In [1]:
```
from keras.models import Sequential
from keras.layers import Dense
from keras.optimizers import Adam

import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, mean_squared_error
```

```
WARNING:tensorflow:From C:\Users\Laptop\AppData\Local\Packages\PythonSoftwareFoundation.
Python.3.11_qbz5n2kfra8p0\LocalCache\local-packages\Python311\site-packages\keras\src\lo
sses.py:2976: The name tf.losses.sparse_softmax_cross_entropy is deprecated. Please use
tf.compat.v1.losses.sparse_softmax_cross_entropy instead.
```

In [10]:
```
dataSet = pd.read_csv('DelhiAQI.csv')
```

In [3]:
```
print(dataSet.head())
print(dataSet.shape)
```

```
    PM2.5    PM10      NO    NO2      NOx    NH3     CO   SO2     O3  Benzene  \
0  454.58  935.18   81.52  41.78  187.66  27.54   9.29  3.41  54.94    25.24
1  440.44  935.18   70.80  43.46  176.83  27.72  13.28  3.88  50.53    23.10
2  409.09  935.18  132.46  41.19  141.02  28.94  29.67  2.83  19.33    19.04
3  436.12  935.18   84.78  39.55  102.84  29.30  21.76  4.33  20.08    13.99
4  415.88  976.99   60.24  37.41   80.12  30.84  26.19  6.17  16.00    11.14

   Toluene  Xylene  AQI
0    58.57   13.80  653
1    49.37   15.63  645
2    38.94   17.18  532
3    27.53   16.82  561
4    21.99   14.29  567
(15000, 13)
```

In [11]:
```
# normalizing the data
dataSetNorm1 = dataSet.dropna()
for i in dataSetNorm1.columns:
    if i != 'AQI':
        # use the median and std of the training data to normalize (Z-score scaling)
        dataSetNorm1[i] = (dataSetNorm1[i] - dataSetNorm1[i].mean()) / dataSetNorm1[i].

X = dataSetNorm1.drop('AQI', axis=1)
y = dataSetNorm1['AQI']
```

In [12]:
```
# Implement deep multilayer perceptron neural network Model-I : Add a fully connected l
# and glorot uniform kernel initializer. Add a fully connected layer layer with 16
# neurons, relu activation and he uniform as kernel initializer. Add a fully
# connected layer with 1 neuron, relu activation function and he uniform as
# kernel initializer. Use Adam optimizer with batch size 16, learning rate 0.01
# and epochs set to 20.
# Test using root mean squared error as loss function.

def model1(X_train, X_val, y_train, y_val):
```

```
    model = Sequential()
    model.add(Dense(32, activation='sigmoid', kernel_initializer='glorot_uniform'))
    model.add(Dense(16, activation='relu', kernel_initializer='he_uniform'))
    model.add(Dense(1, activation='relu', kernel_initializer='he_uniform'))

    model.compile(optimizer=Adam(learning_rate=0.01), loss='mean_squared_error', batch_

    model.fit(X_train, y_train,  validation_data=(X_val, y_val))

    return model

count = 5
avg_mse = 0
for i in range(count):
    # Split data to 60% training 20% validation and 20% testing
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta
    X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.25,
    model = model1(X_train, X_val, y_train, y_val)
    y_pred = model.predict(X_test)

    print('Model:', i+1)
    y_pred = np.round(y_pred)
    mse = mean_squared_error(y_test, y_pred)
    print('Mean Squared Error:', mse)
    print("--------------------")
    avg_mse += mse

print('Average Mean Squared Error:', avg_mse/count)
```

```
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 12386.1943 - val_loss: 31
69.8613
Epoch 2/20
563/563 [==============================] - 1s 989us/step - loss: 3224.3071 - val_loss: 3
002.4209
Epoch 3/20
563/563 [==============================] - 1s 1000us/step - loss: 3121.0959 - val_loss:
3019.6687
Epoch 4/20
563/563 [==============================] - 1s 958us/step - loss: 3042.1355 - val_loss: 2
909.5486
Epoch 5/20
563/563 [==============================] - 1s 933us/step - loss: 2996.9778 - val_loss: 2
874.4570
Epoch 6/20
563/563 [==============================] - 1s 942us/step - loss: 2964.1426 - val_loss: 2
827.1260
Epoch 7/20
563/563 [==============================] - 1s 931us/step - loss: 2923.3037 - val_loss: 2
841.1707
Epoch 8/20
563/563 [==============================] - 1s 929us/step - loss: 2882.3889 - val_loss: 2
938.6287
Epoch 9/20
563/563 [==============================] - 1s 928us/step - loss: 2852.2292 - val_loss: 2
818.6968
Epoch 10/20
563/563 [==============================] - 1s 938us/step - loss: 2832.3335 - val_loss: 2
849.4070
Epoch 11/20
```

```
563/563 [==============================] - 1s 920us/step - loss: 2799.4294 - val_loss: 2
806.5847
Epoch 12/20
563/563 [==============================] - 1s 1ms/step - loss: 2781.4626 - val_loss: 274
3.4207
Epoch 13/20
563/563 [==============================] - 1s 978us/step - loss: 2775.0447 - val_loss: 2
695.7910
Epoch 14/20
563/563 [==============================] - 1s 1ms/step - loss: 2742.0383 - val_loss: 269
7.2566
Epoch 15/20
563/563 [==============================] - 1s 962us/step - loss: 2717.8757 - val_loss: 2
696.4504
Epoch 16/20
563/563 [==============================] - 1s 959us/step - loss: 2704.7046 - val_loss: 2
701.8970
Epoch 17/20
563/563 [==============================] - 1s 1ms/step - loss: 2690.1560 - val_loss: 269
4.3113
Epoch 18/20
563/563 [==============================] - 1s 1ms/step - loss: 2683.0188 - val_loss: 270
2.7073
Epoch 19/20
563/563 [==============================] - 1s 958us/step - loss: 2664.4465 - val_loss: 2
636.5217
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2670.7173 - val_loss: 264
1.7043
94/94 [==============================] - 0s 635us/step
Model: 1
Mean Squared Error: 2833.144
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 67720.2734 - val_loss: 33
91.4583
Epoch 2/20
563/563 [==============================] - 1s 1ms/step - loss: 3262.6853 - val_loss: 299
6.0957
Epoch 3/20
563/563 [==============================] - 1s 1ms/step - loss: 3069.9128 - val_loss: 291
5.0986
Epoch 4/20
563/563 [==============================] - 1s 1ms/step - loss: 2990.0513 - val_loss: 287
2.5991
Epoch 5/20
563/563 [==============================] - 1s 978us/step - loss: 2941.7473 - val_loss: 2
864.8022
Epoch 6/20
563/563 [==============================] - 1s 970us/step - loss: 2909.7000 - val_loss: 2
920.1394
Epoch 7/20
563/563 [==============================] - 1s 966us/step - loss: 2860.5850 - val_loss: 2
788.0869
Epoch 8/20
563/563 [==============================] - 1s 970us/step - loss: 2834.9961 - val_loss: 2
758.7078
Epoch 9/20
563/563 [==============================] - 1s 966us/step - loss: 2812.9812 - val_loss: 2
720.4287
```

```
Epoch 10/20
563/563 [==============================] - 1s 971us/step - loss: 2780.8284 - val_loss: 2
730.7773
Epoch 11/20
563/563 [==============================] - 1s 974us/step - loss: 2765.2202 - val_loss: 2
701.7969
Epoch 12/20
563/563 [==============================] - 1s 971us/step - loss: 2750.9094 - val_loss: 2
755.0935
Epoch 13/20
563/563 [==============================] - 1s 1ms/step - loss: 2718.2415 - val_loss: 268
6.9539
Epoch 14/20
563/563 [==============================] - 1s 1ms/step - loss: 2709.6721 - val_loss: 268
3.2146
Epoch 15/20
563/563 [==============================] - 1s 1ms/step - loss: 2698.4006 - val_loss: 266
9.4521
Epoch 16/20
563/563 [==============================] - 1s 1ms/step - loss: 2677.9604 - val_loss: 266
7.4136
Epoch 17/20
563/563 [==============================] - 1s 997us/step - loss: 2664.0356 - val_loss: 2
709.9001
Epoch 18/20
563/563 [==============================] - 1s 982us/step - loss: 2649.8252 - val_loss: 2
634.8906
Epoch 19/20
563/563 [==============================] - 1s 1ms/step - loss: 2646.6160 - val_loss: 266
5.9331
Epoch 20/20
563/563 [==============================] - 1s 980us/step - loss: 2628.5146 - val_loss: 2
661.7500
94/94 [==============================] - 0s 617us/step
Model: 2
Mean Squared Error: 2813.283
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 15177.6982 - val_loss: 33
04.3887
Epoch 2/20
563/563 [==============================] - 1s 996us/step - loss: 3271.4614 - val_loss: 3
072.2812
Epoch 3/20
563/563 [==============================] - 1s 974us/step - loss: 3138.5293 - val_loss: 2
991.6814
Epoch 4/20
563/563 [==============================] - 1s 985us/step - loss: 3077.4502 - val_loss: 3
094.5723
Epoch 5/20
563/563 [==============================] - 1s 952us/step - loss: 3021.9497 - val_loss: 2
924.0828
Epoch 6/20
563/563 [==============================] - 1s 1ms/step - loss: 2969.6064 - val_loss: 285
3.2686
Epoch 7/20
563/563 [==============================] - 1s 956us/step - loss: 2934.2266 - val_loss: 2
839.5742
Epoch 8/20
563/563 [==============================] - 1s 988us/step - loss: 2902.6880 - val_loss: 2
```

```
874.7520
Epoch 9/20
563/563 [==============================] - 1s 1ms/step - loss: 2870.2756 - val_loss: 278
8.4583
Epoch 10/20
563/563 [==============================] - 1s 1ms/step - loss: 2833.4463 - val_loss: 278
3.4084
Epoch 11/20
563/563 [==============================] - 1s 998us/step - loss: 2817.7791 - val_loss: 2
750.9062
Epoch 12/20
563/563 [==============================] - 1s 999us/step - loss: 2791.2935 - val_loss: 2
744.0894
Epoch 13/20
563/563 [==============================] - 1s 1ms/step - loss: 2776.0776 - val_loss: 268
6.3794
Epoch 14/20
563/563 [==============================] - 1s 960us/step - loss: 2746.2339 - val_loss: 2
744.6260
Epoch 15/20
563/563 [==============================] - 1s 1ms/step - loss: 2726.1538 - val_loss: 266
5.9426
Epoch 16/20
563/563 [==============================] - 1s 966us/step - loss: 2716.7556 - val_loss: 2
649.8630
Epoch 17/20
563/563 [==============================] - 1s 982us/step - loss: 2701.9670 - val_loss: 2
684.5811
Epoch 18/20
563/563 [==============================] - 1s 978us/step - loss: 2687.2585 - val_loss: 2
667.4841
Epoch 19/20
563/563 [==============================] - 1s 1ms/step - loss: 2681.6436 - val_loss: 262
2.9536
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2660.3882 - val_loss: 263
4.6270
94/94 [==============================] - 0s 650us/step
Model: 3
Mean Squared Error: 2827.5693333333334
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 12271.5635 - val_loss: 31
30.0537
Epoch 2/20
563/563 [==============================] - 1s 963us/step - loss: 3206.3442 - val_loss: 3
217.1248
Epoch 3/20
563/563 [==============================] - 1s 959us/step - loss: 3124.7283 - val_loss: 2
996.3950
Epoch 4/20
563/563 [==============================] - 1s 978us/step - loss: 3056.3398 - val_loss: 2
906.5532
Epoch 5/20
563/563 [==============================] - 1s 957us/step - loss: 3023.7029 - val_loss: 2
919.6509
Epoch 6/20
563/563 [==============================] - 1s 962us/step - loss: 2961.8660 - val_loss: 2
891.7434
Epoch 7/20
```

```
563/563 [==============================] - 1s 996us/step - loss: 2934.0178 - val_loss: 2
827.2297
Epoch 8/20
563/563 [==============================] - 1s 974us/step - loss: 2881.8179 - val_loss: 2
803.2207
Epoch 9/20
563/563 [==============================] - 1s 973us/step - loss: 2863.6665 - val_loss: 2
754.5618
Epoch 10/20
563/563 [==============================] - 1s 967us/step - loss: 2831.6968 - val_loss: 2
738.8167
Epoch 11/20
563/563 [==============================] - 1s 1ms/step - loss: 2793.0251 - val_loss: 277
1.6121
Epoch 12/20
563/563 [==============================] - 1s 964us/step - loss: 2777.6580 - val_loss: 2
695.4036
Epoch 13/20
563/563 [==============================] - 1s 956us/step - loss: 2744.1897 - val_loss: 2
663.1221
Epoch 14/20
563/563 [==============================] - 1s 965us/step - loss: 2725.2126 - val_loss: 2
667.6621
Epoch 15/20
563/563 [==============================] - 1s 957us/step - loss: 2724.0776 - val_loss: 2
693.4387
Epoch 16/20
563/563 [==============================] - 1s 963us/step - loss: 2686.2009 - val_loss: 2
651.6179
Epoch 17/20
563/563 [==============================] - 1s 998us/step - loss: 2684.8845 - val_loss: 2
659.5645
Epoch 18/20
563/563 [==============================] - 1s 1ms/step - loss: 2659.0603 - val_loss: 263
6.0557
Epoch 19/20
563/563 [==============================] - 1s 1ms/step - loss: 2654.8752 - val_loss: 261
3.6868
Epoch 20/20
563/563 [==============================] - 1s 989us/step - loss: 2654.6929 - val_loss: 2
595.0212
94/94 [==============================] - 0s 675us/step
Model: 4
Mean Squared Error: 2814.11
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 10612.2402 - val_loss: 31
44.6516
Epoch 2/20
563/563 [==============================] - 1s 1ms/step - loss: 3183.3821 - val_loss: 299
5.6023
Epoch 3/20
563/563 [==============================] - 1s 977us/step - loss: 3091.5159 - val_loss: 2
953.8066
Epoch 4/20
563/563 [==============================] - 1s 981us/step - loss: 3027.6396 - val_loss: 2
932.8113
Epoch 5/20
563/563 [==============================] - 1s 968us/step - loss: 2986.3689 - val_loss: 2
826.3479
```

```
Epoch 6/20
563/563 [==============================] - 1s 978us/step - loss: 2958.3760 - val_loss: 3
035.8328
Epoch 7/20
563/563 [==============================] - 1s 981us/step - loss: 2916.1821 - val_loss: 2
785.8027
Epoch 8/20
563/563 [==============================] - 1s 967us/step - loss: 2866.9260 - val_loss: 2
828.3806
Epoch 9/20
563/563 [==============================] - 1s 961us/step - loss: 2861.6650 - val_loss: 2
748.5144
Epoch 10/20
563/563 [==============================] - 1s 971us/step - loss: 2812.2842 - val_loss: 2
772.7317
Epoch 11/20
563/563 [==============================] - 1s 972us/step - loss: 2798.4849 - val_loss: 2
740.9192
Epoch 12/20
563/563 [==============================] - 1s 1ms/step - loss: 2784.7004 - val_loss: 273
1.5090
Epoch 13/20
563/563 [==============================] - 1s 961us/step - loss: 2743.0798 - val_loss: 2
751.8921
Epoch 14/20
563/563 [==============================] - 1s 982us/step - loss: 2731.4741 - val_loss: 2
642.9124
Epoch 15/20
563/563 [==============================] - 1s 954us/step - loss: 2694.9863 - val_loss: 2
636.0046
Epoch 16/20
563/563 [==============================] - 1s 975us/step - loss: 2684.0081 - val_loss: 2
669.4751
Epoch 17/20
563/563 [==============================] - 1s 954us/step - loss: 2679.3677 - val_loss: 2
659.5439
Epoch 18/20
563/563 [==============================] - 1s 973us/step - loss: 2657.2859 - val_loss: 2
629.3364
Epoch 19/20
563/563 [==============================] - 1s 957us/step - loss: 2641.1350 - val_loss: 2
617.2151
Epoch 20/20
563/563 [==============================] - 1s 960us/step - loss: 2634.3306 - val_loss: 2
633.6499
94/94 [==============================] - 0s 614us/step
Model: 5
Mean Squared Error: 2828.3056666666666
--------------------
Average Mean Squared Error: 2823.2824
```

In [21]:

```
# Model-2: Add a fully connected layer with 32 neurons with sigmoid activation
# and glorot uniform kernel initializer. Add a fully connected layer layer with 8
# neurons, sigmoid activation and glorot normal as kernel initializer. Add a fully
# connected layer with 1 neuron, relu activation function and he uniform as
# kernel initializer. Use Adam optimizer with batch size 8, learning rate 0.01
# and epochs set to 20. Extract the features from second last fully connected
# layer (having 8 neurons) and model it using a Support Vector regressor.
```

```
from keras.models import Model
from sklearn.svm import SVR

def model2(X_train, X_val, y_train, y_val):
    model = Sequential()
    model.add(Dense(32, activation='sigmoid', kernel_initializer='glorot_uniform'))
    model.add(Dense(8, activation='sigmoid', kernel_initializer='glorot_normal'))
    model.add(Dense(1, activation='relu', kernel_initializer='he_uniform'))

    model.compile(optimizer=Adam(learning_rate=0.01), loss='mean_squared_error')

    model.fit(X_train, y_train, batch_size=8, epochs=20, validation_data=(X_val, y_val)

    intermediate_layer_model = Model(inputs=model.input, outputs=model.layers[-2].outpu
    intermediate_output = intermediate_layer_model.predict(X_train)

    svr = SVR()
    svr.fit(intermediate_output, y_train)

    return model, svr

count = 5
avg_mse = 0

for i in range(count):
    # Split data to 60% training 20% validation and 20% testing
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta
    X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.25,

    model, svr = model2(X_train, X_val, y_train, y_val)

    intermediate_output = model.layers[-2].output
    intermediate_layer_model = Model(inputs=model.input, outputs=intermediate_output)
    intermediate_output = intermediate_layer_model.predict(X_test)

    y_pred = svr.predict(intermediate_output)

    print('Model:', i+1)
    y_pred = np.round(y_pred)
    mse = mean_squared_error(y_test, y_pred)
    print('Mean Squared Error:', mse)
    print("--------------------")
    avg_mse += mse

print('Average Mean Squared Error:', avg_mse/count)
```

```
Epoch 1/20
1125/1125 [==============================] - 2s 996us/step - loss: 88622.5859 - val_los
s: 87336.4844
Epoch 2/20
1125/1125 [==============================] - 1s 958us/step - loss: 88622.5703 - val_los
s: 87336.4844
Epoch 3/20
1125/1125 [==============================] - 1s 940us/step - loss: 88622.5469 - val_los
s: 87336.4844
Epoch 4/20
1125/1125 [==============================] - 1s 921us/step - loss: 88622.5781 - val_los
s: 87336.4844
Epoch 5/20
1125/1125 [==============================] - 1s 945us/step - loss: 88622.5859 - val_los
```

```
s: 87336.4844
Epoch 6/20
1125/1125 [==============================] - 1s 935us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 7/20
1125/1125 [==============================] - 1s 989us/step - loss: 88622.5547 - val_los
s: 87336.4844
Epoch 8/20
1125/1125 [==============================] - 1s 964us/step - loss: 88622.6016 - val_los
s: 87336.4844
Epoch 9/20
1125/1125 [==============================] - 1s 961us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 10/20
1125/1125 [==============================] - 1s 965us/step - loss: 88622.5469 - val_los
s: 87336.4844
Epoch 11/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5703 - val_loss:
87336.4844
Epoch 12/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5156 - val_loss:
87336.4844
Epoch 13/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5625 - val_loss:
87336.4844
Epoch 14/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.4922 - val_loss:
87336.4844
Epoch 15/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.6172 - val_loss:
87336.4844
Epoch 16/20
1125/1125 [==============================] - 1s 969us/step - loss: 88622.5078 - val_los
s: 87336.4844
Epoch 17/20
1125/1125 [==============================] - 1s 945us/step - loss: 88622.6172 - val_los
s: 87336.4844
Epoch 18/20
1125/1125 [==============================] - 1s 974us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 19/20
1125/1125 [==============================] - 1s 919us/step - loss: 88622.5000 - val_los
s: 87336.4844
Epoch 20/20
1125/1125 [==============================] - 1s 938us/step - loss: 88622.5312 - val_los
s: 87336.4844
282/282 [==============================] - 0s 572us/step
94/94 [==============================] - 0s 611us/step
Model: 1
Mean Squared Error: 4731.069333333333
--------------------
Epoch 1/20
1125/1125 [==============================] - 2s 985us/step - loss: 67297.6875 - val_los
s: 46958.6758
Epoch 2/20
1125/1125 [==============================] - 1s 947us/step - loss: 35098.2461 - val_los
s: 24068.2637
Epoch 3/20
1125/1125 [==============================] - 1s 1ms/step - loss: 18585.6934 - val_loss:
13300.7422
```

```
Epoch 4/20
1125/1125 [==============================] - 1s 1ms/step - loss: 10751.9238 - val_loss:
7595.8467
Epoch 5/20
1125/1125 [==============================] - 1s 958us/step - loss: 6486.3086 - val_loss:
5031.7549
Epoch 6/20
1125/1125 [==============================] - 1s 958us/step - loss: 4717.8071 - val_loss:
4021.4944
Epoch 7/20
1125/1125 [==============================] - 1s 929us/step - loss: 3983.1685 - val_loss:
3598.6252
Epoch 8/20
1125/1125 [==============================] - 1s 903us/step - loss: 3592.4619 - val_loss:
3362.4221
Epoch 9/20
1125/1125 [==============================] - 1s 940us/step - loss: 3402.0837 - val_loss:
3253.7393
Epoch 10/20
1125/1125 [==============================] - 1s 939us/step - loss: 3231.3818 - val_loss:
3097.0500
Epoch 11/20
1125/1125 [==============================] - 1s 915us/step - loss: 3097.4390 - val_loss:
3105.1289
Epoch 12/20
1125/1125 [==============================] - 1s 912us/step - loss: 3026.4004 - val_loss:
2992.4409
Epoch 13/20
1125/1125 [==============================] - 1s 936us/step - loss: 2948.9893 - val_loss:
2935.9104
Epoch 14/20
1125/1125 [==============================] - 1s 950us/step - loss: 2888.5703 - val_loss:
2862.7556
Epoch 15/20
1125/1125 [==============================] - 1s 964us/step - loss: 2812.3210 - val_loss:
2859.9844
Epoch 16/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2764.9932 - val_loss: 2
841.6377
Epoch 17/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2704.1492 - val_loss: 2
776.0459
Epoch 18/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2671.3445 - val_loss: 2
738.9321
Epoch 19/20
1125/1125 [==============================] - 1s 952us/step - loss: 2631.8655 - val_loss:
2724.4058
Epoch 20/20
1125/1125 [==============================] - 1s 960us/step - loss: 2617.8184 - val_loss:
2679.6694
282/282 [==============================] - 0s 567us/step
94/94 [==============================] - 0s 575us/step
Model: 2
Mean Squared Error: 2957.198
--------------------
Epoch 1/20
1125/1125 [==============================] - 2s 1ms/step - loss: 67699.0625 - val_loss:
50201.3008
Epoch 2/20
```

```
1125/1125 [==============================] - 1s 916us/step - loss: 37512.6367 - val_los
s: 25001.9492
Epoch 3/20
1125/1125 [==============================] - 1s 907us/step - loss: 19162.2539 - val_los
s: 13616.2734
Epoch 4/20
1125/1125 [==============================] - 1s 915us/step - loss: 10853.2910 - val_los
s: 7670.9629
Epoch 5/20
1125/1125 [==============================] - 1s 917us/step - loss: 6583.5645 - val_loss:
5105.7202
Epoch 6/20
1125/1125 [==============================] - 1s 932us/step - loss: 4750.0933 - val_loss:
4027.2471
Epoch 7/20
1125/1125 [==============================] - 1s 898us/step - loss: 3976.0081 - val_loss:
3605.2471
Epoch 8/20
1125/1125 [==============================] - 1s 913us/step - loss: 3547.5894 - val_loss:
3276.8850
Epoch 9/20
1125/1125 [==============================] - 1s 932us/step - loss: 3261.4717 - val_loss:
3120.7939
Epoch 10/20
1125/1125 [==============================] - 1s 955us/step - loss: 3071.2441 - val_loss:
3092.0896
Epoch 11/20
1125/1125 [==============================] - 1s 945us/step - loss: 2961.8394 - val_loss:
2914.6960
Epoch 12/20
1125/1125 [==============================] - 1s 889us/step - loss: 2874.2412 - val_loss:
2835.3433
Epoch 13/20
1125/1125 [==============================] - 1s 910us/step - loss: 2807.8359 - val_loss:
2873.0576
Epoch 14/20
1125/1125 [==============================] - 1s 947us/step - loss: 2765.4314 - val_loss:
2813.1252
Epoch 15/20
1125/1125 [==============================] - 1s 926us/step - loss: 2725.6604 - val_loss:
2767.7368
Epoch 16/20
1125/1125 [==============================] - 1s 934us/step - loss: 2680.7961 - val_loss:
2732.5759
Epoch 17/20
1125/1125 [==============================] - 1s 921us/step - loss: 2651.3953 - val_loss:
2759.2939
Epoch 18/20
1125/1125 [==============================] - 1s 946us/step - loss: 2629.0681 - val_loss:
2698.6003
Epoch 19/20
1125/1125 [==============================] - 1s 902us/step - loss: 2595.8362 - val_loss:
2675.0581
Epoch 20/20
1125/1125 [==============================] - 1s 923us/step - loss: 2570.0564 - val_loss:
2630.8638
282/282 [==============================] - 0s 629us/step
94/94 [==============================] - 0s 627us/step
Model: 3
Mean Squared Error: 2919.4283333333333
```

```
--------------------
Epoch 1/20
1125/1125 [==============================] - 2s 989us/step - loss: 88622.5234 - val_los
s: 87336.4844
Epoch 2/20
1125/1125 [==============================] - 1s 944us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 3/20
1125/1125 [==============================] - 1s 923us/step - loss: 88622.5078 - val_los
s: 87336.4844
Epoch 4/20
1125/1125 [==============================] - 1s 915us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 5/20
1125/1125 [==============================] - 1s 952us/step - loss: 88622.5469 - val_los
s: 87336.4844
Epoch 6/20
1125/1125 [==============================] - 1s 935us/step - loss: 88622.4922 - val_los
s: 87336.4844
Epoch 7/20
1125/1125 [==============================] - 1s 913us/step - loss: 88622.4531 - val_los
s: 87336.4844
Epoch 8/20
1125/1125 [==============================] - 1s 967us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 9/20
1125/1125 [==============================] - 1s 936us/step - loss: 88622.5234 - val_los
s: 87336.4844
Epoch 10/20
1125/1125 [==============================] - 1s 945us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 11/20
1125/1125 [==============================] - 1s 917us/step - loss: 88622.5078 - val_los
s: 87336.4844
Epoch 12/20
1125/1125 [==============================] - 1s 977us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 13/20
1125/1125 [==============================] - 1s 987us/step - loss: 88622.4766 - val_los
s: 87336.4844
Epoch 14/20
1125/1125 [==============================] - 1s 947us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 15/20
1125/1125 [==============================] - 1s 931us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 16/20
1125/1125 [==============================] - 1s 912us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 17/20
1125/1125 [==============================] - 1s 956us/step - loss: 88622.5469 - val_los
s: 87336.4844
Epoch 18/20
1125/1125 [==============================] - 1s 936us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 19/20
1125/1125 [==============================] - 1s 986us/step - loss: 88622.5469 - val_los
s: 87336.4844
Epoch 20/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5547 - val_loss:
```

```
87336.4844
282/282 [==============================] - 0s 596us/step
94/94 [==============================] - 0s 584us/step
Model: 4
Mean Squared Error: 4255.151
--------------------
Epoch 1/20
1125/1125 [==============================] - 2s 1ms/step - loss: 65782.6328 - val_loss:
45830.1875
Epoch 2/20
1125/1125 [==============================] - 1s 922us/step - loss: 34422.0586 - val_los
s: 23672.1777
Epoch 3/20
1125/1125 [==============================] - 1s 909us/step - loss: 18355.7305 - val_los
s: 13199.2109
Epoch 4/20
1125/1125 [==============================] - 1s 921us/step - loss: 10452.9697 - val_los
s: 7474.0571
Epoch 5/20
1125/1125 [==============================] - 1s 899us/step - loss: 6406.0308 - val_loss:
4997.7593
Epoch 6/20
1125/1125 [==============================] - 1s 939us/step - loss: 4685.1440 - val_loss:
4051.9299
Epoch 7/20
1125/1125 [==============================] - 1s 900us/step - loss: 3968.3716 - val_loss:
3609.6589
Epoch 8/20
1125/1125 [==============================] - 1s 915us/step - loss: 3613.8838 - val_loss:
3407.7026
Epoch 9/20
1125/1125 [==============================] - 1s 919us/step - loss: 3368.5674 - val_loss:
3184.5012
Epoch 10/20
1125/1125 [==============================] - 1s 924us/step - loss: 3201.3145 - val_loss:
3058.9360
Epoch 11/20
1125/1125 [==============================] - 1s 930us/step - loss: 3058.5947 - val_loss:
2947.8428
Epoch 12/20
1125/1125 [==============================] - 1s 905us/step - loss: 2958.9607 - val_loss:
2838.8621
Epoch 13/20
1125/1125 [==============================] - 1s 909us/step - loss: 2868.3318 - val_loss:
2844.7798
Epoch 14/20
1125/1125 [==============================] - 1s 938us/step - loss: 2823.2273 - val_loss:
2770.3174
Epoch 15/20
1125/1125 [==============================] - 1s 999us/step - loss: 2767.5830 - val_loss:
2765.5266
Epoch 16/20
1125/1125 [==============================] - 1s 914us/step - loss: 2724.4106 - val_loss:
2786.7683
Epoch 17/20
1125/1125 [==============================] - 1s 908us/step - loss: 2698.3511 - val_loss:
2680.2156
Epoch 18/20
1125/1125 [==============================] - 1s 914us/step - loss: 2654.2588 - val_loss:
2682.2791
```

```
Epoch 19/20
1125/1125 [==============================] - 1s 921us/step - loss: 2629.7961 - val_loss:
2644.6187
Epoch 20/20
1125/1125 [==============================] - 1s 935us/step - loss: 2601.1350 - val_loss:
2610.8401
282/282 [==============================] - 0s 562us/step
94/94 [==============================] - 0s 591us/step
Model: 5
Mean Squared Error: 2925.887333333333
--------------------
Average Mean Squared Error: 3557.7468
```

In [22]:

```
# Model-3: Extract the deep features from Model-I (from 2nd layer) and Model-
# 2 (from 2nd layer) stack the features horizontally and model it using a Support
# Vector Regressor.

def model3(X_train, X_val, y_train, y_val):
    model_1 = model1(X_train, X_val, y_train, y_val)
    model_2, _ = model2(X_train, X_val, y_train, y_val)

    intermediate_output1 = model_1.layers[-2].output
    intermediate_output2 = model_2.layers[-2].output

    intermediate_layer_model_1 = Model(inputs=model_1.input, outputs=intermediate_outpu

    intermediate_output1 = intermediate_layer_model_1.predict(X_train)

    intermediate_layer_model_2 = Model(inputs=model_2.input, outputs=intermediate_outpu

    intermediate_output2 = intermediate_layer_model_2.predict(X_train)

    intermediate_output = np.hstack((intermediate_output1, intermediate_output2))

    svr = SVR()
    svr.fit(intermediate_output, y_train)

    return model_1, model_2, svr

count = 5
avg_mse = 0

for i in range(count):
    # Split data to 60% training 20% validation and 20% testing
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta
    X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.25,

    model_1, model_2, svr = model3(X_train, X_val, y_train, y_val)

    intermediate_output1 = model_1.layers[-2].output
    intermediate_output2 = model_2.layers[-2].output

    intermediate_layer_model_1 = Model(inputs=model_1.input, outputs=intermediate_outpu

    intermediate_output1 = intermediate_layer_model_1.predict(X_test)

    intermediate_layer_model_2 = Model(inputs=model_2.input, outputs=intermediate_outpu

    intermediate_output2 = intermediate_layer_model_2.predict(X_test)
```

```
    intermediate_output = np.hstack((intermediate_output1, intermediate_output2))

    y_pred = svr.predict(intermediate_output)

    print('Model:', i+1)
    y_pred = np.round(y_pred)
    mse = mean_squared_error(y_test, y_pred)
    print('Mean Squared Error:', mse)
    print("--------------------")
    avg_mse += mse

print('Average Mean Squared Error:', avg_mse/count)
```

```
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 11945.1299 - val_loss: 31
44.1050
Epoch 2/20
563/563 [==============================] - 1s 948us/step - loss: 3207.5786 - val_loss: 3
050.7461
Epoch 3/20
563/563 [==============================] - 1s 944us/step - loss: 3104.2451 - val_loss: 2
954.7461
Epoch 4/20
563/563 [==============================] - 1s 954us/step - loss: 3062.3867 - val_loss: 3
009.6094
Epoch 5/20
563/563 [==============================] - 1s 957us/step - loss: 3024.0359 - val_loss: 2
870.3667
Epoch 6/20
563/563 [==============================] - 1s 939us/step - loss: 2983.6787 - val_loss: 2
916.1250
Epoch 7/20
563/563 [==============================] - 1s 986us/step - loss: 2919.1902 - val_loss: 2
819.6453
Epoch 8/20
563/563 [==============================] - 1s 993us/step - loss: 2906.6006 - val_loss: 2
790.2700
Epoch 9/20
563/563 [==============================] - 1s 936us/step - loss: 2873.9065 - val_loss: 2
809.4346
Epoch 10/20
563/563 [==============================] - 1s 947us/step - loss: 2847.3323 - val_loss: 2
740.3032
Epoch 11/20
563/563 [==============================] - 1s 945us/step - loss: 2797.2759 - val_loss: 2
711.7197
Epoch 12/20
563/563 [==============================] - 1s 936us/step - loss: 2786.1023 - val_loss: 2
716.6248
Epoch 13/20
563/563 [==============================] - 1s 938us/step - loss: 2747.5251 - val_loss: 2
693.9026
Epoch 14/20
563/563 [==============================] - 1s 949us/step - loss: 2735.9082 - val_loss: 2
767.4211
Epoch 15/20
563/563 [==============================] - 1s 944us/step - loss: 2725.5481 - val_loss: 2
```

```
674.4001
Epoch 16/20
563/563 [==============================] - 1s 944us/step - loss: 2701.1360 - val_loss: 2
688.4128
Epoch 17/20
563/563 [==============================] - 1s 976us/step - loss: 2695.2520 - val_loss: 2
674.8105
Epoch 18/20
563/563 [==============================] - 1s 954us/step - loss: 2692.1406 - val_loss: 2
701.1467
Epoch 19/20
563/563 [==============================] - 1s 947us/step - loss: 2658.6807 - val_loss: 2
639.5505
Epoch 20/20
563/563 [==============================] - 1s 951us/step - loss: 2652.3108 - val_loss: 2
638.8616
Epoch 1/20
1125/1125 [==============================] - 2s 993us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 2/20
1125/1125 [==============================] - 1s 904us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 3/20
1125/1125 [==============================] - 1s 947us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 4/20
1125/1125 [==============================] - 1s 905us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 5/20
1125/1125 [==============================] - 1s 912us/step - loss: 88622.5859 - val_los
s: 87336.4844
Epoch 6/20
1125/1125 [==============================] - 1s 922us/step - loss: 88622.6172 - val_los
s: 87336.4844
Epoch 7/20
1125/1125 [==============================] - 1s 994us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 8/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5234 - val_loss:
87336.4844
Epoch 9/20
1125/1125 [==============================] - 1s 966us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 10/20
1125/1125 [==============================] - 1s 954us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 11/20
1125/1125 [==============================] - 1s 932us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 12/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5000 - val_loss:
87336.4844
Epoch 13/20
1125/1125 [==============================] - 1s 961us/step - loss: 88622.6250 - val_los
s: 87336.4844
Epoch 14/20
1125/1125 [==============================] - 1s 997us/step - loss: 88622.5781 - val_los
s: 87336.4844
Epoch 15/20
1125/1125 [==============================] - 1s 950us/step - loss: 88622.5391 - val_los
```

```
s: 87336.4844
Epoch 16/20
1125/1125 [==============================] - 1s 983us/step - loss: 88622.4766 - val_los
s: 87336.4844
Epoch 17/20
1125/1125 [==============================] - 1s 1000us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 18/20
1125/1125 [==============================] - 1s 1ms/step - loss: 88622.5391 - val_loss:
87336.4844
Epoch 19/20
1125/1125 [==============================] - 1s 985us/step - loss: 88622.5547 - val_los
s: 87336.4844
Epoch 20/20
1125/1125 [==============================] - 1s 984us/step - loss: 88622.6719 - val_los
s: 87336.4844
282/282 [==============================] - 0s 741us/step
282/282 [==============================] - 0s 566us/step
282/282 [==============================] - 0s 563us/step
94/94 [==============================] - 0s 587us/step
94/94 [==============================] - 0s 600us/step
Model: 1
Mean Squared Error: 2954.1633333333334
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 10008.2842 - val_loss: 30
86.7427
Epoch 2/20
563/563 [==============================] - 1s 1ms/step - loss: 3199.8962 - val_loss: 303
6.8157
Epoch 3/20
563/563 [==============================] - 1s 970us/step - loss: 3123.4253 - val_loss: 3
047.5601
Epoch 4/20
563/563 [==============================] - 1s 977us/step - loss: 3061.5872 - val_loss: 2
951.2502
Epoch 5/20
563/563 [==============================] - 1s 1ms/step - loss: 3012.5869 - val_loss: 288
6.9316
Epoch 6/20
563/563 [==============================] - 1s 980us/step - loss: 2969.0300 - val_loss: 2
820.8374
Epoch 7/20
563/563 [==============================] - 1s 1ms/step - loss: 2940.1226 - val_loss: 282
7.8354
Epoch 8/20
563/563 [==============================] - 1s 986us/step - loss: 2898.6726 - val_loss: 2
811.5676
Epoch 9/20
563/563 [==============================] - 1s 985us/step - loss: 2856.5151 - val_loss: 2
772.6782
Epoch 10/20
563/563 [==============================] - 1s 962us/step - loss: 2817.8313 - val_loss: 2
767.0742
Epoch 11/20
563/563 [==============================] - 1s 977us/step - loss: 2818.6040 - val_loss: 2
770.4902
Epoch 12/20
563/563 [==============================] - 1s 1ms/step - loss: 2793.7268 - val_loss: 269
3.3662
```

```
Epoch 13/20
563/563 [==============================] - 1s 964us/step - loss: 2762.7043 - val_loss: 2
681.4985
Epoch 14/20
563/563 [==============================] - 1s 972us/step - loss: 2769.4031 - val_loss: 2
737.4854
Epoch 15/20
563/563 [==============================] - 1s 973us/step - loss: 2734.2690 - val_loss: 2
677.8940
Epoch 16/20
563/563 [==============================] - 1s 968us/step - loss: 2720.9526 - val_loss: 2
679.7388
Epoch 17/20
563/563 [==============================] - 1s 975us/step - loss: 2706.3804 - val_loss: 2
651.6670
Epoch 18/20
563/563 [==============================] - 1s 995us/step - loss: 2692.2712 - val_loss: 2
663.7329
Epoch 19/20
563/563 [==============================] - 1s 1ms/step - loss: 2692.7522 - val_loss: 269
0.6167
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2681.3787 - val_loss: 273
2.4475
Epoch 1/20
1125/1125 [==============================] - 2s 983us/step - loss: 67907.6797 - val_los
s: 50208.4688
Epoch 2/20
1125/1125 [==============================] - 1s 923us/step - loss: 39273.8203 - val_los
s: 28356.7012
Epoch 3/20
1125/1125 [==============================] - 1s 923us/step - loss: 22283.9648 - val_los
s: 16109.8799
Epoch 4/20
1125/1125 [==============================] - 1s 941us/step - loss: 13354.7168 - val_los
s: 9615.3115
Epoch 5/20
1125/1125 [==============================] - 1s 934us/step - loss: 8076.1484 - val_loss:
6125.2231
Epoch 6/20
1125/1125 [==============================] - 1s 950us/step - loss: 5527.2432 - val_loss:
4522.5806
Epoch 7/20
1125/1125 [==============================] - 1s 932us/step - loss: 4330.6958 - val_loss:
3756.8506
Epoch 8/20
1125/1125 [==============================] - 1s 938us/step - loss: 3760.5964 - val_loss:
3498.5200
Epoch 9/20
1125/1125 [==============================] - 1s 941us/step - loss: 3485.5964 - val_loss:
3288.3403
Epoch 10/20
1125/1125 [==============================] - 1s 921us/step - loss: 3286.4666 - val_loss:
3183.3677
Epoch 11/20
1125/1125 [==============================] - 1s 933us/step - loss: 3147.9548 - val_loss:
3096.9766
Epoch 12/20
1125/1125 [==============================] - 1s 935us/step - loss: 3049.9680 - val_loss:
2979.8027
```

```
Epoch 13/20
1125/1125 [==============================] - 1s 955us/step - loss: 2983.7471 - val_loss:
2975.9221
Epoch 14/20
1125/1125 [==============================] - 1s 926us/step - loss: 2933.1226 - val_loss:
2877.1814
Epoch 15/20
1125/1125 [==============================] - 1s 936us/step - loss: 2866.0461 - val_loss:
2826.5002
Epoch 16/20
1125/1125 [==============================] - 1s 932us/step - loss: 2802.2319 - val_loss:
2901.6204
Epoch 17/20
1125/1125 [==============================] - 1s 928us/step - loss: 2771.1936 - val_loss:
2822.2219
Epoch 18/20
1125/1125 [==============================] - 1s 957us/step - loss: 2732.2324 - val_loss:
2794.9041
Epoch 19/20
1125/1125 [==============================] - 1s 959us/step - loss: 2686.7539 - val_loss:
2760.5459
Epoch 20/20
1125/1125 [==============================] - 1s 944us/step - loss: 2662.1375 - val_loss:
2680.1074
282/282 [==============================] - 0s 558us/step
282/282 [==============================] - 0s 564us/step
282/282 [==============================] - 0s 575us/step
94/94 [==============================] - 0s 601us/step
94/94 [==============================] - 0s 568us/step
Model: 2
Mean Squared Error: 2941.9313333333334
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 15843.0986 - val_loss: 33
22.3120
Epoch 2/20
563/563 [==============================] - 1s 959us/step - loss: 3298.2097 - val_loss: 3
056.3147
Epoch 3/20
563/563 [==============================] - 1s 1ms/step - loss: 3130.4861 - val_loss: 306
2.8611
Epoch 4/20
563/563 [==============================] - 1s 1ms/step - loss: 3061.1362 - val_loss: 291
8.4043
Epoch 5/20
563/563 [==============================] - 1s 1ms/step - loss: 3004.3521 - val_loss: 283
4.7302
Epoch 6/20
563/563 [==============================] - 1s 971us/step - loss: 2959.3403 - val_loss: 2
822.2686
Epoch 7/20
563/563 [==============================] - 1s 1ms/step - loss: 2920.4324 - val_loss: 277
7.1992
Epoch 8/20
563/563 [==============================] - 1s 969us/step - loss: 2872.3311 - val_loss: 2
829.3567
Epoch 9/20
563/563 [==============================] - 1s 1ms/step - loss: 2853.6587 - val_loss: 273
9.7109
Epoch 10/20
```

```
563/563 [==============================] - 1s 979us/step - loss: 2813.7317 - val_loss: 2
746.7163
Epoch 11/20
563/563 [==============================] - 1s 1ms/step - loss: 2788.6794 - val_loss: 279
9.6951
Epoch 12/20
563/563 [==============================] - 1s 993us/step - loss: 2759.4102 - val_loss: 2
685.9041
Epoch 13/20
563/563 [==============================] - 1s 985us/step - loss: 2740.9377 - val_loss: 2
697.0869
Epoch 14/20
563/563 [==============================] - 1s 961us/step - loss: 2727.9089 - val_loss: 2
749.1265
Epoch 15/20
563/563 [==============================] - 1s 972us/step - loss: 2707.5010 - val_loss: 2
666.6025
Epoch 16/20
563/563 [==============================] - 1s 961us/step - loss: 2694.9565 - val_loss: 2
670.0474
Epoch 17/20
563/563 [==============================] - 1s 1ms/step - loss: 2677.3201 - val_loss: 266
7.7393
Epoch 18/20
563/563 [==============================] - 1s 982us/step - loss: 2675.4624 - val_loss: 2
681.0649
Epoch 19/20
563/563 [==============================] - 1s 985us/step - loss: 2665.0234 - val_loss: 2
653.2661
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2645.5740 - val_loss: 267
1.2068
Epoch 1/20
1125/1125 [==============================] - 2s 982us/step - loss: 88622.4922 - val_los
s: 87336.4844
Epoch 2/20
1125/1125 [==============================] - 1s 962us/step - loss: 88622.6250 - val_los
s: 87336.4844
Epoch 3/20
1125/1125 [==============================] - 1s 937us/step - loss: 88622.5859 - val_los
s: 87336.4844
Epoch 4/20
1125/1125 [==============================] - 1s 953us/step - loss: 88622.5000 - val_los
s: 87336.4844
Epoch 5/20
1125/1125 [==============================] - 1s 928us/step - loss: 88622.6562 - val_los
s: 87336.4844
Epoch 6/20
1125/1125 [==============================] - 1s 932us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 7/20
1125/1125 [==============================] - 1s 903us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 8/20
1125/1125 [==============================] - 1s 908us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 9/20
1125/1125 [==============================] - 1s 910us/step - loss: 88622.4688 - val_los
s: 87336.4844
Epoch 10/20
```

```
1125/1125 [==============================] - 1s 912us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 11/20
1125/1125 [==============================] - 1s 929us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 12/20
1125/1125 [==============================] - 1s 912us/step - loss: 88622.6250 - val_los
s: 87336.4844
Epoch 13/20
1125/1125 [==============================] - 1s 913us/step - loss: 88622.5156 - val_los
s: 87336.4844
Epoch 14/20
1125/1125 [==============================] - 1s 907us/step - loss: 88622.5234 - val_los
s: 87336.4844
Epoch 15/20
1125/1125 [==============================] - 1s 942us/step - loss: 88622.6094 - val_los
s: 87336.4844
Epoch 16/20
1125/1125 [==============================] - 1s 909us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 17/20
1125/1125 [==============================] - 1s 925us/step - loss: 88622.5156 - val_los
s: 87336.4844
Epoch 18/20
1125/1125 [==============================] - 1s 900us/step - loss: 88622.5547 - val_los
s: 87336.4844
Epoch 19/20
1125/1125 [==============================] - 1s 907us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 20/20
1125/1125 [==============================] - 1s 901us/step - loss: 88622.4922 - val_los
s: 87336.4844
282/282 [==============================] - 0s 568us/step
282/282 [==============================] - 0s 577us/step
282/282 [==============================] - 0s 602us/step
94/94 [==============================] - 0s 547us/step
94/94 [==============================] - 0s 606us/step
Model: 3
Mean Squared Error: 2911.193
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 11374.5020 - val_loss: 32
33.7229
Epoch 2/20
563/563 [==============================] - 1s 938us/step - loss: 3212.9531 - val_loss: 3
052.9551
Epoch 3/20
563/563 [==============================] - 1s 946us/step - loss: 3117.6724 - val_loss: 3
059.5913
Epoch 4/20
563/563 [==============================] - 1s 941us/step - loss: 3053.8989 - val_loss: 2
909.4988
Epoch 5/20
563/563 [==============================] - 1s 938us/step - loss: 2995.6077 - val_loss: 2
920.9871
Epoch 6/20
563/563 [==============================] - 1s 941us/step - loss: 2989.5183 - val_loss: 2
851.5503
Epoch 7/20
563/563 [==============================] - 1s 946us/step - loss: 2943.0027 - val_loss: 2
```

```
812.1689
Epoch 8/20
563/563 [==============================] - 1s 1ms/step - loss: 2915.3879 - val_loss: 280
0.5566
Epoch 9/20
563/563 [==============================] - 1s 944us/step - loss: 2887.6794 - val_loss: 2
792.9456
Epoch 10/20
563/563 [==============================] - 1s 943us/step - loss: 2842.5486 - val_loss: 2
780.5901
Epoch 11/20
563/563 [==============================] - 1s 947us/step - loss: 2818.5352 - val_loss: 2
755.5859
Epoch 12/20
563/563 [==============================] - 1s 941us/step - loss: 2792.4785 - val_loss: 2
706.9338
Epoch 13/20
563/563 [==============================] - 1s 935us/step - loss: 2770.8945 - val_loss: 2
689.1570
Epoch 14/20
563/563 [==============================] - 1s 966us/step - loss: 2751.1440 - val_loss: 2
703.7961
Epoch 15/20
563/563 [==============================] - 1s 936us/step - loss: 2737.9888 - val_loss: 2
707.7153
Epoch 16/20
563/563 [==============================] - 1s 949us/step - loss: 2719.6448 - val_loss: 2
646.6394
Epoch 17/20
563/563 [==============================] - 1s 941us/step - loss: 2694.7947 - val_loss: 2
629.0342
Epoch 18/20
563/563 [==============================] - 1s 974us/step - loss: 2680.5015 - val_loss: 2
662.9802
Epoch 19/20
563/563 [==============================] - 1s 969us/step - loss: 2673.4509 - val_loss: 2
650.8433
Epoch 20/20
563/563 [==============================] - 1s 938us/step - loss: 2638.3816 - val_loss: 2
653.0955
Epoch 1/20
1125/1125 [==============================] - 2s 989us/step - loss: 65439.1523 - val_los
s: 46109.1953
Epoch 2/20
1125/1125 [==============================] - 1s 888us/step - loss: 34734.4922 - val_los
s: 23958.7949
Epoch 3/20
1125/1125 [==============================] - 1s 930us/step - loss: 18531.0977 - val_los
s: 13278.2842
Epoch 4/20
1125/1125 [==============================] - 1s 948us/step - loss: 10634.4209 - val_los
s: 7512.2915
Epoch 5/20
1125/1125 [==============================] - 1s 911us/step - loss: 6453.9033 - val_loss:
5047.6694
Epoch 6/20
1125/1125 [==============================] - 1s 915us/step - loss: 4686.8350 - val_loss:
4007.0200
Epoch 7/20
1125/1125 [==============================] - 1s 922us/step - loss: 3966.6555 - val_loss:
```

```
3594.4431
Epoch 8/20
1125/1125 [==============================] - 1s 924us/step - loss: 3598.4419 - val_loss:
3369.2991
Epoch 9/20
1125/1125 [==============================] - 1s 950us/step - loss: 3369.0508 - val_loss:
3182.1599
Epoch 10/20
1125/1125 [==============================] - 1s 940us/step - loss: 3195.1226 - val_loss:
3012.5601
Epoch 11/20
1125/1125 [==============================] - 1s 931us/step - loss: 3059.9275 - val_loss:
2962.7993
Epoch 12/20
1125/1125 [==============================] - 1s 982us/step - loss: 2957.8379 - val_loss:
2888.3547
Epoch 13/20
1125/1125 [==============================] - 1s 965us/step - loss: 2895.9822 - val_loss:
2851.3584
Epoch 14/20
1125/1125 [==============================] - 1s 995us/step - loss: 2828.6726 - val_loss:
2879.9460
Epoch 15/20
1125/1125 [==============================] - 1s 937us/step - loss: 2779.7605 - val_loss:
2831.8049
Epoch 16/20
1125/1125 [==============================] - 1s 987us/step - loss: 2750.8254 - val_loss:
2843.3196
Epoch 17/20
1125/1125 [==============================] - 1s 977us/step - loss: 2719.9065 - val_loss:
2764.3765
Epoch 18/20
1125/1125 [==============================] - 1s 974us/step - loss: 2686.2427 - val_loss:
2740.7009
Epoch 19/20
1125/1125 [==============================] - 1s 939us/step - loss: 2658.5042 - val_loss:
2986.2676
Epoch 20/20
1125/1125 [==============================] - 1s 924us/step - loss: 2627.6296 - val_loss:
2740.8047
282/282 [==============================] - 0s 573us/step
282/282 [==============================] - 0s 534us/step
282/282 [==============================] - 1s 579us/step
94/94 [==============================] - 0s 606us/step
94/94 [==============================] - 0s 579us/step
Model: 4
Mean Squared Error: 2947.3006666666665
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 10915.9609 - val_loss: 31
64.4871
Epoch 2/20
563/563 [==============================] - 1s 952us/step - loss: 3185.9873 - val_loss: 3
028.2126
Epoch 3/20
563/563 [==============================] - 1s 945us/step - loss: 3102.9368 - val_loss: 2
979.6736
Epoch 4/20
563/563 [==============================] - 1s 1ms/step - loss: 3045.3047 - val_loss: 291
1.9377
```

```
Epoch 5/20
563/563 [==============================] - 1s 1ms/step - loss: 2985.3445 - val_loss: 289
6.5117
Epoch 6/20
563/563 [==============================] - 1s 991us/step - loss: 2939.1321 - val_loss: 2
802.6816
Epoch 7/20
563/563 [==============================] - 1s 1ms/step - loss: 2895.9390 - val_loss: 276
9.5337
Epoch 8/20
563/563 [==============================] - 1s 1ms/step - loss: 2867.9121 - val_loss: 281
0.2520
Epoch 9/20
563/563 [==============================] - 1s 995us/step - loss: 2854.7891 - val_loss: 2
918.4690
Epoch 10/20
563/563 [==============================] - 1s 944us/step - loss: 2811.3318 - val_loss: 2
835.1299
Epoch 11/20
563/563 [==============================] - 1s 940us/step - loss: 2789.8201 - val_loss: 2
711.3501
Epoch 12/20
563/563 [==============================] - 1s 933us/step - loss: 2771.0442 - val_loss: 2
682.3149
Epoch 13/20
563/563 [==============================] - 1s 984us/step - loss: 2758.7185 - val_loss: 2
788.6262
Epoch 14/20
563/563 [==============================] - 1s 1ms/step - loss: 2742.7712 - val_loss: 264
5.6934
Epoch 15/20
563/563 [==============================] - 1s 1ms/step - loss: 2708.8718 - val_loss: 263
4.6711
Epoch 16/20
563/563 [==============================] - 1s 1ms/step - loss: 2692.5630 - val_loss: 268
6.2200
Epoch 17/20
563/563 [==============================] - 1s 1ms/step - loss: 2681.3235 - val_loss: 265
1.9294
Epoch 18/20
563/563 [==============================] - 1s 1ms/step - loss: 2666.9790 - val_loss: 270
9.1372
Epoch 19/20
563/563 [==============================] - 1s 1ms/step - loss: 2656.7449 - val_loss: 261
3.7534
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2641.9241 - val_loss: 262
2.5774
Epoch 1/20
1125/1125 [==============================] - 2s 1ms/step - loss: 67999.8750 - val_loss:
49615.8359
Epoch 2/20
1125/1125 [==============================] - 1s 948us/step - loss: 36012.0352 - val_los
s: 24438.2070
Epoch 3/20
1125/1125 [==============================] - 1s 909us/step - loss: 18821.8555 - val_los
s: 13426.3096
Epoch 4/20
1125/1125 [==============================] - 1s 914us/step - loss: 10722.9043 - val_los
s: 7626.0527
```

```
Epoch 5/20
1125/1125 [==============================] - 1s 956us/step - loss: 6487.3135 - val_loss:
5053.8169
Epoch 6/20
1125/1125 [==============================] - 1s 964us/step - loss: 4734.0684 - val_loss:
4090.6057
Epoch 7/20
1125/1125 [==============================] - 1s 955us/step - loss: 4015.6636 - val_loss:
3613.6758
Epoch 8/20
1125/1125 [==============================] - 1s 996us/step - loss: 3612.7224 - val_loss:
3331.2336
Epoch 9/20
1125/1125 [==============================] - 1s 919us/step - loss: 3328.5527 - val_loss:
3157.3040
Epoch 10/20
1125/1125 [==============================] - 1s 1ms/step - loss: 3128.5178 - val_loss: 2
980.0500
Epoch 11/20
1125/1125 [==============================] - 1s 1ms/step - loss: 3006.2302 - val_loss: 2
922.2612
Epoch 12/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2917.0210 - val_loss: 2
861.4727
Epoch 13/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2865.1323 - val_loss: 2
915.9761
Epoch 14/20
1125/1125 [==============================] - 1s 927us/step - loss: 2822.1267 - val_loss:
2785.9866
Epoch 15/20
1125/1125 [==============================] - 1s 950us/step - loss: 2778.6267 - val_loss:
2766.4812
Epoch 16/20
1125/1125 [==============================] - 1s 945us/step - loss: 2731.3921 - val_loss:
2797.2014
Epoch 17/20
1125/1125 [==============================] - 1s 957us/step - loss: 2709.2686 - val_loss:
2775.4104
Epoch 18/20
1125/1125 [==============================] - 1s 920us/step - loss: 2692.0420 - val_loss:
2726.1853
Epoch 19/20
1125/1125 [==============================] - 1s 950us/step - loss: 2665.0259 - val_loss:
2686.8391
Epoch 20/20
1125/1125 [==============================] - 1s 925us/step - loss: 2632.2463 - val_loss:
2721.8665
282/282 [==============================] - 0s 571us/step
282/282 [==============================] - 0s 565us/step
282/282 [==============================] - 0s 597us/step
94/94 [==============================] - 0s 626us/step
94/94 [==============================] - 0s 649us/step
Model: 5
Mean Squared Error: 2959.4843333333333
--------------------
Average Mean Squared Error: 2942.814533333333
```

In [23]:

```
# Model-4: Extract the deep features from Model-I and Model-2 stack the
# features horizontally, reduce the dimension to either 8, IO or 12 using
# principal component analysis (PCA) and model the reduced features using a
# Random Forest classifier. Identify the best number of reduced components of
# PCA.

from sklearn.decomposition import PCA
from sklearn.ensemble import RandomForestRegressor

def model4(X_train, X_val, y_train, y_val):
    model_1 = model1(X_train, X_val, y_train, y_val)
    model_2, _ = model2(X_train, X_val, y_train, y_val)

    intermediate_output1 = model_1.layers[-2].output
    intermediate_output2 = model_2.layers[-2].output

    intermediate_layer_model_1 = Model(inputs=model_1.input, outputs=intermediate_outpu

    intermediate_output1 = intermediate_layer_model_1.predict(X_train)

    intermediate_layer_model_2 = Model(inputs=model_2.input, outputs=intermediate_outpu

    intermediate_output2 = intermediate_layer_model_2.predict(X_train)

    intermediate_output = np.hstack((intermediate_output1, intermediate_output2))

    pca = PCA(n_components=8)
    pca.fit(intermediate_output)
    intermediate_output = pca.transform(intermediate_output)

    rf = RandomForestRegressor()
    rf.fit(intermediate_output, y_train)

    return model_1, model_2, pca, rf

count = 5
avg_mse = 0

for i in range(count):
    # Split data to 60% training 20% validation and 20% testing
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta
    X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.25,

    model_1, model_2, pca, rf = model4(X_train, X_val, y_train, y_val)

    intermediate_output1 = model_1.layers[-2].output
    intermediate_output2 = model_2.layers[-2].output

    intermediate_layer_model_1 = Model(inputs=model_1.input, outputs=intermediate_outpu
    intermediate_output1 = intermediate_layer_model_1.predict(X_test)

    intermediate_layer_model_2 = Model(inputs=model_2.input, outputs=intermediate_outpu
    intermediate_output2 = intermediate_layer_model_2.predict(X_test)

    intermediate_output = np.hstack((intermediate_output1, intermediate_output2))

    intermediate_output = pca.transform(intermediate_output)

    y_pred = rf.predict(intermediate_output)
```

```
    print('Model:', i+1)
    y_pred = np.round(y_pred)
    mse = mean_squared_error(y_test, y_pred)

    print('Mean Squared Error:', mse)
    print("--------------------")

    avg_mse += mse

print('Average Mean Squared Error:', avg_mse/count)
```

```
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 12018.9316 - val_loss: 32
43.3008
Epoch 2/20
563/563 [==============================] - 1s 952us/step - loss: 3221.0396 - val_loss: 3
031.9114
Epoch 3/20
563/563 [==============================] - 1s 952us/step - loss: 3121.9602 - val_loss: 2
995.2710
Epoch 4/20
563/563 [==============================] - 1s 950us/step - loss: 3065.3274 - val_loss: 2
928.5117
Epoch 5/20
563/563 [==============================] - 1s 1ms/step - loss: 3002.2068 - val_loss: 297
3.2566
Epoch 6/20
563/563 [==============================] - 1s 970us/step - loss: 2976.8367 - val_loss: 2
833.1746
Epoch 7/20
563/563 [==============================] - 1s 1ms/step - loss: 2941.4402 - val_loss: 280
8.6130
Epoch 8/20
563/563 [==============================] - 1s 961us/step - loss: 2891.0303 - val_loss: 2
784.0286
Epoch 9/20
563/563 [==============================] - 1s 1ms/step - loss: 2846.9150 - val_loss: 283
8.1917
Epoch 10/20
563/563 [==============================] - 1s 1ms/step - loss: 2833.8262 - val_loss: 274
7.2976
Epoch 11/20
563/563 [==============================] - 1s 963us/step - loss: 2801.2634 - val_loss: 2
732.3027
Epoch 12/20
563/563 [==============================] - 1s 1ms/step - loss: 2783.2715 - val_loss: 269
2.3333
Epoch 13/20
563/563 [==============================] - 1s 977us/step - loss: 2745.7415 - val_loss: 2
709.0298
Epoch 14/20
563/563 [==============================] - 1s 967us/step - loss: 2738.9697 - val_loss: 2
666.6453
Epoch 15/20
563/563 [==============================] - 1s 1ms/step - loss: 2717.9265 - val_loss: 268
2.7349
Epoch 16/20
563/563 [==============================] - 1s 959us/step - loss: 2706.8298 - val_loss: 2
715.1587
```

```
Epoch 17/20
563/563 [==============================] - 1s 1ms/step - loss: 2690.9951 - val_loss: 265
7.8647
Epoch 18/20
563/563 [==============================] - 1s 962us/step - loss: 2686.6980 - val_loss: 2
645.9009
Epoch 19/20
563/563 [==============================] - 1s 964us/step - loss: 2672.1438 - val_loss: 2
649.5842
Epoch 20/20
563/563 [==============================] - 1s 952us/step - loss: 2658.8188 - val_loss: 2
859.0193
Epoch 1/20
1125/1125 [==============================] - 2s 974us/step - loss: 88622.5312 - val_los
s: 87336.4844
Epoch 2/20
1125/1125 [==============================] - 1s 916us/step - loss: 88622.5547 - val_los
s: 87336.4844
Epoch 3/20
1125/1125 [==============================] - 1s 908us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 4/20
1125/1125 [==============================] - 1s 908us/step - loss: 88622.5781 - val_los
s: 87336.4844
Epoch 5/20
1125/1125 [==============================] - 1s 932us/step - loss: 88622.6172 - val_los
s: 87336.4844
Epoch 6/20
1125/1125 [==============================] - 1s 942us/step - loss: 88622.5703 - val_los
s: 87336.4844
Epoch 7/20
1125/1125 [==============================] - 1s 914us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 8/20
1125/1125 [==============================] - 1s 916us/step - loss: 88622.6016 - val_los
s: 87336.4844
Epoch 9/20
1125/1125 [==============================] - 1s 911us/step - loss: 88622.5938 - val_los
s: 87336.4844
Epoch 10/20
1125/1125 [==============================] - 1s 922us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 11/20
1125/1125 [==============================] - 1s 921us/step - loss: 88622.5234 - val_los
s: 87336.4844
Epoch 12/20
1125/1125 [==============================] - 1s 920us/step - loss: 88622.4531 - val_los
s: 87336.4844
Epoch 13/20
1125/1125 [==============================] - 1s 939us/step - loss: 88622.6016 - val_los
s: 87336.4844
Epoch 14/20
1125/1125 [==============================] - 1s 906us/step - loss: 88622.5391 - val_los
s: 87336.4844
Epoch 15/20
1125/1125 [==============================] - 1s 919us/step - loss: 88622.5000 - val_los
s: 87336.4844
Epoch 16/20
1125/1125 [==============================] - 1s 906us/step - loss: 88622.5000 - val_los
s: 87336.4844
```

```
Epoch 17/20
1125/1125 [==============================] - 1s 908us/step - loss: 88622.5625 - val_los
s: 87336.4844
Epoch 18/20
1125/1125 [==============================] - 1s 913us/step - loss: 88622.5156 - val_los
s: 87336.4844
Epoch 19/20
1125/1125 [==============================] - 1s 915us/step - loss: 88622.6562 - val_los
s: 87336.4844
Epoch 20/20
1125/1125 [==============================] - 1s 916us/step - loss: 88622.5469 - val_los
s: 87336.4844
282/282 [==============================] - 0s 563us/step
282/282 [==============================] - 0s 587us/step
282/282 [==============================] - 0s 609us/step
94/94 [==============================] - 0s 573us/step
94/94 [==============================] - 0s 600us/step
Model: 1
Mean Squared Error: 2751.744
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 10767.2871 - val_loss: 31
53.9331
Epoch 2/20
563/563 [==============================] - 1s 1ms/step - loss: 3203.0681 - val_loss: 303
9.6631
Epoch 3/20
563/563 [==============================] - 1s 965us/step - loss: 3112.7908 - val_loss: 3
025.1003
Epoch 4/20
563/563 [==============================] - 1s 962us/step - loss: 3061.9187 - val_loss: 2
891.5806
Epoch 5/20
563/563 [==============================] - 1s 946us/step - loss: 3002.6055 - val_loss: 2
852.5474
Epoch 6/20
563/563 [==============================] - 1s 970us/step - loss: 2965.3767 - val_loss: 2
826.4072
Epoch 7/20
563/563 [==============================] - 1s 962us/step - loss: 2921.4915 - val_loss: 2
830.2637
Epoch 8/20
563/563 [==============================] - 1s 1ms/step - loss: 2887.0310 - val_loss: 281
5.2571
Epoch 9/20
563/563 [==============================] - 1s 957us/step - loss: 2846.7131 - val_loss: 2
747.7722
Epoch 10/20
563/563 [==============================] - 1s 968us/step - loss: 2841.8752 - val_loss: 2
749.9941
Epoch 11/20
563/563 [==============================] - 1s 950us/step - loss: 2803.7959 - val_loss: 2
705.0662
Epoch 12/20
563/563 [==============================] - 1s 955us/step - loss: 2786.7690 - val_loss: 2
678.4570
Epoch 13/20
563/563 [==============================] - 1s 962us/step - loss: 2758.8704 - val_loss: 2
675.4189
Epoch 14/20
```

```
563/563 [==============================] - 1s 1ms/step - loss: 2745.6851 - val_loss: 275
8.2666
Epoch 15/20
563/563 [==============================] - 1s 1ms/step - loss: 2716.4290 - val_loss: 267
4.7649
Epoch 16/20
563/563 [==============================] - 1s 1ms/step - loss: 2711.8582 - val_loss: 267
2.3501
Epoch 17/20
563/563 [==============================] - 1s 1ms/step - loss: 2703.1418 - val_loss: 274
5.0906
Epoch 18/20
563/563 [==============================] - 1s 967us/step - loss: 2690.7529 - val_loss: 2
599.9062
Epoch 19/20
563/563 [==============================] - 1s 954us/step - loss: 2659.7146 - val_loss: 2
661.2976
Epoch 20/20
563/563 [==============================] - 1s 955us/step - loss: 2651.9465 - val_loss: 2
613.2417
Epoch 1/20
1125/1125 [==============================] - 2s 984us/step - loss: 67900.1016 - val_los
s: 49688.4844
Epoch 2/20
1125/1125 [==============================] - 1s 930us/step - loss: 38784.0742 - val_los
s: 27955.9316
Epoch 3/20
1125/1125 [==============================] - 1s 926us/step - loss: 22007.6113 - val_los
s: 15935.0078
Epoch 4/20
1125/1125 [==============================] - 1s 927us/step - loss: 13163.5498 - val_los
s: 9551.4482
Epoch 5/20
1125/1125 [==============================] - 1s 936us/step - loss: 7959.7734 - val_loss:
6095.4238
Epoch 6/20
1125/1125 [==============================] - 1s 920us/step - loss: 5461.9897 - val_loss:
4484.7124
Epoch 7/20
1125/1125 [==============================] - 1s 963us/step - loss: 4357.8691 - val_loss:
3864.6760
Epoch 8/20
1125/1125 [==============================] - 1s 935us/step - loss: 3848.3577 - val_loss:
3517.2686
Epoch 9/20
1125/1125 [==============================] - 1s 921us/step - loss: 3515.4355 - val_loss:
3270.2141
Epoch 10/20
1125/1125 [==============================] - 1s 948us/step - loss: 3284.1584 - val_loss:
3150.5591
Epoch 11/20
1125/1125 [==============================] - 1s 922us/step - loss: 3130.7966 - val_loss:
3176.7234
Epoch 12/20
1125/1125 [==============================] - 1s 967us/step - loss: 3034.2661 - val_loss:
3000.8875
Epoch 13/20
1125/1125 [==============================] - 1s 970us/step - loss: 2943.5398 - val_loss:
2996.8259
Epoch 14/20
```

```
1125/1125 [==============================] - 1s 977us/step - loss: 2881.2192 - val_loss:
2951.4600
Epoch 15/20
1125/1125 [==============================] - 1s 959us/step - loss: 2820.3438 - val_loss:
2788.2395
Epoch 16/20
1125/1125 [==============================] - 1s 983us/step - loss: 2768.0042 - val_loss:
2825.8760
Epoch 17/20
1125/1125 [==============================] - 1s 965us/step - loss: 2723.1584 - val_loss:
2790.7009
Epoch 18/20
1125/1125 [==============================] - 1s 946us/step - loss: 2687.7739 - val_loss:
2859.9373
Epoch 19/20
1125/1125 [==============================] - 1s 927us/step - loss: 2671.8323 - val_loss:
2799.7625
Epoch 20/20
1125/1125 [==============================] - 1s 951us/step - loss: 2639.9915 - val_loss:
2765.1165
282/282 [==============================] - 0s 568us/step
282/282 [==============================] - 0s 552us/step
282/282 [==============================] - 0s 558us/step
94/94 [==============================] - 0s 603us/step
94/94 [==============================] - 0s 583us/step
Model: 2
Mean Squared Error: 2708.8306666666667
--------------------
Epoch 1/20
563/563 [==============================] - 1s 1ms/step - loss: 11276.0439 - val_loss: 31
94.4080
Epoch 2/20
563/563 [==============================] - 1s 951us/step - loss: 3213.0591 - val_loss: 3
018.0964
Epoch 3/20
563/563 [==============================] - 1s 962us/step - loss: 3104.2017 - val_loss: 2
983.7410
Epoch 4/20
563/563 [==============================] - 1s 961us/step - loss: 3054.6670 - val_loss: 3
087.4863
Epoch 5/20
563/563 [==============================] - 1s 951us/step - loss: 2989.3933 - val_loss: 2
887.9866
Epoch 6/20
563/563 [==============================] - 1s 958us/step - loss: 2962.8423 - val_loss: 2
833.9929
Epoch 7/20
563/563 [==============================] - 1s 947us/step - loss: 2928.8777 - val_loss: 2
886.5530
Epoch 8/20
563/563 [==============================] - 1s 966us/step - loss: 2880.7166 - val_loss: 2
806.2671
Epoch 9/20
563/563 [==============================] - 1s 940us/step - loss: 2853.1555 - val_loss: 2
784.0635
Epoch 10/20
563/563 [==============================] - 1s 982us/step - loss: 2818.6426 - val_loss: 2
790.7532
Epoch 11/20
563/563 [==============================] - 1s 949us/step - loss: 2800.3623 - val_loss: 2
```

```
754.3323
Epoch 12/20
563/563 [==============================] - 1s 951us/step - loss: 2767.4836 - val_loss: 2
812.0967
Epoch 13/20
563/563 [==============================] - 1s 965us/step - loss: 2739.7710 - val_loss: 2
677.5107
Epoch 14/20
563/563 [==============================] - 1s 945us/step - loss: 2727.3713 - val_loss: 2
780.1484
Epoch 15/20
563/563 [==============================] - 1s 955us/step - loss: 2710.5332 - val_loss: 2
711.6396
Epoch 16/20
563/563 [==============================] - 1s 955us/step - loss: 2689.9541 - val_loss: 2
646.1152
Epoch 17/20
563/563 [==============================] - 1s 966us/step - loss: 2677.2170 - val_loss: 2
636.1648
Epoch 18/20
563/563 [==============================] - 1s 963us/step - loss: 2666.8840 - val_loss: 2
805.2483
Epoch 19/20
563/563 [==============================] - 1s 956us/step - loss: 2663.8379 - val_loss: 2
765.0342
Epoch 20/20
563/563 [==============================] - 1s 1ms/step - loss: 2650.3684 - val_loss: 264
0.6350
Epoch 1/20
1125/1125 [==============================] - 2s 983us/step - loss: 70627.4453 - val_los
s: 54774.1289
Epoch 2/20
1125/1125 [==============================] - 1s 890us/step - loss: 44520.6211 - val_los
s: 33750.4648
Epoch 3/20
1125/1125 [==============================] - 1s 897us/step - loss: 27330.6777 - val_los
s: 20420.0059
Epoch 4/20
1125/1125 [==============================] - 1s 901us/step - loss: 16958.4648 - val_los
s: 13038.4492
Epoch 5/20
1125/1125 [==============================] - 1s 906us/step - loss: 10950.4932 - val_los
s: 8117.9341
Epoch 6/20
1125/1125 [==============================] - 1s 925us/step - loss: 7070.3574 - val_loss:
5639.3013
Epoch 7/20
1125/1125 [==============================] - 1s 918us/step - loss: 5196.1655 - val_loss:
4349.7949
Epoch 8/20
1125/1125 [==============================] - 1s 915us/step - loss: 4232.3682 - val_loss:
3728.5803
Epoch 9/20
1125/1125 [==============================] - 1s 906us/step - loss: 3726.6052 - val_loss:
3450.0049
Epoch 10/20
1125/1125 [==============================] - 1s 910us/step - loss: 3443.7305 - val_loss:
3251.2944
Epoch 11/20
1125/1125 [==============================] - 1s 919us/step - loss: 3287.1819 - val_loss:
```

```
3198.0391
Epoch 12/20
1125/1125 [==============================] - 1s 896us/step - loss: 3161.9575 - val_loss:
3018.9136
Epoch 13/20
1125/1125 [==============================] - 1s 900us/step - loss: 3035.5911 - val_loss:
2963.7300
Epoch 14/20
1125/1125 [==============================] - 1s 895us/step - loss: 2964.5286 - val_loss:
2920.4534
Epoch 15/20
1125/1125 [==============================] - 1s 905us/step - loss: 2907.8208 - val_loss:
2963.5071
Epoch 16/20
1125/1125 [==============================] - 1s 990us/step - loss: 2848.6909 - val_loss:
2921.3130
Epoch 17/20
1125/1125 [==============================] - 1s 1ms/step - loss: 2811.9121 - val_loss: 2
866.0356
Epoch 18/20
1125/1125 [==============================] - 1s 977us/step - loss: 2774.8027 - val_loss:
2777.5452
Epoch 19/20
1125/1125 [==============================] - 1s 910us/step - loss: 2741.7505 - val_loss:
2813.3269
Epoch 20/20
1125/1125 [==============================] - 1s 899us/step - loss: 2725.2898 - val_loss:
2736.0710
282/282 [==============================] - 0s 573us/step
282/282 [==============================] - 0s 570us/step
282/282 [==============================] - 0s 586us/step
94/94 [==============================] - 0s 1ms/step
94/94 [==============================] - 0s 1ms/step
Model: 3
Mean Squared Error: 2712.2943333333333
--------------------
Epoch 1/20
563/563 [==============================] - 3s 3ms/step - loss: 10751.4883 - val_loss: 31
54.7388
Epoch 2/20
563/563 [==============================] - 1s 2ms/step - loss: 3199.5081 - val_loss: 307
5.0730
Epoch 3/20
563/563 [==============================] - 1s 2ms/step - loss: 3126.3303 - val_loss: 317
4.5784
Epoch 4/20
563/563 [==============================] - 1s 3ms/step - loss: 3057.6025 - val_loss: 294
4.9746
Epoch 5/20
563/563 [==============================] - 2s 3ms/step - loss: 2999.4312 - val_loss: 292
5.6060
Epoch 6/20
563/563 [==============================] - 1s 2ms/step - loss: 2970.3677 - val_loss: 283
4.4580
Epoch 7/20
563/563 [==============================] - 1s 3ms/step - loss: 2931.5593 - val_loss: 298
8.7781
Epoch 8/20
563/563 [==============================] - 2s 3ms/step - loss: 2899.4272 - val_loss: 280
0.5547
```

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Epoch 9/20
563/563 [==============================] - 1s 3ms/step - loss: 2864.3623 - val_loss: 282
5.7690
Epoch 10/20
563/563 [==============================] - 1s 2ms/step - loss: 2843.2546 - val_loss: 283
9.7546
Epoch 11/20
563/563 [==============================] - 1s 3ms/step - loss: 2809.5259 - val_loss: 274
9.2507
Epoch 12/20
563/563 [==============================] - 2s 3ms/step - loss: 2764.2515 - val_loss: 271
4.3044
Epoch 13/20
563/563 [==============================] - 1s 2ms/step - loss: 2776.8154 - val_loss: 276
4.1934
Epoch 14/20
563/563 [==============================] - 1s 2ms/step - loss: 2733.7859 - val_loss: 270
3.1675
Epoch 15/20
563/563 [==============================] - 1s 2ms/step - loss: 2711.7361 - val_loss: 266
6.7009
Epoch 16/20
563/563 [==============================] - 1s 2ms/step - loss: 2703.4900 - val_loss: 279
9.2913
Epoch 17/20
563/563 [==============================] - 1s 2ms/step - loss: 2684.4292 - val_loss: 266
2.8787
Epoch 18/20
563/563 [==============================] - 1s 2ms/step - loss: 2671.5422 - val_loss: 278
1.9138
Epoch 19/20
563/563 [==============================] - 1s 2ms/step - loss: 2654.7490 - val_loss: 271
1.8518
Epoch 20/20
563/563 [==============================] - 1s 2ms/step - loss: 2648.8203 - val_loss: 265
3.9724
Epoch 1/20
1125/1125 [==============================] - 3s 2ms/step - loss: 65333.2422 - val_loss:
46315.3281
Epoch 2/20
1125/1125 [==============================] - 3s 2ms/step - loss: 35005.0625 - val_loss:
24182.8926
Epoch 3/20
1125/1125 [==============================] - 3s 2ms/step - loss: 18689.5566 - val_loss:
13376.8877
Epoch 4/20
1125/1125 [==============================] - 3s 2ms/step - loss: 10779.8447 - val_loss:
7606.8179
Epoch 5/20
1125/1125 [==============================] - 3s 2ms/step - loss: 6544.9282 - val_loss: 5
092.2881
Epoch 6/20
1125/1125 [==============================] - 2s 2ms/step - loss: 4727.1621 - val_loss: 4
032.4106
Epoch 7/20
1125/1125 [==============================] - 2s 2ms/step - loss: 3943.4658 - val_loss: 3
537.9446
Epoch 8/20
1125/1125 [==============================] - 2s 2ms/step - loss: 3559.9287 - val_loss: 3
312.3313
```

```
Epoch 9/20
1125/1125 [==============================] - 2s 2ms/step - loss: 3332.1848 - val_loss: 3
136.4500
Epoch 10/20
1125/1125 [==============================] - 2s 2ms/step - loss: 3142.5432 - val_loss: 3
026.4426
Epoch 11/20
1125/1125 [==============================] - 2s 2ms/step - loss: 3022.1428 - val_loss: 2
995.3538
Epoch 12/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2935.3101 - val_loss: 2
923.5491
Epoch 13/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2875.7134 - val_loss: 2
813.4482
Epoch 14/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2823.2117 - val_loss: 2
821.4646
Epoch 15/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2771.0718 - val_loss: 2
794.4688
Epoch 16/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2734.6453 - val_loss: 2
791.9104
Epoch 17/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2710.3752 - val_loss: 2
784.4641
Epoch 18/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2680.8750 - val_loss: 2
788.6636
Epoch 19/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2656.0449 - val_loss: 2
839.7964
Epoch 20/20
1125/1125 [==============================] - 2s 2ms/step - loss: 2623.3489 - val_loss: 2
734.8628
282/282 [==============================] - 0s 1ms/step
282/282 [==============================] - 0s 1ms/step
282/282 [==============================] - 1s 2ms/step
94/94 [==============================] - 0s 2ms/step
94/94 [==============================] - 0s 1ms/step
Model: 4
Mean Squared Error: 2658.7156666666665
--------------------
Epoch 1/20
563/563 [==============================] - 3s 3ms/step - loss: 88622.5938 - val_loss: 87
336.4453
Epoch 2/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5781 - val_loss: 87
336.4453
Epoch 3/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5781 - val_loss: 87
336.4453
Epoch 4/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.6094 - val_loss: 87
336.4453
Epoch 5/20
563/563 [==============================] - 2s 3ms/step - loss: 88622.5547 - val_loss: 87
336.4453
Epoch 6/20
```

```
563/563 [==============================] - 1s 2ms/step - loss: 88622.6016 - val_loss: 87
336.4453
Epoch 7/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5703 - val_loss: 87
336.4453
Epoch 8/20
563/563 [==============================] - 1s 3ms/step - loss: 88622.5391 - val_loss: 87
336.4453
Epoch 9/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5312 - val_loss: 87
336.4453
Epoch 10/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5391 - val_loss: 87
336.4453
Epoch 11/20
563/563 [==============================] - 1s 2ms/step - loss: 88622.5938 - val_loss: 87
336.4453
Epoch 12/20
563/563 [==============================] - 2s 4ms/step - loss: 88622.5156 - val_loss: 87
336.4453
Epoch 13/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.6016 - val_loss: 87
336.4453
Epoch 14/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.5547 - val_loss: 87
336.4453
Epoch 15/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.6094 - val_loss: 87
336.4453
Epoch 16/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.5703 - val_loss: 87
336.4453
Epoch 17/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.5547 - val_loss: 87
336.4453
Epoch 18/20
563/563 [==============================] - 3s 5ms/step - loss: 88622.5312 - val_loss: 87
336.4453
Epoch 19/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.5703 - val_loss: 87
336.4453
Epoch 20/20
563/563 [==============================] - 3s 6ms/step - loss: 88622.5703 - val_loss: 87
336.4453
Epoch 1/20
1125/1125 [==============================] - 10s 7ms/step - loss: 65760.8281 - val_loss:
46148.9766
Epoch 2/20
1125/1125 [==============================] - 7s 6ms/step - loss: 34771.9727 - val_loss:
23976.4805
Epoch 3/20
1125/1125 [==============================] - 6s 6ms/step - loss: 18564.7070 - val_loss:
13314.9199
Epoch 4/20
1125/1125 [==============================] - 6s 5ms/step - loss: 10625.3711 - val_loss:
7528.9795
Epoch 5/20
1125/1125 [==============================] - 6s 5ms/step - loss: 6464.7324 - val_loss: 5
044.1284
Epoch 6/20
```

```
1125/1125 [==============================] - 3s 2ms/step - loss: 4731.6431 - val_loss: 4
011.5740
Epoch 7/20
1125/1125 [==============================] - 3s 3ms/step - loss: 3898.5320 - val_loss: 3
611.7720
Epoch 8/20
1125/1125 [==============================] - 3s 2ms/step - loss: 3519.0408 - val_loss: 3
284.8816
Epoch 9/20
1125/1125 [==============================] - 1s 785us/step - loss: 3330.6406 - val_loss:
3188.5408
Epoch 10/20
1125/1125 [==============================] - 3s 2ms/step - loss: 3199.5342 - val_loss: 3
078.6143
Epoch 11/20
1125/1125 [==============================] - 3s 2ms/step - loss: 3105.6514 - val_loss: 3
017.3213
Epoch 12/20
1125/1125 [==============================] - 3s 2ms/step - loss: 3036.2556 - val_loss: 2
999.6113
Epoch 13/20
1125/1125 [==============================] - 3s 2ms/step - loss: 3002.5476 - val_loss: 2
959.0901
Epoch 14/20
1125/1125 [==============================] - 3s 2ms/step - loss: 2937.9927 - val_loss: 2
863.7153
Epoch 15/20
1125/1125 [==============================] - 3s 2ms/step - loss: 2871.9333 - val_loss: 2
894.5596
Epoch 16/20
1125/1125 [==============================] - 3s 3ms/step - loss: 2837.8821 - val_loss: 2
855.2156
Epoch 17/20
1125/1125 [==============================] - 3s 3ms/step - loss: 2795.2029 - val_loss: 2
750.3057
Epoch 18/20
1125/1125 [==============================] - 3s 3ms/step - loss: 2757.9226 - val_loss: 2
801.4744
Epoch 19/20
1125/1125 [==============================] - 4s 4ms/step - loss: 2727.2542 - val_loss: 2
751.8027
Epoch 20/20
1125/1125 [==============================] - 6s 6ms/step - loss: 2710.3035 - val_loss: 2
725.7539
282/282 [==============================] - 0s 1ms/step
282/282 [==============================] - 1s 2ms/step
282/282 [==============================] - 1s 2ms/step
94/94 [==============================] - 0s 1ms/step
94/94 [==============================] - 0s 2ms/step
Model: 5
Mean Squared Error: 2755.363
--------------------
Average Mean Squared Error: 2717.3895333333335
```

QNo 5

For model1: Average Mean Squared Error: 2823.2824

For model2: Average Mean Squared Error: 3557.7468

For model3: Average Mean Squared Error: 2942.814533333333

For model4: Average Mean Squared Error: 2717.3895333333335

so by seeing this avg mean square error we can conclude model 4 is best but when we also consider time to train model 1 is faster