facial keypoints

June 4, 2020

1 Facial Keypoints Detection

The data can be downloaded from https://www.kaggle.com/c/facial-keypoints-detection/data

The notebook was originally a kaggle notebook, the link to which is https://www.kaggle.com/vikrantdey/facial-keypoints

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

     import os
     for dirname, _, filenames in os.walk('/kaggle/input'):
         for filename in filenames:
             print(os.path.join(dirname, filename))
```

```
/kaggle/input/facial-keypoints-detection/IdLookupTable.csv
/kaggle/input/facial-keypoints-detection/SampleSubmission.csv
/kaggle/input/facial-keypoints-detection/training.zip
/kaggle/input/facial-keypoints-detection/test.zip
```

```python
[6]: print("Contents of input/facial-keypoints-detection directory: ")
     !ls ../input/facial-keypoints-detection/

     print("\nExtracting .zip dataset files to working directory ...")
     !unzip -u ../input/facial-keypoints-detection/test.zip
     !unzip -u ../input/facial-keypoints-detection/training.zip

     print("\nCurrent working directory:")
     !pwd
     print("\nContents of working directory:")
     !ls
```

```
Contents of input/facial-keypoints-detection directory:
IdLookupTable.csv  SampleSubmission.csv  test.zip  training.zip

Extracting .zip dataset files to working directory …
Archive:  ../input/facial-keypoints-detection/test.zip
  inflating: test.csv
```

```
Archive:  ../input/facial-keypoints-detection/training.zip
  inflating: training.csv

Current working directory:
/kaggle/working

Contents of working directory:
__notebook_source__.ipynb  test.csv  training.csv
```

[2]:
```python
from sklearn.model_selection import train_test_split
from matplotlib import pyplot as plt
%matplotlib inline
```

[3]:
```python
IdLookupTable = pd.read_csv('/kaggle/input/facial-keypoints-detection/
 ↪IdLookupTable.csv')
IdLookupTable.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 27124 entries, 0 to 27123
Data columns (total 4 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   RowId        27124 non-null  int64
 1   ImageId      27124 non-null  int64
 2   FeatureName  27124 non-null  object
 3   Location     0 non-null      float64
dtypes: float64(1), int64(2), object(1)
memory usage: 847.8+ KB
```

[4]:
```python
IdLookupTable.head()
```

[4]:
	RowId	ImageId	FeatureName	Location
0	1	1	left_eye_center_x	NaN
1	2	1	left_eye_center_y	NaN
2	3	1	right_eye_center_x	NaN
3	4	1	right_eye_center_y	NaN
4	5	1	left_eye_inner_corner_x	NaN

[10]:
```python
training = pd.read_csv('/kaggle/working/training.csv')
training.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7049 entries, 0 to 7048
Data columns (total 31 columns):
 #   Column                  Non-Null Count  Dtype
---  ------                  --------------  -----
 0   left_eye_center_x       7039 non-null   float64
 1   left_eye_center_y       7039 non-null   float64
```

```
2   right_eye_center_x         7036 non-null   float64
3   right_eye_center_y         7036 non-null   float64
4   left_eye_inner_corner_x    2271 non-null   float64
5   left_eye_inner_corner_y    2271 non-null   float64
6   left_eye_outer_corner_x    2267 non-null   float64
7   left_eye_outer_corner_y    2267 non-null   float64
8   right_eye_inner_corner_x   2268 non-null   float64
9   right_eye_inner_corner_y   2268 non-null   float64
10  right_eye_outer_corner_x   2268 non-null   float64
11  right_eye_outer_corner_y   2268 non-null   float64
12  left_eyebrow_inner_end_x   2270 non-null   float64
13  left_eyebrow_inner_end_y   2270 non-null   float64
14  left_eyebrow_outer_end_x   2225 non-null   float64
15  left_eyebrow_outer_end_y   2225 non-null   float64
16  right_eyebrow_inner_end_x  2270 non-null   float64
17  right_eyebrow_inner_end_y  2270 non-null   float64
18  right_eyebrow_outer_end_x  2236 non-null   float64
19  right_eyebrow_outer_end_y  2236 non-null   float64
20  nose_tip_x                 7049 non-null   float64
21  nose_tip_y                 7049 non-null   float64
22  mouth_left_corner_x        2269 non-null   float64
23  mouth_left_corner_y        2269 non-null   float64
24  mouth_right_corner_x       2270 non-null   float64
25  mouth_right_corner_y       2270 non-null   float64
26  mouth_center_top_lip_x     2275 non-null   float64
27  mouth_center_top_lip_y     2275 non-null   float64
28  mouth_center_bottom_lip_x  7016 non-null   float64
29  mouth_center_bottom_lip_y  7016 non-null   float64
30  Image                      7049 non-null   object
dtypes: float64(30), object(1)
memory usage: 1.7+ MB
```

[11]: `training.head(5)`

[11]:
```
   left_eye_center_x  left_eye_center_y  right_eye_center_x  \
0          66.033564          39.002274           30.227008
1          64.332936          34.970077           29.949277
2          65.057053          34.909642           30.903789
3          65.225739          37.261774           32.023096
4          66.725301          39.621261           32.244810

   right_eye_center_y  left_eye_inner_corner_x  left_eye_inner_corner_y  \
0           36.421678                59.582075                39.647423
1           33.448715                58.856170                35.274349
2           34.909642                59.412000                36.320968
3           37.261774                60.003339                39.127179
4           38.042032                58.565890                39.621261
```

```
     left_eye_outer_corner_x  left_eye_outer_corner_y  right_eye_inner_corner_x  \
0               73.130346                39.969997                36.356571
1               70.722723                36.187166                36.034723
2               70.984421                36.320968                37.678105
3               72.314713                38.380967                37.618643
4               72.515926                39.884466                36.982380

     right_eye_inner_corner_y  …  nose_tip_y  mouth_left_corner_x  \
0                37.389402     …   57.066803           61.195308
1                34.361532     …   55.660936           56.421447
2                36.320968     …   53.538947           60.822947
3                38.754115     …   54.166539           65.598887
4                39.094852     …   64.889521           60.671411

     mouth_left_corner_y  mouth_right_corner_x  mouth_right_corner_y  \
0              79.970165             28.614496             77.388992
1              76.352000             35.122383             76.047660
2              73.014316             33.726316             72.732000
3              72.703722             37.245496             74.195478
4              77.523239             31.191755             76.997301

     mouth_center_top_lip_x  mouth_center_top_lip_y  mouth_center_bottom_lip_x  \
0               43.312602               72.935459                  43.130707
1               46.684596               70.266553                  45.467915
2               47.274947               70.191789                  47.274947
3               50.303165               70.091687                  51.561183
4               44.962748               73.707387                  44.227141

     mouth_center_bottom_lip_y  \
0                84.485774
1                85.480170
2                78.659368
3                78.268383
4                86.871166

                                               Image
0  238 236 237 238 240 240 239 241 241 243 240 23…
1  219 215 204 196 204 211 212 200 180 168 178 19…
2  144 142 159 180 188 188 184 180 167 132 84 59 …
3  193 192 193 194 194 194 193 192 168 111 50 12 …
4  147 148 160 196 215 214 216 217 219 220 206 18…

[5 rows x 31 columns]
```

```python
test = pd.read_csv('/kaggle/working/test.csv')
test.info()
```
[8]:

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1783 entries, 0 to 1782
Data columns (total 2 columns):
 #   Column   Non-Null Count  Dtype
---  ------   --------------  -----
 0   ImageId  1783 non-null   int64
 1   Image    1783 non-null   object
dtypes: int64(1), object(1)
memory usage: 28.0+ KB
```

[9]: `test.head(5)`

[9]:
```
   ImageId                                              Image
0        1  182 183 182 182 180 180 176 169 156 137 124 10…
1        2  76 87 81 72 65 59 64 76 69 42 31 38 49 58 58 4…
2        3  177 176 174 170 169 169 168 166 166 166 161 14…
3        4  176 174 174 175 174 174 176 176 175 171 165 15…
4        5  50 47 44 101 144 149 120 58 48 42 35 35 37 39 …
```

[12]:
```python
training = training.dropna()
training.shape, type(training)
```

[12]: `((2140, 31), pandas.core.frame.DataFrame)`

[13]:
```python
training['Image'] = training['Image'].apply(lambda x: np.fromstring(x,
   dtype=int, sep=' ').reshape((96,96)))
```

[14]:
```python
def get_image_and_dots(df, index):
    image = plt.imshow(df['Image'][index],cmap='gray')
    l = []
    for i in range(1,31,2):
        l.append(plt.plot(df.loc[index][i-1], df.loc[index][i], 'ro'))

    return image, l
```

[16]:
```python
fig = plt.figure(figsize=(8, 8))
fig.subplots_adjust(
    left=0, right=1, bottom=0, top=1, hspace=0.05, wspace=0.05)

for i in range(16):
    ax = fig.add_subplot(4, 4, i + 1, xticks=[], yticks=[])
    get_image_and_dots(training, i)

plt.show()
plt.savefig('fkeypoints.png')
```

<Figure size 432x288 with 0 Axes>

```
[18]: X = np.asarray([training['Image']], dtype=np.uint8).reshape(training.
       ↪shape[0],96,96,1)
      y = training.drop(['Image'], axis=1)
      X.shape, y.shape, type(X), type(y)
```

```
[18]: ((2140, 96, 96, 1), (2140, 30), numpy.ndarray, pandas.core.frame.DataFrame)
```

```
[19]: Y = y.to_numpy()
      type(Y), Y.shape
```

```
[19]: (numpy.ndarray, (2140, 30))
```

```
[20]: X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.25,␣
       ↪random_state=42)
```

1.0.1 Model

```
[21]: from keras.models import Sequential
      from keras.layers import Dense, Conv2D, Flatten, AvgPool2D, BatchNormalization,␣
       ↪Dropout, Activation, MaxPooling2D
      from keras.optimizers import Adam
      from keras import regularizers
      from keras.layers.advanced_activations import LeakyReLU
      from keras.models import Sequential, Model
      from keras.layers import Activation, Convolution2D, MaxPooling2D,␣
       ↪BatchNormalization, Flatten, Dense, Dropout, Conv2D,MaxPool2D, ZeroPadding2D
```

Using TensorFlow backend.

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

      model.add(Convolution2D(32, (3,3), padding='same', use_bias=False,␣
       ↪input_shape=(96,96,1)))
      model.add(LeakyReLU(alpha = 0.1))
      model.add(BatchNormalization())

      model.add(Convolution2D(32, (3,3), padding='same', use_bias=False))
      model.add(LeakyReLU(alpha = 0.1))
      model.add(BatchNormalization())
      model.add(MaxPool2D(pool_size=(2, 2)))

      model.add(Convolution2D(64, (3,3), padding='same', use_bias=False))
      model.add(LeakyReLU(alpha = 0.1))
      model.add(BatchNormalization())

      model.add(Convolution2D(64, (3,3), padding='same', use_bias=False))
      model.add(LeakyReLU(alpha = 0.1))
      model.add(BatchNormalization())
      model.add(MaxPool2D(pool_size=(2, 2)))

      model.add(Convolution2D(96, (3,3), padding='same', use_bias=False))
      model.add(LeakyReLU(alpha = 0.1))
      model.add(BatchNormalization())

      model.add(Convolution2D(96, (3,3), padding='same', use_bias=False))
      model.add(LeakyReLU(alpha = 0.1))
```

```python
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))

model.add(Convolution2D(128, (3,3),padding='same', use_bias=False))
# model.add(BatchNormalization())
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())

model.add(Convolution2D(128, (3,3),padding='same', use_bias=False))
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))

model.add(Convolution2D(256, (3,3),padding='same',use_bias=False))
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())

model.add(Convolution2D(256, (3,3),padding='same',use_bias=False))
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())
model.add(MaxPool2D(pool_size=(2, 2)))

model.add(Convolution2D(512, (3,3), padding='same', use_bias=False))
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())

model.add(Convolution2D(512, (3,3), padding='same', use_bias=False))
model.add(LeakyReLU(alpha = 0.1))
model.add(BatchNormalization())


model.add(Flatten())
model.add(Dense(512,activation='relu'))
model.add(Dropout(0.1))
model.add(Dense(30))
model.summary()
```

```
Model: "sequential_3"

_____
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_25 (Conv2D)           (None, 96, 96, 32)        288
_____
leaky_re_lu_25 (LeakyReLU)   (None, 96, 96, 32)        0
_____
batch_normalization_25 (Batc (None, 96, 96, 32)        128
_____
```

```
conv2d_26 (Conv2D)            (None, 96, 96, 32)        9216
_____
leaky_re_lu_26 (LeakyReLU)    (None, 96, 96, 32)        0
_____
batch_normalization_26 (Batc  (None, 96, 96, 32)        128
_____
max_pooling2d_11 (MaxPooling  (None, 48, 48, 32)        0
_____
conv2d_27 (Conv2D)            (None, 48, 48, 64)        18432
_____
leaky_re_lu_27 (LeakyReLU)    (None, 48, 48, 64)        0
_____
batch_normalization_27 (Batc  (None, 48, 48, 64)        256
_____
conv2d_28 (Conv2D)            (None, 48, 48, 64)        36864
_____
leaky_re_lu_28 (LeakyReLU)    (None, 48, 48, 64)        0
_____
batch_normalization_28 (Batc  (None, 48, 48, 64)        256
_____
max_pooling2d_12 (MaxPooling  (None, 24, 24, 64)        0
_____
conv2d_29 (Conv2D)            (None, 24, 24, 96)        55296
_____
leaky_re_lu_29 (LeakyReLU)    (None, 24, 24, 96)        0
_____
batch_normalization_29 (Batc  (None, 24, 24, 96)        384
_____
conv2d_30 (Conv2D)            (None, 24, 24, 96)        82944
_____
leaky_re_lu_30 (LeakyReLU)    (None, 24, 24, 96)        0
_____
batch_normalization_30 (Batc  (None, 24, 24, 96)        384
_____
max_pooling2d_13 (MaxPooling  (None, 12, 12, 96)        0
_____
conv2d_31 (Conv2D)            (None, 12, 12, 128)       110592
_____
leaky_re_lu_31 (LeakyReLU)    (None, 12, 12, 128)       0
_____
batch_normalization_31 (Batc  (None, 12, 12, 128)       512
_____
conv2d_32 (Conv2D)            (None, 12, 12, 128)       147456
_____
leaky_re_lu_32 (LeakyReLU)    (None, 12, 12, 128)       0
_____
batch_normalization_32 (Batc  (None, 12, 12, 128)       512
_____
```

```
max_pooling2d_14 (MaxPooling  (None, 6, 6, 128)          0
------------------------------------------------------------------
conv2d_33 (Conv2D)            (None, 6, 6, 256)          294912
------------------------------------------------------------------
leaky_re_lu_33 (LeakyReLU)    (None, 6, 6, 256)          0
------------------------------------------------------------------
batch_normalization_33 (Batc  (None, 6, 6, 256)          1024
------------------------------------------------------------------
conv2d_34 (Conv2D)            (None, 6, 6, 256)          589824
------------------------------------------------------------------
leaky_re_lu_34 (LeakyReLU)    (None, 6, 6, 256)          0
------------------------------------------------------------------
batch_normalization_34 (Batc  (None, 6, 6, 256)          1024
------------------------------------------------------------------
max_pooling2d_15 (MaxPooling  (None, 3, 3, 256)          0
------------------------------------------------------------------
conv2d_35 (Conv2D)            (None, 3, 3, 512)          1179648
------------------------------------------------------------------
leaky_re_lu_35 (LeakyReLU)    (None, 3, 3, 512)          0
------------------------------------------------------------------
batch_normalization_35 (Batc  (None, 3, 3, 512)          2048
------------------------------------------------------------------
conv2d_36 (Conv2D)            (None, 3, 3, 512)          2359296
------------------------------------------------------------------
leaky_re_lu_36 (LeakyReLU)    (None, 3, 3, 512)          0
------------------------------------------------------------------
batch_normalization_36 (Batc  (None, 3, 3, 512)          2048
------------------------------------------------------------------
flatten_3 (Flatten)           (None, 4608)               0
------------------------------------------------------------------
dense_5 (Dense)               (None, 512)                2359808
------------------------------------------------------------------
dropout_3 (Dropout)           (None, 512)                0
------------------------------------------------------------------
dense_6 (Dense)               (None, 30)                 15390
==================================================================
Total params: 7,268,670
Trainable params: 7,264,318
Non-trainable params: 4,352
------------------------------------------------------------------
```

```
[26]: model.compile(optimizer='Adam',
              loss='mse',
              metrics=['mae'])

      model.fit(X_train, y_train, epochs=600)
```

```
Epoch 1/600
```

```
1605/1605 [==============================] - 8s 5ms/step - loss: 185.7766 - mae:
8.2838
Epoch 2/600
1605/1605 [==============================] - 2s 1ms/step - loss: 26.4794 - mae:
4.0540
Epoch 3/600
1605/1605 [==============================] - 2s 1ms/step - loss: 21.2252 - mae:
3.6241
Epoch 4/600
1605/1605 [==============================] - 2s 1ms/step - loss: 18.9259 - mae:
3.4118
Epoch 5/600
1605/1605 [==============================] - 2s 1ms/step - loss: 16.1479 - mae:
3.1581
Epoch 6/600
1605/1605 [==============================] - 2s 1ms/step - loss: 14.8296 - mae:
3.0203
Epoch 7/600
1605/1605 [==============================] - 2s 1ms/step - loss: 14.2294 - mae:
2.9459
Epoch 8/600
1605/1605 [==============================] - 2s 1ms/step - loss: 12.1489 - mae:
2.7325
Epoch 9/600
1605/1605 [==============================] - 2s 1ms/step - loss: 12.3484 - mae:
2.7494
Epoch 10/600
1605/1605 [==============================] - 2s 1ms/step - loss: 10.7879 - mae:
2.5696
Epoch 11/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.8739 - mae:
2.4580
Epoch 12/600
1605/1605 [==============================] - 2s 1ms/step - loss: 11.8089 - mae:
2.6962
Epoch 13/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.8647 - mae:
2.4514
Epoch 14/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.0453 - mae:
2.3462
Epoch 15/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.2664 - mae:
2.3842
Epoch 16/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.6379 - mae:
2.4269
Epoch 17/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 8.9975 - mae:
2.3308
Epoch 18/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.6514 - mae:
2.1542
Epoch 19/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.7976 - mae:
2.1801
Epoch 20/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.4641 - mae:
2.1331
Epoch 21/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.4659 - mae:
2.1339
Epoch 22/600
1605/1605 [==============================] - 2s 1ms/step - loss: 8.3566 - mae:
2.2461
Epoch 23/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.2772 - mae:
2.3583
Epoch 24/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.1083 - mae:
2.0723
Epoch 25/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.7523 - mae:
2.0194
Epoch 26/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.3105 - mae:
2.0914
Epoch 27/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.8865 - mae:
1.8878
Epoch 28/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.2935 - mae:
2.0949
Epoch 29/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.3950 - mae:
2.1124
Epoch 30/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.2363 - mae:
1.9360
Epoch 31/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.5846 - mae:
1.8371
Epoch 32/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.1948 - mae:
1.9249
Epoch 33/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 5.8260 - mae:
1.8696
Epoch 34/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.2340 - mae:
1.9371
Epoch 35/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.0626 - mae:
1.9093
Epoch 36/600
1605/1605 [==============================] - 2s 1ms/step - loss: 8.7993 - mae:
2.2844
Epoch 37/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.9046 - mae:
1.8746
Epoch 38/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.7312 - mae:
2.0004
Epoch 39/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.2404 - mae:
1.7710
Epoch 40/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.9668 - mae:
1.8833
Epoch 41/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.6900 - mae:
1.8392
Epoch 42/600
1605/1605 [==============================] - 2s 1ms/step - loss: 6.3363 - mae:
1.9392
Epoch 43/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.8438 - mae:
1.8675
Epoch 44/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.9021 - mae:
1.8701
Epoch 45/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.0503 - mae:
1.7298
Epoch 46/600
1605/1605 [==============================] - 2s 1ms/step - loss: 9.9824 - mae:
2.4432
Epoch 47/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.0220 - mae:
1.7269
Epoch 48/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.5637 - mae:
1.6432
Epoch 49/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 5.4065 - mae:
1.7887
Epoch 50/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.3340 - mae:
1.7754
Epoch 51/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.7279 - mae:
1.8397
Epoch 52/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.6712 - mae:
1.8257
Epoch 53/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.3648 - mae:
1.7824
Epoch 54/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.1893 - mae:
1.7511
Epoch 55/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.9494 - mae:
1.7265
Epoch 56/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8196 - mae:
1.6839
Epoch 57/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.7972 - mae:
1.6897
Epoch 58/600
1605/1605 [==============================] - 2s 1ms/step - loss: 7.1600 - mae:
2.0732
Epoch 59/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.5531 - mae:
1.6399
Epoch 60/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2046 - mae:
1.5681
Epoch 61/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.0166 - mae:
1.7199
Epoch 62/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.4816 - mae:
1.6264
Epoch 63/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.5475 - mae:
1.6378
Epoch 64/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.4278 - mae:
1.7927
Epoch 65/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 4.8616 - mae:
1.6939
Epoch 66/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9694 - mae:
1.5340
Epoch 67/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.3443 - mae:
1.6026
Epoch 68/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9343 - mae:
1.5160
Epoch 69/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8586 - mae:
1.6915
Epoch 70/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2242 - mae:
1.5766
Epoch 71/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2851 - mae:
1.5926
Epoch 72/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8575 - mae:
1.7028
Epoch 73/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8216 - mae:
1.6910
Epoch 74/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.5457 - mae:
1.6454
Epoch 75/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.9742 - mae:
1.8963
Epoch 76/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.6863 - mae:
1.8278
Epoch 77/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9185 - mae:
1.5216
Epoch 78/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.3616 - mae:
1.6099
Epoch 79/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.4903 - mae:
1.6247
Epoch 80/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9238 - mae:
1.5229
Epoch 81/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.7969 - mae:
1.4921
Epoch 82/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8013 - mae:
1.4947
Epoch 83/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.1623 - mae:
1.5640
Epoch 84/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9587 - mae:
1.5200
Epoch 85/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.5314 - mae:
1.6368
Epoch 86/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7685 - mae:
1.4845
Epoch 87/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2106 - mae:
1.5809
Epoch 88/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8290 - mae:
1.5074
Epoch 89/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6744 - mae:
1.4709
Epoch 90/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2788 - mae:
1.6025
Epoch 91/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2294 - mae:
1.5904
Epoch 92/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5725 - mae:
1.4484
Epoch 93/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7964 - mae:
1.5005
Epoch 94/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7278 - mae:
1.4795
Epoch 95/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.1681 - mae:
1.5742
Epoch 96/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8635 - mae:
1.5155
Epoch 97/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.6771 - mae:
1.4782
Epoch 98/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5205 - mae:
1.4414
Epoch 99/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7374 - mae:
1.4841
Epoch 100/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.4738 - mae:
1.6241
Epoch 101/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2940 - mae:
1.5985
Epoch 102/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.3216 - mae:
1.7865
Epoch 103/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7737 - mae:
1.4981
Epoch 104/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6501 - mae:
1.4734
Epoch 105/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8534 - mae:
1.6906
Epoch 106/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6064 - mae:
1.4671
Epoch 107/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8421 - mae:
1.5060
Epoch 108/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8913 - mae:
1.5113
Epoch 109/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9959 - mae:
1.5458
Epoch 110/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8679 - mae:
1.5179
Epoch 111/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4597 - mae:
1.4304
Epoch 112/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5853 - mae:
1.4524
Epoch 113/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 4.0269 - mae:
1.5536
Epoch 114/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4289 - mae:
1.4252
Epoch 115/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5714 - mae:
1.4633
Epoch 116/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1661 - mae:
1.3688
Epoch 117/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.4155 - mae:
1.6194
Epoch 118/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4409 - mae:
1.4350
Epoch 119/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.0630 - mae:
1.5636A: 2s - l
Epoch 120/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3424 - mae:
1.4031
Epoch 121/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.0678 - mae:
1.5492
Epoch 122/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.1071 - mae:
1.5759
Epoch 123/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8125 - mae:
1.5051
Epoch 124/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3949 - mae:
1.4196
Epoch 125/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6696 - mae:
1.4705
Epoch 126/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3195 - mae:
1.3974
Epoch 127/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7272 - mae:
1.4894
Epoch 128/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.8400 - mae:
1.6959
Epoch 129/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 4.0745 - mae:
1.5480
Epoch 130/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7243 - mae:
1.4973
Epoch 131/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8164 - mae:
1.5033
Epoch 132/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8621 - mae:
1.5103
Epoch 133/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.6220 - mae:
1.6729
Epoch 134/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.0431 - mae:
1.7289
Epoch 135/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2284 - mae:
1.5955
Epoch 136/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5891 - mae:
1.4551
Epoch 137/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5445 - mae:
1.4512
Epoch 138/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5548 - mae:
1.4311
Epoch 139/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2733 - mae:
1.3873
Epoch 140/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2085 - mae:
1.3788
Epoch 141/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9628 - mae:
1.3258
Epoch 142/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2898 - mae:
1.4065
Epoch 143/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.3104 - mae:
1.6206
Epoch 144/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7765 - mae:
1.4940
Epoch 145/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.4874 - mae:
1.4411
Epoch 146/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6936 - mae:
1.4736
Epoch 147/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5860 - mae:
1.4627
Epoch 148/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.4897 - mae:
1.6488
Epoch 149/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7447 - mae:
1.4948
Epoch 150/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6922 - mae:
1.4861
Epoch 151/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2836 - mae:
1.4027
Epoch 152/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4651 - mae:
1.4368
Epoch 153/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5018 - mae:
1.4470
Epoch 154/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1030 - mae:
1.3573
Epoch 155/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6447 - mae:
1.4811
Epoch 156/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4920 - mae:
1.4356
Epoch 157/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4321 - mae:
1.4295
Epoch 158/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3835 - mae:
1.4066
Epoch 159/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4075 - mae:
1.4133
Epoch 160/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4286 - mae:
1.4340
Epoch 161/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.1307 - mae:
1.3665
Epoch 162/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3450 - mae:
1.4195
Epoch 163/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9357 - mae:
1.5310
Epoch 164/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6473 - mae:
1.4785
Epoch 165/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5698 - mae:
1.4518
Epoch 166/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5229 - mae:
1.4389
Epoch 167/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.0915 - mae:
1.5575
Epoch 168/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2616 - mae:
1.6008
Epoch 169/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9507 - mae:
1.5356
Epoch 170/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6581 - mae:
1.4703
Epoch 171/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2368 - mae:
1.3916
Epoch 172/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8770 - mae:
1.5241
Epoch 173/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3462 - mae:
1.4099
Epoch 174/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2945 - mae:
1.3995
Epoch 175/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3412 - mae:
1.4165
Epoch 176/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1399 - mae:
1.3612
Epoch 177/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.6860 - mae:
1.4820
Epoch 178/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3179 - mae:
1.3967
Epoch 179/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4478 - mae:
1.4406
Epoch 180/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1538 - mae:
1.3730
Epoch 181/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2204 - mae:
1.3751
Epoch 182/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6143 - mae:
1.4621
Epoch 183/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2897 - mae:
1.4029
Epoch 184/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1308 - mae:
1.3649
Epoch 185/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5561 - mae:
1.4631
Epoch 186/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3338 - mae:
1.4107
Epoch 187/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1721 - mae:
1.3646
Epoch 188/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0144 - mae:
1.3334
Epoch 189/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0746 - mae:
1.3540
Epoch 190/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6657 - mae:
1.4874
Epoch 191/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3210 - mae:
1.4105
Epoch 192/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3022 - mae:
1.3996
Epoch 193/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.3371 - mae:
1.4173
Epoch 194/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3705 - mae:
1.4059
Epoch 195/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2769 - mae:
1.3973
Epoch 196/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.1972 - mae:
1.7725
Epoch 197/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4097 - mae:
1.4109
Epoch 198/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9600 - mae:
1.3269
Epoch 199/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4264 - mae:
1.4253
Epoch 200/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0652 - mae:
1.3509
Epoch 201/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2047 - mae:
1.3769
Epoch 202/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2083 - mae:
1.3731
Epoch 203/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6978 - mae:
1.4982
Epoch 204/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3530 - mae:
1.4111
Epoch 205/600
1605/1605 [==============================] - 2s 1ms/step - loss: 5.7822 - mae:
1.8813
Epoch 206/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2474 - mae:
1.5999
Epoch 207/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1912 - mae:
1.3793
Epoch 208/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1998 - mae:
1.3854
Epoch 209/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.0230 - mae:
1.3405
Epoch 210/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1291 - mae:
1.3601
Epoch 211/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7166 - mae:
1.4923
Epoch 212/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3189 - mae:
1.4160
Epoch 213/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0973 - mae:
1.3490
Epoch 214/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5234 - mae:
1.4476
Epoch 215/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1363 - mae:
1.3650
Epoch 216/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9548 - mae:
1.3253
Epoch 217/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4232 - mae:
1.4366
Epoch 218/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9045 - mae:
1.3174
Epoch 219/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2615 - mae:
1.3875
Epoch 220/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4825 - mae:
1.4363
Epoch 221/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3040 - mae:
1.4074
Epoch 222/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5799 - mae:
1.4720
Epoch 223/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3190 - mae:
1.4090
Epoch 224/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8446 - mae:
1.2983
Epoch 225/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.3544 - mae:
1.4118
Epoch 226/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3091 - mae:
1.4013
Epoch 227/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1522 - mae:
1.3670
Epoch 228/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9951 - mae:
1.3382
Epoch 229/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0193 - mae:
1.3449
Epoch 230/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9622 - mae:
1.3318
Epoch 231/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1108 - mae:
1.3666
Epoch 232/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1327 - mae:
1.3642
Epoch 233/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4212 - mae:
1.4375
Epoch 234/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2893 - mae:
1.4041
Epoch 235/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.2491 - mae:
1.6058
Epoch 236/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3575 - mae:
1.4133
Epoch 237/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2422 - mae:
1.3912
Epoch 238/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0520 - mae:
1.3483
Epoch 239/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0697 - mae:
1.3567
Epoch 240/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2267 - mae:
1.3839
Epoch 241/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.2689 - mae:
1.3887
Epoch 242/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5381 - mae:
1.4546
Epoch 243/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0005 - mae:
1.3376
Epoch 244/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2687 - mae:
1.3894
Epoch 245/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7529 - mae:
1.4918
Epoch 246/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0601 - mae:
1.3598
Epoch 247/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7684 - mae:
1.4995
Epoch 248/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1150 - mae:
1.3569
Epoch 249/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0771 - mae:
1.3511
Epoch 250/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9160 - mae:
1.3195
Epoch 251/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7628 - mae:
1.5079
Epoch 252/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9682 - mae:
1.3338
Epoch 253/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3509 - mae:
1.4163
Epoch 254/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0785 - mae:
1.3561
Epoch 255/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9037 - mae:
1.3083
Epoch 256/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1692 - mae:
1.3656
Epoch 257/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.0555 - mae:
1.3466
Epoch 258/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3369 - mae:
1.4121
Epoch 259/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9531 - mae:
1.3294
Epoch 260/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2551 - mae:
1.3951
Epoch 261/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5548 - mae:
1.4615
Epoch 262/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1377 - mae:
1.3624
Epoch 263/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9807 - mae:
1.3336
Epoch 264/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9203 - mae:
1.3161
Epoch 265/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1921 - mae:
1.3777
Epoch 266/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2183 - mae:
1.3691
Epoch 267/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2153 - mae:
1.3716
Epoch 268/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8292 - mae:
1.2983
Epoch 269/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5644 - mae:
1.4514
Epoch 270/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5960 - mae:
1.4659
Epoch 271/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1484 - mae:
1.3624
Epoch 272/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9475 - mae:
1.3198
Epoch 273/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.1760 - mae:
1.3873
Epoch 274/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9484 - mae:
1.3232
Epoch 275/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1553 - mae:
1.3650
Epoch 276/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9968 - mae:
1.3278
Epoch 277/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1532 - mae:
1.3705
Epoch 278/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9172 - mae:
1.3200
Epoch 279/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4191 - mae:
1.4201
Epoch 280/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9532 - mae:
1.3268
Epoch 281/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5013 - mae:
1.4429
Epoch 282/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7517 - mae:
1.2825
Epoch 283/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1616 - mae:
1.3644
Epoch 284/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4462 - mae:
1.4157
Epoch 285/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.0044 - mae:
1.5454
Epoch 286/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0445 - mae:
1.3501
Epoch 287/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7798 - mae:
1.5046
Epoch 288/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7284 - mae:
1.4967
Epoch 289/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.2457 - mae:
1.3803
Epoch 290/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8649 - mae:
1.3073
Epoch 291/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2684 - mae:
1.3938
Epoch 292/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0852 - mae:
1.3575
Epoch 293/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2431 - mae:
1.3925
Epoch 294/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2709 - mae:
1.3932
Epoch 295/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0345 - mae:
1.3374
Epoch 296/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9023 - mae:
1.3212
Epoch 297/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2417 - mae:
1.3951
Epoch 298/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0765 - mae:
1.3486
Epoch 299/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6368 - mae:
1.2524
Epoch 300/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.9940 - mae:
1.5536
Epoch 301/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7368 - mae:
1.2670
Epoch 302/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9062 - mae:
1.3114
Epoch 303/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9415 - mae:
1.3204
Epoch 304/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2477 - mae:
1.3950
Epoch 305/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.1723 - mae:
1.3676
Epoch 306/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0857 - mae:
1.3517
Epoch 307/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8216 - mae:
1.2921
Epoch 308/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5851 - mae:
1.4622
Epoch 309/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.1523 - mae:
1.5858
Epoch 310/600
1605/1605 [==============================] - 2s 1ms/step - loss: 4.0172 - mae:
1.5526
Epoch 311/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1941 - mae:
1.3755
Epoch 312/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1435 - mae:
1.3752
Epoch 313/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8921 - mae:
1.3135
Epoch 314/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8826 - mae:
1.3016
Epoch 315/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4024 - mae:
1.4189
Epoch 316/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7743 - mae:
1.2783
Epoch 317/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9839 - mae:
1.3376
Epoch 318/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7986 - mae:
1.2868
Epoch 319/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9407 - mae:
1.3211
Epoch 320/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9766 - mae:
1.3259
Epoch 321/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8729 - mae:
1.3057
Epoch 322/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1732 - mae:
1.3823
Epoch 323/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8764 - mae:
1.3138
Epoch 324/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7244 - mae:
1.2648
Epoch 325/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9699 - mae:
1.3305
Epoch 326/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2473 - mae:
1.3870
Epoch 327/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1096 - mae:
1.3627
Epoch 328/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9053 - mae:
1.3103
Epoch 329/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3899 - mae:
1.4299
Epoch 330/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7404 - mae:
1.2791
Epoch 331/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1345 - mae:
1.3696
Epoch 332/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7009 - mae:
1.4787
Epoch 333/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2418 - mae:
1.3911
Epoch 334/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8681 - mae:
1.2994
Epoch 335/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7127 - mae:
1.2677
Epoch 336/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8967 - mae:
1.3137
Epoch 337/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8859 - mae:
1.3025
Epoch 338/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7693 - mae:
1.2848
Epoch 339/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8801 - mae:
1.3038A: 1s - loss: 2.91
Epoch 340/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3809 - mae:
1.4121
Epoch 341/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8331 - mae:
1.2940
Epoch 342/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1758 - mae:
1.3733
Epoch 343/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2860 - mae:
1.3974
Epoch 344/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6884 - mae:
1.2667
Epoch 345/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0438 - mae:
1.3423
Epoch 346/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3990 - mae:
1.4200
Epoch 347/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9947 - mae:
1.3342
Epoch 348/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.5111 - mae:
1.4367
Epoch 349/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2565 - mae:
1.3914
Epoch 350/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8490 - mae:
1.3029
Epoch 351/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8284 - mae:
1.2973
Epoch 352/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7836 - mae:
1.2835
Epoch 353/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8631 - mae:
1.3053
Epoch 354/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2059 - mae:
1.3836
Epoch 355/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9466 - mae:
1.3077
Epoch 356/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6946 - mae:
1.2636
Epoch 357/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8466 - mae:
1.3039
Epoch 358/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5993 - mae:
1.2457
Epoch 359/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9270 - mae:
1.3220
Epoch 360/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9643 - mae:
1.3220
Epoch 361/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1227 - mae:
1.3676
Epoch 362/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8046 - mae:
1.2902
Epoch 363/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4788 - mae:
1.4365
Epoch 364/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.7080 - mae:
1.4805
Epoch 365/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8360 - mae:
1.5177
Epoch 366/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6747 - mae:
1.4814
Epoch 367/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9957 - mae:
1.3360
Epoch 368/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0180 - mae:
1.3447
Epoch 369/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8329 - mae:
1.3006
Epoch 370/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7563 - mae:
1.2778
Epoch 371/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8913 - mae:
1.3155A: 0s - loss: 2.6785 -
Epoch 372/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1211 - mae:
1.3564
Epoch 373/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7624 - mae:
1.2774
Epoch 374/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0357 - mae:
1.3449
Epoch 375/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9378 - mae:
1.3121
Epoch 376/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2944 - mae:
1.3988
Epoch 377/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9176 - mae:
1.3150
Epoch 378/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8052 - mae:
1.2937
Epoch 379/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0904 - mae:
1.3529
Epoch 380/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8032 - mae:
1.2834
Epoch 381/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7864 - mae:
1.2703
Epoch 382/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1250 - mae:
1.3612
Epoch 383/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6278 - mae:
1.2494
Epoch 384/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8949 - mae:
1.3138
Epoch 385/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.6345 - mae:
1.2445
Epoch 386/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8025 - mae:
1.2888
Epoch 387/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1460 - mae:
1.3686
Epoch 388/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8615 - mae:
1.3048
Epoch 389/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8570 - mae:
1.5275
Epoch 390/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0366 - mae:
1.3502
Epoch 391/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5853 - mae:
1.2311
Epoch 392/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8293 - mae:
1.2905
Epoch 393/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5940 - mae:
1.2405
Epoch 394/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6363 - mae:
1.2544
Epoch 395/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6258 - mae:
1.2407
Epoch 396/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1459 - mae:
1.3670
Epoch 397/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4936 - mae:
1.4465
Epoch 398/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2149 - mae:
1.3806
Epoch 399/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7807 - mae:
1.2890
Epoch 400/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7901 - mae:
1.2951
Epoch 401/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8164 - mae:
1.2935
Epoch 402/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6008 - mae:
1.2479
Epoch 403/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6227 - mae:
1.2514
Epoch 404/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2734 - mae:
1.3951
Epoch 405/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7771 - mae:
1.2892
Epoch 406/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6179 - mae:
1.2494
Epoch 407/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9720 - mae:
1.3236
Epoch 408/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6513 - mae:
1.2549
Epoch 409/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6220 - mae:
1.2388
Epoch 410/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6852 - mae:
1.2669
Epoch 411/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0819 - mae:
1.3562
Epoch 412/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8002 - mae:
1.2822
Epoch 413/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7375 - mae:
1.2726
Epoch 414/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.8346 - mae:
1.5205
Epoch 415/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8280 - mae:
1.2954
Epoch 416/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3673 - mae:
1.4221
Epoch 417/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 3.2110 - mae:
1.3767
Epoch 418/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1157 - mae:
1.3656
Epoch 419/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2808 - mae:
1.4003
Epoch 420/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7799 - mae:
1.2884
Epoch 421/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8481 - mae:
1.3007
Epoch 422/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7517 - mae:
1.2814
Epoch 423/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6896 - mae:
1.2699
Epoch 424/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8624 - mae:
1.3029
Epoch 425/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7194 - mae:
1.2726
Epoch 426/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0400 - mae:
1.3386
Epoch 427/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1421 - mae:
1.3662
Epoch 428/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9403 - mae:
1.3182
Epoch 429/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6568 - mae:
1.2642
Epoch 430/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0403 - mae:
1.3433
Epoch 431/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5701 - mae:
1.2206
Epoch 432/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0612 - mae:
1.3434
Epoch 433/600
```

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1605/1605 [==============================] - 2s 1ms/step - loss: 2.8673 - mae:
1.2991
Epoch 434/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8859 - mae:
1.3121
Epoch 435/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0070 - mae:
1.3413
Epoch 436/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6145 - mae:
1.2466
Epoch 437/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8082 - mae:
1.2883
Epoch 438/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.6004 - mae:
1.4817
Epoch 439/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7163 - mae:
1.2686
Epoch 440/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6542 - mae:
1.2489
Epoch 441/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7287 - mae:
1.2681
Epoch 442/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0362 - mae:
1.3403
Epoch 443/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7771 - mae:
1.2838
Epoch 444/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8954 - mae:
1.3092
Epoch 445/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6223 - mae:
1.2510
Epoch 446/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8180 - mae:
1.2856
Epoch 447/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7039 - mae:
1.2724
Epoch 448/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1648 - mae:
1.3765
Epoch 449/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7350 - mae:
1.2757
Epoch 450/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8761 - mae:
1.3091
Epoch 451/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6358 - mae:
1.2523
Epoch 452/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0517 - mae:
1.3403
Epoch 453/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6042 - mae:
1.2400
Epoch 454/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0004 - mae:
1.3380
Epoch 455/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0480 - mae:
1.3543
Epoch 456/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7094 - mae:
1.2662
Epoch 457/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0941 - mae:
1.3577
Epoch 458/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2724 - mae:
1.3995
Epoch 459/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9450 - mae:
1.3219
Epoch 460/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7333 - mae:
1.2734
Epoch 461/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9855 - mae:
1.3271
Epoch 462/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1396 - mae:
1.3702
Epoch 463/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0323 - mae:
1.3505
Epoch 464/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6996 - mae:
1.2661
Epoch 465/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8719 - mae:
1.3077
Epoch 466/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6676 - mae:
1.2472
Epoch 467/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9586 - mae:
1.3135
Epoch 468/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5856 - mae:
1.2357
Epoch 469/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7944 - mae:
1.2896
Epoch 470/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6766 - mae:
1.2608
Epoch 471/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7810 - mae:
1.2849
Epoch 472/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5613 - mae:
1.2309
Epoch 473/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9554 - mae:
1.3285
Epoch 474/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1079 - mae:
1.3551
Epoch 475/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5255 - mae:
1.2236
Epoch 476/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7185 - mae:
1.2703
Epoch 477/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0948 - mae:
1.3502
Epoch 478/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1761 - mae:
1.3804
Epoch 479/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8420 - mae:
1.2958
Epoch 480/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3910 - mae:
1.4262
Epoch 481/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9410 - mae:
1.3244
Epoch 482/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.3197 - mae:
1.4014
Epoch 483/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5937 - mae:
1.2313
Epoch 484/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0112 - mae:
1.3434
Epoch 485/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5879 - mae:
1.2379
Epoch 486/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6118 - mae:
1.2460
Epoch 487/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8633 - mae:
1.3085
Epoch 488/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5767 - mae:
1.2357
Epoch 489/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5038 - mae:
1.2178
Epoch 490/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6523 - mae:
1.2496
Epoch 491/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.0525 - mae:
1.3375
Epoch 492/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6073 - mae:
1.2374
Epoch 493/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7300 - mae:
1.2712
Epoch 494/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5923 - mae:
1.2315
Epoch 495/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.2996 - mae:
1.4020
Epoch 496/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8648 - mae:
1.3043
Epoch 497/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7202 - mae:
1.2721
Epoch 498/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8052 - mae:
1.2927
Epoch 499/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5971 - mae:
1.2453
Epoch 500/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7213 - mae:
1.2689
Epoch 501/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9469 - mae:
1.3255
Epoch 502/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5747 - mae:
1.2343
Epoch 503/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9233 - mae:
1.3062
Epoch 504/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7043 - mae:
1.2590
Epoch 505/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5358 - mae:
1.2300
Epoch 506/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6043 - mae:
1.2363
Epoch 507/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4479 - mae:
1.2065
Epoch 508/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5687 - mae:
1.2308
Epoch 509/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8652 - mae:
1.3057
Epoch 510/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7726 - mae:
1.2810
Epoch 511/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8330 - mae:
1.2959
Epoch 512/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7172 - mae:
1.2691
Epoch 513/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5272 - mae:
1.2208
Epoch 514/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8526 - mae:
1.2990
Epoch 515/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6331 - mae:
1.2494
Epoch 516/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7472 - mae:
1.2733
Epoch 517/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7787 - mae:
1.2770
Epoch 518/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5825 - mae:
1.2320
Epoch 519/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7464 - mae:
1.2812
Epoch 520/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5697 - mae:
1.2307
Epoch 521/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4111 - mae:
1.1997
Epoch 522/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9044 - mae:
1.3113
Epoch 523/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8427 - mae:
1.3023
Epoch 524/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8037 - mae:
1.2921
Epoch 525/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8563 - mae:
1.2997
Epoch 526/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6729 - mae:
1.2533
Epoch 527/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9333 - mae:
1.3195
Epoch 528/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8517 - mae:
1.2938
Epoch 529/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1317 - mae:
1.3611
Epoch 530/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9055 - mae:
1.3142
Epoch 531/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6952 - mae:
1.2688
Epoch 532/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6060 - mae:
1.2440
Epoch 533/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6270 - mae:
1.2422
Epoch 534/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5866 - mae:
1.2373
Epoch 535/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8961 - mae:
1.3087
Epoch 536/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5744 - mae:
1.2394
Epoch 537/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7693 - mae:
1.2795
Epoch 538/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4769 - mae:
1.2110
Epoch 539/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6652 - mae:
1.2594
Epoch 540/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4645 - mae:
1.4369
Epoch 541/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5150 - mae:
1.2229
Epoch 542/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5633 - mae:
1.2270
Epoch 543/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1032 - mae:
1.3554
Epoch 544/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7327 - mae:
1.2750
Epoch 545/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9363 - mae:
1.3213
Epoch 546/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7383 - mae:
1.2735
Epoch 547/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5875 - mae:
1.2351
Epoch 548/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6685 - mae:
1.2644
Epoch 549/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5560 - mae:
1.2321
Epoch 550/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5980 - mae:
1.2364
Epoch 551/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6172 - mae:
1.2420
Epoch 552/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5621 - mae:
1.2314
Epoch 553/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7984 - mae:
1.2949
Epoch 554/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8533 - mae:
1.3046
Epoch 555/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6315 - mae:
1.2508
Epoch 556/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7093 - mae:
1.2772
Epoch 557/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.1919 - mae:
1.3857
Epoch 558/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7856 - mae:
1.2971
Epoch 559/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5933 - mae:
1.2358
Epoch 560/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6027 - mae:
1.2436
Epoch 561/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5051 - mae:
1.2158
Epoch 562/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6605 - mae:
1.2590
Epoch 563/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5506 - mae:
1.2233
Epoch 564/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9369 - mae:
1.3151
Epoch 565/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6269 - mae:
1.2498
Epoch 566/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9550 - mae:
1.3161
Epoch 567/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7159 - mae:
1.2661
Epoch 568/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5578 - mae:
1.2297
Epoch 569/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5468 - mae:
1.2205
Epoch 570/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9075 - mae:
1.3088
Epoch 571/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9837 - mae:
1.3415
Epoch 572/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8185 - mae:
1.2945
Epoch 573/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6969 - mae:
1.2641
Epoch 574/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5012 - mae:
1.2111
Epoch 575/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6286 - mae:
1.2452
Epoch 576/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8394 - mae:
1.3016
Epoch 577/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.3716 - mae:
1.1814
Epoch 578/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4761 - mae:
1.2087
Epoch 579/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8698 - mae:
1.3052
Epoch 580/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8602 - mae:
1.2989
Epoch 581/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8845 - mae:
1.3041
Epoch 582/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8660 - mae:
1.3001
Epoch 583/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4856 - mae:
1.2122
Epoch 584/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.3640 - mae:
1.1787
Epoch 585/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8442 - mae:
1.2900
Epoch 586/600
1605/1605 [==============================] - 2s 1ms/step - loss: 3.4634 - mae:
1.4406
Epoch 587/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.3876 - mae:
1.1838
Epoch 588/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7256 - mae:
1.2752
Epoch 589/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5942 - mae:
1.2327
Epoch 590/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5220 - mae:
1.2173
Epoch 591/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.9635 - mae:
1.3168
Epoch 592/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.8315 - mae:
1.2916
Epoch 593/600
```

```
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7030 - mae:
1.2613
Epoch 594/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5627 - mae:
1.2338
Epoch 595/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.5314 - mae:
1.2239A: 0s - loss: 2.5357
Epoch 596/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.7102 - mae:
1.2680
Epoch 597/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4070 - mae:
1.1943
Epoch 598/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.3427 - mae:
1.1787
Epoch 599/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.6308 - mae:
1.2412
Epoch 600/600
1605/1605 [==============================] - 2s 1ms/step - loss: 2.4374 - mae:
1.2052
```

[26]: `<keras.callbacks.callbacks.History at 0x7fd53c1a4e10>`

[27]:
```python
score = model.evaluate(X_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Test loss: 1.6637967334729489
Test accuracy: 0.9066632390022278
```

[28]:
```python
model.save('keypoint_model03.h5')
```

[29]:
```python
test['Image'] = test['Image'].apply(lambda x: np.fromstring(x, dtype=int, sep='␣
 ↪').reshape((96,96)))
test.shape, type(test)
```

[29]: `((1783, 2), pandas.core.frame.DataFrame)`

[30]:
```python
test_X = np.asarray([test['Image']], dtype=np.uint8).reshape(test.
 ↪shape[0],96,96,1)
test_res = model.predict(test_X)

train_predicts = model.predict(X_train)
```
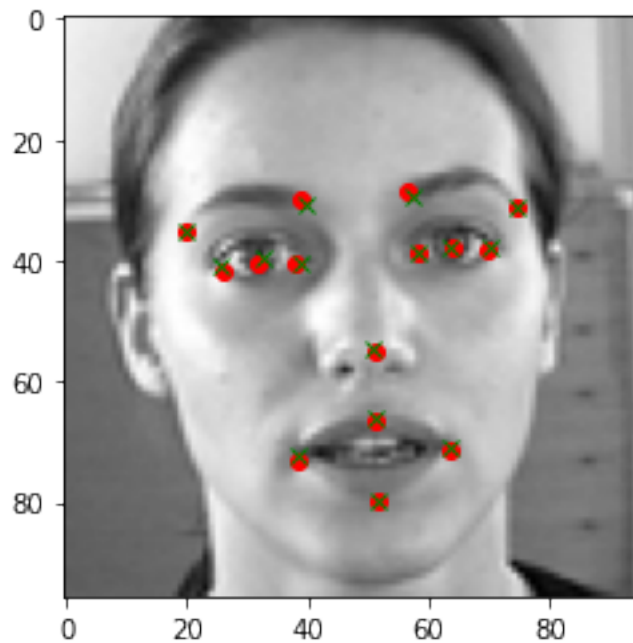
```python
[31]: n = 12

xv = X_train[n].reshape((96,96))
plt.imshow(xv,cmap='gray')

for i in range(1,31,2):
    plt.plot(train_predicts[n][i-1], train_predicts[n][i], 'ro')
    plt.plot(y_train[n][i-1], y_train[n][i], 'x', color='green')

plt.show()
```



```python
[38]: lookid_dir = '../input/facial-keypoints-detection/IdLookupTable.csv'
      lookid_data = pd.read_csv(lookid_dir)
```

```python
[42]: lookid_list = list(lookid_data['FeatureName'])
      imageID = list(lookid_data['ImageId']-1)
      pre_list = list(test_res)
      rowid = lookid_data['RowId']
      rowid=list(rowid)
      feature = []
      for f in list(lookid_data['FeatureName']):
          feature.append(lookid_list.index(f))
      preded = []
      for x,y in zip(imageID,feature):
          preded.append(pre_list[x][y])
```

```python
rowid = pd.Series(rowid,name = 'RowId')
loc = pd.Series(preded,name = 'Location')
submission = pd.concat([rowid,loc],axis = 1)
submission.to_csv('face_key_detection_submission.csv',index = False)
```