University_Building_ANN_Model

November 23, 2020

[120]:
```
# import the libraries
import numpy as np
import matplotlib.pyplot as plt
import datetime
import seaborn as sns
import tensorflow as tf
import pandas as pd
from datetime import datetime
print("TensorFlow version: ",tf.__version__)  #print the version of tensorflow
```

TensorFlow version: 2.3.0

[121]:
```
from tensorflow.python.keras.layers import Dense
from tensorflow.keras.layers import Dropout
from tensorflow.python.keras.models import Sequential
from tensorflow.python.keras.wrappers.scikit_learn import KerasRegressor
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense, Activation, Dropout
from tensorflow.keras.callbacks import EarlyStopping
from tensorflow.keras import regularizers
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau
from tensorflow.keras import regularizers
```

[122]:
```
#Helper Functions
def get_weekday2(year, month, day):
    dates = pd.DataFrame()
    dates['y'] = year
    dates['m'] = month
    dates['d'] = day
    dates['dates'] = dates['y'].astype('str') + '-' + dates['m'].astype('str')␣
↪+ '-' + dates['d'].astype('str')
    return get_weekday(dates['dates'])

#Get day of week based on date
def get_weekday(dates):
```

```
    return [1 if (datetime.strptime(d,"%Y-%m-%d").weekday() >= 5) else 0 for d␣
↪in dates]
```

1 Exploratory Data Analysis

[123]:
```
data = pd.read_csv('https://raw.githubusercontent.com/A-Wadhwani/ME597-Project/
↪main/Datasets/Combined_PowerWeatherData.csv')
copy = data
data
```

[123]:
```
       Year  Month  …  Square Feet             Type
0      2019      1  …       113866  College Building
1      2019      1  …       113866  College Building
2      2019      1  …       113866  College Building
3      2019      1  …       113866  College Building
4      2019      1  …       113866  College Building
…       …     …  …          …               …
21179  2019     12  …       135129        Laboratory
21180  2019     12  …       135129        Laboratory
21181  2019     12  …       135129        Laboratory
21182  2019     12  …       135129        Laboratory
21183  2019     12  …       135129        Laboratory

[21184 rows x 18 columns]
```

[124]:
```
data.describe()
```

[124]:
```
          Year         Month  …       Weekday    Square Feet
count  21184.0  21184.000000  …  21184.000000   21184.000000
mean    2019.0      6.524264  …      0.284838   99734.046969
std        0.0      3.449431  …      0.451348   42419.512278
min     2019.0      1.000000  …      0.000000   10932.000000
25%     2019.0      4.000000  …      0.000000   57714.000000
50%     2019.0      7.000000  …      0.000000  111891.000000
75%     2019.0     10.000000  …      1.000000  131464.000000
max     2019.0     12.000000  …      1.000000  421939.000000

[8 rows x 15 columns]
```

[125]:
```
#Creating column to denote each building type
from sklearn.preprocessing import OrdinalEncoder
encoder = OrdinalEncoder()
data['Type'] = encoder.fit_transform(np.reshape(data['Type'].values, (-1,1)))
data['Type'].describe()
```

[125]:
```
count    21184.000000
mean         1.758403
std          0.726795
min          0.000000
25%          2.000000
50%          2.000000
75%          2.000000
max          3.000000
Name: Type, dtype: float64
```

[126]:
```
encoder.inverse_transform(np.reshape([0, 1], (-1,1)))
```

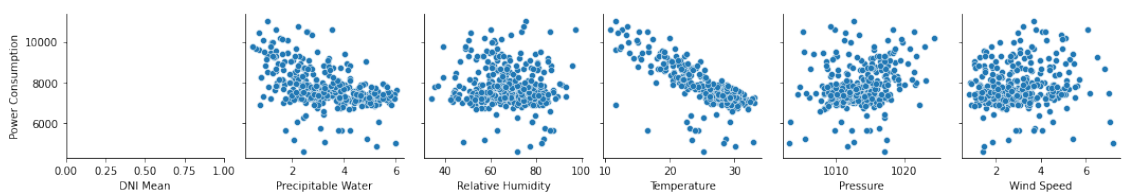
[126]:
```
array([['College Building'],
       ['Facility']], dtype=object)
```

[127]:
```
#Removing unnecessary columns
data = data.drop(['Year'], axis=1)
data = data.drop(['University Name', 'Building Name'], axis=1)
data.head()
```

[127]:
```
   Month  Day    DNI Mean  …  Weekday  Square Feet  Type
0      1    1  576.363636  …        0       113866   0.0
1      1    1  576.363636  …        0       113866   0.0
2      1    2  349.636364  …        0       113866   0.0
3      1    3  262.818182  …        0       113866   0.0
4      1    4  316.000000  …        0       113866   0.0

[5 rows x 15 columns]
```

[128]:
```
#Select one building's data
view = data[data['Square Feet'] == 113866]
#See graphs for data vs Power Consumption
sns.pairplot(view, x_vars = ['DNI Mean', 'Precipitable Water', 'Relative␣
↪Humidity', 'Temperature', 'Pressure', 'Wind Speed'], y_vars=['Power␣
↪Consumption'])
plt.show()
```



[129]:
```
#Splitting into X and Y
X = data.drop(["Power Consumption"],axis=1)
y = data["Power Consumption"]
```

[130]:
```
y = np.reshape(y.values, (-1,1))
```

[131]:
```
# scaling inputs using RobustScaler
from sklearn.preprocessing import RobustScaler
x_scaler = RobustScaler()
y_scaler = RobustScaler()

x_f = x_scaler.fit_transform(X)
y_f = y_scaler.fit_transform(y)

x_f = pd.DataFrame(x_f)
```

[132]:
```
x_f
```

[132]:
```
              0         1         2         3  …        10   11        12   13
0     -1.000000 -1.000000 -0.008079 -0.259615  …  2.367305  0.0  0.026780 -2.0
1     -1.000000 -1.000000 -0.008079 -0.259615  …  2.367305  0.0  0.026780 -2.0
2     -1.000000 -0.933333 -0.537107 -0.264423  …  2.377706  0.0  0.026780 -2.0
3     -1.000000 -0.866667 -0.739682 -1.134615  …  2.024090  0.0  0.026780 -2.0
4     -1.000000 -0.800000 -0.615591 -0.072115  …  1.597671  0.0  0.026780 -2.0
…           …         …         …         …  …         …    …         …    …
21179  0.833333  0.733333  0.049522 -0.072115  …  0.267972  0.0  0.315092  0.0
21180  0.833333  0.800000  0.190338  0.000000  …  0.548264  1.0  0.315092  0.0
21181  0.833333  0.866667 -1.263255 -3.860577  …  0.332529  1.0  0.315092  0.0
21182  0.833333  0.933333  0.201888 -0.096154  …  0.445300  0.0  0.315092  0.0
21183  0.833333  1.000000 -0.237360 -0.716346  …  0.531104  0.0  0.315092  0.0

[21184 rows x 14 columns]
```

[133]:
```
x_f = x_f.values
```

[134]:
```
x_f.dtype
```

[134]:
```
dtype('float64')
```

[135]:
```
# split the data into train and test sets
from sklearn.model_selection import train_test_split
x_f_train, x_f_test, y_f_train, y_f_test = train_test_split(x_f,y_f, test_size␣
↪= 0.25, shuffle=True,random_state=24)
```

[136]:
```
# print the number of training and test damples
print("Number of training samples: ",len(x_f_train))
print("Number of testing samples: ",len(x_f_test))
```

```
Number of training samples:  15888
Number of testing samples:  5296
```

2 Building the Model

[137]:
```
model = Sequential()

model.add(Dense(512, input_shape=(14, ), activation='relu', name='dense_1'))
model.add(Dense(256, activation='relu', name='dense_2'))
model.add(Dense(128, activation='relu', name='dense_3'))
model.add(Dense(64, activation='relu', name='dense_4'))
model.add(Dense(32, activation='relu', name='dense_5'))
model.add(Dense(16, activation='relu', name='dense_6'))
model.add(Dense(1, activation='linear', name='dense_output'))

model.summary()
```

```
Model: "sequential_8"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 512)               7680
_________________________________________________________________
dense_2 (Dense)              (None, 256)               131328
_________________________________________________________________
dense_3 (Dense)              (None, 128)               32896
_________________________________________________________________
dense_4 (Dense)              (None, 64)                8256
_________________________________________________________________
dense_5 (Dense)              (None, 32)                2080
_________________________________________________________________
dense_6 (Dense)              (None, 16)                528
_________________________________________________________________
dense_output (Dense)         (None, 1)                 17
=================================================================
Total params: 182,785
Trainable params: 182,785
Non-trainable params: 0
_________________________________________________________________
```

[138]:
```
opt = keras.optimizers.Adam(learning_rate = 0.001)
model.compile(loss='mae', optimizer=opt, metrics=['mse', 'mae'])

#Tensorboard tool callback
log_dir = ''
#log_dir = "logs\\fit3\\" + datetime.now().strftime("%M")
```

```
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir,␣
↪histogram_freq=1, profile_batch = 100000000)

#Reduce Learning rate on Plateau
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=10,␣
↪verbose = 1)

#Earlystopping callback
early_stop = EarlyStopping(monitor ='val_loss', min_delta= 1e-3, patience = 40,␣
↪verbose = 1, restore_best_weights=True)

history = model.fit(x_f_train, y_f_train, callbacks = [tensorboard_callback,␣
↪early_stop, reduce_lr],
                    validation_data=(x_f_test, y_f_test), epochs=400,␣
↪batch_size=90, verbose=1)
```

```
Epoch 1/400
177/177 [==============================] - 1s 5ms/step - loss: 0.2894 - mse:
0.1705 - mae: 0.2894 - val_loss: 0.2408 - val_mse: 0.1451 - val_mae: 0.2408
Epoch 2/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2330 - mse:
0.1426 - mae: 0.2330 - val_loss: 0.2237 - val_mse: 0.1392 - val_mae: 0.2237
Epoch 3/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2243 - mse:
0.1400 - mae: 0.2243 - val_loss: 0.2204 - val_mse: 0.1431 - val_mae: 0.2204
Epoch 4/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2188 - mse:
0.1384 - mae: 0.2188 - val_loss: 0.2243 - val_mse: 0.1395 - val_mae: 0.2243
Epoch 5/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2146 - mse:
0.1381 - mae: 0.2146 - val_loss: 0.2230 - val_mse: 0.1393 - val_mae: 0.2230
Epoch 6/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2115 - mse:
0.1364 - mae: 0.2115 - val_loss: 0.2209 - val_mse: 0.1411 - val_mae: 0.2209
Epoch 7/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2105 - mse:
0.1368 - mae: 0.2105 - val_loss: 0.2073 - val_mse: 0.1286 - val_mae: 0.2073
Epoch 8/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2037 - mse:
0.1336 - mae: 0.2037 - val_loss: 0.2037 - val_mse: 0.1323 - val_mae: 0.2037
Epoch 9/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2001 - mse:
0.1333 - mae: 0.2001 - val_loss: 0.2034 - val_mse: 0.1352 - val_mae: 0.2034
Epoch 10/400
177/177 [==============================] - 1s 4ms/step - loss: 0.2023 - mse:
0.1349 - mae: 0.2023 - val_loss: 0.1976 - val_mse: 0.1271 - val_mae: 0.1976
Epoch 11/400
```

```
177/177 [==============================] - 1s 4ms/step - loss: 0.1938 - mse:
0.1283 - mae: 0.1938 - val_loss: 0.1947 - val_mse: 0.1276 - val_mae: 0.1947
Epoch 12/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1900 - mse:
0.1274 - mae: 0.1900 - val_loss: 0.1908 - val_mse: 0.1246 - val_mae: 0.1908
Epoch 13/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1893 - mse:
0.1278 - mae: 0.1893 - val_loss: 0.1915 - val_mse: 0.1298 - val_mae: 0.1915
Epoch 14/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1884 - mse:
0.1281 - mae: 0.1884 - val_loss: 0.1918 - val_mse: 0.1320 - val_mae: 0.1918
Epoch 15/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1885 - mse:
0.1284 - mae: 0.1885 - val_loss: 0.1851 - val_mse: 0.1266 - val_mae: 0.1851
Epoch 16/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1802 - mse:
0.1228 - mae: 0.1802 - val_loss: 0.1968 - val_mse: 0.1451 - val_mae: 0.1968
Epoch 17/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1853 - mse:
0.1279 - mae: 0.1853 - val_loss: 0.1859 - val_mse: 0.1314 - val_mae: 0.1859
Epoch 18/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1850 - mse:
0.1278 - mae: 0.1850 - val_loss: 0.1884 - val_mse: 0.1315 - val_mae: 0.1884
Epoch 19/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1768 - mse:
0.1232 - mae: 0.1768 - val_loss: 0.1832 - val_mse: 0.1259 - val_mae: 0.1832
Epoch 20/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1759 - mse:
0.1229 - mae: 0.1759 - val_loss: 0.1823 - val_mse: 0.1292 - val_mae: 0.1823
Epoch 21/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1770 - mse:
0.1250 - mae: 0.1770 - val_loss: 0.1807 - val_mse: 0.1188 - val_mae: 0.1807
Epoch 22/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1743 - mse:
0.1228 - mae: 0.1743 - val_loss: 0.1853 - val_mse: 0.1232 - val_mae: 0.1853
Epoch 23/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1740 - mse:
0.1214 - mae: 0.1740 - val_loss: 0.1786 - val_mse: 0.1225 - val_mae: 0.1786
Epoch 24/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1709 - mse:
0.1194 - mae: 0.1709 - val_loss: 0.1735 - val_mse: 0.1239 - val_mae: 0.1735
Epoch 25/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1688 - mse:
0.1221 - mae: 0.1688 - val_loss: 0.1713 - val_mse: 0.1132 - val_mae: 0.1713
Epoch 26/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1609 - mse:
0.1172 - mae: 0.1609 - val_loss: 0.1634 - val_mse: 0.1186 - val_mae: 0.1634
Epoch 27/400
```

```
177/177 [==============================] - 1s 4ms/step - loss: 0.1619 - mse:
0.1181 - mae: 0.1619 - val_loss: 0.1679 - val_mse: 0.1274 - val_mae: 0.1679
Epoch 28/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1536 - mse:
0.1129 - mae: 0.1536 - val_loss: 0.1575 - val_mse: 0.1224 - val_mae: 0.1575
Epoch 29/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1519 - mse:
0.1149 - mae: 0.1519 - val_loss: 0.1589 - val_mse: 0.1220 - val_mae: 0.1589
Epoch 30/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1487 - mse:
0.1127 - mae: 0.1487 - val_loss: 0.1608 - val_mse: 0.1224 - val_mae: 0.1608
Epoch 31/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1462 - mse:
0.1117 - mae: 0.1462 - val_loss: 0.1520 - val_mse: 0.1257 - val_mae: 0.1520
Epoch 32/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1465 - mse:
0.1142 - mae: 0.1465 - val_loss: 0.1463 - val_mse: 0.1046 - val_mae: 0.1463
Epoch 33/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1408 - mse:
0.1090 - mae: 0.1408 - val_loss: 0.1557 - val_mse: 0.1316 - val_mae: 0.1557
Epoch 34/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1393 - mse:
0.1094 - mae: 0.1393 - val_loss: 0.1462 - val_mse: 0.1100 - val_mae: 0.1462
Epoch 35/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1432 - mse:
0.1114 - mae: 0.1432 - val_loss: 0.1481 - val_mse: 0.1143 - val_mae: 0.1481
Epoch 36/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1359 - mse:
0.1093 - mae: 0.1359 - val_loss: 0.1438 - val_mse: 0.1275 - val_mae: 0.1438
Epoch 37/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1333 - mse:
0.1089 - mae: 0.1333 - val_loss: 0.1469 - val_mse: 0.1139 - val_mae: 0.1469
Epoch 38/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1294 - mse:
0.1066 - mae: 0.1294 - val_loss: 0.1334 - val_mse: 0.1068 - val_mae: 0.1334
Epoch 39/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1340 - mse:
0.1085 - mae: 0.1340 - val_loss: 0.1494 - val_mse: 0.1295 - val_mae: 0.1494
Epoch 40/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1300 - mse:
0.1027 - mae: 0.1300 - val_loss: 0.1332 - val_mse: 0.1050 - val_mae: 0.1332
Epoch 41/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1273 - mse:
0.1006 - mae: 0.1273 - val_loss: 0.1310 - val_mse: 0.1043 - val_mae: 0.1310
Epoch 42/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1262 - mse:
0.1002 - mae: 0.1262 - val_loss: 0.1375 - val_mse: 0.0983 - val_mae: 0.1375
Epoch 43/400
```

```
177/177 [==============================] - 1s 4ms/step - loss: 0.1299 - mse:
0.1003 - mae: 0.1299 - val_loss: 0.1250 - val_mse: 0.1035 - val_mae: 0.1250
Epoch 44/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1241 - mse:
0.0979 - mae: 0.1241 - val_loss: 0.1286 - val_mse: 0.0988 - val_mae: 0.1286
Epoch 45/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1196 - mse:
0.0900 - mae: 0.1196 - val_loss: 0.1174 - val_mse: 0.0875 - val_mae: 0.1174
Epoch 46/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1158 - mse:
0.0798 - mae: 0.1158 - val_loss: 0.1234 - val_mse: 0.0858 - val_mae: 0.1234
Epoch 47/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1197 - mse:
0.0864 - mae: 0.1197 - val_loss: 0.1187 - val_mse: 0.1114 - val_mae: 0.1187
Epoch 48/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1072 - mse:
0.0725 - mae: 0.1072 - val_loss: 0.1081 - val_mse: 0.0857 - val_mae: 0.1081
Epoch 49/400
177/177 [==============================] - 1s 4ms/step - loss: 0.1056 - mse:
0.0781 - mae: 0.1056 - val_loss: 0.1253 - val_mse: 0.0950 - val_mae: 0.1253
Epoch 50/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0982 - mse:
0.0699 - mae: 0.0982 - val_loss: 0.0990 - val_mse: 0.0706 - val_mae: 0.0990
Epoch 51/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0986 - mse:
0.0732 - mae: 0.0986 - val_loss: 0.0969 - val_mse: 0.0651 - val_mae: 0.0969
Epoch 52/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0931 - mse:
0.0710 - mae: 0.0931 - val_loss: 0.1103 - val_mse: 0.0942 - val_mae: 0.1103
Epoch 53/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0940 - mse:
0.0711 - mae: 0.0940 - val_loss: 0.1055 - val_mse: 0.0880 - val_mae: 0.1055
Epoch 54/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0888 - mse:
0.0680 - mae: 0.0888 - val_loss: 0.1208 - val_mse: 0.0928 - val_mae: 0.1208
Epoch 55/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0839 - mse:
0.0577 - mae: 0.0839 - val_loss: 0.0924 - val_mse: 0.0651 - val_mae: 0.0924
Epoch 56/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0815 - mse:
0.0574 - mae: 0.0815 - val_loss: 0.1097 - val_mse: 0.1027 - val_mae: 0.1097
Epoch 57/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0826 - mse:
0.0557 - mae: 0.0826 - val_loss: 0.0999 - val_mse: 0.0786 - val_mae: 0.0999
Epoch 58/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0812 - mse:
0.0592 - mae: 0.0812 - val_loss: 0.0864 - val_mse: 0.0672 - val_mae: 0.0864
Epoch 59/400
```

```
177/177 [==============================] - 1s 4ms/step - loss: 0.0884 - mse:
0.0700 - mae: 0.0884 - val_loss: 0.1109 - val_mse: 0.1011 - val_mae: 0.1109
Epoch 60/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0810 - mse:
0.0603 - mae: 0.0810 - val_loss: 0.1054 - val_mse: 0.0840 - val_mae: 0.1054
Epoch 61/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0706 - mse:
0.0493 - mae: 0.0706 - val_loss: 0.0850 - val_mse: 0.0664 - val_mae: 0.0850
Epoch 62/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0768 - mse:
0.0574 - mae: 0.0768 - val_loss: 0.0765 - val_mse: 0.0551 - val_mae: 0.0765
Epoch 63/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0746 - mse:
0.0535 - mae: 0.0746 - val_loss: 0.0869 - val_mse: 0.0454 - val_mae: 0.0869
Epoch 64/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0863 - mse:
0.0629 - mae: 0.0863 - val_loss: 0.0822 - val_mse: 0.0572 - val_mae: 0.0822
Epoch 65/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0764 - mse:
0.0556 - mae: 0.0764 - val_loss: 0.0746 - val_mse: 0.0434 - val_mae: 0.0746
Epoch 66/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0758 - mse:
0.0588 - mae: 0.0758 - val_loss: 0.0958 - val_mse: 0.0891 - val_mae: 0.0958
Epoch 67/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0605 - mse:
0.0381 - mae: 0.0605 - val_loss: 0.0605 - val_mse: 0.0308 - val_mae: 0.0605
Epoch 68/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0545 - mse:
0.0315 - mae: 0.0545 - val_loss: 0.0730 - val_mse: 0.0551 - val_mae: 0.0730
Epoch 69/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0571 - mse:
0.0350 - mae: 0.0571 - val_loss: 0.0556 - val_mse: 0.0275 - val_mae: 0.0556
Epoch 70/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0540 - mse:
0.0291 - mae: 0.0540 - val_loss: 0.0544 - val_mse: 0.0263 - val_mae: 0.0544
Epoch 71/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0625 - mse:
0.0420 - mae: 0.0625 - val_loss: 0.0639 - val_mse: 0.0417 - val_mae: 0.0639
Epoch 72/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0594 - mse:
0.0376 - mae: 0.0594 - val_loss: 0.0599 - val_mse: 0.0324 - val_mae: 0.0599
Epoch 73/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0616 - mse:
0.0384 - mae: 0.0616 - val_loss: 0.0600 - val_mse: 0.0367 - val_mae: 0.0600
Epoch 74/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0777 - mse:
0.0643 - mae: 0.0777 - val_loss: 0.0637 - val_mse: 0.0442 - val_mae: 0.0637
Epoch 75/400
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177/177 [==============================] - 1s 4ms/step - loss: 0.0623 - mse:
0.0452 - mae: 0.0623 - val_loss: 0.0815 - val_mse: 0.0760 - val_mae: 0.0815
Epoch 76/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0640 - mse:
0.0444 - mae: 0.0640 - val_loss: 0.0788 - val_mse: 0.0614 - val_mae: 0.0788
Epoch 77/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0579 - mse:
0.0400 - mae: 0.0579 - val_loss: 0.0703 - val_mse: 0.0576 - val_mae: 0.0703
Epoch 78/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0660 - mse:
0.0520 - mae: 0.0660 - val_loss: 0.0793 - val_mse: 0.0716 - val_mae: 0.0793
Epoch 79/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0522 - mse:
0.0336 - mae: 0.0522 - val_loss: 0.0882 - val_mse: 0.0798 - val_mae: 0.0882
Epoch 80/400
177/177 [==============================] - ETA: 0s - loss: 0.0599 - mse: 0.0415
- mae: 0.0599
Epoch 00080: ReduceLROnPlateau reducing learning rate to 0.00020000000949949026.
177/177 [==============================] - 1s 4ms/step - loss: 0.0599 - mse:
0.0415 - mae: 0.0599 - val_loss: 0.0708 - val_mse: 0.0610 - val_mae: 0.0708
Epoch 81/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0272 - mse:
0.0092 - mae: 0.0272 - val_loss: 0.0284 - val_mse: 0.0069 - val_mae: 0.0284
Epoch 82/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0200 - mse:
0.0027 - mae: 0.0200 - val_loss: 0.0266 - val_mse: 0.0058 - val_mae: 0.0266
Epoch 83/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0186 - mse:
0.0022 - mae: 0.0186 - val_loss: 0.0264 - val_mse: 0.0056 - val_mae: 0.0264
Epoch 84/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0178 - mse:
0.0020 - mae: 0.0178 - val_loss: 0.0259 - val_mse: 0.0055 - val_mae: 0.0259
Epoch 85/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0173 - mse:
0.0018 - mae: 0.0173 - val_loss: 0.0250 - val_mse: 0.0047 - val_mae: 0.0250
Epoch 86/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0165 - mse:
0.0015 - mae: 0.0165 - val_loss: 0.0244 - val_mse: 0.0049 - val_mae: 0.0244
Epoch 87/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0164 - mse:
0.0015 - mae: 0.0164 - val_loss: 0.0246 - val_mse: 0.0051 - val_mae: 0.0246
Epoch 88/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0159 - mse:
0.0015 - mae: 0.0159 - val_loss: 0.0238 - val_mse: 0.0046 - val_mae: 0.0238
Epoch 89/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0156 - mse:
0.0015 - mae: 0.0156 - val_loss: 0.0239 - val_mse: 0.0046 - val_mae: 0.0239
Epoch 90/400
```

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177/177 [==============================] - 1s 4ms/step - loss: 0.0156 - mse:
0.0015 - mae: 0.0156 - val_loss: 0.0237 - val_mse: 0.0045 - val_mae: 0.0237
Epoch 91/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0155 - mse:
0.0014 - mae: 0.0155 - val_loss: 0.0237 - val_mse: 0.0047 - val_mae: 0.0237
Epoch 92/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0155 - mse:
0.0015 - mae: 0.0155 - val_loss: 0.0233 - val_mse: 0.0044 - val_mae: 0.0233
Epoch 93/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0151 - mse:
0.0014 - mae: 0.0151 - val_loss: 0.0234 - val_mse: 0.0042 - val_mae: 0.0234
Epoch 94/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0149 - mse:
0.0014 - mae: 0.0149 - val_loss: 0.0229 - val_mse: 0.0041 - val_mae: 0.0229
Epoch 95/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0159 - mse:
0.0021 - mae: 0.0159 - val_loss: 0.0244 - val_mse: 0.0045 - val_mae: 0.0244
Epoch 96/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0152 - mse:
0.0016 - mae: 0.0152 - val_loss: 0.0280 - val_mse: 0.0081 - val_mae: 0.0280
Epoch 97/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0169 - mse:
0.0033 - mae: 0.0169 - val_loss: 0.0223 - val_mse: 0.0032 - val_mae: 0.0223
Epoch 98/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0142 - mse:
0.0013 - mae: 0.0142 - val_loss: 0.0221 - val_mse: 0.0037 - val_mae: 0.0221
Epoch 99/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0140 - mse:
0.0014 - mae: 0.0140 - val_loss: 0.0216 - val_mse: 0.0035 - val_mae: 0.0216
Epoch 100/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0138 - mse:
0.0013 - mae: 0.0138 - val_loss: 0.0217 - val_mse: 0.0037 - val_mae: 0.0217
Epoch 101/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0140 - mse:
0.0014 - mae: 0.0140 - val_loss: 0.0225 - val_mse: 0.0043 - val_mae: 0.0225
Epoch 102/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0160 - mse:
0.0032 - mae: 0.0160 - val_loss: 0.0301 - val_mse: 0.0120 - val_mae: 0.0301
Epoch 103/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0155 - mse:
0.0025 - mae: 0.0155 - val_loss: 0.0218 - val_mse: 0.0032 - val_mae: 0.0218
Epoch 104/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0141 - mse:
0.0013 - mae: 0.0141 - val_loss: 0.0225 - val_mse: 0.0043 - val_mae: 0.0225
Epoch 105/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0144 - mse:
0.0017 - mae: 0.0144 - val_loss: 0.0218 - val_mse: 0.0043 - val_mae: 0.0218
Epoch 106/400
```

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177/177 [==============================] - 1s 4ms/step - loss: 0.0133 - mse:
0.0013 - mae: 0.0133 - val_loss: 0.0215 - val_mse: 0.0043 - val_mae: 0.0215
Epoch 107/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0130 - mse:
0.0012 - mae: 0.0130 - val_loss: 0.0211 - val_mse: 0.0041 - val_mae: 0.0211
Epoch 108/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0131 - mse:
0.0013 - mae: 0.0131 - val_loss: 0.0210 - val_mse: 0.0037 - val_mae: 0.0210
Epoch 109/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0134 - mse:
0.0013 - mae: 0.0134 - val_loss: 0.0228 - val_mse: 0.0045 - val_mae: 0.0228
Epoch 110/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0128 - mse:
0.0012 - mae: 0.0128 - val_loss: 0.0209 - val_mse: 0.0036 - val_mae: 0.0209
Epoch 111/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0168 - mse:
0.0048 - mae: 0.0168 - val_loss: 0.0227 - val_mse: 0.0052 - val_mae: 0.0227
Epoch 112/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0139 - mse:
0.0018 - mae: 0.0139 - val_loss: 0.0230 - val_mse: 0.0045 - val_mae: 0.0230
Epoch 113/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0146 - mse:
0.0023 - mae: 0.0146 - val_loss: 0.0221 - val_mse: 0.0043 - val_mae: 0.0221
Epoch 114/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0151 - mse:
0.0030 - mae: 0.0151 - val_loss: 0.0283 - val_mse: 0.0112 - val_mae: 0.0283
Epoch 115/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0129 - mse:
0.0015 - mae: 0.0129 - val_loss: 0.0210 - val_mse: 0.0039 - val_mae: 0.0210
Epoch 116/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0122 - mse:
0.0012 - mae: 0.0122 - val_loss: 0.0207 - val_mse: 0.0037 - val_mae: 0.0207
Epoch 117/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0122 - mse:
0.0011 - mae: 0.0122 - val_loss: 0.0206 - val_mse: 0.0035 - val_mae: 0.0206
Epoch 118/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0121 - mse:
0.0012 - mae: 0.0121 - val_loss: 0.0201 - val_mse: 0.0036 - val_mae: 0.0201
Epoch 119/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0120 - mse:
0.0011 - mae: 0.0120 - val_loss: 0.0209 - val_mse: 0.0035 - val_mae: 0.0209
Epoch 120/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0134 - mse:
0.0020 - mae: 0.0134 - val_loss: 0.0227 - val_mse: 0.0047 - val_mae: 0.0227
Epoch 121/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0123 - mse:
0.0013 - mae: 0.0123 - val_loss: 0.0204 - val_mse: 0.0038 - val_mae: 0.0204
Epoch 122/400
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177/177 [==============================] - 1s 4ms/step - loss: 0.0118 - mse:
0.0011 - mae: 0.0118 - val_loss: 0.0209 - val_mse: 0.0039 - val_mae: 0.0209
Epoch 123/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0119 - mse:
0.0011 - mae: 0.0119 - val_loss: 0.0256 - val_mse: 0.0086 - val_mae: 0.0256
Epoch 124/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0166 - mse:
0.0063 - mae: 0.0166 - val_loss: 0.0201 - val_mse: 0.0035 - val_mae: 0.0201
Epoch 125/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0128 - mse:
0.0017 - mae: 0.0128 - val_loss: 0.0232 - val_mse: 0.0063 - val_mae: 0.0232
Epoch 126/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0127 - mse:
0.0015 - mae: 0.0127 - val_loss: 0.0210 - val_mse: 0.0036 - val_mae: 0.0210
Epoch 127/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0116 - mse:
0.0011 - mae: 0.0116 - val_loss: 0.0203 - val_mse: 0.0037 - val_mae: 0.0203
Epoch 128/400
167/177 [===========================>..] - ETA: 0s - loss: 0.0114 - mse: 0.0011
- mae: 0.0114
Epoch 00128: ReduceLROnPlateau reducing learning rate to 4.0000001899898055e-05.
177/177 [==============================] - 1s 4ms/step - loss: 0.0115 - mse:
0.0011 - mae: 0.0115 - val_loss: 0.0202 - val_mse: 0.0040 - val_mae: 0.0202
Epoch 129/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0100 - mse:
0.0010 - mae: 0.0100 - val_loss: 0.0189 - val_mse: 0.0038 - val_mae: 0.0189
Epoch 130/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0095 - mse:
9.8267e-04 - mae: 0.0095 - val_loss: 0.0188 - val_mse: 0.0038 - val_mae: 0.0188
Epoch 131/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0093 - mse:
9.7636e-04 - mae: 0.0093 - val_loss: 0.0189 - val_mse: 0.0038 - val_mae: 0.0189
Epoch 132/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0092 - mse:
9.8214e-04 - mae: 0.0092 - val_loss: 0.0187 - val_mse: 0.0038 - val_mae: 0.0187
Epoch 133/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0091 - mse:
9.7822e-04 - mae: 0.0091 - val_loss: 0.0186 - val_mse: 0.0038 - val_mae: 0.0186
Epoch 134/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0090 - mse:
9.7715e-04 - mae: 0.0090 - val_loss: 0.0188 - val_mse: 0.0040 - val_mae: 0.0188
Epoch 135/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0090 - mse:
9.7792e-04 - mae: 0.0090 - val_loss: 0.0186 - val_mse: 0.0039 - val_mae: 0.0186
Epoch 136/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0090 - mse:
9.7252e-04 - mae: 0.0090 - val_loss: 0.0188 - val_mse: 0.0040 - val_mae: 0.0188
Epoch 137/400
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177/177 [==============================] - 1s 4ms/step - loss: 0.0089 - mse:
9.6900e-04 - mae: 0.0089 - val_loss: 0.0185 - val_mse: 0.0038 - val_mae: 0.0185
Epoch 138/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0089 - mse:
9.6606e-04 - mae: 0.0089 - val_loss: 0.0186 - val_mse: 0.0039 - val_mae: 0.0186
Epoch 139/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0089 - mse:
9.6645e-04 - mae: 0.0089 - val_loss: 0.0185 - val_mse: 0.0038 - val_mae: 0.0185
Epoch 140/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0088 - mse:
9.6575e-04 - mae: 0.0088 - val_loss: 0.0187 - val_mse: 0.0040 - val_mae: 0.0187
Epoch 141/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0088 - mse:
9.6213e-04 - mae: 0.0088 - val_loss: 0.0185 - val_mse: 0.0039 - val_mae: 0.0185
Epoch 142/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0088 - mse:
9.6247e-04 - mae: 0.0088 - val_loss: 0.0185 - val_mse: 0.0039 - val_mae: 0.0185
Epoch 143/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0088 - mse:
9.5988e-04 - mae: 0.0088 - val_loss: 0.0186 - val_mse: 0.0041 - val_mae: 0.0186
Epoch 144/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0087 - mse:
9.5765e-04 - mae: 0.0087 - val_loss: 0.0185 - val_mse: 0.0039 - val_mae: 0.0185
Epoch 145/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0087 - mse:
9.5199e-04 - mae: 0.0087 - val_loss: 0.0185 - val_mse: 0.0039 - val_mae: 0.0185
Epoch 146/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0087 - mse:
9.5085e-04 - mae: 0.0087 - val_loss: 0.0184 - val_mse: 0.0038 - val_mae: 0.0184
Epoch 147/400
166/177 [===========================>..] - ETA: 0s - loss: 0.0087 - mse:
9.4488e-04 - mae: 0.0087
Epoch 00147: ReduceLROnPlateau reducing learning rate to 8.000000525498762e-06.
177/177 [==============================] - 1s 4ms/step - loss: 0.0087 - mse:
9.4254e-04 - mae: 0.0087 - val_loss: 0.0185 - val_mse: 0.0039 - val_mae: 0.0185
Epoch 148/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0084 - mse:
9.3839e-04 - mae: 0.0084 - val_loss: 0.0182 - val_mse: 0.0038 - val_mae: 0.0182
Epoch 149/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0082 - mse:
9.3657e-04 - mae: 0.0082 - val_loss: 0.0182 - val_mse: 0.0038 - val_mae: 0.0182
Epoch 150/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0082 - mse:
9.3595e-04 - mae: 0.0082 - val_loss: 0.0182 - val_mse: 0.0038 - val_mae: 0.0182
Epoch 151/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3385e-04 - mae: 0.0081 - val_loss: 0.0182 - val_mse: 0.0039 - val_mae: 0.0182
Epoch 152/400
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177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3459e-04 - mae: 0.0081 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 153/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3390e-04 - mae: 0.0081 - val_loss: 0.0182 - val_mse: 0.0039 - val_mae: 0.0182
Epoch 154/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3414e-04 - mae: 0.0081 - val_loss: 0.0182 - val_mse: 0.0039 - val_mae: 0.0182
Epoch 155/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3394e-04 - mae: 0.0081 - val_loss: 0.0181 - val_mse: 0.0038 - val_mae: 0.0181
Epoch 156/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3356e-04 - mae: 0.0081 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 157/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3133e-04 - mae: 0.0081 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 158/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0081 - mse:
9.3253e-04 - mae: 0.0081 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 159/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3164e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0040 - val_mae: 0.0181
Epoch 160/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3330e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 161/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3113e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 162/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3339e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 163/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3034e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 164/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3042e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 165/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3141e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 166/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3134e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 167/400
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3240e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0038 - val_mae: 0.0181
Epoch 168/400
```
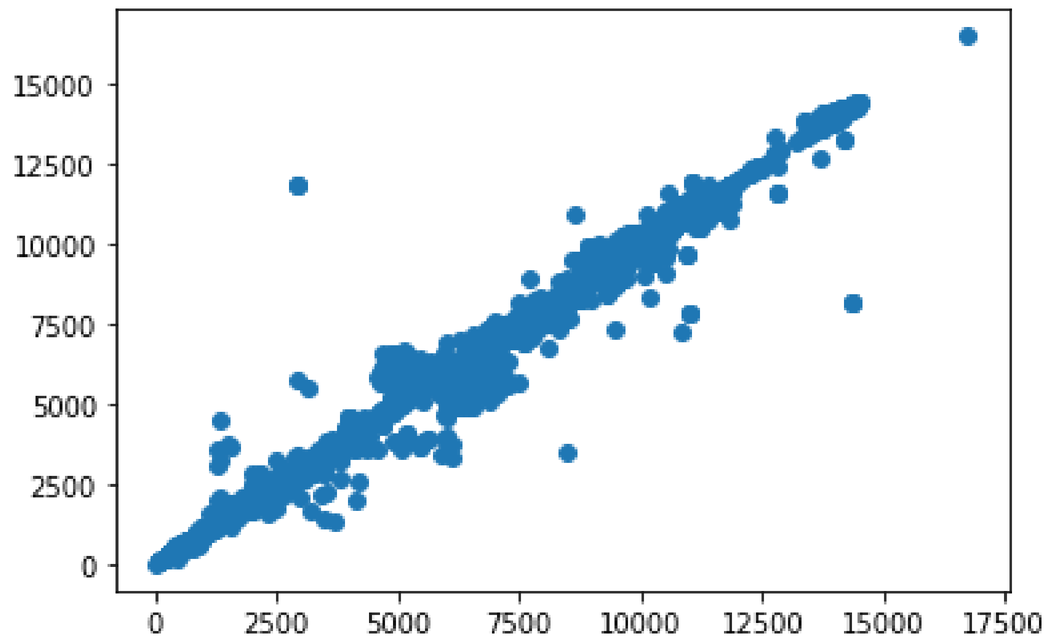

```
176/177 [============================>.] - ETA: 0s - loss: 0.0080 - mse:
9.3026e-04 - mae: 0.0080
Epoch 00168: ReduceLROnPlateau reducing learning rate to 1.6000001778593287e-06.
177/177 [==============================] - 1s 4ms/step - loss: 0.0080 - mse:
9.3091e-04 - mae: 0.0080 - val_loss: 0.0181 - val_mse: 0.0039 - val_mae: 0.0181
Epoch 169/400
168/177 [===========================>..] - ETA: 0s - loss: 0.0080 - mse:
9.4242e-04 - mae: 0.0080Restoring model weights from the end of the best epoch.
177/177 [==============================] - 1s 4ms/step - loss: 0.0079 - mse:
9.2818e-04 - mae: 0.0079 - val_loss: 0.0180 - val_mse: 0.0039 - val_mae: 0.0180
Epoch 00169: early stopping
```

3 Testing accuracy of Model with validation data

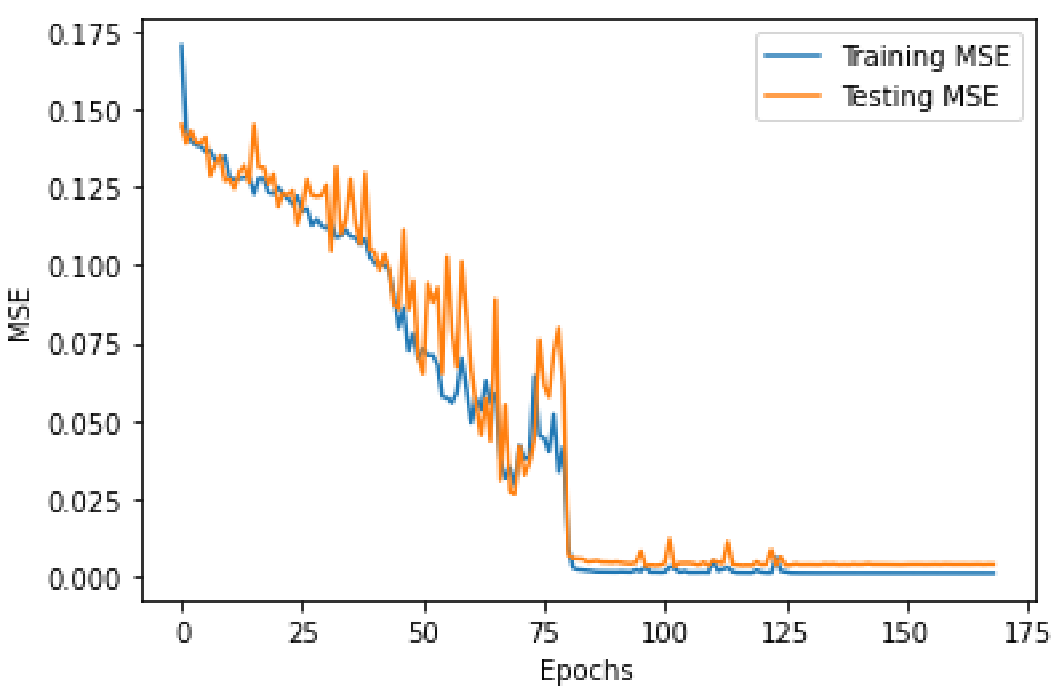
[139]:
```
y_f_result = model.predict(x_f_test)
y_result = y_scaler.inverse_transform(y_f_result)
y_actual = y_scaler.inverse_transform(y_f_test)

compare = pd.DataFrame()
compare['Expected'] = y_actual.reshape(1,-1)[0]
compare['Result'] = y_result.reshape(1,-1)[0]
compare['Difference'] = compare['Expected'] - compare['Result']
compare['Percentage Error'] = 100 * compare['Difference']/compare['Expected']

#Print out percentile descriptions of model accuracy
compare['Percentage Error'].describe(percentiles=[0.001, 0.01, 0.05, 0.25, 0.5,␣
↪0.75, 0.95, 0.99, 0.999])
```

[139]:
```
count    5296.000000
mean       -0.654780
std        12.096885
min      -306.197923
0.1%     -155.362372
1%        -27.918138
5%         -7.758211
25%        -0.691242
50%        -0.015267
75%         0.547683
95%         7.036125
99%        21.412407
99.9%      46.142001
max        63.309345
Name: Percentage Error, dtype: float64
```

[140]:
```
plt.scatter(compare['Expected'], compare['Result'])
plt.show()
```



[141]:
```
plt.plot(history.history['mse'],label='Training MSE')
plt.plot(history.history['val_mse'],label='Testing MSE')
plt.xlabel('Epochs')
plt.ylabel('MSE')
plt.legend()
plt.show()
```



[145]:
```
model.save('Trained_Models/Building_Model' + datetime.now().
↪strftime("%Y%m%d-%H%M%S") + '.h5')
```

4 Building Model Analysis

[146]:
```
def clean_data(location, skiprows = 0):
    df_weather = pd.read_csv(location, skiprows=skiprows)
    df_weather = df_weather.drop(columns=['Hour', 'Minute'])
    df_weather = df_weather[df_weather.DNI != 0]

    #Take mean, max and min for each DNI in DataFrame and mean for everything␣
↪else

    max_dni = df_weather.groupby(['Year', 'Month', 'Day']).max().
↪reset_index()['DNI']
    min_dni = df_weather.groupby(['Year', 'Month', 'Day']).min().
↪reset_index()['DNI']

    df_weather = pd.DataFrame(df_weather.groupby(['Year', 'Month', 'Day']).
↪mean().reset_index())

    df_weather.insert(4, 'DNI Max', max_dni)
    df_weather.insert(5, 'DNI Min', min_dni)

    return df_weather
```

[147]:
```
def training_prep(data, square_feet, building_type):
    data = data.loc[:, ['Year', 'Month', 'Day', 'DNI', 'DNI Max', 'DNI Min',␣
↪'Wind Speed', 'Precipitable Water', 'Wind Direction', 'Relative Humidity',␣
↪'Temperature', 'Pressure']]
    data.loc[:, 'Weekday'] = get_weekday2(data['Year'], data['Month'],␣
↪data['Day'])
    data = data.drop(['Year'], axis=1)
    data.loc[:, 'Square Feet'] = square_feet
    data.loc[:, 'Type'] = building_type
    return data
```

[157]:
```
#Taking data for University of Michigan Research Building
michigan_data = training_prep(clean_data('https://raw.githubusercontent.com/
↪A-Wadhwani/ME597-Project/main/Datasets/AnnArbor_Weather.csv'), 100000, 1)
michigan_data.head()
```

[157]:

```
   Month  Day         DNI  DNI Max  …     Pressure  Weekday  Square Feet  Type
0      1    1   52.111111      178  …   993.888889        0       100000     1
1      1    2  396.000000      751  …  1011.400000        0       100000     1
2      1    3  299.700000      752  …   997.400000        0       100000     1
3      1    4  281.900000      576  …   997.300000        0       100000     1
4      1    5   10.000000       21  …   986.000000        1       100000     1

[5 rows x 14 columns]
```

[158]:

```
#Applying transform to data
mi_test = x_scaler.transform(michigan_data)
```

[159]:

```
#Testing model:
mi_result = y_scaler.inverse_transform(model.predict(mi_test))
compare = pd.DataFrame()
compare['Month'] = michigan_data['Month']
compare['Result'] = mi_result.reshape(1,-1)[0]
compare.head()
```

[159]:

```
   Month       Result
0      1  4895.604004
1      1  6315.085938
2      1  4469.236328
3      1  3986.015869
4      1  4031.808105
```

[160]:

```
compare = pd.DataFrame(compare.groupby(['Month']).sum().reset_index())
actual = [212259, 240083, 218423, 233777, 240106, 272017, 300123, 295701,␣
↪288447, 254802, 228097, 220258]
compare['Actual'] = actual
compare['Difference'] = compare['Actual'] - compare['Result']
compare['Percentage Error'] = 100 * compare['Difference']/compare['Actual']
compare.head(12)
```

[160]:

```
    Month         Result  Actual     Difference  Percentage Error
0       1  134455.828125  212259   77803.171875         36.654828
1       2  143473.031250  240083   96609.968750         40.240237
2       3  194498.750000  218423   23924.250000         10.953173
3       4  204883.156250  233777   28893.843750         12.359575
4       5  194221.453125  240106   45884.546875         19.110121
5       6  180275.687500  272017   91741.312500         33.726316
6       7  178017.578125  300123  122105.421875         40.685126
7       8  177075.234375  295701  118625.765625         40.116796
8       9  190250.078125  288447   98196.921875         34.043315
9      10  201368.203125  254802   53433.796875         20.970713
10     11  175134.781250  228097   52962.218750         23.219165
11     12  154103.718750  220258   66154.281250         30.034905
```

[161]:
```
compare.describe()
```

[161]:
```
           Month         Result         Actual     Difference  Percentage Error
count  12.000000      12.000000      12.000000      12.000000         12.000000
mean    6.500000  177313.125000  250341.083333   73027.958333         28.509523
std     3.605551   22607.332031   31378.512646   33001.252345         10.826360
min     1.000000  134455.828125  212259.000000   23924.250000         10.953173
25%     3.750000  169877.015625  226137.250000   51192.800781         20.505565
50%     6.500000  179146.632812  240094.500000   71978.726562         31.880610
75%     9.250000  194290.777344  276124.500000   97006.707031         37.520320
max    12.000000  204883.156250  300123.000000  122105.421875         40.685126
```

5 Comparison against UIUC data

[153]:
```
uiuc_test = pd.read_csv('https://raw.githubusercontent.com/A-Wadhwani/
 ↪ME597-Project/main/Datasets/UIUC_PowerWeatherData.csv')
#Adding other relevant data, including square feet and type
uiuc_test['Square Feet'] = 100000
#Laboratory
uiuc_test['Type'] = 1
uiuc_actual = uiuc_test['Power Consumption']
uiuc_test = uiuc_test.drop(['Building Name', 'University Name', 'Year','Power␣
 ↪Consumption'], axis=1)
uiuc_test.head()
```

[153]:
```
   Month  Day    DNI Mean  DNI Max  …    Pressure  Weekday  Square Feet  Type
0     10    1  597.916667      898  …  988.333333        0       100000     1
1     10    2  332.250000      772  …  986.250000        0       100000     1
2     10    3  408.000000      923  …  991.555556        0       100000     1
3     10    4  617.250000      931  …  999.416667        0       100000     1
4     10    5  309.400000      810  …  990.500000        1       100000     1

[5 rows x 14 columns]
```

[154]:
```
#Applying transform to data
uiuc_test = x_scaler.transform(uiuc_test)
```

[155]:
```
#Testing model:
uiuc_result = y_scaler.inverse_transform(model.predict(uiuc_test))

compare = pd.DataFrame()
compare['Actual'] = uiuc_actual
compare['Result'] = uiuc_result.reshape(1,-1)[0]
compare['Difference'] = compare['Actual'] - compare['Result']
compare['Percentage Error'] = 100 * compare['Difference']/compare['Actual']
```

```
compare.describe()
```

[155]:

	Actual	Result	Difference	Percentage Error
count	51.000000	51.000000	51.000000	51.000000
mean	6189.156863	6120.660156	68.496223	0.870158
std	228.978372	1833.974487	1866.649114	30.106029
min	5069.000000	975.114746	-2872.380859	-46.009625
25%	6142.000000	5669.620117	-1163.810547	-18.707773
50%	6243.000000	6721.865723	-519.716797	-7.973562
75%	6301.000000	7376.884521	449.379883	7.327076
max	6518.000000	9115.380859	5351.885254	84.588039

[156]:

```
plt.hist(compare['Percentage Error'])
plt.show()
```