model_pitching

April 30, 2020

[1]:
```python
import tensorflow as tf
import pandas as pd
import numpy as np
```

[2]:
```python
df = pd.read_csv('../core/output/pitchers.csv')
indexer = df.reset_index()[['index', 'retroID']].to_dict()['retroID']
y = df['Pitching'].values
```

[3]:
```python
df
```

[3]:
```
       retroID   BAOpp  CG  SHO  IPouts     H   ER   HR   BB   SO  ...  \
0     aardd001  0.2574   0    0    1011   296  160   41  183  340  ...
1     aased001  0.2508  22    5    3328  1085  468   89  457  641  ...
2     abadf001  0.2447   0    0     992   309  135   42  116  280  ...
3     abbog001  0.2786  37    5    3858  1405  627  162  352  484  ...
4     abboj001  0.2804  31    6    5022  1779  791  154  620  888  ...
...        ...     ...  ..  ...     ...   ...  ...  ...  ...  ...  ...
8020  zolds101  0.2700  30    5    2788   956  366   54  301  207  ...
8021  zubeb101  0.2717  23    3    2358   767  374   35  468  383  ...
8022  zumaj001  0.2286   0    0     629   169   71   18  114  210  ...
8023  zuveg101  0.2760   9    2    1927   660  253   56  203  223  ...
8024  zycht001  0.2183   0    0     218    57   22    3   34   80  ...

            IP   K/9  BB/9  HR/9  BABIP  LOB%   ERA   FIP   WAR  Pitching
0     0.062360  9.08  4.89  1.09  0.285  74.5  4.27  4.45   1.1  0.602913
1     0.205233  5.20  3.71  0.72  0.282  73.4  3.80  3.85  11.7  0.636924
2     0.061102  7.62  3.16  1.14  0.281  77.7  3.67  4.24   0.6  0.603736
3     0.237967  3.39  2.46  1.13  0.278  69.3  4.39  4.46  10.2  0.628847
4     0.309765  4.77  3.33  0.83  0.295  70.0  4.25  4.25  22.7  0.666725
...        ...   ...   ...   ...    ...   ...   ...   ...   ...       ...
8020  0.171925  2.00  2.91  0.52  0.267  70.7  3.54  3.80   9.3  0.630540
8021  0.145445  4.39  5.36  0.40  0.283  69.0  4.28  3.96   3.3  0.610437
8022  0.038711  9.01  4.89  0.77  0.267  78.7  3.00  3.94   2.7  0.612847
8023  0.118817  3.12  2.84  0.78  0.270  73.2  3.54  3.93   1.9  0.608497
8024  0.013360  9.91  4.21  0.37  0.293  79.1  2.72  3.22   1.1  0.611166

[8025 rows x 31 columns]
```

Building the Model

[4]:
```
from sklearn.model_selection import train_test_split
```

[5]:
```
X = df.drop(columns=['Pitching']).values
y = df[['retroID', 'Pitching']].values
```

When we do our train-test split, since it's random in how it splits up the data, we need to keep track of the appropriate keys (retro IDs) for each data point.

[6]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=101)
X_train_keys = np.asarray([x[0] for x in X_train])
X_train = np.asarray([x[1:] for x in X_train])
X_test_keys = np.asarray([x[0] for x in X_test])
X_test = np.asarray([x[1:] for x in X_test])
y_train_keys = np.asarray([y[0] for y in y_train])
y_train = np.asarray([y[1] for y in y_train])
y_test_keys = np.asarray([y[0] for y in y_test])
y_test = np.asarray([y[1] for y in y_test])
```

[7]:
```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras import regularizers
```

[8]:
```
X_train.shape
```

[8]:
```
(6420, 29)
```

[9]:
```
from sklearn.preprocessing import MinMaxScaler
```

[10]:
```
scaler = MinMaxScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

[11]:
```
def to_tensor_input(player):
    return scaler.transform(player.values.reshape(-1,29))[0]
```

[12]:
```
tensor = df.drop(columns=['retroID', 'Pitching'])
player_tensor_inputs = tensor.apply(lambda player: to_tensor_input(player),␣
 ↪axis=1)
```

[13]:
```
player_tensor_inputs
```

[13]:
```
0        [0.2574, 0.0, 0.0, 0.06256962495358337, 0.0599...
1        [0.2508, 0.06567164179104477, 0.08196721311475...
```

```
2       [0.2447, 0.0, 0.0, 0.06139373684861988, 0.0625...
3       [0.2786, 0.11044776119402985, 0.08196721311475...
4       [0.2804, 0.09253731343283582, 0.09836065573770...
                                 ...
8020    [0.27, 0.08955223880597014, 0.0819672131147541...
8021    [0.2717, 0.06865671641791045, 0.04918032786885...
8022    [0.2286, 0.0, 0.0, 0.03892808515905434, 0.0342...
8023    [0.276, 0.026865671641791045, 0.03278688524590...
8024    [0.2183, 0.0, 0.0, 0.013491768783265256, 0.011...
Length: 8025, dtype: object
```

[14]:
```
tensor = pd.DataFrame(player_tensor_inputs.values.tolist())
```

[15]:
```
tensor.to_csv('../core/tensors/t_pitching.csv', index=False, float_format='%g')
```

[17]:
```
epochs = 4000
batch_size = 32
loss_param = 'mse'
optimizer_param = 'adam'
stop_monitor = 'val_loss'
stop_patience = 50
```

[18]:
```
from tensorflow.keras.callbacks import EarlyStopping
```

[19]:
```
early_stop = EarlyStopping(monitor=stop_monitor, patience=stop_patience)
```

[20]:
```
model = Sequential()

model.add(Dense(29, activation='relu', kernel_regularizer=regularizers.l2(0.
 ↪0001)))
model.add(Dropout(0.5))

model.add(Dense(58, activation='relu', kernel_regularizer=regularizers.l2(0.
 ↪0001)))
model.add(Dropout(0.5))

model.add(Dense(units=1, activation='sigmoid'))

model.compile(loss=loss_param, optimizer=optimizer_param)
```

[21]:
```
results = model.fit(x=X_train, y=y_train,
                        epochs=epochs,
                        batch_size=batch_size,
                        validation_data=(X_test, y_test),
                        callbacks=[early_stop]
                    )
```

```
Train on 6420 samples, validate on 1605 samples
Epoch 1/4000
6420/6420 [==============================] - 1s 183us/sample - loss: 0.0069 -
val_loss: 0.0035
Epoch 2/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 0.0033 -
val_loss: 0.0021
Epoch 3/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 0.0021 -
val_loss: 0.0013
Epoch 4/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 0.0015 -
val_loss: 8.8244e-04
Epoch 5/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 0.0011 -
val_loss: 6.9195e-04
Epoch 6/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 9.0205e-04 -
val_loss: 5.2742e-04
Epoch 7/4000
6420/6420 [==============================] - 0s 52us/sample - loss: 7.3946e-04 -
val_loss: 4.4965e-04
Epoch 8/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 6.7641e-04 -
val_loss: 4.5362e-04
Epoch 9/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 6.3987e-04 -
val_loss: 3.7094e-04
Epoch 10/4000
6420/6420 [==============================] - 0s 52us/sample - loss: 5.5052e-04 -
val_loss: 3.7966e-04
Epoch 11/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 5.8589e-04 -
val_loss: 3.5014e-04
Epoch 12/4000
6420/6420 [==============================] - 0s 52us/sample - loss: 5.5244e-04 -
val_loss: 3.2501e-04
Epoch 13/4000
6420/6420 [==============================] - 0s 76us/sample - loss: 5.2412e-04 -
val_loss: 3.1699e-04
Epoch 14/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 5.2772e-04 -
val_loss: 3.1689e-04
Epoch 15/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 5.1187e-04 -
val_loss: 3.1092e-04
Epoch 16/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 4.7594e-04 -
```

```
val_loss: 3.1406e-04
Epoch 17/4000
6420/6420 [==============================] - 0s 68us/sample - loss: 4.8153e-04 -
val_loss: 2.9968e-04
Epoch 18/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 4.5966e-04 -
val_loss: 2.9325e-04
Epoch 19/4000
6420/6420 [==============================] - 0s 73us/sample - loss: 5.0300e-04 -
val_loss: 2.7578e-04
Epoch 20/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 4.9546e-04 -
val_loss: 3.3074e-04
Epoch 21/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 4.5345e-04 -
val_loss: 3.0079e-04
Epoch 22/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.8102e-04 -
val_loss: 2.7513e-04
Epoch 23/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 4.5643e-04 -
val_loss: 2.7033e-04
Epoch 24/4000
6420/6420 [==============================] - 0s 57us/sample - loss: 4.5910e-04 -
val_loss: 2.9084e-04
Epoch 25/4000
6420/6420 [==============================] - 0s 71us/sample - loss: 4.3354e-04 -
val_loss: 2.6616e-04
Epoch 26/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 4.9588e-04 -
val_loss: 2.7724e-04
Epoch 27/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 4.5755e-04 -
val_loss: 2.5632e-04
Epoch 28/4000
6420/6420 [==============================] - 0s 75us/sample - loss: 4.2857e-04 -
val_loss: 2.6314e-04
Epoch 29/4000
6420/6420 [==============================] - 1s 92us/sample - loss: 4.6816e-04 -
val_loss: 2.4323e-04
Epoch 30/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 4.1988e-04 -
val_loss: 2.4475e-04
Epoch 31/4000
6420/6420 [==============================] - 1s 85us/sample - loss: 4.2199e-04 -
val_loss: 2.6340e-04
Epoch 32/4000
6420/6420 [==============================] - 1s 88us/sample - loss: 4.2470e-04 -
```

```
val_loss: 2.5903e-04
Epoch 33/4000
6420/6420 [==============================] - 1s 104us/sample - loss: 4.1919e-04
- val_loss: 2.5305e-04
Epoch 34/4000
6420/6420 [==============================] - 1s 85us/sample - loss: 4.3582e-04 -
val_loss: 2.4753e-04
Epoch 35/4000
6420/6420 [==============================] - 0s 58us/sample - loss: 4.2053e-04 -
val_loss: 2.2769e-04
Epoch 36/4000
6420/6420 [==============================] - 0s 59us/sample - loss: 4.4114e-04 -
val_loss: 2.3009e-04
Epoch 37/4000
6420/6420 [==============================] - 0s 57us/sample - loss: 4.1271e-04 -
val_loss: 2.6178e-04
Epoch 38/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 3.6627e-04 -
val_loss: 2.3378e-04
Epoch 39/4000
6420/6420 [==============================] - 0s 63us/sample - loss: 4.1566e-04 -
val_loss: 2.2211e-04
Epoch 40/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.8745e-04 -
val_loss: 2.3926e-04
Epoch 41/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 4.1845e-04 -
val_loss: 2.2952e-04
Epoch 42/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 4.7070e-04 -
val_loss: 2.1442e-04
Epoch 43/4000
6420/6420 [==============================] - 0s 58us/sample - loss: 4.3976e-04 -
val_loss: 2.3676e-04
Epoch 44/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 4.1991e-04 -
val_loss: 2.2202e-04
Epoch 45/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 3.8917e-04 -
val_loss: 2.2512e-04
Epoch 46/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 4.0262e-04 -
val_loss: 2.2537e-04
Epoch 47/4000
6420/6420 [==============================] - 0s 57us/sample - loss: 3.8574e-04 -
val_loss: 2.1841e-04
Epoch 48/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.9176e-04 -
```

```
val_loss: 2.4825e-04
Epoch 49/4000
6420/6420 [==============================] - 1s 108us/sample - loss: 4.3170e-04
- val_loss: 2.1427e-04
Epoch 50/4000
6420/6420 [==============================] - 0s 62us/sample - loss: 3.8348e-04 -
val_loss: 2.2604e-04
Epoch 51/4000
6420/6420 [==============================] - 1s 116us/sample - loss: 3.8706e-04
- val_loss: 2.0489e-04
Epoch 52/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.8088e-04 -
val_loss: 2.0127e-04
Epoch 53/4000
6420/6420 [==============================] - 0s 62us/sample - loss: 3.6288e-04 -
val_loss: 2.1046e-04
Epoch 54/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 3.9881e-04 -
val_loss: 2.1971e-04
Epoch 55/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 3.8779e-04 -
val_loss: 2.2584e-04
Epoch 56/4000
6420/6420 [==============================] - 0s 60us/sample - loss: 4.1901e-04 -
val_loss: 2.0682e-04
Epoch 57/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 4.2708e-04 -
val_loss: 2.3885e-04
Epoch 58/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 3.8187e-04 -
val_loss: 2.7590e-04
Epoch 59/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.6134e-04 -
val_loss: 2.0648e-04
Epoch 60/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 4.0795e-04 -
val_loss: 2.1653e-04
Epoch 61/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.8923e-04 -
val_loss: 1.8850e-04
Epoch 62/4000
6420/6420 [==============================] - 1s 111us/sample - loss: 3.9704e-04
- val_loss: 2.1104e-04
Epoch 63/4000
6420/6420 [==============================] - 0s 52us/sample - loss: 3.6265e-04 -
val_loss: 1.9132e-04
Epoch 64/4000
6420/6420 [==============================] - 0s 48us/sample - loss: 4.2228e-04 -
```

```
val_loss: 1.9923e-04
Epoch 65/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 4.0619e-04 -
val_loss: 1.9194e-04
Epoch 66/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.7996e-04 -
val_loss: 1.9624e-04
Epoch 67/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.6837e-04 -
val_loss: 2.0513e-04
Epoch 68/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.6470e-04 -
val_loss: 1.7655e-04
Epoch 69/4000
6420/6420 [==============================] - 0s 71us/sample - loss: 3.8834e-04 -
val_loss: 1.8333e-04
Epoch 70/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 4.3093e-04 -
val_loss: 2.1346e-04
Epoch 71/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.3164e-04 -
val_loss: 1.9133e-04
Epoch 72/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 4.1030e-04 -
val_loss: 1.9094e-04
Epoch 73/4000
6420/6420 [==============================] - 0s 62us/sample - loss: 3.8602e-04 -
val_loss: 1.8424e-04
Epoch 74/4000
6420/6420 [==============================] - 0s 71us/sample - loss: 3.6348e-04 -
val_loss: 2.0681e-04
Epoch 75/4000
6420/6420 [==============================] - 1s 92us/sample - loss: 3.9697e-04 -
val_loss: 2.1290e-04
Epoch 76/4000
6420/6420 [==============================] - 1s 85us/sample - loss: 3.9244e-04 -
val_loss: 1.9260e-04
Epoch 77/4000
6420/6420 [==============================] - 1s 93us/sample - loss: 4.3826e-04 -
val_loss: 2.0310e-04
Epoch 78/4000
6420/6420 [==============================] - 1s 82us/sample - loss: 3.9858e-04 -
val_loss: 2.3436e-04
Epoch 79/4000
6420/6420 [==============================] - 0s 74us/sample - loss: 4.1854e-04 -
val_loss: 1.9851e-04
Epoch 80/4000
6420/6420 [==============================] - 1s 99us/sample - loss: 3.5836e-04 -
```

```
val_loss: 2.1497e-04
Epoch 81/4000
6420/6420 [==============================] - 1s 82us/sample - loss: 3.6437e-04 -
val_loss: 2.1052e-04
Epoch 82/4000
6420/6420 [==============================] - 1s 109us/sample - loss: 4.2871e-04
- val_loss: 1.7637e-04
Epoch 83/4000
6420/6420 [==============================] - 1s 116us/sample - loss: 3.9076e-04
- val_loss: 1.8840e-04
Epoch 84/4000
6420/6420 [==============================] - 1s 124us/sample - loss: 3.9362e-04
- val_loss: 2.1731e-04
Epoch 85/4000
6420/6420 [==============================] - 1s 119us/sample - loss: 3.8175e-04
- val_loss: 2.2192e-04
Epoch 86/4000
6420/6420 [==============================] - 1s 96us/sample - loss: 3.7041e-04 -
val_loss: 1.7459e-04
Epoch 87/4000
6420/6420 [==============================] - 1s 101us/sample - loss: 3.8738e-04
- val_loss: 2.2406e-04
Epoch 88/4000
6420/6420 [==============================] - 1s 95us/sample - loss: 3.8013e-04 -
val_loss: 1.7943e-04
Epoch 89/4000
6420/6420 [==============================] - 1s 96us/sample - loss: 3.8381e-04 -
val_loss: 1.9004e-04
Epoch 90/4000
6420/6420 [==============================] - 1s 86us/sample - loss: 3.9642e-04 -
val_loss: 1.7015e-04
Epoch 91/4000
6420/6420 [==============================] - 1s 84us/sample - loss: 4.0069e-04 -
val_loss: 2.0521e-04
Epoch 92/4000
6420/6420 [==============================] - 1s 92us/sample - loss: 3.7681e-04 -
val_loss: 1.7749e-04
Epoch 93/4000
6420/6420 [==============================] - 1s 83us/sample - loss: 3.7360e-04 -
val_loss: 1.9228e-04
Epoch 94/4000
6420/6420 [==============================] - 1s 109us/sample - loss: 3.9241e-04
- val_loss: 2.1736e-04
Epoch 95/4000
6420/6420 [==============================] - 1s 91us/sample - loss: 3.7107e-04 -
val_loss: 1.9194e-04
Epoch 96/4000
6420/6420 [==============================] - 0s 77us/sample - loss: 4.1142e-04 -
```

```
val_loss: 1.7863e-04
Epoch 97/4000
6420/6420 [==============================] - 0s 69us/sample - loss: 3.7993e-04 -
val_loss: 1.7402e-04
Epoch 98/4000
6420/6420 [==============================] - 1s 82us/sample - loss: 3.7388e-04 -
val_loss: 1.9996e-04
Epoch 99/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 3.8071e-04 -
val_loss: 1.6832e-04
Epoch 100/4000
6420/6420 [==============================] - 1s 80us/sample - loss: 3.7083e-04 -
val_loss: 1.7974e-04
Epoch 101/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 4.1656e-04 -
val_loss: 2.1374e-04
Epoch 102/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 4.1230e-04 -
val_loss: 1.9933e-04
Epoch 103/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 3.9648e-04 -
val_loss: 1.8338e-04
Epoch 104/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.6543e-04 -
val_loss: 1.8833e-04
Epoch 105/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7677e-04 -
val_loss: 1.6929e-04
Epoch 106/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 4.1184e-04 -
val_loss: 1.8619e-04
Epoch 107/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.0038e-04 -
val_loss: 1.7728e-04
Epoch 108/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 4.0880e-04 -
val_loss: 1.7525e-04
Epoch 109/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.5400e-04 -
val_loss: 1.7394e-04
Epoch 110/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.7377e-04 -
val_loss: 1.9005e-04
Epoch 111/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.5676e-04 -
val_loss: 1.5734e-04
Epoch 112/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.6328e-04 -
```

```
val_loss: 1.9043e-04
Epoch 113/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 4.0993e-04 -
val_loss: 1.8249e-04
Epoch 114/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7068e-04 -
val_loss: 2.0348e-04
Epoch 115/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 4.1091e-04 -
val_loss: 2.0192e-04
Epoch 116/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 4.1776e-04 -
val_loss: 1.8761e-04
Epoch 117/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 3.5270e-04 -
val_loss: 1.8552e-04
Epoch 118/4000
6420/6420 [==============================] - 0s 70us/sample - loss: 3.8690e-04 -
val_loss: 1.7253e-04
Epoch 119/4000
6420/6420 [==============================] - 0s 67us/sample - loss: 4.0213e-04 -
val_loss: 1.8870e-04
Epoch 120/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.5177e-04 -
val_loss: 1.6634e-04
Epoch 121/4000
6420/6420 [==============================] - 0s 77us/sample - loss: 4.2021e-04 -
val_loss: 1.7592e-04
Epoch 122/4000
6420/6420 [==============================] - 0s 60us/sample - loss: 3.9119e-04 -
val_loss: 1.6329e-04
Epoch 123/4000
6420/6420 [==============================] - 0s 63us/sample - loss: 3.4388e-04 -
val_loss: 1.7831e-04
Epoch 124/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 3.8592e-04 -
val_loss: 2.1806e-04
Epoch 125/4000
6420/6420 [==============================] - 0s 57us/sample - loss: 3.6078e-04 -
val_loss: 1.8532e-04
Epoch 126/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.8341e-04 -
val_loss: 1.6547e-04
Epoch 127/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 3.5188e-04 -
val_loss: 1.5375e-04
Epoch 128/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 3.9971e-04 -
```

```
val_loss: 1.8052e-04
Epoch 129/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.9857e-04 -
val_loss: 2.4237e-04
Epoch 130/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.5901e-04 -
val_loss: 1.5623e-04
Epoch 131/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.7680e-04 -
val_loss: 2.1051e-04
Epoch 132/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7886e-04 -
val_loss: 1.5456e-04
Epoch 133/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.8955e-04 -
val_loss: 1.8789e-04
Epoch 134/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.5765e-04 -
val_loss: 1.6933e-04
Epoch 135/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.7434e-04 -
val_loss: 1.7699e-04
Epoch 136/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.8558e-04 -
val_loss: 1.6628e-04
Epoch 137/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.9230e-04 -
val_loss: 1.6465e-04
Epoch 138/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.8368e-04 -
val_loss: 1.7166e-04
Epoch 139/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.5695e-04 -
val_loss: 1.7670e-04
Epoch 140/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.7813e-04 -
val_loss: 1.8580e-04
Epoch 141/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.7063e-04 -
val_loss: 1.9484e-04
Epoch 142/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8097e-04 -
val_loss: 2.1516e-04
Epoch 143/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.0369e-04 -
val_loss: 1.8775e-04
Epoch 144/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8564e-04 -
```

```
val_loss: 2.3136e-04
Epoch 145/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7312e-04 -
val_loss: 1.7378e-04
Epoch 146/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.6275e-04 -
val_loss: 1.7078e-04
Epoch 147/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.9961e-04 -
val_loss: 1.7361e-04
Epoch 148/4000
6420/6420 [==============================] - 0s 59us/sample - loss: 4.0065e-04 -
val_loss: 2.1212e-04
Epoch 149/4000
6420/6420 [==============================] - 0s 63us/sample - loss: 3.6188e-04 -
val_loss: 1.9285e-04
Epoch 150/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.9891e-04 -
val_loss: 1.7574e-04
Epoch 151/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 3.5630e-04 -
val_loss: 1.8421e-04
Epoch 152/4000
6420/6420 [==============================] - 0s 71us/sample - loss: 4.4336e-04 -
val_loss: 1.7520e-04
Epoch 153/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.7000e-04 -
val_loss: 1.6459e-04
Epoch 154/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 4.0566e-04 -
val_loss: 1.6536e-04
Epoch 155/4000
6420/6420 [==============================] - 0s 73us/sample - loss: 3.6789e-04 -
val_loss: 1.7232e-04
Epoch 156/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 3.6652e-04 -
val_loss: 1.8355e-04
Epoch 157/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.6724e-04 -
val_loss: 1.8785e-04
Epoch 158/4000
6420/6420 [==============================] - 0s 76us/sample - loss: 3.9953e-04 -
val_loss: 1.8905e-04
Epoch 159/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 3.7878e-04 -
val_loss: 2.1174e-04
Epoch 160/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 4.0052e-04 -
```

```
val_loss: 1.9447e-04
Epoch 161/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.7289e-04 -
val_loss: 1.7476e-04
Epoch 162/4000
6420/6420 [==============================] - 0s 48us/sample - loss: 3.9438e-04 -
val_loss: 1.6093e-04
Epoch 163/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.8562e-04 -
val_loss: 1.6319e-04
Epoch 164/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.6413e-04 -
val_loss: 2.0747e-04
Epoch 165/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7078e-04 -
val_loss: 1.5520e-04
Epoch 166/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.3178e-04 -
val_loss: 1.5067e-04
Epoch 167/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.6772e-04 -
val_loss: 1.7527e-04
Epoch 168/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.7344e-04 -
val_loss: 1.8171e-04
Epoch 169/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 4.1335e-04 -
val_loss: 2.5147e-04
Epoch 170/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.9727e-04 -
val_loss: 1.7804e-04
Epoch 171/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.9421e-04 -
val_loss: 1.5357e-04
Epoch 172/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 4.0950e-04 -
val_loss: 1.6474e-04
Epoch 173/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.6053e-04 -
val_loss: 1.7761e-04
Epoch 174/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 4.1252e-04 -
val_loss: 1.9731e-04
Epoch 175/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.8814e-04 -
val_loss: 1.4349e-04
Epoch 176/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 4.3570e-04 -
```

```
val_loss: 2.0685e-04
Epoch 177/4000
6420/6420 [==============================] - 0s 52us/sample - loss: 3.8089e-04 -
val_loss: 1.7820e-04
Epoch 178/4000
6420/6420 [==============================] - 0s 57us/sample - loss: 3.5555e-04 -
val_loss: 1.4901e-04
Epoch 179/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.9112e-04 -
val_loss: 1.8517e-04
Epoch 180/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 3.7667e-04 -
val_loss: 1.5498e-04
Epoch 181/4000
6420/6420 [==============================] - 1s 80us/sample - loss: 3.8949e-04 -
val_loss: 1.9027e-04
Epoch 182/4000
6420/6420 [==============================] - 0s 72us/sample - loss: 3.8668e-04 -
val_loss: 1.5464e-04
Epoch 183/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 3.9501e-04 -
val_loss: 1.6829e-04
Epoch 184/4000
6420/6420 [==============================] - 0s 63us/sample - loss: 3.9367e-04 -
val_loss: 2.2951e-04
Epoch 185/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 3.7516e-04 -
val_loss: 1.6364e-04
Epoch 186/4000
6420/6420 [==============================] - 0s 74us/sample - loss: 4.0604e-04 -
val_loss: 1.6113e-04
Epoch 187/4000
6420/6420 [==============================] - 0s 59us/sample - loss: 4.4246e-04 -
val_loss: 1.6503e-04
Epoch 188/4000
6420/6420 [==============================] - 0s 56us/sample - loss: 3.9377e-04 -
val_loss: 1.9615e-04
Epoch 189/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.9532e-04 -
val_loss: 1.9750e-04
Epoch 190/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.0413e-04 -
val_loss: 1.5363e-04
Epoch 191/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.8147e-04 -
val_loss: 1.7732e-04
Epoch 192/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.6523e-04 -
```

```
val_loss: 1.6430e-04
Epoch 193/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.8917e-04 -
val_loss: 1.7617e-04
Epoch 194/4000
6420/6420 [==============================] - 0s 48us/sample - loss: 3.7432e-04 -
val_loss: 2.2310e-04
Epoch 195/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 3.8312e-04 -
val_loss: 1.6982e-04
Epoch 196/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.8935e-04 -
val_loss: 1.4669e-04
Epoch 197/4000
6420/6420 [==============================] - 0s 63us/sample - loss: 3.6802e-04 -
val_loss: 1.4314e-04
Epoch 198/4000
6420/6420 [==============================] - 0s 71us/sample - loss: 3.6925e-04 -
val_loss: 1.5511e-04
Epoch 199/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 3.8408e-04 -
val_loss: 1.7227e-04
Epoch 200/4000
6420/6420 [==============================] - 0s 70us/sample - loss: 3.7144e-04 -
val_loss: 1.6129e-04
Epoch 201/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.7737e-04 -
val_loss: 2.0729e-04
Epoch 202/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.5967e-04 -
val_loss: 1.5644e-04
Epoch 203/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.7491e-04 -
val_loss: 1.5643e-04
Epoch 204/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.8401e-04 -
val_loss: 1.5636e-04
Epoch 205/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 4.1449e-04 -
val_loss: 1.5338e-04
Epoch 206/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 4.1122e-04 -
val_loss: 1.6970e-04
Epoch 207/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 4.2181e-04 -
val_loss: 1.5571e-04
Epoch 208/4000
6420/6420 [==============================] - 0s 77us/sample - loss: 3.7934e-04 -
```

```
val_loss: 1.4740e-04
Epoch 209/4000
6420/6420 [==============================] - ETA: 0s - loss: 3.4250e-04- ETA: 0s
- loss: 3.2 - 0s 71us/sample - loss: 3.4491e-04 - val_loss: 1.4933e-04
Epoch 210/4000
6420/6420 [==============================] - 0s 68us/sample - loss: 3.8353e-04 -
val_loss: 1.9531e-04
Epoch 211/4000
6420/6420 [==============================] - 0s 68us/sample - loss: 3.8864e-04 -
val_loss: 1.7508e-04
Epoch 212/4000
6420/6420 [==============================] - 0s 75us/sample - loss: 3.6905e-04 -
val_loss: 1.6643e-04
Epoch 213/4000
6420/6420 [==============================] - 0s 77us/sample - loss: 4.0698e-04 -
val_loss: 1.7517e-04
Epoch 214/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 4.0734e-04 -
val_loss: 1.9799e-04
Epoch 215/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 4.1990e-04 -
val_loss: 1.6936e-04
Epoch 216/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.9171e-04 -
val_loss: 1.9487e-04
Epoch 217/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.9314e-04 -
val_loss: 1.6527e-04
Epoch 218/4000
6420/6420 [==============================] - 0s 54us/sample - loss: 4.1101e-04 -
val_loss: 1.6359e-04
Epoch 219/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8098e-04 -
val_loss: 1.6258e-04
Epoch 220/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.7306e-04 -
val_loss: 1.4014e-04
Epoch 221/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.9563e-04 -
val_loss: 1.3826e-04
Epoch 222/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.6621e-04 -
val_loss: 1.6607e-04
Epoch 223/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.6504e-04 -
val_loss: 1.4828e-04
Epoch 224/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.7195e-04 -
```

```
val_loss: 1.6845e-04
Epoch 225/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.6580e-04 -
val_loss: 1.7061e-04
Epoch 226/4000
6420/6420 [==============================] - 0s 48us/sample - loss: 3.5988e-04 -
val_loss: 1.4069e-04
Epoch 227/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8396e-04 -
val_loss: 1.6442e-04
Epoch 228/4000
6420/6420 [==============================] - 0s 45us/sample - loss: 3.6081e-04 -
val_loss: 1.6840e-04
Epoch 229/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8802e-04 -
val_loss: 1.6799e-04
Epoch 230/4000
6420/6420 [==============================] - 0s 67us/sample - loss: 3.9271e-04 -
val_loss: 1.7598e-04
Epoch 231/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 3.9200e-04 -
val_loss: 1.7821e-04
Epoch 232/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.9613e-04 -
val_loss: 1.6983e-04
Epoch 233/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 3.8921e-04 -
val_loss: 1.6949e-04
Epoch 234/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.9164e-04 -
val_loss: 2.3774e-04
Epoch 235/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 3.6622e-04 -
val_loss: 1.5798e-04
Epoch 236/4000
6420/6420 [==============================] - 0s 61us/sample - loss: 3.6441e-04 -
val_loss: 1.9084e-04
Epoch 237/4000
6420/6420 [==============================] - 0s 69us/sample - loss: 4.0341e-04 -
val_loss: 1.8301e-04
Epoch 238/4000
6420/6420 [==============================] - 0s 73us/sample - loss: 3.6314e-04 -
val_loss: 1.7106e-04
Epoch 239/4000
6420/6420 [==============================] - 0s 78us/sample - loss: 3.7995e-04 -
val_loss: 1.7895e-04
Epoch 240/4000
6420/6420 [==============================] - 0s 78us/sample - loss: 3.8314e-04 -
```

```
val_loss: 1.5395e-04
Epoch 241/4000
6420/6420 [==============================] - 0s 70us/sample - loss: 4.5325e-04 -
val_loss: 2.7468e-04
Epoch 242/4000
6420/6420 [==============================] - 0s 66us/sample - loss: 4.1948e-04 -
val_loss: 2.0811e-04
Epoch 243/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 3.5239e-04 -
val_loss: 1.4190e-04
Epoch 244/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 3.8547e-04 -
val_loss: 1.4648e-04
Epoch 245/4000
6420/6420 [==============================] - 0s 49us/sample - loss: 3.8467e-04 -
val_loss: 1.5179e-04
Epoch 246/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.8492e-04 -
val_loss: 1.5877e-04
Epoch 247/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.8039e-04 -
val_loss: 1.7363e-04
Epoch 248/4000
6420/6420 [==============================] - 0s 51us/sample - loss: 4.1558e-04 -
val_loss: 1.5646e-04
Epoch 249/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.7851e-04 -
val_loss: 1.9639e-04
Epoch 250/4000
6420/6420 [==============================] - 0s 44us/sample - loss: 3.9576e-04 -
val_loss: 1.6500e-04
Epoch 251/4000
6420/6420 [==============================] - 0s 47us/sample - loss: 4.1462e-04 -
val_loss: 1.8896e-04
Epoch 252/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.6546e-04 -
val_loss: 1.4212e-04
Epoch 253/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.9780e-04 -
val_loss: 1.5303e-04
Epoch 254/4000
6420/6420 [==============================] - 0s 48us/sample - loss: 3.9610e-04 -
val_loss: 1.6398e-04
Epoch 255/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.1971e-04 -
val_loss: 1.6363e-04
Epoch 256/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.6570e-04 -
```

```
val_loss: 1.5956e-04
Epoch 257/4000
6420/6420 [==============================] - 0s 42us/sample - loss: 3.4217e-04 -
val_loss: 1.4108e-04
Epoch 258/4000
6420/6420 [==============================] - 0s 43us/sample - loss: 3.8853e-04 -
val_loss: 1.5824e-04
Epoch 259/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.8600e-04 -
val_loss: 1.6287e-04
Epoch 260/4000
6420/6420 [==============================] - 0s 46us/sample - loss: 4.1746e-04 -
val_loss: 2.1092e-04
Epoch 261/4000
6420/6420 [==============================] - 0s 53us/sample - loss: 3.8136e-04 -
val_loss: 1.4752e-04
Epoch 262/4000
6420/6420 [==============================] - 0s 55us/sample - loss: 3.4157e-04 -
val_loss: 1.8513e-04
Epoch 263/4000
6420/6420 [==============================] - 0s 50us/sample - loss: 3.7130e-04 -
val_loss: 1.6227e-04
Epoch 264/4000
6420/6420 [==============================] - 0s 64us/sample - loss: 3.8783e-04 -
val_loss: 1.4024e-04
Epoch 265/4000
6420/6420 [==============================] - 0s 67us/sample - loss: 3.7614e-04 -
val_loss: 1.4579e-04
Epoch 266/4000
6420/6420 [==============================] - 1s 78us/sample - loss: 4.1468e-04 -
val_loss: 1.4124e-04
Epoch 267/4000
6420/6420 [==============================] - 0s 65us/sample - loss: 3.9763e-04 -
val_loss: 2.0330e-04
Epoch 268/4000
6420/6420 [==============================] - 1s 91us/sample - loss: 3.7932e-04 -
val_loss: 1.8770e-04
Epoch 269/4000
6420/6420 [==============================] - 0s 69us/sample - loss: 3.4800e-04 -
val_loss: 2.0037e-04
Epoch 270/4000
6420/6420 [==============================] - 0s 67us/sample - loss: 3.9476e-04 -
val_loss: 1.8254e-04
Epoch 271/4000
6420/6420 [==============================] - 0s 68us/sample - loss: 3.5524e-04 -
val_loss: 1.5522e-04
```

[22]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                multiple                  870
_________________________________________________________________
dropout (Dropout)            multiple                  0
_________________________________________________________________
dense_1 (Dense)              multiple                  1740
_________________________________________________________________
dropout_1 (Dropout)          multiple                  0
_________________________________________________________________
dense_2 (Dense)              multiple                  59
=================================================================
Total params: 2,669
Trainable params: 2,669
Non-trainable params: 0
_________________________________________________________________
```

[23]:
```
import os
```

[24]:
```
losses = model.history.history
losses['loss'] = np.asarray(losses['loss'])
losses['val_loss'] = np.asarray(losses['val_loss'])
final_number_of_epochs = len(losses['loss'])
min_loss = losses['loss'].min()
mean_loss = losses['loss'].mean()
final_loss = losses['loss'][-1]
min_val_loss = losses['val_loss'].min()
mean_val_loss = losses['val_loss'].mean()
final_val_loss = losses['val_loss'][-1]

def get_model_summary():
    output = []
    model.summary(print_fn=lambda line: output.append(line))
    return str(output).strip('[]')

summary = get_model_summary()

record = {
    'Epochs': final_number_of_epochs,
    'Batch_Size': batch_size,
    'Loss_Func': loss_param,
    'Optimizer': optimizer_param,
    'Early_Stop_Monitor': stop_monitor,
```

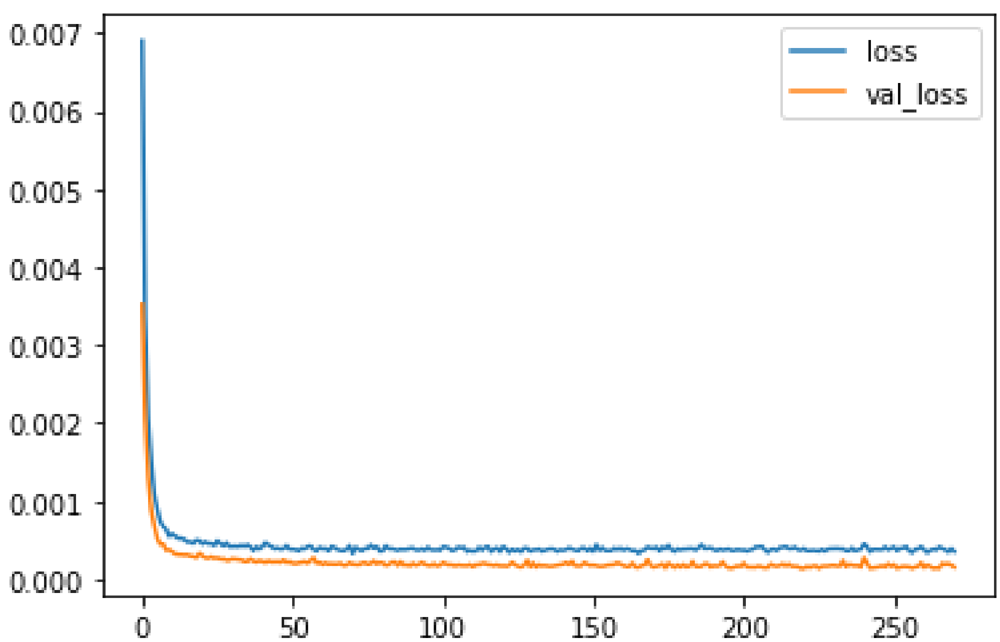
```python
    'Early_Stop_Patience': stop_patience,
    'Min_Loss': min_loss,
    'Mean_Loss': mean_loss,
    'Final_Loss': final_loss,
    'Min_Val_Loss': min_val_loss,
    'Mean_Val_Loss': mean_val_loss,
    'Final_Val_Loss': final_val_loss,
    'Model': summary
}

new_data = pd.DataFrame(record, index=[0])

if os.path.exists('../core/records/pitching_results.csv'):
    df_records = pd.read_csv('../core/records/pitching_results.csv')
    df_records = df_records.append(new_data)
else:
    df_records = pd.DataFrame(new_data)

df_records.to_csv('../core/records/pitching_results.csv', index=False,␣
 ↪float_format='%g')
```

Model Evaluation

[25]:
```python
losses = pd.DataFrame(model.history.history)
```

[26]:
```python
losses.plot()
```

[26]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x145c796d0>
```



[27]:
```
predictions = model.predict(X_test)
predictions = [pred for sublist in predictions for pred in sublist]
```

[28]:
```
test_player_ratings = dict(zip(X_test_keys, predictions))
```

[29]:
```
player_key = df['retroID']
```

[30]:
```
player_key
```

[30]:
```
0       aardd001
1       aased001
2       abadf001
3       abbog001
4       abboj001
          ...
8020    zolds101
8021    zubeb101
8022    zumaj001
8023    zuveg101
8024    zycht001
Name: retroID, Length: 8025, dtype: object
```

[31]:
```
results = model.predict(tensor.to_numpy())
```

[32]:
```
len(results)
```

[32]:
```
8025
```

[33]:
```
results.mean()
```

[33]:
```
0.6065751
```

[34]:
```
df['Pitching'].shape
```

[34]:
```
(8025,)
```

[35]:
```
results.shape
```

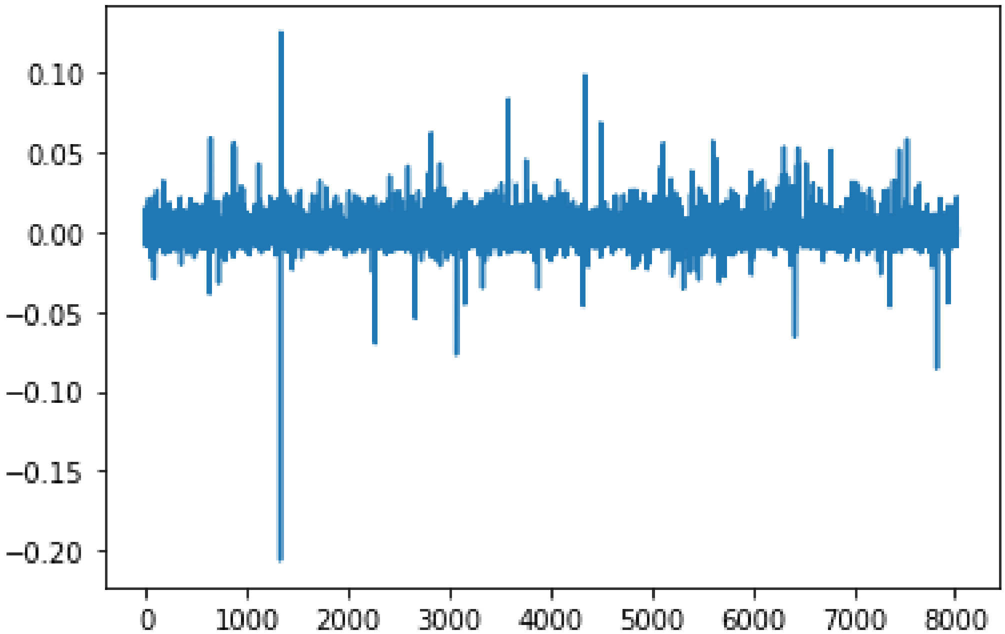
[35]:
```
(8025, 1)
```

[36]:
```
results = [pred for sublist in results for pred in sublist]
```

[37]:
```
diff = df['Pitching'] - results
```

[38]:
```
diff.plot()
```

[38]: <matplotlib.axes._subplots.AxesSubplot at 0x14684bd90>



[39]:
```
diff.mean()
```

[39]: -0.0009138342898704561

[ ]: