439/500
1/1 [==============================] - 0s 13ms/step - loss: 493.5645 -
mse: 493.5645
Epoch 440/500
1/1 [==============================] - 0s 12ms/step - loss: 493.3062 -
mse: 493.3062
Epoch 441/500
1/1 [==============================] - 0s 14ms/step - loss: 493.0478 -
mse: 493.0478
Epoch 442/500
1/1 [==============================] - 0s 11ms/step - loss: 492.7886 -
mse: 492.7886
Epoch 443/500
1/1 [==============================] - 0s 10ms/step - loss: 492.5294 -
mse: 492.5294
Epoch 444/500
1/1 [==============================] - 0s 9ms/step - loss: 492.2701 -
mse: 492.2701
Epoch 445/500
1/1 [==============================] - 0s 8ms/step - loss: 492.0104 -
mse: 492.0104
Epoch 446/500
1/1 [==============================] - 0s 7ms/step - loss: 491.7506 -
mse: 491.7506
Epoch 447/500
1/1 [==============================] - 0s 12ms/step - loss: 491.4903 -
```

```
mse: 491.4903
Epoch 448/500
1/1 [==============================] - 0s 7ms/step - loss: 491.2298 -
mse: 491.2298
Epoch 449/500
1/1 [==============================] - 0s 7ms/step - loss: 490.9691 -
mse: 490.9691
Epoch 450/500
1/1 [==============================] - 0s 9ms/step - loss: 490.7080 -
mse: 490.7080
Epoch 451/500
1/1 [==============================] - 0s 10ms/step - loss: 490.4467 -
mse: 490.4467
Epoch 452/500
1/1 [==============================] - 0s 7ms/step - loss: 490.1852 -
mse: 490.1852
Epoch 453/500
1/1 [==============================] - 0s 5ms/step - loss: 489.9232 -
mse: 489.9232
Epoch 454/500
1/1 [==============================] - 0s 5ms/step - loss: 489.6611 -
mse: 489.6611
Epoch 455/500
1/1 [==============================] - 0s 8ms/step - loss: 489.3987 -
mse: 489.3987
Epoch 456/500
1/1 [==============================] - 0s 7ms/step - loss: 489.1361 -
mse: 489.1361
Epoch 457/500
1/1 [==============================] - 0s 7ms/step - loss: 488.8732 -
mse: 488.8732
Epoch 458/500
1/1 [==============================] - 0s 5ms/step - loss: 488.6100 -
mse: 488.6100
Epoch 459/500
1/1 [==============================] - 0s 9ms/step - loss: 488.3464 -
mse: 488.3464
Epoch 460/500
1/1 [==============================] - 0s 7ms/step - loss: 488.0825 -
mse: 488.0825
Epoch 461/500
1/1 [==============================] - 0s 12ms/step - loss: 487.8185 -
mse: 487.8185
Epoch 462/500
1/1 [==============================] - 0s 7ms/step - loss: 487.5541 -
mse: 487.5541
Epoch 463/500
1/1 [==============================] - 0s 7ms/step - loss: 487.2896 -
mse: 487.2896
Epoch 464/500
```

```
1/1 [==============================] - 0s 12ms/step - loss: 487.0247 -
mse: 487.0247
Epoch 465/500
1/1 [==============================] - 0s 9ms/step - loss: 486.7593 -
mse: 486.7593
Epoch 466/500
1/1 [==============================] - 0s 5ms/step - loss: 486.4940 -
mse: 486.4940
Epoch 467/500
1/1 [==============================] - 0s 7ms/step - loss: 486.2282 -
mse: 486.2282
Epoch 468/500
1/1 [==============================] - 0s 7ms/step - loss: 485.9622 -
mse: 485.9622
Epoch 469/500
1/1 [==============================] - 0s 8ms/step - loss: 485.6961 -
mse: 485.6961
Epoch 470/500
1/1 [==============================] - 0s 6ms/step - loss: 485.4294 -
mse: 485.4294
Epoch 471/500
1/1 [==============================] - 0s 9ms/step - loss: 485.1627 -
mse: 485.1627
Epoch 472/500
1/1 [==============================] - 0s 6ms/step - loss: 484.8956 -
mse: 484.8956
Epoch 473/500
1/1 [==============================] - 0s 5ms/step - loss: 484.6279 -
mse: 484.6279
Epoch 474/500
1/1 [==============================] - 0s 10ms/step - loss: 484.3603 -
mse: 484.3603
Epoch 475/500
1/1 [==============================] - 0s 8ms/step - loss: 484.0925 -
mse: 484.0925
Epoch 476/500
1/1 [==============================] - 0s 6ms/step - loss: 483.8242 -
mse: 483.8242
Epoch 477/500
1/1 [==============================] - 0s 8ms/step - loss: 483.5554 -
mse: 483.5554
Epoch 478/500
1/1 [==============================] - 0s 6ms/step - loss: 483.2867 -
mse: 483.2867
Epoch 479/500
1/1 [==============================] - 0s 5ms/step - loss: 483.0177 -
mse: 483.0177
Epoch 480/500
1/1 [==============================] - 0s 7ms/step - loss: 482.7483 -
mse: 482.7483
```

```
Epoch 481/500
1/1 [==============================] - 0s 12ms/step - loss: 482.4786 -
mse: 482.4786
Epoch 482/500
1/1 [==============================] - 0s 8ms/step - loss: 482.2084 -
mse: 482.2084
Epoch 483/500
1/1 [==============================] - 0s 7ms/step - loss: 481.9384 -
mse: 481.9384
Epoch 484/500
1/1 [==============================] - 0s 9ms/step - loss: 481.6676 -
mse: 481.6676
Epoch 485/500
1/1 [==============================] - 0s 5ms/step - loss: 481.3970 -
mse: 481.3970
Epoch 486/500
1/1 [==============================] - 0s 9ms/step - loss: 481.1258 -
mse: 481.1258
Epoch 487/500
1/1 [==============================] - 0s 8ms/step - loss: 480.8544 -
mse: 480.8544
Epoch 488/500
1/1 [==============================] - 0s 5ms/step - loss: 480.5826 -
mse: 480.5826
Epoch 489/500
1/1 [==============================] - 0s 11ms/step - loss: 480.3108 -
mse: 480.3108
Epoch 490/500
1/1 [==============================] - 0s 7ms/step - loss: 480.0384 -
mse: 480.0384
Epoch 491/500
1/1 [==============================] - 0s 6ms/step - loss: 479.7659 -
mse: 479.7659
Epoch 492/500
1/1 [==============================] - 0s 5ms/step - loss: 479.4932 -
mse: 479.4932
Epoch 493/500
1/1 [==============================] - 0s 8ms/step - loss: 479.2199 -
mse: 479.2199
Epoch 494/500
1/1 [==============================] - 0s 9ms/step - loss: 478.9465 -
mse: 478.9465
Epoch 495/500
1/1 [==============================] - 0s 11ms/step - loss: 478.6726 -
mse: 478.6726
Epoch 496/500
1/1 [==============================] - 0s 10ms/step - loss: 478.3985 -
mse: 478.3985
Epoch 497/500
```

```
1/1 [==============================] - 0s 7ms/step - loss: 478.1244 -
mse: 478.1244
Epoch 498/500
1/1 [==============================] - 0s 9ms/step - loss: 477.8499 -
mse: 477.8499
Epoch 499/500
1/1 [==============================] - 0s 9ms/step - loss: 477.5749 -
mse: 477.5749
Epoch 500/500
1/1 [==============================] - 0s 6ms/step - loss: 477.2995 -
mse: 477.2995
Done with model training
```

Step 10 : Test the performance of the model using the testing dataset

```
y_pred = model.predict(X_test)

print('Actual Values\tPredicted Values')
print(y_test,'    ',y_pred.reshape(1,-1))

score=r2_score(y_test,y_pred)
print("Overall R_squared score: {}".format(score*100))
```

```
Actual Values    Predicted Values
[200. 100. 170.]     [[196.75392   52.905807 148.80455 ]]
Overall R_squared score: 49.158599619316
```

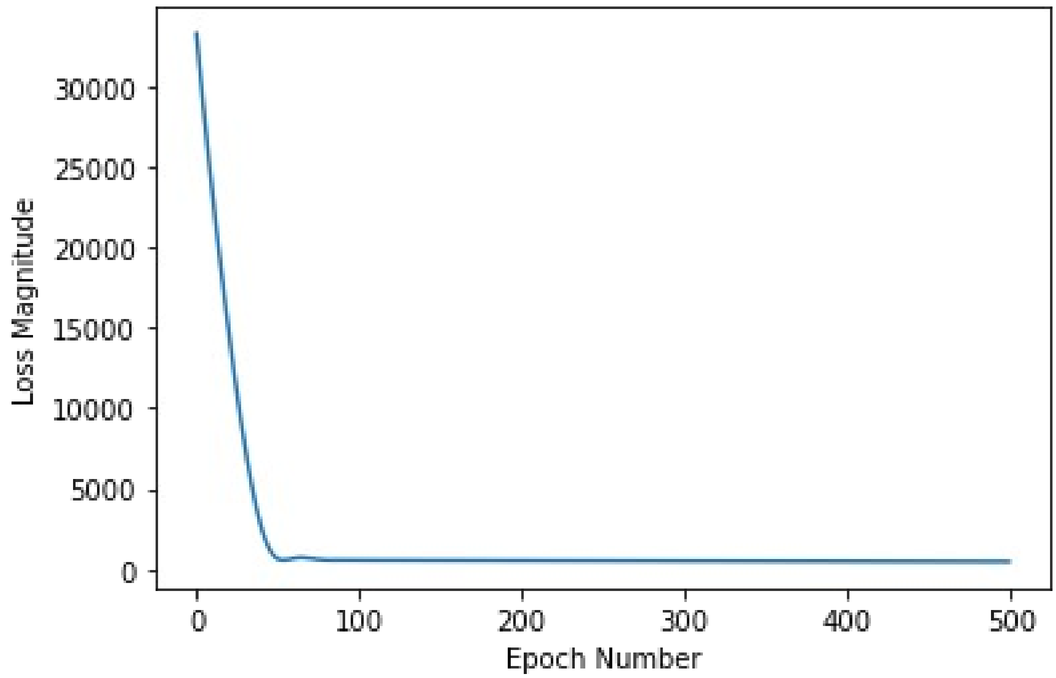
Other things we can do:

---

1. Analyze training statistics

```
plt.xlabel('Epoch Number')
plt.ylabel("Loss Magnitude")
plt.plot(trained_model.history['loss'])
```

```
[<matplotlib.lines.Line2D at 0x1eca6a22370>]
```



1. Test NN performance using validation dataset

```
#Array of test values
print("Marketing Budget Values:",X_test.reshape(1,-1))
y_pred = model.predict(X_test)
print('Actual Values\tPredicted Values')
print(y_test.reshape(1,-1),'    ',y_pred.reshape(1,-1))
```

```
Marketing Budget Values: [[80. 20. 60.]]
Actual Values	Predicted Values
[[200. 100. 170.]]     [[196.75392   52.905807 148.80455 ]]
```

```
#Single data test value
budget = float(input("Enter Amount for Marketing Budget: "))
predicted_Cust_Gain =  model.predict([budget])
print("Estimated number of customer gain is ",predicted_Cust_Gain)
```

```
Enter Amount for Marketing Budget: 80
Estimated number of customer gain is  [[196.75392]]
```