



Keras TF 2.0 - Code Along Classification Project

Let's explore a classification task with Keras API for TF 2.0

The Data

Breast cancer wisconsin (diagnostic) dataset

Data Set Characteristics:

:Number of Instances: 569

:Number of Attributes: 30 numeric, predictive attributes and the class

:Attribute Information:

- radius (mean of distances from center to points on the perimeter)
- texture (standard deviation of gray-scale values)
- perimeter
- area
- smoothness (local variation in radius lengths)
- compactness ($\text{perimeter}^2 / \text{area} - 1.0$)
- concavity (severity of concave portions of the contour)
- concave points (number of concave portions of the contour)
- symmetry
- fractal dimension ("coastline approximation" - 1)

The mean, standard error, and "worst" or largest (mean of the three largest values) of these features were computed for each image, resulting in 30 features. For instance, field 3 is Mean Radius, field 13 is Radius SE, field 23 is Worst Radius.

- class:
 - WDBC-Malignant
 - WDBC-Benign

:Summary Statistics:

	Min	Max
radius (mean):	6.981	28.11
texture (mean):	9.71	39.28
perimeter (mean):	43.79	188.5
area (mean):	143.5	2501.0
smoothness (mean):	0.053	0.163
compactness (mean):	0.019	0.345
concavity (mean):	0.0	0.427
concave points (mean):	0.0	0.201
symmetry (mean):	0.106	0.304
fractal dimension (mean):	0.05	0.097
radius (standard error):	0.112	2.873
texture (standard error):	0.36	4.885
perimeter (standard error):	0.757	21.98
area (standard error):	6.802	542.2
smoothness (standard error):	0.002	0.031
compactness (standard error):	0.002	0.135
concavity (standard error):	0.0	0.396
concave points (standard error):	0.0	0.053
symmetry (standard error):	0.008	0.079
fractal dimension (standard error):	0.001	0.03
radius (worst):	7.93	36.04
texture (worst):	12.02	49.54
perimeter (worst):	50.41	251.2
area (worst):	185.2	4254.0
smoothness (worst):	0.071	0.223
compactness (worst):	0.027	1.058
concavity (worst):	0.0	1.252

```

concave points (worst):      0.0    0.291
symmetry (worst):           0.156  0.664
fractal dimension (worst):   0.055  0.208
=====

```

:Missing Attribute Values: None

:Class Distribution: 212 - Malignant, 357 - Benign

:Creator: Dr. William H. Wolberg, W. Nick Street, Olvi L. Mangasarian

:Donor: Nick Street

:Date: November, 1995

This is a copy of UCI ML Breast Cancer Wisconsin (Diagnostic) datasets. <https://goo.gl/U2Uwz2>

Features are computed from a digitized image of a fine needle aspirate (FNA) of a breast mass. They describe characteristics of the cell nuclei present in the image.

Separating plane described above was obtained using Multisurface Method-Tree (MSM-T) [K. P. Bennett, "Decision Tree Construction Via Linear Programming." Proceedings of the 4th Midwest Artificial Intelligence and Cognitive Science Society, pp. 97-101, 1992], a classification method which uses linear programming to construct a decision tree. Relevant features were selected using an exhaustive search in the space of 1-4 features and 1-3 separating planes.

The actual linear program used to obtain the separating plane in the 3-dimensional space is that described in: [K. P. Bennett and O. L. Mangasarian: "Robust Linear Programming Discrimination of Two Linearly Inseparable Sets", Optimization Methods and Software 1, 1992, 23-34].

This database is also available through the UW CS ftp server:

ftp ftp.cs.wisc.edu cd math-prog/cpo-dataset/machine-learn/WDBC/

.. topic:: References

- W.N. Street, W.H. Wolberg and O.L. Mangasarian. Nuclear feature extraction for breast tumor diagnosis. IS&T/SPIE 1993 International Symposium on Electronic Imaging: Science and Technology, volume 1905, pages 861-870, San Jose, CA, 1993.
- O.L. Mangasarian, W.N. Street and W.H. Wolberg. Breast cancer diagnosis and prognosis via linear programming. Operations Research, 43(4), pages 570-577, July-August 1995.
- W.H. Wolberg, W.N. Street, and O.L. Mangasarian. Machine learning techniques to diagnose breast cancer from fine-needle aspirates. Cancer Letters 77 (1994) 163-171.

```

In [1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

```

```

In [2]: df = pd.read_csv('../DATA/cancer_classification.csv')

```

```

In [3]: df.info()

```

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 569 entries, 0 to 568
Data columns (total 31 columns):
#   Column                                Non-Null Count  Dtype
---  -
0   mean radius                           569 non-null    float64
1   mean texture                           569 non-null    float64
2   mean perimeter                         569 non-null    float64
3   mean area                             569 non-null    float64
4   mean smoothness                        569 non-null    float64
5   mean compactness                       569 non-null    float64
6   mean concavity                          569 non-null    float64
7   mean concave points                    569 non-null    float64
8   mean symmetry                          569 non-null    float64
9   mean fractal dimension                  569 non-null    float64
10  radius error                           569 non-null    float64
11  texture error                           569 non-null    float64
12  perimeter error                         569 non-null    float64
13  area error                             569 non-null    float64
14  smoothness error                       569 non-null    float64
15  compactness error                      569 non-null    float64
16  concavity error                        569 non-null    float64
17  concave points error                   569 non-null    float64
18  symmetry error                         569 non-null    float64
19  fractal dimension error                 569 non-null    float64
20  worst radius                           569 non-null    float64
21  worst texture                           569 non-null    float64
22  worst perimeter                         569 non-null    float64
23  worst area                             569 non-null    float64
24  worst smoothness                       569 non-null    float64
25  worst compactness                      569 non-null    float64
26  worst concavity                        569 non-null    float64
27  worst concave points                    569 non-null    float64
28  worst symmetry                          569 non-null    float64
29  worst fractal dimension                 569 non-null    float64
30  benign_0__mal_1                        569 non-null    int64
dtypes: float64(30), int64(1)
memory usage: 137.9 KB

```

```
In [4]: df.describe().transpose()
```

Out[4]:

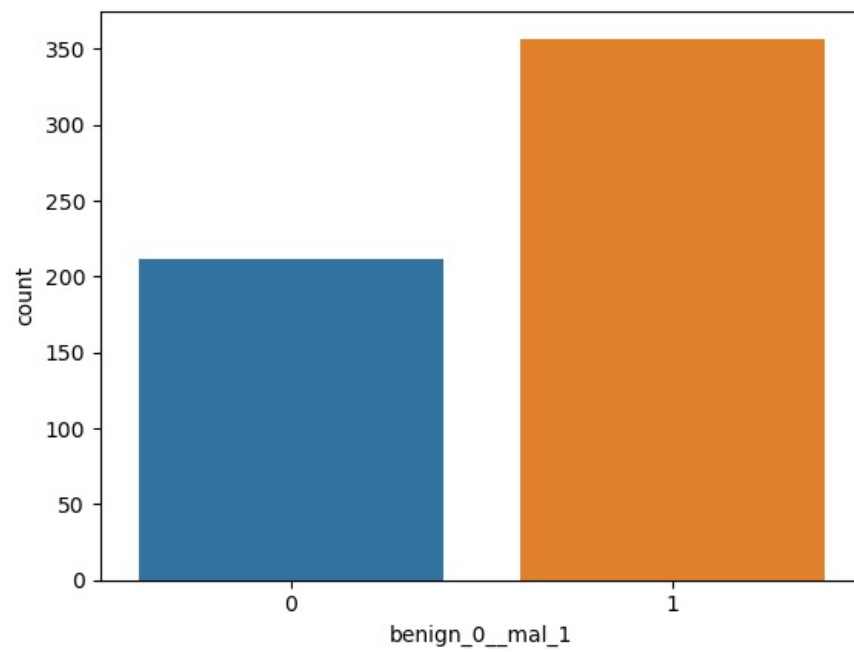
	count	mean	std	min	25%	50%	75%	max
mean radius	569.0	14.127292	3.524049	6.981000	11.700000	13.370000	15.780000	28.11000
mean texture	569.0	19.289649	4.301036	9.710000	16.170000	18.840000	21.800000	39.28000
mean perimeter	569.0	91.969033	24.298981	43.790000	75.170000	86.240000	104.100000	188.50000
mean area	569.0	654.889104	351.914129	143.500000	420.300000	551.100000	782.700000	2501.00000
mean smoothness	569.0	0.096360	0.014064	0.052630	0.086370	0.095870	0.105300	0.16340
mean compactness	569.0	0.104341	0.052813	0.019380	0.064920	0.092630	0.130400	0.34540
mean concavity	569.0	0.088799	0.079720	0.000000	0.029560	0.061540	0.130700	0.42680
mean concave points	569.0	0.048919	0.038803	0.000000	0.020310	0.033500	0.074000	0.20120
mean symmetry	569.0	0.181162	0.027414	0.106000	0.161900	0.179200	0.195700	0.30400
mean fractal dimension	569.0	0.062798	0.007060	0.049960	0.057700	0.061540	0.066120	0.09744
radius error	569.0	0.405172	0.277313	0.111500	0.232400	0.324200	0.478900	2.87300
texture error	569.0	1.216853	0.551648	0.360200	0.833900	1.108000	1.474000	4.88500
perimeter error	569.0	2.866059	2.021855	0.757000	1.606000	2.287000	3.357000	21.98000
area error	569.0	40.337079	45.491006	6.802000	17.850000	24.530000	45.190000	542.20000
smoothness error	569.0	0.007041	0.003003	0.001713	0.005169	0.006380	0.008146	0.03113
compactness error	569.0	0.025478	0.017908	0.002252	0.013080	0.020450	0.032450	0.13540
concavity error	569.0	0.031894	0.030186	0.000000	0.015090	0.025890	0.042050	0.39600
concave points error	569.0	0.011796	0.006170	0.000000	0.007638	0.010930	0.014710	0.05279
symmetry error	569.0	0.020542	0.008266	0.007882	0.015160	0.018730	0.023480	0.07895
fractal dimension error	569.0	0.003795	0.002646	0.000895	0.002248	0.003187	0.004558	0.02984
worst radius	569.0	16.269190	4.833242	7.930000	13.010000	14.970000	18.790000	36.04000
worst texture	569.0	25.677223	6.146258	12.020000	21.080000	25.410000	29.720000	49.54000
worst perimeter	569.0	107.261213	33.602542	50.410000	84.110000	97.660000	125.400000	251.20000
worst area	569.0	880.583128	569.356993	185.200000	515.300000	686.500000	1084.000000	4254.00000
worst smoothness	569.0	0.132369	0.022832	0.071170	0.116600	0.131300	0.146000	0.22260
worst compactness	569.0	0.254265	0.157336	0.027290	0.147200	0.211900	0.339100	1.05800
worst concavity	569.0	0.272188	0.208624	0.000000	0.114500	0.226700	0.382900	1.25200
worst concave points	569.0	0.114606	0.065732	0.000000	0.064930	0.099930	0.161400	0.29100
worst symmetry	569.0	0.290076	0.061867	0.156500	0.250400	0.282200	0.317900	0.66380
worst fractal dimension	569.0	0.083946	0.018061	0.055040	0.071460	0.080040	0.092080	0.20750
benign_0__mal_1	569.0	0.627417	0.483918	0.000000	0.000000	1.000000	1.000000	1.00000

EDA

```
In [5]: import seaborn as sns
import matplotlib.pyplot as plt
```

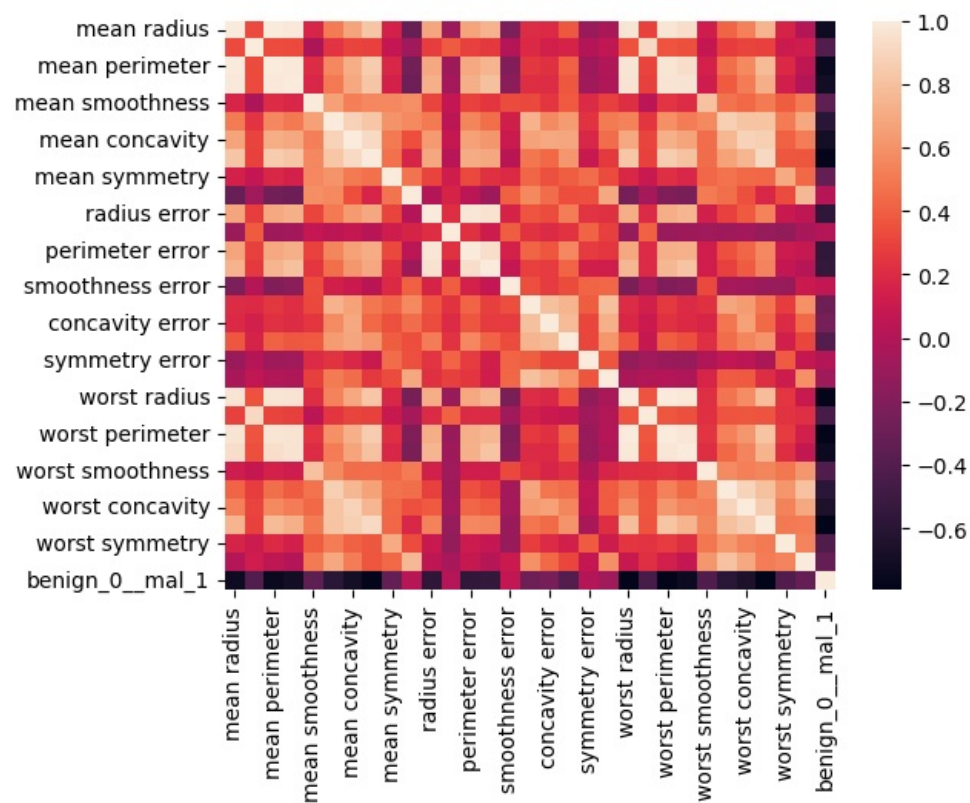
```
In [6]: sns.countplot(x='benign_0__mal_1',data=df)
```

```
Out[6]: <AxesSubplot:xlabel='benign_0__mal_1', ylabel='count'>
```



```
In [7]: sns.heatmap(df.corr())
```

```
Out[7]: <AxesSubplot:>
```

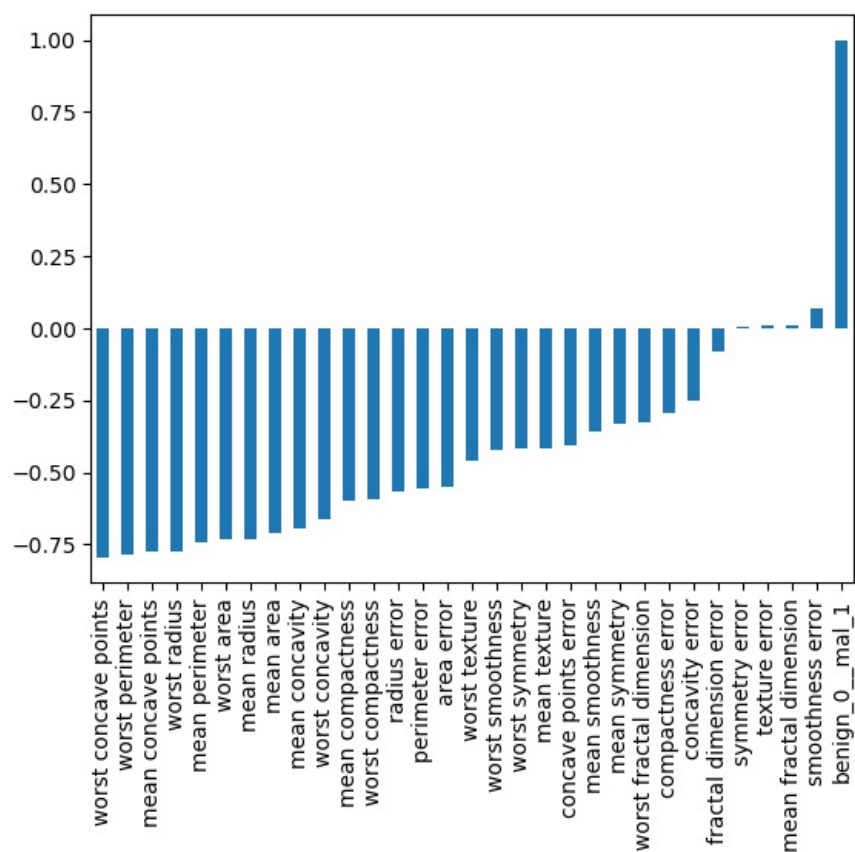


```
In [8]: df.corr()['benign_0__mal_1'].sort_values()
```

```
Out[8]: worst concave points    -0.793566
worst perimeter              -0.782914
mean concave points         -0.776614
worst radius                 -0.776454
mean perimeter              -0.742636
worst area                  -0.733825
mean radius                 -0.730029
mean area                   -0.708984
mean concavity              -0.696360
worst concavity             -0.659610
mean compactness            -0.596534
worst compactness           -0.590998
radius error                -0.567134
perimeter error             -0.556141
area error                  -0.548236
worst texture               -0.456903
worst smoothness            -0.421465
worst symmetry              -0.416294
mean texture                -0.415185
concave points error        -0.408042
mean smoothness             -0.358560
mean symmetry               -0.330499
worst fractal dimension     -0.323872
compactness error           -0.292999
concavity error             -0.253730
fractal dimension error     -0.077972
symmetry error              0.006522
texture error               0.008303
mean fractal dimension      0.012838
smoothness error            0.067016
benign_0_mal_1              1.000000
Name: benign_0_mal_1, dtype: float64
```

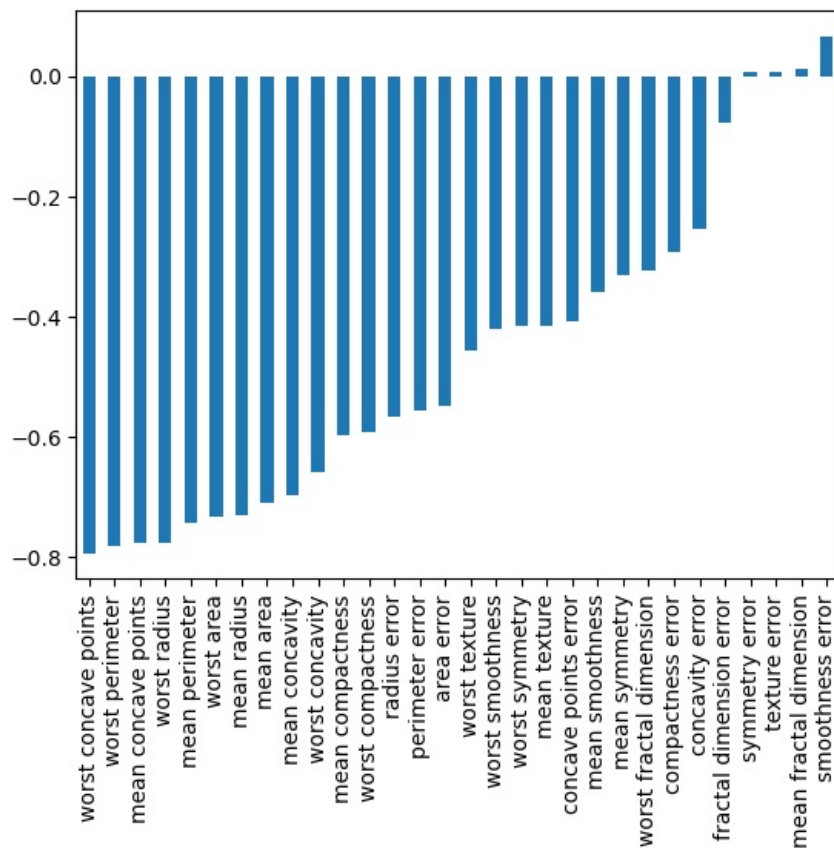
```
In [9]: df.corr()['benign_0_mal_1'].sort_values().plot(kind='bar')
```

```
Out[9]: <AxesSubplot:>
```



```
In [10]: df.corr()['benign_0_mal_1'][::-1].sort_values().plot(kind='bar')
```

```
Out[10]: <AxesSubplot:>
```



Train Test Split

```
In [11]: X = df.drop('benign_0__mal_1',axis=1).values
        y = df['benign_0__mal_1'].values
```

```
In [12]: from sklearn.model_selection import train_test_split
```

```
In [13]: X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=0.25,random_state=101)
```

Scaling Data

```
In [14]: from sklearn.preprocessing import MinMaxScaler
```

```
In [15]: scaler = MinMaxScaler()
```

```
In [16]: scaler.fit(X_train)
```

```
Out[16]: MinMaxScaler()
```

```
In [17]: X_train = scaler.transform(X_train)
        X_test = scaler.transform(X_test)
```

Creating the Model

```
# For a binary classification problem
model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

```
In [18]: import tensorflow as tf
        from tensorflow.keras.models import Sequential
```



```
from tensorflow.keras.layers import Dense, Activation, Dropout
```

```
In [19]: X_train.shape
```

```
Out[19]: (426, 30)
```

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

# https://stats.stackexchange.com/questions/181/how-to-choose-the-number-of-hidden-layers-and-nodes-in-a-feedfo

model.add(Dense(units=30,activation='relu'))

model.add(Dense(units=15,activation='relu'))

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

# For a binary classification problem
model.compile(loss='binary_crossentropy', optimizer='adam')
```

Training the Model

Example One: Choosing too many epochs and overfitting!

```
In [21]: # https://stats.stackexchange.com/questions/164876/tradeoff-batch-size-vs-number-of-iterations-to-train-a-neura
# https://datascience.stackexchange.com/questions/18414/are-there-any-rules-for-choosing-the-size-of-a-mini-bat
```

```
model.fit(x=X_train,
          y=y_train,
          epochs=600,
          validation_data=(X_test, y_test), verbose=1
        )
```

```
Epoch 1/600
14/14 [=====] - 2s 35ms/step - loss: 0.6787 - val_loss: 0.6714
Epoch 2/600
14/14 [=====] - 0s 13ms/step - loss: 0.6460 - val_loss: 0.6460
Epoch 3/600
14/14 [=====] - 0s 9ms/step - loss: 0.6142 - val_loss: 0.6151
Epoch 4/600
14/14 [=====] - 0s 9ms/step - loss: 0.5787 - val_loss: 0.5750
Epoch 5/600
14/14 [=====] - 0s 5ms/step - loss: 0.5381 - val_loss: 0.5338
Epoch 6/600
14/14 [=====] - 0s 6ms/step - loss: 0.4973 - val_loss: 0.4879
Epoch 7/600
14/14 [=====] - 0s 5ms/step - loss: 0.4517 - val_loss: 0.4377
Epoch 8/600
14/14 [=====] - 0s 5ms/step - loss: 0.4033 - val_loss: 0.3891
Epoch 9/600
14/14 [=====] - 0s 5ms/step - loss: 0.3623 - val_loss: 0.3435
Epoch 10/600
14/14 [=====] - 0s 7ms/step - loss: 0.3216 - val_loss: 0.3067
Epoch 11/600
14/14 [=====] - 0s 5ms/step - loss: 0.2892 - val_loss: 0.2736
Epoch 12/600
14/14 [=====] - 0s 5ms/step - loss: 0.2632 - val_loss: 0.2467
Epoch 13/600
14/14 [=====] - 0s 5ms/step - loss: 0.2406 - val_loss: 0.2277
Epoch 14/600
14/14 [=====] - 0s 5ms/step - loss: 0.2232 - val_loss: 0.2087
Epoch 15/600
14/14 [=====] - 0s 5ms/step - loss: 0.2121 - val_loss: 0.1955
Epoch 16/600
14/14 [=====] - 0s 5ms/step - loss: 0.1954 - val_loss: 0.1834
Epoch 17/600
14/14 [=====] - 0s 5ms/step - loss: 0.1846 - val_loss: 0.1759
Epoch 18/600
14/14 [=====] - 0s 5ms/step - loss: 0.1771 - val_loss: 0.1664
Epoch 19/600
14/14 [=====] - 0s 5ms/step - loss: 0.1709 - val_loss: 0.1607
Epoch 20/600
14/14 [=====] - 0s 6ms/step - loss: 0.1583 - val_loss: 0.1527
Epoch 21/600
14/14 [=====] - 0s 6ms/step - loss: 0.1550 - val_loss: 0.1533
Epoch 22/600
14/14 [=====] - 0s 5ms/step - loss: 0.1452 - val_loss: 0.1441
Epoch 23/600
14/14 [=====] - 0s 5ms/step - loss: 0.1371 - val_loss: 0.1386
Epoch 24/600
14/14 [=====] - 0s 5ms/step - loss: 0.1320 - val_loss: 0.1350
Epoch 25/600
14/14 [=====] - 0s 5ms/step - loss: 0.1251 - val_loss: 0.1360
Epoch 26/600
14/14 [=====] - 0s 6ms/step - loss: 0.1225 - val_loss: 0.1272
```

Epoch 27/600
14/14 [=====] - 0s 6ms/step - loss: 0.1235 - val_loss: 0.1338
Epoch 28/600
14/14 [=====] - 0s 5ms/step - loss: 0.1173 - val_loss: 0.1237
Epoch 29/600
14/14 [=====] - 0s 5ms/step - loss: 0.1088 - val_loss: 0.1211
Epoch 30/600
14/14 [=====] - 0s 5ms/step - loss: 0.1061 - val_loss: 0.1213
Epoch 31/600
14/14 [=====] - 0s 5ms/step - loss: 0.1007 - val_loss: 0.1216
Epoch 32/600
14/14 [=====] - 0s 5ms/step - loss: 0.0998 - val_loss: 0.1211
Epoch 33/600
14/14 [=====] - 0s 5ms/step - loss: 0.0989 - val_loss: 0.1153
Epoch 34/600
14/14 [=====] - 0s 5ms/step - loss: 0.0935 - val_loss: 0.1150
Epoch 35/600
14/14 [=====] - 0s 6ms/step - loss: 0.0890 - val_loss: 0.1173
Epoch 36/600
14/14 [=====] - 0s 6ms/step - loss: 0.0890 - val_loss: 0.1150
Epoch 37/600
14/14 [=====] - 0s 5ms/step - loss: 0.0869 - val_loss: 0.1121
Epoch 38/600
14/14 [=====] - 0s 5ms/step - loss: 0.0827 - val_loss: 0.1124
Epoch 39/600
14/14 [=====] - 0s 5ms/step - loss: 0.0800 - val_loss: 0.1139
Epoch 40/600
14/14 [=====] - 0s 5ms/step - loss: 0.0790 - val_loss: 0.1103
Epoch 41/600
14/14 [=====] - 0s 5ms/step - loss: 0.0778 - val_loss: 0.1108
Epoch 42/600
14/14 [=====] - 0s 6ms/step - loss: 0.0757 - val_loss: 0.1123
Epoch 43/600
14/14 [=====] - 0s 6ms/step - loss: 0.0745 - val_loss: 0.1114
Epoch 44/600
14/14 [=====] - 0s 5ms/step - loss: 0.0729 - val_loss: 0.1109
Epoch 45/600
14/14 [=====] - 0s 5ms/step - loss: 0.0727 - val_loss: 0.1092
Epoch 46/600
14/14 [=====] - 0s 5ms/step - loss: 0.0701 - val_loss: 0.1129
Epoch 47/600
14/14 [=====] - 0s 6ms/step - loss: 0.0710 - val_loss: 0.1090
Epoch 48/600
14/14 [=====] - 0s 6ms/step - loss: 0.0693 - val_loss: 0.1078
Epoch 49/600
14/14 [=====] - 0s 7ms/step - loss: 0.0670 - val_loss: 0.1116
Epoch 50/600
14/14 [=====] - 0s 7ms/step - loss: 0.0681 - val_loss: 0.1098
Epoch 51/600
14/14 [=====] - 0s 6ms/step - loss: 0.0659 - val_loss: 0.1113
Epoch 52/600
14/14 [=====] - 0s 6ms/step - loss: 0.0645 - val_loss: 0.1075
Epoch 53/600
14/14 [=====] - 0s 5ms/step - loss: 0.0642 - val_loss: 0.1135
Epoch 54/600
14/14 [=====] - 0s 6ms/step - loss: 0.0642 - val_loss: 0.1070
Epoch 55/600
14/14 [=====] - 0s 6ms/step - loss: 0.0651 - val_loss: 0.1144
Epoch 56/600
14/14 [=====] - 0s 6ms/step - loss: 0.0619 - val_loss: 0.1068
Epoch 57/600
14/14 [=====] - 0s 6ms/step - loss: 0.0650 - val_loss: 0.1114
Epoch 58/600
14/14 [=====] - 0s 5ms/step - loss: 0.0629 - val_loss: 0.1082
Epoch 59/600
14/14 [=====] - 0s 5ms/step - loss: 0.0602 - val_loss: 0.1074
Epoch 60/600
14/14 [=====] - 0s 6ms/step - loss: 0.0618 - val_loss: 0.1074
Epoch 61/600
14/14 [=====] - 0s 5ms/step - loss: 0.0589 - val_loss: 0.1129
Epoch 62/600
14/14 [=====] - 0s 5ms/step - loss: 0.0594 - val_loss: 0.1075
Epoch 63/600
14/14 [=====] - 0s 5ms/step - loss: 0.0588 - val_loss: 0.1166
Epoch 64/600
14/14 [=====] - 0s 5ms/step - loss: 0.0581 - val_loss: 0.1073
Epoch 65/600
14/14 [=====] - 0s 5ms/step - loss: 0.0593 - val_loss: 0.1119
Epoch 66/600
14/14 [=====] - 0s 5ms/step - loss: 0.0634 - val_loss: 0.1135
Epoch 67/600
14/14 [=====] - 0s 6ms/step - loss: 0.0583 - val_loss: 0.1067
Epoch 68/600
14/14 [=====] - 0s 5ms/step - loss: 0.0581 - val_loss: 0.1147
Epoch 69/600
14/14 [=====] - 0s 6ms/step - loss: 0.0568 - val_loss: 0.1095
Epoch 70/600
14/14 [=====] - 0s 5ms/step - loss: 0.0568 - val_loss: 0.1068
Epoch 71/600

```
14/14 [=====] - 0s 5ms/step - loss: 0.0550 - val_loss: 0.1146
Epoch 72/600
14/14 [=====] - 0s 5ms/step - loss: 0.0548 - val_loss: 0.1056
Epoch 73/600
14/14 [=====] - 0s 6ms/step - loss: 0.0561 - val_loss: 0.1133
Epoch 74/600
14/14 [=====] - 0s 6ms/step - loss: 0.0543 - val_loss: 0.1097
Epoch 75/600
14/14 [=====] - 0s 5ms/step - loss: 0.0558 - val_loss: 0.1075
Epoch 76/600
14/14 [=====] - 0s 5ms/step - loss: 0.0556 - val_loss: 0.1105
Epoch 77/600
14/14 [=====] - 0s 5ms/step - loss: 0.0550 - val_loss: 0.1124
Epoch 78/600
14/14 [=====] - 0s 5ms/step - loss: 0.0534 - val_loss: 0.1080
Epoch 79/600
14/14 [=====] - 0s 5ms/step - loss: 0.0530 - val_loss: 0.1133
Epoch 80/600
14/14 [=====] - 0s 5ms/step - loss: 0.0532 - val_loss: 0.1069
Epoch 81/600
14/14 [=====] - 0s 5ms/step - loss: 0.0535 - val_loss: 0.1188
Epoch 82/600
14/14 [=====] - 0s 5ms/step - loss: 0.0527 - val_loss: 0.1082
Epoch 83/600
14/14 [=====] - 0s 5ms/step - loss: 0.0540 - val_loss: 0.1144
Epoch 84/600
14/14 [=====] - 0s 5ms/step - loss: 0.0524 - val_loss: 0.1078
Epoch 85/600
14/14 [=====] - 0s 5ms/step - loss: 0.0567 - val_loss: 0.1136
Epoch 86/600
14/14 [=====] - 0s 5ms/step - loss: 0.0521 - val_loss: 0.1114
Epoch 87/600
14/14 [=====] - 0s 4ms/step - loss: 0.0518 - val_loss: 0.1127
Epoch 88/600
14/14 [=====] - 0s 5ms/step - loss: 0.0539 - val_loss: 0.1127
Epoch 89/600
14/14 [=====] - 0s 6ms/step - loss: 0.0549 - val_loss: 0.1156
Epoch 90/600
14/14 [=====] - 0s 6ms/step - loss: 0.0509 - val_loss: 0.1095
Epoch 91/600
14/14 [=====] - 0s 5ms/step - loss: 0.0529 - val_loss: 0.1141
Epoch 92/600
14/14 [=====] - 0s 5ms/step - loss: 0.0516 - val_loss: 0.1091
Epoch 93/600
14/14 [=====] - 0s 5ms/step - loss: 0.0502 - val_loss: 0.1114
Epoch 94/600
14/14 [=====] - 0s 5ms/step - loss: 0.0497 - val_loss: 0.1135
Epoch 95/600
14/14 [=====] - 0s 5ms/step - loss: 0.0508 - val_loss: 0.1105
Epoch 96/600
14/14 [=====] - 0s 5ms/step - loss: 0.0556 - val_loss: 0.1083
Epoch 97/600
14/14 [=====] - 0s 6ms/step - loss: 0.0509 - val_loss: 0.1108
Epoch 98/600
14/14 [=====] - 0s 6ms/step - loss: 0.0496 - val_loss: 0.1145
Epoch 99/600
14/14 [=====] - 0s 5ms/step - loss: 0.0494 - val_loss: 0.1090
Epoch 100/600
14/14 [=====] - 0s 5ms/step - loss: 0.0495 - val_loss: 0.1170
Epoch 101/600
14/14 [=====] - 0s 5ms/step - loss: 0.0521 - val_loss: 0.1140
Epoch 102/600
14/14 [=====] - 0s 5ms/step - loss: 0.0477 - val_loss: 0.1088
Epoch 103/600
14/14 [=====] - 0s 5ms/step - loss: 0.0517 - val_loss: 0.1191
Epoch 104/600
14/14 [=====] - 0s 5ms/step - loss: 0.0495 - val_loss: 0.1086
Epoch 105/600
14/14 [=====] - 0s 5ms/step - loss: 0.0500 - val_loss: 0.1115
Epoch 106/600
14/14 [=====] - 0s 5ms/step - loss: 0.0471 - val_loss: 0.1109
Epoch 107/600
14/14 [=====] - 0s 5ms/step - loss: 0.0502 - val_loss: 0.1203
Epoch 108/600
14/14 [=====] - 0s 5ms/step - loss: 0.0496 - val_loss: 0.1101
Epoch 109/600
14/14 [=====] - 0s 5ms/step - loss: 0.0485 - val_loss: 0.1131
Epoch 110/600
14/14 [=====] - 0s 5ms/step - loss: 0.0511 - val_loss: 0.1103
Epoch 111/600
14/14 [=====] - 0s 5ms/step - loss: 0.0469 - val_loss: 0.1100
Epoch 112/600
14/14 [=====] - 0s 5ms/step - loss: 0.0468 - val_loss: 0.1110
Epoch 113/600
14/14 [=====] - 0s 5ms/step - loss: 0.0471 - val_loss: 0.1143
Epoch 114/600
14/14 [=====] - 0s 5ms/step - loss: 0.0499 - val_loss: 0.1131
Epoch 115/600
14/14 [=====] - 0s 5ms/step - loss: 0.0465 - val_loss: 0.1117
```

Epoch 116/600
14/14 [=====] - 0s 5ms/step - loss: 0.0471 - val_loss: 0.1136
Epoch 117/600
14/14 [=====] - 0s 5ms/step - loss: 0.0519 - val_loss: 0.1128
Epoch 118/600
14/14 [=====] - 0s 5ms/step - loss: 0.0465 - val_loss: 0.1093
Epoch 119/600
14/14 [=====] - 0s 7ms/step - loss: 0.0486 - val_loss: 0.1224
Epoch 120/600
14/14 [=====] - 0s 5ms/step - loss: 0.0442 - val_loss: 0.1084
Epoch 121/600
14/14 [=====] - 0s 6ms/step - loss: 0.0490 - val_loss: 0.1187
Epoch 122/600
14/14 [=====] - 0s 6ms/step - loss: 0.0478 - val_loss: 0.1094
Epoch 123/600
14/14 [=====] - 0s 5ms/step - loss: 0.0517 - val_loss: 0.1243
Epoch 124/600
14/14 [=====] - 0s 5ms/step - loss: 0.0452 - val_loss: 0.1141
Epoch 125/600
14/14 [=====] - 0s 5ms/step - loss: 0.0460 - val_loss: 0.1138
Epoch 126/600
14/14 [=====] - 0s 5ms/step - loss: 0.0459 - val_loss: 0.1140
Epoch 127/600
14/14 [=====] - 0s 7ms/step - loss: 0.0462 - val_loss: 0.1150
Epoch 128/600
14/14 [=====] - 0s 7ms/step - loss: 0.0449 - val_loss: 0.1181
Epoch 129/600
14/14 [=====] - 0s 6ms/step - loss: 0.0456 - val_loss: 0.1145
Epoch 130/600
14/14 [=====] - 0s 6ms/step - loss: 0.0466 - val_loss: 0.1246
Epoch 131/600
14/14 [=====] - 0s 6ms/step - loss: 0.0451 - val_loss: 0.1135
Epoch 132/600
14/14 [=====] - 0s 5ms/step - loss: 0.0458 - val_loss: 0.1121
Epoch 133/600
14/14 [=====] - 0s 5ms/step - loss: 0.0466 - val_loss: 0.1115
Epoch 134/600
14/14 [=====] - 0s 5ms/step - loss: 0.0451 - val_loss: 0.1166
Epoch 135/600
14/14 [=====] - 0s 5ms/step - loss: 0.0449 - val_loss: 0.1216
Epoch 136/600
14/14 [=====] - 0s 6ms/step - loss: 0.0445 - val_loss: 0.1127
Epoch 137/600
14/14 [=====] - 0s 6ms/step - loss: 0.0472 - val_loss: 0.1257
Epoch 138/600
14/14 [=====] - 0s 5ms/step - loss: 0.0445 - val_loss: 0.1155
Epoch 139/600
14/14 [=====] - 0s 5ms/step - loss: 0.0434 - val_loss: 0.1118
Epoch 140/600
14/14 [=====] - 0s 5ms/step - loss: 0.0432 - val_loss: 0.1211
Epoch 141/600
14/14 [=====] - 0s 5ms/step - loss: 0.0479 - val_loss: 0.1165
Epoch 142/600
14/14 [=====] - 0s 5ms/step - loss: 0.0466 - val_loss: 0.1155
Epoch 143/600
14/14 [=====] - 0s 5ms/step - loss: 0.0433 - val_loss: 0.1224
Epoch 144/600
14/14 [=====] - 0s 5ms/step - loss: 0.0494 - val_loss: 0.1112
Epoch 145/600
14/14 [=====] - 0s 6ms/step - loss: 0.0469 - val_loss: 0.1113
Epoch 146/600
14/14 [=====] - 0s 5ms/step - loss: 0.0486 - val_loss: 0.1116
Epoch 147/600
14/14 [=====] - 0s 5ms/step - loss: 0.0435 - val_loss: 0.1163
Epoch 148/600
14/14 [=====] - 0s 5ms/step - loss: 0.0441 - val_loss: 0.1210
Epoch 149/600
14/14 [=====] - 0s 5ms/step - loss: 0.0456 - val_loss: 0.1135
Epoch 150/600
14/14 [=====] - 0s 5ms/step - loss: 0.0453 - val_loss: 0.1150
Epoch 151/600
14/14 [=====] - 0s 5ms/step - loss: 0.0469 - val_loss: 0.1187
Epoch 152/600
14/14 [=====] - 0s 5ms/step - loss: 0.0447 - val_loss: 0.1177
Epoch 153/600
14/14 [=====] - 0s 5ms/step - loss: 0.0490 - val_loss: 0.1142
Epoch 154/600
14/14 [=====] - 0s 6ms/step - loss: 0.0439 - val_loss: 0.1177
Epoch 155/600
14/14 [=====] - 0s 5ms/step - loss: 0.0433 - val_loss: 0.1233
Epoch 156/600
14/14 [=====] - 0s 5ms/step - loss: 0.0416 - val_loss: 0.1133
Epoch 157/600
14/14 [=====] - 0s 5ms/step - loss: 0.0431 - val_loss: 0.1185
Epoch 158/600
14/14 [=====] - 0s 5ms/step - loss: 0.0418 - val_loss: 0.1170
Epoch 159/600
14/14 [=====] - 0s 5ms/step - loss: 0.0411 - val_loss: 0.1183
Epoch 160/600

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14/14 [=====] - 0s 5ms/step - loss: 0.0430 - val_loss: 0.1152
Epoch 161/600
14/14 [=====] - 0s 5ms/step - loss: 0.0401 - val_loss: 0.1257
Epoch 162/600
14/14 [=====] - 0s 6ms/step - loss: 0.0416 - val_loss: 0.1182
Epoch 163/600
14/14 [=====] - 0s 5ms/step - loss: 0.0419 - val_loss: 0.1196
Epoch 164/600
14/14 [=====] - 0s 5ms/step - loss: 0.0409 - val_loss: 0.1223
Epoch 165/600
14/14 [=====] - 0s 5ms/step - loss: 0.0439 - val_loss: 0.1157
Epoch 166/600
14/14 [=====] - 0s 5ms/step - loss: 0.0467 - val_loss: 0.1259
Epoch 167/600
14/14 [=====] - 0s 5ms/step - loss: 0.0598 - val_loss: 0.1128
Epoch 168/600
14/14 [=====] - 0s 5ms/step - loss: 0.0464 - val_loss: 0.1180
Epoch 169/600
14/14 [=====] - 0s 5ms/step - loss: 0.0475 - val_loss: 0.1131
Epoch 170/600
14/14 [=====] - 0s 6ms/step - loss: 0.0465 - val_loss: 0.1279
Epoch 171/600
14/14 [=====] - 0s 5ms/step - loss: 0.0416 - val_loss: 0.1167
Epoch 172/600
14/14 [=====] - 0s 5ms/step - loss: 0.0416 - val_loss: 0.1202
Epoch 173/600
14/14 [=====] - 0s 6ms/step - loss: 0.0504 - val_loss: 0.1248
Epoch 174/600
14/14 [=====] - 0s 7ms/step - loss: 0.0517 - val_loss: 0.1208
Epoch 175/600
14/14 [=====] - 0s 6ms/step - loss: 0.0505 - val_loss: 0.1208
Epoch 176/600
14/14 [=====] - 0s 7ms/step - loss: 0.0521 - val_loss: 0.1127
Epoch 177/600
14/14 [=====] - 0s 8ms/step - loss: 0.0446 - val_loss: 0.1176
Epoch 178/600
14/14 [=====] - 0s 7ms/step - loss: 0.0402 - val_loss: 0.1161
Epoch 179/600
14/14 [=====] - 0s 6ms/step - loss: 0.0444 - val_loss: 0.1187
Epoch 180/600
14/14 [=====] - 0s 5ms/step - loss: 0.0388 - val_loss: 0.1129
Epoch 181/600
14/14 [=====] - 0s 6ms/step - loss: 0.0395 - val_loss: 0.1225
Epoch 182/600
14/14 [=====] - 0s 6ms/step - loss: 0.0407 - val_loss: 0.1137
Epoch 183/600
14/14 [=====] - 0s 7ms/step - loss: 0.0392 - val_loss: 0.1166
Epoch 184/600
14/14 [=====] - 0s 6ms/step - loss: 0.0393 - val_loss: 0.1161
Epoch 185/600
14/14 [=====] - 0s 6ms/step - loss: 0.0382 - val_loss: 0.1146
Epoch 186/600
14/14 [=====] - 0s 6ms/step - loss: 0.0399 - val_loss: 0.1236
Epoch 187/600
14/14 [=====] - 0s 5ms/step - loss: 0.0409 - val_loss: 0.1230
Epoch 188/600
14/14 [=====] - 0s 6ms/step - loss: 0.0401 - val_loss: 0.1192
Epoch 189/600
14/14 [=====] - 0s 5ms/step - loss: 0.0378 - val_loss: 0.1201
Epoch 190/600
14/14 [=====] - 0s 5ms/step - loss: 0.0388 - val_loss: 0.1152
Epoch 191/600
14/14 [=====] - 0s 5ms/step - loss: 0.0407 - val_loss: 0.1225
Epoch 192/600
14/14 [=====] - 0s 6ms/step - loss: 0.0397 - val_loss: 0.1186
Epoch 193/600
14/14 [=====] - 0s 6ms/step - loss: 0.0375 - val_loss: 0.1169
Epoch 194/600
14/14 [=====] - 0s 5ms/step - loss: 0.0428 - val_loss: 0.1251
Epoch 195/600
14/14 [=====] - 0s 5ms/step - loss: 0.0446 - val_loss: 0.1141
Epoch 196/600
14/14 [=====] - 0s 6ms/step - loss: 0.0591 - val_loss: 0.1174
Epoch 197/600
14/14 [=====] - 0s 5ms/step - loss: 0.0483 - val_loss: 0.1234
Epoch 198/600
14/14 [=====] - 0s 6ms/step - loss: 0.0427 - val_loss: 0.1175
Epoch 199/600
14/14 [=====] - 0s 6ms/step - loss: 0.0405 - val_loss: 0.1174
Epoch 200/600
14/14 [=====] - 0s 6ms/step - loss: 0.0393 - val_loss: 0.1204
Epoch 201/600
14/14 [=====] - 0s 6ms/step - loss: 0.0372 - val_loss: 0.1179
Epoch 202/600
14/14 [=====] - 0s 5ms/step - loss: 0.0370 - val_loss: 0.1217
Epoch 203/600
14/14 [=====] - 0s 5ms/step - loss: 0.0436 - val_loss: 0.1246
Epoch 204/600
14/14 [=====] - 0s 5ms/step - loss: 0.0382 - val_loss: 0.1216
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Epoch 205/600
14/14 [=====] - 0s 6ms/step - loss: 0.0371 - val_loss: 0.1238
Epoch 206/600
14/14 [=====] - 0s 5ms/step - loss: 0.0375 - val_loss: 0.1205
Epoch 207/600
14/14 [=====] - 0s 6ms/step - loss: 0.0372 - val_loss: 0.1202
Epoch 208/600
14/14 [=====] - 0s 7ms/step - loss: 0.0368 - val_loss: 0.1299
Epoch 209/600
14/14 [=====] - 0s 6ms/step - loss: 0.0374 - val_loss: 0.1248
Epoch 210/600
14/14 [=====] - 0s 5ms/step - loss: 0.0363 - val_loss: 0.1191
Epoch 211/600
14/14 [=====] - 0s 6ms/step - loss: 0.0376 - val_loss: 0.1279
Epoch 212/600
14/14 [=====] - 0s 6ms/step - loss: 0.0367 - val_loss: 0.1217
Epoch 213/600
14/14 [=====] - 0s 6ms/step - loss: 0.0360 - val_loss: 0.1194
Epoch 214/600
14/14 [=====] - 0s 6ms/step - loss: 0.0384 - val_loss: 0.1376
Epoch 215/600
14/14 [=====] - 0s 6ms/step - loss: 0.0384 - val_loss: 0.1189
Epoch 216/600
14/14 [=====] - 0s 6ms/step - loss: 0.0380 - val_loss: 0.1261
Epoch 217/600
14/14 [=====] - 0s 5ms/step - loss: 0.0367 - val_loss: 0.1248
Epoch 218/600
14/14 [=====] - 0s 5ms/step - loss: 0.0432 - val_loss: 0.1326
Epoch 219/600
14/14 [=====] - 0s 7ms/step - loss: 0.0367 - val_loss: 0.1230
Epoch 220/600
14/14 [=====] - 0s 6ms/step - loss: 0.0348 - val_loss: 0.1205
Epoch 221/600
14/14 [=====] - 0s 6ms/step - loss: 0.0387 - val_loss: 0.1347
Epoch 222/600
14/14 [=====] - 0s 6ms/step - loss: 0.0388 - val_loss: 0.1185
Epoch 223/600
14/14 [=====] - 0s 5ms/step - loss: 0.0360 - val_loss: 0.1285
Epoch 224/600
14/14 [=====] - 0s 5ms/step - loss: 0.0350 - val_loss: 0.1210
Epoch 225/600
14/14 [=====] - 0s 5ms/step - loss: 0.0358 - val_loss: 0.1221
Epoch 226/600
14/14 [=====] - 0s 5ms/step - loss: 0.0345 - val_loss: 0.1202
Epoch 227/600
14/14 [=====] - 0s 5ms/step - loss: 0.0356 - val_loss: 0.1368
Epoch 228/600
14/14 [=====] - 0s 6ms/step - loss: 0.0373 - val_loss: 0.1193
Epoch 229/600
14/14 [=====] - 0s 5ms/step - loss: 0.0452 - val_loss: 0.1277
Epoch 230/600
14/14 [=====] - 0s 5ms/step - loss: 0.0369 - val_loss: 0.1217
Epoch 231/600
14/14 [=====] - 0s 6ms/step - loss: 0.0337 - val_loss: 0.1305
Epoch 232/600
14/14 [=====] - 0s 5ms/step - loss: 0.0341 - val_loss: 0.1220
Epoch 233/600
14/14 [=====] - 0s 5ms/step - loss: 0.0343 - val_loss: 0.1277
Epoch 234/600
14/14 [=====] - 0s 5ms/step - loss: 0.0340 - val_loss: 0.1222
Epoch 235/600
14/14 [=====] - 0s 5ms/step - loss: 0.0354 - val_loss: 0.1283
Epoch 236/600
14/14 [=====] - 0s 5ms/step - loss: 0.0343 - val_loss: 0.1230
Epoch 237/600
14/14 [=====] - 0s 5ms/step - loss: 0.0351 - val_loss: 0.1245
Epoch 238/600
14/14 [=====] - 0s 6ms/step - loss: 0.0353 - val_loss: 0.1346
Epoch 239/600
14/14 [=====] - 0s 5ms/step - loss: 0.0381 - val_loss: 0.1264
Epoch 240/600
14/14 [=====] - 0s 5ms/step - loss: 0.0338 - val_loss: 0.1257
Epoch 241/600
14/14 [=====] - 0s 6ms/step - loss: 0.0332 - val_loss: 0.1255
Epoch 242/600
14/14 [=====] - 0s 5ms/step - loss: 0.0333 - val_loss: 0.1256
Epoch 243/600
14/14 [=====] - 0s 5ms/step - loss: 0.0365 - val_loss: 0.1272
Epoch 244/600
14/14 [=====] - 0s 6ms/step - loss: 0.0335 - val_loss: 0.1215
Epoch 245/600
14/14 [=====] - 0s 6ms/step - loss: 0.0369 - val_loss: 0.1360
Epoch 246/600
14/14 [=====] - 0s 5ms/step - loss: 0.0361 - val_loss: 0.1288
Epoch 247/600
14/14 [=====] - 0s 5ms/step - loss: 0.0329 - val_loss: 0.1287
Epoch 248/600
14/14 [=====] - 0s 5ms/step - loss: 0.0330 - val_loss: 0.1241
Epoch 249/600

14/14 [=====] - 0s 5ms/step - loss: 0.0389 - val_loss: 0.1508
Epoch 250/600
14/14 [=====] - 0s 5ms/step - loss: 0.0358 - val_loss: 0.1232
Epoch 251/600
14/14 [=====] - 0s 5ms/step - loss: 0.0379 - val_loss: 0.1324
Epoch 252/600
14/14 [=====] - 0s 5ms/step - loss: 0.0380 - val_loss: 0.1245
Epoch 253/600
14/14 [=====] - 0s 5ms/step - loss: 0.0335 - val_loss: 0.1291
Epoch 254/600
14/14 [=====] - 0s 6ms/step - loss: 0.0352 - val_loss: 0.1245
Epoch 255/600
14/14 [=====] - 0s 5ms/step - loss: 0.0335 - val_loss: 0.1363
Epoch 256/600
14/14 [=====] - 0s 5ms/step - loss: 0.0314 - val_loss: 0.1246
Epoch 257/600
14/14 [=====] - 0s 5ms/step - loss: 0.0338 - val_loss: 0.1332
Epoch 258/600
14/14 [=====] - 0s 5ms/step - loss: 0.0380 - val_loss: 0.1267
Epoch 259/600
14/14 [=====] - 0s 4ms/step - loss: 0.0351 - val_loss: 0.1303
Epoch 260/600
14/14 [=====] - 0s 5ms/step - loss: 0.0315 - val_loss: 0.1380
Epoch 261/600
14/14 [=====] - 0s 6ms/step - loss: 0.0321 - val_loss: 0.1309
Epoch 262/600
14/14 [=====] - 0s 5ms/step - loss: 0.0318 - val_loss: 0.1292
Epoch 263/600
14/14 [=====] - 0s 5ms/step - loss: 0.0333 - val_loss: 0.1285
Epoch 264/600
14/14 [=====] - 0s 5ms/step - loss: 0.0333 - val_loss: 0.1300
Epoch 265/600
14/14 [=====] - 0s 5ms/step - loss: 0.0388 - val_loss: 0.1449
Epoch 266/600
14/14 [=====] - 0s 5ms/step - loss: 0.0348 - val_loss: 0.1362
Epoch 267/600
14/14 [=====] - 0s 5ms/step - loss: 0.0317 - val_loss: 0.1361
Epoch 268/600
14/14 [=====] - 0s 5ms/step - loss: 0.0316 - val_loss: 0.1314
Epoch 269/600
14/14 [=====] - 0s 5ms/step - loss: 0.0327 - val_loss: 0.1332
Epoch 270/600
14/14 [=====] - 0s 5ms/step - loss: 0.0312 - val_loss: 0.1345
Epoch 271/600
14/14 [=====] - 0s 5ms/step - loss: 0.0324 - val_loss: 0.1278
Epoch 272/600
14/14 [=====] - 0s 5ms/step - loss: 0.0393 - val_loss: 0.1448
Epoch 273/600
14/14 [=====] - 0s 5ms/step - loss: 0.0345 - val_loss: 0.1277
Epoch 274/600
14/14 [=====] - 0s 4ms/step - loss: 0.0319 - val_loss: 0.1370
Epoch 275/600
14/14 [=====] - 0s 5ms/step - loss: 0.0314 - val_loss: 0.1297
Epoch 276/600
14/14 [=====] - 0s 4ms/step - loss: 0.0305 - val_loss: 0.1442
Epoch 277/600
14/14 [=====] - 0s 5ms/step - loss: 0.0310 - val_loss: 0.1285
Epoch 278/600
14/14 [=====] - 0s 5ms/step - loss: 0.0347 - val_loss: 0.1350
Epoch 279/600
14/14 [=====] - 0s 5ms/step - loss: 0.0342 - val_loss: 0.1382
Epoch 280/600
14/14 [=====] - 0s 5ms/step - loss: 0.0342 - val_loss: 0.1324
Epoch 281/600
14/14 [=====] - 0s 4ms/step - loss: 0.0313 - val_loss: 0.1320
Epoch 282/600
14/14 [=====] - 0s 5ms/step - loss: 0.0299 - val_loss: 0.1389
Epoch 283/600
14/14 [=====] - 0s 5ms/step - loss: 0.0305 - val_loss: 0.1395
Epoch 284/600
14/14 [=====] - 0s 4ms/step - loss: 0.0323 - val_loss: 0.1305
Epoch 285/600
14/14 [=====] - 0s 4ms/step - loss: 0.0310 - val_loss: 0.1357
Epoch 286/600
14/14 [=====] - 0s 5ms/step - loss: 0.0308 - val_loss: 0.1366
Epoch 287/600
14/14 [=====] - 0s 5ms/step - loss: 0.0298 - val_loss: 0.1395
Epoch 288/600
14/14 [=====] - 0s 5ms/step - loss: 0.0306 - val_loss: 0.1398
Epoch 289/600
14/14 [=====] - 0s 4ms/step - loss: 0.0302 - val_loss: 0.1405
Epoch 290/600
14/14 [=====] - 0s 5ms/step - loss: 0.0302 - val_loss: 0.1352
Epoch 291/600
14/14 [=====] - 0s 5ms/step - loss: 0.0301 - val_loss: 0.1341
Epoch 292/600
14/14 [=====] - 0s 4ms/step - loss: 0.0300 - val_loss: 0.1327
Epoch 293/600
14/14 [=====] - 0s 4ms/step - loss: 0.0306 - val_loss: 0.1339

Epoch 294/600
14/14 [=====] - 0s 5ms/step - loss: 0.0299 - val_loss: 0.1370
Epoch 295/600
14/14 [=====] - 0s 5ms/step - loss: 0.0298 - val_loss: 0.1352
Epoch 296/600
14/14 [=====] - 0s 5ms/step - loss: 0.0307 - val_loss: 0.1419
Epoch 297/600
14/14 [=====] - 0s 4ms/step - loss: 0.0310 - val_loss: 0.1355
Epoch 298/600
14/14 [=====] - 0s 5ms/step - loss: 0.0316 - val_loss: 0.1435
Epoch 299/600
14/14 [=====] - 0s 4ms/step - loss: 0.0302 - val_loss: 0.1355
Epoch 300/600
14/14 [=====] - 0s 5ms/step - loss: 0.0305 - val_loss: 0.1444
Epoch 301/600
14/14 [=====] - 0s 5ms/step - loss: 0.0316 - val_loss: 0.1387
Epoch 302/600
14/14 [=====] - 0s 4ms/step - loss: 0.0388 - val_loss: 0.1384
Epoch 303/600
14/14 [=====] - 0s 4ms/step - loss: 0.0352 - val_loss: 0.1369
Epoch 304/600
14/14 [=====] - 0s 5ms/step - loss: 0.0398 - val_loss: 0.1397
Epoch 305/600
14/14 [=====] - 0s 5ms/step - loss: 0.0310 - val_loss: 0.1371
Epoch 306/600
14/14 [=====] - 0s 5ms/step - loss: 0.0284 - val_loss: 0.1419
Epoch 307/600
14/14 [=====] - 0s 5ms/step - loss: 0.0292 - val_loss: 0.1327
Epoch 308/600
14/14 [=====] - 0s 5ms/step - loss: 0.0298 - val_loss: 0.1433
Epoch 309/600
14/14 [=====] - 0s 4ms/step - loss: 0.0299 - val_loss: 0.1382
Epoch 310/600
14/14 [=====] - 0s 5ms/step - loss: 0.0307 - val_loss: 0.1397
Epoch 311/600
14/14 [=====] - 0s 5ms/step - loss: 0.0284 - val_loss: 0.1371
Epoch 312/600
14/14 [=====] - 0s 5ms/step - loss: 0.0308 - val_loss: 0.1447
Epoch 313/600
14/14 [=====] - 0s 5ms/step - loss: 0.0280 - val_loss: 0.1397
Epoch 314/600
14/14 [=====] - 0s 5ms/step - loss: 0.0295 - val_loss: 0.1495
Epoch 315/600
14/14 [=====] - 0s 5ms/step - loss: 0.0327 - val_loss: 0.1396
Epoch 316/600
14/14 [=====] - 0s 5ms/step - loss: 0.0281 - val_loss: 0.1394
Epoch 317/600
14/14 [=====] - 0s 5ms/step - loss: 0.0272 - val_loss: 0.1402
Epoch 318/600
14/14 [=====] - 0s 5ms/step - loss: 0.0274 - val_loss: 0.1437
Epoch 319/600
14/14 [=====] - 0s 5ms/step - loss: 0.0277 - val_loss: 0.1440
Epoch 320/600
14/14 [=====] - 0s 5ms/step - loss: 0.0266 - val_loss: 0.1381
Epoch 321/600
14/14 [=====] - 0s 5ms/step - loss: 0.0292 - val_loss: 0.1437
Epoch 322/600
14/14 [=====] - 0s 5ms/step - loss: 0.0268 - val_loss: 0.1404
Epoch 323/600
14/14 [=====] - 0s 6ms/step - loss: 0.0273 - val_loss: 0.1457
Epoch 324/600
14/14 [=====] - 0s 5ms/step - loss: 0.0266 - val_loss: 0.1384
Epoch 325/600
14/14 [=====] - 0s 5ms/step - loss: 0.0373 - val_loss: 0.1840
Epoch 326/600
14/14 [=====] - 0s 5ms/step - loss: 0.0401 - val_loss: 0.1379
Epoch 327/600
14/14 [=====] - 0s 5ms/step - loss: 0.0401 - val_loss: 0.1380
Epoch 328/600
14/14 [=====] - 0s 4ms/step - loss: 0.0327 - val_loss: 0.1442
Epoch 329/600
14/14 [=====] - 0s 5ms/step - loss: 0.0285 - val_loss: 0.1385
Epoch 330/600
14/14 [=====] - 0s 5ms/step - loss: 0.0291 - val_loss: 0.1446
Epoch 331/600
14/14 [=====] - 0s 5ms/step - loss: 0.0282 - val_loss: 0.1384
Epoch 332/600
14/14 [=====] - 0s 4ms/step - loss: 0.0264 - val_loss: 0.1421
Epoch 333/600
14/14 [=====] - 0s 5ms/step - loss: 0.0275 - val_loss: 0.1466
Epoch 334/600
14/14 [=====] - 0s 5ms/step - loss: 0.0265 - val_loss: 0.1421
Epoch 335/600
14/14 [=====] - 0s 5ms/step - loss: 0.0299 - val_loss: 0.1451
Epoch 336/600
14/14 [=====] - 0s 4ms/step - loss: 0.0286 - val_loss: 0.1448
Epoch 337/600
14/14 [=====] - 0s 4ms/step - loss: 0.0301 - val_loss: 0.1427
Epoch 338/600

14/14 [=====] - 0s 5ms/step - loss: 0.0284 - val_loss: 0.1446
Epoch 339/600
14/14 [=====] - 0s 5ms/step - loss: 0.0256 - val_loss: 0.1420
Epoch 340/600
14/14 [=====] - 0s 5ms/step - loss: 0.0258 - val_loss: 0.1470
Epoch 341/600
14/14 [=====] - 0s 5ms/step - loss: 0.0277 - val_loss: 0.1497
Epoch 342/600
14/14 [=====] - 0s 5ms/step - loss: 0.0253 - val_loss: 0.1428
Epoch 343/600
14/14 [=====] - 0s 5ms/step - loss: 0.0261 - val_loss: 0.1443
Epoch 344/600
14/14 [=====] - 0s 4ms/step - loss: 0.0272 - val_loss: 0.1434
Epoch 345/600
14/14 [=====] - 0s 4ms/step - loss: 0.0275 - val_loss: 0.1516
Epoch 346/600
14/14 [=====] - 0s 5ms/step - loss: 0.0268 - val_loss: 0.1452
Epoch 347/600
14/14 [=====] - 0s 6ms/step - loss: 0.0251 - val_loss: 0.1446
Epoch 348/600
14/14 [=====] - 0s 5ms/step - loss: 0.0257 - val_loss: 0.1435
Epoch 349/600
14/14 [=====] - 0s 6ms/step - loss: 0.0263 - val_loss: 0.1466
Epoch 350/600
14/14 [=====] - 0s 6ms/step - loss: 0.0280 - val_loss: 0.1419
Epoch 351/600
14/14 [=====] - 0s 8ms/step - loss: 0.0260 - val_loss: 0.1424
Epoch 352/600
14/14 [=====] - 0s 8ms/step - loss: 0.0246 - val_loss: 0.1484
Epoch 353/600
14/14 [=====] - 0s 7ms/step - loss: 0.0250 - val_loss: 0.1467
Epoch 354/600
14/14 [=====] - 0s 9ms/step - loss: 0.0253 - val_loss: 0.1533
Epoch 355/600
14/14 [=====] - 0s 9ms/step - loss: 0.0270 - val_loss: 0.1443
Epoch 356/600
14/14 [=====] - 0s 8ms/step - loss: 0.0254 - val_loss: 0.1481
Epoch 357/600
14/14 [=====] - 0s 6ms/step - loss: 0.0245 - val_loss: 0.1453
Epoch 358/600
14/14 [=====] - 0s 7ms/step - loss: 0.0284 - val_loss: 0.1432
Epoch 359/600
14/14 [=====] - 0s 8ms/step - loss: 0.0261 - val_loss: 0.1539
Epoch 360/600
14/14 [=====] - 0s 7ms/step - loss: 0.0250 - val_loss: 0.1464
Epoch 361/600
14/14 [=====] - 0s 6ms/step - loss: 0.0248 - val_loss: 0.1448
Epoch 362/600
14/14 [=====] - 0s 6ms/step - loss: 0.0246 - val_loss: 0.1580
Epoch 363/600
14/14 [=====] - 0s 6ms/step - loss: 0.0280 - val_loss: 0.1432
Epoch 364/600
14/14 [=====] - 0s 6ms/step - loss: 0.0275 - val_loss: 0.1732
Epoch 365/600
14/14 [=====] - 0s 6ms/step - loss: 0.0256 - val_loss: 0.1460
Epoch 366/600
14/14 [=====] - 0s 7ms/step - loss: 0.0254 - val_loss: 0.1491
Epoch 367/600
14/14 [=====] - 0s 7ms/step - loss: 0.0247 - val_loss: 0.1472
Epoch 368/600
14/14 [=====] - 0s 7ms/step - loss: 0.0263 - val_loss: 0.1456
Epoch 369/600
14/14 [=====] - 0s 6ms/step - loss: 0.0256 - val_loss: 0.1531
Epoch 370/600
14/14 [=====] - 0s 8ms/step - loss: 0.0240 - val_loss: 0.1445
Epoch 371/600
14/14 [=====] - 0s 8ms/step - loss: 0.0243 - val_loss: 0.1500
Epoch 372/600
14/14 [=====] - 0s 8ms/step - loss: 0.0233 - val_loss: 0.1460
Epoch 373/600
14/14 [=====] - 0s 6ms/step - loss: 0.0232 - val_loss: 0.1574
Epoch 374/600
14/14 [=====] - 0s 7ms/step - loss: 0.0255 - val_loss: 0.1446
Epoch 375/600
14/14 [=====] - 0s 12ms/step - loss: 0.0285 - val_loss: 0.1773
Epoch 376/600
14/14 [=====] - 0s 9ms/step - loss: 0.0276 - val_loss: 0.1437
Epoch 377/600
14/14 [=====] - 0s 10ms/step - loss: 0.0248 - val_loss: 0.1586
Epoch 378/600
14/14 [=====] - 0s 12ms/step - loss: 0.0250 - val_loss: 0.1467
Epoch 379/600
14/14 [=====] - 0s 12ms/step - loss: 0.0257 - val_loss: 0.1594
Epoch 380/600
14/14 [=====] - 0s 14ms/step - loss: 0.0255 - val_loss: 0.1469
Epoch 381/600
14/14 [=====] - 0s 14ms/step - loss: 0.0233 - val_loss: 0.1562
Epoch 382/600
14/14 [=====] - 0s 13ms/step - loss: 0.0239 - val_loss: 0.1473

Epoch 383/600
14/14 [=====] - 0s 11ms/step - loss: 0.0257 - val_loss: 0.1475
Epoch 384/600
14/14 [=====] - 0s 11ms/step - loss: 0.0236 - val_loss: 0.1510
Epoch 385/600
14/14 [=====] - 0s 12ms/step - loss: 0.0226 - val_loss: 0.1499
Epoch 386/600
14/14 [=====] - 0s 11ms/step - loss: 0.0234 - val_loss: 0.1524
Epoch 387/600
14/14 [=====] - 0s 10ms/step - loss: 0.0236 - val_loss: 0.1581
Epoch 388/600
14/14 [=====] - 0s 15ms/step - loss: 0.0238 - val_loss: 0.1503
Epoch 389/600
14/14 [=====] - 0s 11ms/step - loss: 0.0235 - val_loss: 0.1762
Epoch 390/600
14/14 [=====] - 0s 12ms/step - loss: 0.0230 - val_loss: 0.1495
Epoch 391/600
14/14 [=====] - 0s 8ms/step - loss: 0.0278 - val_loss: 0.1636
Epoch 392/600
14/14 [=====] - 0s 9ms/step - loss: 0.0261 - val_loss: 0.1579
Epoch 393/600
14/14 [=====] - 0s 9ms/step - loss: 0.0224 - val_loss: 0.1505
Epoch 394/600
14/14 [=====] - 0s 9ms/step - loss: 0.0224 - val_loss: 0.1554
Epoch 395/600
14/14 [=====] - 0s 8ms/step - loss: 0.0241 - val_loss: 0.1512
Epoch 396/600
14/14 [=====] - 0s 7ms/step - loss: 0.0221 - val_loss: 0.1633
Epoch 397/600
14/14 [=====] - 0s 7ms/step - loss: 0.0265 - val_loss: 0.1523
Epoch 398/600
14/14 [=====] - 0s 8ms/step - loss: 0.0242 - val_loss: 0.1633
Epoch 399/600
14/14 [=====] - 0s 8ms/step - loss: 0.0307 - val_loss: 0.1493
Epoch 400/600
14/14 [=====] - 0s 8ms/step - loss: 0.0290 - val_loss: 0.1620
Epoch 401/600
14/14 [=====] - 0s 7ms/step - loss: 0.0252 - val_loss: 0.1533
Epoch 402/600
14/14 [=====] - 0s 7ms/step - loss: 0.0238 - val_loss: 0.1588
Epoch 403/600
14/14 [=====] - 0s 7ms/step - loss: 0.0218 - val_loss: 0.1525
Epoch 404/600
14/14 [=====] - 0s 7ms/step - loss: 0.0261 - val_loss: 0.1835
Epoch 405/600
14/14 [=====] - 0s 12ms/step - loss: 0.0283 - val_loss: 0.1523
Epoch 406/600
14/14 [=====] - 0s 20ms/step - loss: 0.0275 - val_loss: 0.1633
Epoch 407/600
14/14 [=====] - 0s 12ms/step - loss: 0.0210 - val_loss: 0.1531
Epoch 408/600
14/14 [=====] - 0s 17ms/step - loss: 0.0220 - val_loss: 0.1595
Epoch 409/600
14/14 [=====] - 0s 12ms/step - loss: 0.0212 - val_loss: 0.1564
Epoch 410/600
14/14 [=====] - 0s 13ms/step - loss: 0.0212 - val_loss: 0.1623
Epoch 411/600
14/14 [=====] - 0s 19ms/step - loss: 0.0208 - val_loss: 0.1585
Epoch 412/600
14/14 [=====] - 0s 11ms/step - loss: 0.0218 - val_loss: 0.1613
Epoch 413/600
14/14 [=====] - 0s 12ms/step - loss: 0.0207 - val_loss: 0.1595
Epoch 414/600
14/14 [=====] - 0s 16ms/step - loss: 0.0213 - val_loss: 0.1577
Epoch 415/600
14/14 [=====] - 0s 13ms/step - loss: 0.0212 - val_loss: 0.1643
Epoch 416/600
14/14 [=====] - 0s 12ms/step - loss: 0.0227 - val_loss: 0.1574
Epoch 417/600
14/14 [=====] - 0s 15ms/step - loss: 0.0207 - val_loss: 0.1646
Epoch 418/600
14/14 [=====] - 0s 13ms/step - loss: 0.0208 - val_loss: 0.1600
Epoch 419/600
14/14 [=====] - 0s 12ms/step - loss: 0.0200 - val_loss: 0.1594
Epoch 420/600
14/14 [=====] - 0s 10ms/step - loss: 0.0198 - val_loss: 0.1650
Epoch 421/600
14/14 [=====] - 0s 10ms/step - loss: 0.0210 - val_loss: 0.1650
Epoch 422/600
14/14 [=====] - 0s 11ms/step - loss: 0.0238 - val_loss: 0.1589
Epoch 423/600
14/14 [=====] - 0s 9ms/step - loss: 0.0246 - val_loss: 0.1744
Epoch 424/600
14/14 [=====] - 0s 9ms/step - loss: 0.0203 - val_loss: 0.1583
Epoch 425/600
14/14 [=====] - 0s 10ms/step - loss: 0.0268 - val_loss: 0.1634
Epoch 426/600
14/14 [=====] - 0s 11ms/step - loss: 0.0205 - val_loss: 0.1653
Epoch 427/600

14/14 [=====] - 0s 12ms/step - loss: 0.0197 - val_loss: 0.1612
Epoch 428/600
14/14 [=====] - 0s 11ms/step - loss: 0.0198 - val_loss: 0.1636
Epoch 429/600
14/14 [=====] - 0s 10ms/step - loss: 0.0200 - val_loss: 0.1616
Epoch 430/600
14/14 [=====] - 0s 10ms/step - loss: 0.0192 - val_loss: 0.1625
Epoch 431/600
14/14 [=====] - 0s 11ms/step - loss: 0.0198 - val_loss: 0.1631
Epoch 432/600
14/14 [=====] - 0s 9ms/step - loss: 0.0224 - val_loss: 0.1665
Epoch 433/600
14/14 [=====] - 0s 9ms/step - loss: 0.0221 - val_loss: 0.1581
Epoch 434/600
14/14 [=====] - 0s 9ms/step - loss: 0.0475 - val_loss: 0.2083
Epoch 435/600
14/14 [=====] - 0s 9ms/step - loss: 0.0303 - val_loss: 0.1538
Epoch 436/600
14/14 [=====] - 0s 9ms/step - loss: 0.0254 - val_loss: 0.1690
Epoch 437/600
14/14 [=====] - 0s 9ms/step - loss: 0.0212 - val_loss: 0.1538
Epoch 438/600
14/14 [=====] - 0s 8ms/step - loss: 0.0205 - val_loss: 0.1570
Epoch 439/600
14/14 [=====] - 0s 8ms/step - loss: 0.0282 - val_loss: 0.1549
Epoch 440/600
14/14 [=====] - 0s 8ms/step - loss: 0.0227 - val_loss: 0.1548
Epoch 441/600
14/14 [=====] - 0s 8ms/step - loss: 0.0215 - val_loss: 0.1533
Epoch 442/600
14/14 [=====] - 0s 8ms/step - loss: 0.0239 - val_loss: 0.1588
Epoch 443/600
14/14 [=====] - 0s 8ms/step - loss: 0.0196 - val_loss: 0.1580
Epoch 444/600
14/14 [=====] - 0s 7ms/step - loss: 0.0179 - val_loss: 0.1603
Epoch 445/600
14/14 [=====] - 0s 6ms/step - loss: 0.0182 - val_loss: 0.1582
Epoch 446/600
14/14 [=====] - 0s 5ms/step - loss: 0.0200 - val_loss: 0.1673
Epoch 447/600
14/14 [=====] - 0s 5ms/step - loss: 0.0192 - val_loss: 0.1603
Epoch 448/600
14/14 [=====] - 0s 6ms/step - loss: 0.0206 - val_loss: 0.1628
Epoch 449/600
14/14 [=====] - 0s 5ms/step - loss: 0.0218 - val_loss: 0.1571
Epoch 450/600
14/14 [=====] - 0s 5ms/step - loss: 0.0183 - val_loss: 0.1605
Epoch 451/600
14/14 [=====] - 0s 5ms/step - loss: 0.0187 - val_loss: 0.1658
Epoch 452/600
14/14 [=====] - 0s 5ms/step - loss: 0.0182 - val_loss: 0.1580
Epoch 453/600
14/14 [=====] - 0s 5ms/step - loss: 0.0202 - val_loss: 0.1655
Epoch 454/600
14/14 [=====] - 0s 6ms/step - loss: 0.0195 - val_loss: 0.1600
Epoch 455/600
14/14 [=====] - 0s 5ms/step - loss: 0.0186 - val_loss: 0.1714
Epoch 456/600
14/14 [=====] - 0s 6ms/step - loss: 0.0187 - val_loss: 0.1655
Epoch 457/600
14/14 [=====] - 0s 6ms/step - loss: 0.0184 - val_loss: 0.1654
Epoch 458/600
14/14 [=====] - 0s 5ms/step - loss: 0.0264 - val_loss: 0.1615
Epoch 459/600
14/14 [=====] - 0s 5ms/step - loss: 0.0190 - val_loss: 0.1646
Epoch 460/600
14/14 [=====] - 0s 5ms/step - loss: 0.0184 - val_loss: 0.1636
Epoch 461/600
14/14 [=====] - 0s 4ms/step - loss: 0.0174 - val_loss: 0.1656
Epoch 462/600
14/14 [=====] - 0s 5ms/step - loss: 0.0173 - val_loss: 0.1654
Epoch 463/600
14/14 [=====] - 0s 5ms/step - loss: 0.0175 - val_loss: 0.1666
Epoch 464/600
14/14 [=====] - 0s 5ms/step - loss: 0.0170 - val_loss: 0.1672
Epoch 465/600
14/14 [=====] - 0s 5ms/step - loss: 0.0205 - val_loss: 0.1616
Epoch 466/600
14/14 [=====] - 0s 5ms/step - loss: 0.0197 - val_loss: 0.1786
Epoch 467/600
14/14 [=====] - 0s 5ms/step - loss: 0.0203 - val_loss: 0.1650
Epoch 468/600
14/14 [=====] - 0s 5ms/step - loss: 0.0192 - val_loss: 0.1654
Epoch 469/600
14/14 [=====] - 0s 5ms/step - loss: 0.0168 - val_loss: 0.1637
Epoch 470/600
14/14 [=====] - 0s 4ms/step - loss: 0.0160 - val_loss: 0.1673
Epoch 471/600
14/14 [=====] - 0s 5ms/step - loss: 0.0182 - val_loss: 0.1658

Epoch 472/600
14/14 [=====] - 0s 5ms/step - loss: 0.0242 - val_loss: 0.1639
Epoch 473/600
14/14 [=====] - 0s 5ms/step - loss: 0.0220 - val_loss: 0.1782
Epoch 474/600
14/14 [=====] - 0s 5ms/step - loss: 0.0165 - val_loss: 0.1644
Epoch 475/600
14/14 [=====] - 0s 4ms/step - loss: 0.0173 - val_loss: 0.1762
Epoch 476/600
14/14 [=====] - 0s 5ms/step - loss: 0.0175 - val_loss: 0.1643
Epoch 477/600
14/14 [=====] - 0s 5ms/step - loss: 0.0166 - val_loss: 0.1655
Epoch 478/600
14/14 [=====] - 0s 5ms/step - loss: 0.0161 - val_loss: 0.1677
Epoch 479/600
14/14 [=====] - 0s 5ms/step - loss: 0.0156 - val_loss: 0.1683
Epoch 480/600
14/14 [=====] - 0s 5ms/step - loss: 0.0169 - val_loss: 0.1745
Epoch 481/600
14/14 [=====] - 0s 5ms/step - loss: 0.0171 - val_loss: 0.1647
Epoch 482/600
14/14 [=====] - 0s 6ms/step - loss: 0.0150 - val_loss: 0.1713
Epoch 483/600
14/14 [=====] - 0s 5ms/step - loss: 0.0167 - val_loss: 0.1659
Epoch 484/600
14/14 [=====] - 0s 5ms/step - loss: 0.0166 - val_loss: 0.1696
Epoch 485/600
14/14 [=====] - 0s 5ms/step - loss: 0.0149 - val_loss: 0.1678
Epoch 486/600
14/14 [=====] - 0s 5ms/step - loss: 0.0189 - val_loss: 0.1756
Epoch 487/600
14/14 [=====] - 0s 5ms/step - loss: 0.0171 - val_loss: 0.1713
Epoch 488/600
14/14 [=====] - 0s 5ms/step - loss: 0.0160 - val_loss: 0.1708
Epoch 489/600
14/14 [=====] - 0s 5ms/step - loss: 0.0177 - val_loss: 0.1707
Epoch 490/600
14/14 [=====] - 0s 5ms/step - loss: 0.0169 - val_loss: 0.1781
Epoch 491/600
14/14 [=====] - 0s 5ms/step - loss: 0.0157 - val_loss: 0.1722
Epoch 492/600
14/14 [=====] - 0s 5ms/step - loss: 0.0166 - val_loss: 0.1839
Epoch 493/600
14/14 [=====] - 0s 5ms/step - loss: 0.0176 - val_loss: 0.1705
Epoch 494/600
14/14 [=====] - 0s 5ms/step - loss: 0.0166 - val_loss: 0.1854
Epoch 495/600
14/14 [=====] - 0s 4ms/step - loss: 0.0191 - val_loss: 0.1679
Epoch 496/600
14/14 [=====] - 0s 4ms/step - loss: 0.0162 - val_loss: 0.1749
Epoch 497/600
14/14 [=====] - 0s 4ms/step - loss: 0.0149 - val_loss: 0.1720
Epoch 498/600
14/14 [=====] - 0s 5ms/step - loss: 0.0156 - val_loss: 0.1711
Epoch 499/600
14/14 [=====] - 0s 5ms/step - loss: 0.0177 - val_loss: 0.1785
Epoch 500/600
14/14 [=====] - 0s 5ms/step - loss: 0.0188 - val_loss: 0.1682
Epoch 501/600
14/14 [=====] - 0s 5ms/step - loss: 0.0164 - val_loss: 0.1700
Epoch 502/600
14/14 [=====] - 0s 5ms/step - loss: 0.0173 - val_loss: 0.1849
Epoch 503/600
14/14 [=====] - 0s 4ms/step - loss: 0.0184 - val_loss: 0.1656
Epoch 504/600
14/14 [=====] - 0s 5ms/step - loss: 0.0180 - val_loss: 0.1882
Epoch 505/600
14/14 [=====] - 0s 4ms/step - loss: 0.0182 - val_loss: 0.1679
Epoch 506/600
14/14 [=====] - 0s 5ms/step - loss: 0.0145 - val_loss: 0.1697
Epoch 507/600
14/14 [=====] - 0s 5ms/step - loss: 0.0143 - val_loss: 0.1739
Epoch 508/600
14/14 [=====] - 0s 5ms/step - loss: 0.0138 - val_loss: 0.1709
Epoch 509/600
14/14 [=====] - 0s 4ms/step - loss: 0.0136 - val_loss: 0.1713
Epoch 510/600
14/14 [=====] - 0s 4ms/step - loss: 0.0139 - val_loss: 0.1713
Epoch 511/600
14/14 [=====] - 0s 5ms/step - loss: 0.0135 - val_loss: 0.1699
Epoch 512/600
14/14 [=====] - 0s 5ms/step - loss: 0.0137 - val_loss: 0.1713
Epoch 513/600
14/14 [=====] - 0s 4ms/step - loss: 0.0135 - val_loss: 0.1712
Epoch 514/600
14/14 [=====] - 0s 5ms/step - loss: 0.0132 - val_loss: 0.1763
Epoch 515/600
14/14 [=====] - 0s 5ms/step - loss: 0.0137 - val_loss: 0.1761
Epoch 516/600

14/14 [=====] - 0s 5ms/step - loss: 0.0148 - val_loss: 0.1720
Epoch 517/600
14/14 [=====] - 0s 5ms/step - loss: 0.0145 - val_loss: 0.1807
Epoch 518/600
14/14 [=====] - 0s 5ms/step - loss: 0.0137 - val_loss: 0.1702
Epoch 519/600
14/14 [=====] - 0s 5ms/step - loss: 0.0129 - val_loss: 0.1743
Epoch 520/600
14/14 [=====] - 0s 5ms/step - loss: 0.0130 - val_loss: 0.1735
Epoch 521/600
14/14 [=====] - 0s 5ms/step - loss: 0.0131 - val_loss: 0.1769
Epoch 522/600
14/14 [=====] - 0s 5ms/step - loss: 0.0140 - val_loss: 0.1751
Epoch 523/600
14/14 [=====] - 0s 5ms/step - loss: 0.0136 - val_loss: 0.1735
Epoch 524/600
14/14 [=====] - 0s 5ms/step - loss: 0.0125 - val_loss: 0.1776
Epoch 525/600
14/14 [=====] - 0s 5ms/step - loss: 0.0128 - val_loss: 0.1746
Epoch 526/600
14/14 [=====] - 0s 5ms/step - loss: 0.0157 - val_loss: 0.1826
Epoch 527/600
14/14 [=====] - 0s 7ms/step - loss: 0.0142 - val_loss: 0.1740
Epoch 528/600
14/14 [=====] - 0s 6ms/step - loss: 0.0149 - val_loss: 0.1726
Epoch 529/600
14/14 [=====] - 0s 5ms/step - loss: 0.0213 - val_loss: 0.2102
Epoch 530/600
14/14 [=====] - 0s 5ms/step - loss: 0.0152 - val_loss: 0.1730
Epoch 531/600
14/14 [=====] - 0s 5ms/step - loss: 0.0143 - val_loss: 0.1795
Epoch 532/600
14/14 [=====] - 0s 5ms/step - loss: 0.0134 - val_loss: 0.1815
Epoch 533/600
14/14 [=====] - 0s 5ms/step - loss: 0.0129 - val_loss: 0.1747
Epoch 534/600
14/14 [=====] - 0s 5ms/step - loss: 0.0127 - val_loss: 0.1862
Epoch 535/600
14/14 [=====] - 0s 7ms/step - loss: 0.0169 - val_loss: 0.1757
Epoch 536/600
14/14 [=====] - 0s 5ms/step - loss: 0.0127 - val_loss: 0.1760
Epoch 537/600
14/14 [=====] - 0s 6ms/step - loss: 0.0119 - val_loss: 0.1807
Epoch 538/600
14/14 [=====] - 0s 6ms/step - loss: 0.0130 - val_loss: 0.1749
Epoch 539/600
14/14 [=====] - 0s 6ms/step - loss: 0.0124 - val_loss: 0.1777
Epoch 540/600
14/14 [=====] - 0s 6ms/step - loss: 0.0124 - val_loss: 0.1820
Epoch 541/600
14/14 [=====] - 0s 5ms/step - loss: 0.0164 - val_loss: 0.1767
Epoch 542/600
14/14 [=====] - 0s 5ms/step - loss: 0.0184 - val_loss: 0.2088
Epoch 543/600
14/14 [=====] - 0s 5ms/step - loss: 0.0116 - val_loss: 0.1747
Epoch 544/600
14/14 [=====] - 0s 7ms/step - loss: 0.0160 - val_loss: 0.2280
Epoch 545/600
14/14 [=====] - 0s 6ms/step - loss: 0.0230 - val_loss: 0.1750
Epoch 546/600
14/14 [=====] - 0s 6ms/step - loss: 0.0209 - val_loss: 0.1780
Epoch 547/600
14/14 [=====] - 0s 6ms/step - loss: 0.0174 - val_loss: 0.1788
Epoch 548/600
14/14 [=====] - 0s 6ms/step - loss: 0.0127 - val_loss: 0.1792
Epoch 549/600
14/14 [=====] - 0s 6ms/step - loss: 0.0117 - val_loss: 0.1798
Epoch 550/600
14/14 [=====] - 0s 5ms/step - loss: 0.0110 - val_loss: 0.1813
Epoch 551/600
14/14 [=====] - 0s 5ms/step - loss: 0.0119 - val_loss: 0.1879
Epoch 552/600
14/14 [=====] - 0s 6ms/step - loss: 0.0125 - val_loss: 0.1795
Epoch 553/600
14/14 [=====] - 0s 7ms/step - loss: 0.0127 - val_loss: 0.1835
Epoch 554/600
14/14 [=====] - 0s 7ms/step - loss: 0.0134 - val_loss: 0.1805
Epoch 555/600
14/14 [=====] - 0s 7ms/step - loss: 0.0128 - val_loss: 0.1799
Epoch 556/600
14/14 [=====] - 0s 6ms/step - loss: 0.0146 - val_loss: 0.2050
Epoch 557/600
14/14 [=====] - 0s 6ms/step - loss: 0.0170 - val_loss: 0.1788
Epoch 558/600
14/14 [=====] - 0s 7ms/step - loss: 0.0105 - val_loss: 0.1997
Epoch 559/600
14/14 [=====] - 0s 7ms/step - loss: 0.0171 - val_loss: 0.1791
Epoch 560/600
14/14 [=====] - 0s 6ms/step - loss: 0.0116 - val_loss: 0.1887

```

Epoch 561/600
14/14 [=====] - 0s 7ms/step - loss: 0.0111 - val_loss: 0.1818
Epoch 562/600
14/14 [=====] - 0s 7ms/step - loss: 0.0104 - val_loss: 0.1858
Epoch 563/600
14/14 [=====] - 0s 6ms/step - loss: 0.0104 - val_loss: 0.1829
Epoch 564/600
14/14 [=====] - 0s 6ms/step - loss: 0.0112 - val_loss: 0.1876
Epoch 565/600
14/14 [=====] - 0s 6ms/step - loss: 0.0114 - val_loss: 0.1811
Epoch 566/600
14/14 [=====] - 0s 6ms/step - loss: 0.0119 - val_loss: 0.1877
Epoch 567/600
14/14 [=====] - 0s 7ms/step - loss: 0.0123 - val_loss: 0.1834
Epoch 568/600
14/14 [=====] - 0s 6ms/step - loss: 0.0113 - val_loss: 0.1846
Epoch 569/600
14/14 [=====] - 0s 6ms/step - loss: 0.0107 - val_loss: 0.1822
Epoch 570/600
14/14 [=====] - 0s 6ms/step - loss: 0.0102 - val_loss: 0.1850
Epoch 571/600
14/14 [=====] - 0s 6ms/step - loss: 0.0116 - val_loss: 0.1981
Epoch 572/600
14/14 [=====] - 0s 5ms/step - loss: 0.0147 - val_loss: 0.1806
Epoch 573/600
14/14 [=====] - 0s 5ms/step - loss: 0.0106 - val_loss: 0.1904
Epoch 574/600
14/14 [=====] - 0s 5ms/step - loss: 0.0103 - val_loss: 0.1844
Epoch 575/600
14/14 [=====] - 0s 6ms/step - loss: 0.0104 - val_loss: 0.1954
Epoch 576/600
14/14 [=====] - 0s 6ms/step - loss: 0.0104 - val_loss: 0.1823
Epoch 577/600
14/14 [=====] - 0s 5ms/step - loss: 0.0111 - val_loss: 0.1960
Epoch 578/600
14/14 [=====] - 0s 6ms/step - loss: 0.0118 - val_loss: 0.1863
Epoch 579/600
14/14 [=====] - 0s 6ms/step - loss: 0.0095 - val_loss: 0.1889
Epoch 580/600
14/14 [=====] - 0s 6ms/step - loss: 0.0101 - val_loss: 0.1876
Epoch 581/600
14/14 [=====] - 0s 6ms/step - loss: 0.0096 - val_loss: 0.1890
Epoch 582/600
14/14 [=====] - 0s 7ms/step - loss: 0.0096 - val_loss: 0.1878
Epoch 583/600
14/14 [=====] - 0s 6ms/step - loss: 0.0095 - val_loss: 0.1914
Epoch 584/600
14/14 [=====] - 0s 5ms/step - loss: 0.0109 - val_loss: 0.1855
Epoch 585/600
14/14 [=====] - 0s 6ms/step - loss: 0.0133 - val_loss: 0.2147
Epoch 586/600
14/14 [=====] - 0s 6ms/step - loss: 0.0145 - val_loss: 0.1831
Epoch 587/600
14/14 [=====] - 0s 5ms/step - loss: 0.0106 - val_loss: 0.1965
Epoch 588/600
14/14 [=====] - 0s 5ms/step - loss: 0.0102 - val_loss: 0.1842
Epoch 589/600
14/14 [=====] - 0s 5ms/step - loss: 0.0101 - val_loss: 0.1840
Epoch 590/600
14/14 [=====] - 0s 5ms/step - loss: 0.0094 - val_loss: 0.1889
Epoch 591/600
14/14 [=====] - 0s 5ms/step - loss: 0.0123 - val_loss: 0.1870
Epoch 592/600
14/14 [=====] - 0s 5ms/step - loss: 0.0111 - val_loss: 0.1930
Epoch 593/600
14/14 [=====] - 0s 5ms/step - loss: 0.0119 - val_loss: 0.1859
Epoch 594/600
14/14 [=====] - 0s 5ms/step - loss: 0.0103 - val_loss: 0.1936
Epoch 595/600
14/14 [=====] - 0s 5ms/step - loss: 0.0094 - val_loss: 0.1883
Epoch 596/600
14/14 [=====] - 0s 6ms/step - loss: 0.0098 - val_loss: 0.1989
Epoch 597/600
14/14 [=====] - 0s 5ms/step - loss: 0.0095 - val_loss: 0.1897
Epoch 598/600
14/14 [=====] - 0s 5ms/step - loss: 0.0102 - val_loss: 0.1944
Epoch 599/600
14/14 [=====] - 0s 5ms/step - loss: 0.0095 - val_loss: 0.1956
Epoch 600/600
14/14 [=====] - 0s 5ms/step - loss: 0.0088 - val_loss: 0.1905

```

```
Out[21]: <keras.callbacks.History at 0x13c2e6d4af0>
```

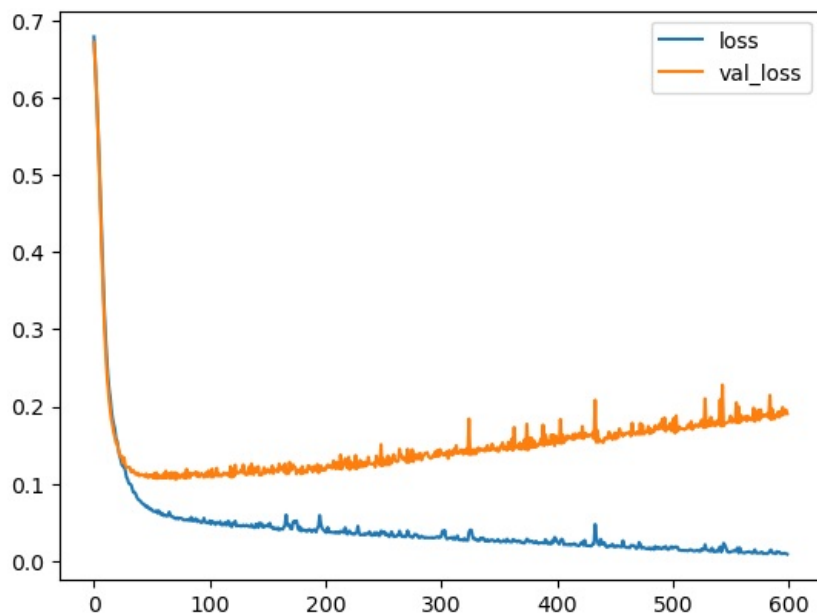
```
In [22]: # model.history.history
```

```
In [23]: model_loss = pd.DataFrame(model.history.history)
```

```
In [24]: # model_loss
```

```
In [25]: model_loss.plot() #Perfect example of overfitting #Training for too many epochs
```

```
Out[25]: <AxesSubplot:>
```



Example Two: Early Stopping

We obviously trained too much! Let's use early stopping to track the val_loss and stop training once it begins increasing too much!

```
In [26]: model = Sequential()  
model.add(Dense(units=30,activation='relu'))  
model.add(Dense(units=15,activation='relu'))  
model.add(Dense(units=1,activation='sigmoid'))  
model.compile(loss='binary_crossentropy', optimizer='adam')
```

```
In [27]: from tensorflow.keras.callbacks import EarlyStopping
```

Stop training when a monitored quantity has stopped improving.

Arguments:

- monitor: Quantity to be monitored.
- min_delta: Minimum change in the monitored quantity to qualify as an improvement, i.e. an absolute change of less than min_delta, will count as no improvement.
- patience: Number of epochs with no improvement after which training will be stopped.
- verbose: verbosity mode.
- mode: One of `{"auto", "min", "max"}`. In `min` mode, training will stop when the quantity monitored has stopped decreasing; in `max` mode it will stop when the quantity monitored has stopped increasing; in `auto` mode, the direction is automatically inferred from the name of the monitored quantity.

```
In [28]: early_stop = EarlyStopping(monitor='val_loss', mode='min', verbose=1, patience=25)
```

```
In [29]: model.fit(x=X_train,  
                y=y_train,  
                epochs=600,  
                validation_data=(X_test, y_test), verbose=1,  
                callbacks=[early_stop]  
            )
```

```
Epoch 1/600  
14/14 [=====] - 1s 20ms/step - loss: 0.6643 - val_loss: 0.6439  
Epoch 2/600  
14/14 [=====] - 0s 10ms/step - loss: 0.6113 - val_loss: 0.5874  
Epoch 3/600  
14/14 [=====] - 0s 6ms/step - loss: 0.5490 - val_loss: 0.5244  
Epoch 4/600  
14/14 [=====] - 0s 7ms/step - loss: 0.4835 - val_loss: 0.4566  
Epoch 5/600  
14/14 [=====] - 0s 18ms/step - loss: 0.4211 - val_loss: 0.3955  
Epoch 6/600
```

```
14/14 [=====] - 0s 9ms/step - loss: 0.3683 - val_loss: 0.3414
Epoch 7/600
14/14 [=====] - 0s 8ms/step - loss: 0.3184 - val_loss: 0.2960
Epoch 8/600
14/14 [=====] - 0s 9ms/step - loss: 0.2810 - val_loss: 0.2632
Epoch 9/600
14/14 [=====] - 0s 7ms/step - loss: 0.2511 - val_loss: 0.2302
Epoch 10/600
14/14 [=====] - 0s 6ms/step - loss: 0.2256 - val_loss: 0.2075
Epoch 11/600
14/14 [=====] - 0s 7ms/step - loss: 0.2068 - val_loss: 0.1888
Epoch 12/600
14/14 [=====] - 0s 10ms/step - loss: 0.1899 - val_loss: 0.1759
Epoch 13/600
14/14 [=====] - 0s 8ms/step - loss: 0.1766 - val_loss: 0.1661
Epoch 14/600
14/14 [=====] - 0s 6ms/step - loss: 0.1648 - val_loss: 0.1579
Epoch 15/600
14/14 [=====] - 0s 6ms/step - loss: 0.1563 - val_loss: 0.1519
Epoch 16/600
14/14 [=====] - 0s 7ms/step - loss: 0.1465 - val_loss: 0.1440
Epoch 17/600
14/14 [=====] - 0s 6ms/step - loss: 0.1422 - val_loss: 0.1413
Epoch 18/600
14/14 [=====] - 0s 6ms/step - loss: 0.1322 - val_loss: 0.1369
Epoch 19/600
14/14 [=====] - 0s 6ms/step - loss: 0.1265 - val_loss: 0.1307
Epoch 20/600
14/14 [=====] - 0s 5ms/step - loss: 0.1219 - val_loss: 0.1320
Epoch 21/600
14/14 [=====] - 0s 6ms/step - loss: 0.1174 - val_loss: 0.1288
Epoch 22/600
14/14 [=====] - 0s 6ms/step - loss: 0.1117 - val_loss: 0.1243
Epoch 23/600
14/14 [=====] - 0s 6ms/step - loss: 0.1069 - val_loss: 0.1238
Epoch 24/600
14/14 [=====] - 0s 6ms/step - loss: 0.1034 - val_loss: 0.1208
Epoch 25/600
14/14 [=====] - 0s 6ms/step - loss: 0.1012 - val_loss: 0.1170
Epoch 26/600
14/14 [=====] - 0s 6ms/step - loss: 0.0968 - val_loss: 0.1204
Epoch 27/600
14/14 [=====] - 0s 6ms/step - loss: 0.0940 - val_loss: 0.1170
Epoch 28/600
14/14 [=====] - 0s 6ms/step - loss: 0.0903 - val_loss: 0.1172
Epoch 29/600
14/14 [=====] - 0s 6ms/step - loss: 0.0881 - val_loss: 0.1129
Epoch 30/600
14/14 [=====] - 0s 6ms/step - loss: 0.0858 - val_loss: 0.1124
Epoch 31/600
14/14 [=====] - 0s 7ms/step - loss: 0.0847 - val_loss: 0.1152
Epoch 32/600
14/14 [=====] - 0s 6ms/step - loss: 0.0823 - val_loss: 0.1130
Epoch 33/600
14/14 [=====] - 0s 7ms/step - loss: 0.0826 - val_loss: 0.1089
Epoch 34/600
14/14 [=====] - 0s 8ms/step - loss: 0.0808 - val_loss: 0.1090
Epoch 35/600
14/14 [=====] - 0s 7ms/step - loss: 0.0783 - val_loss: 0.1097
Epoch 36/600
14/14 [=====] - 0s 7ms/step - loss: 0.0752 - val_loss: 0.1092
Epoch 37/600
14/14 [=====] - 0s 7ms/step - loss: 0.0756 - val_loss: 0.1085
Epoch 38/600
14/14 [=====] - 0s 6ms/step - loss: 0.0712 - val_loss: 0.1119
Epoch 39/600
14/14 [=====] - 0s 7ms/step - loss: 0.0720 - val_loss: 0.1057
Epoch 40/600
14/14 [=====] - 0s 7ms/step - loss: 0.0702 - val_loss: 0.1098
Epoch 41/600
14/14 [=====] - 0s 6ms/step - loss: 0.0686 - val_loss: 0.1088
Epoch 42/600
14/14 [=====] - 0s 6ms/step - loss: 0.0687 - val_loss: 0.1098
Epoch 43/600
14/14 [=====] - 0s 7ms/step - loss: 0.0665 - val_loss: 0.1067
Epoch 44/600
14/14 [=====] - 0s 6ms/step - loss: 0.0651 - val_loss: 0.1144
Epoch 45/600
14/14 [=====] - 0s 5ms/step - loss: 0.0747 - val_loss: 0.1068
Epoch 46/600
14/14 [=====] - 0s 5ms/step - loss: 0.0696 - val_loss: 0.1115
Epoch 47/600
14/14 [=====] - 0s 5ms/step - loss: 0.0644 - val_loss: 0.1122
Epoch 48/600
14/14 [=====] - 0s 6ms/step - loss: 0.0626 - val_loss: 0.1156
Epoch 49/600
14/14 [=====] - 0s 5ms/step - loss: 0.0629 - val_loss: 0.1124
Epoch 50/600
14/14 [=====] - 0s 5ms/step - loss: 0.0610 - val_loss: 0.1082
```


Epoch 51/600
14/14 [=====] - 0s 5ms/step - loss: 0.0600 - val_loss: 0.1089
Epoch 52/600
14/14 [=====] - 0s 4ms/step - loss: 0.0601 - val_loss: 0.1106
Epoch 53/600
14/14 [=====] - 0s 5ms/step - loss: 0.0606 - val_loss: 0.1090
Epoch 54/600
14/14 [=====] - 0s 6ms/step - loss: 0.0597 - val_loss: 0.1157
Epoch 55/600
14/14 [=====] - 0s 6ms/step - loss: 0.0601 - val_loss: 0.1089
Epoch 56/600
14/14 [=====] - 0s 7ms/step - loss: 0.0578 - val_loss: 0.1101
Epoch 57/600
14/14 [=====] - 0s 8ms/step - loss: 0.0570 - val_loss: 0.1094
Epoch 58/600
14/14 [=====] - 0s 7ms/step - loss: 0.0561 - val_loss: 0.1095
Epoch 59/600
14/14 [=====] - 0s 6ms/step - loss: 0.0570 - val_loss: 0.1090
Epoch 60/600
14/14 [=====] - 0s 5ms/step - loss: 0.0579 - val_loss: 0.1088
Epoch 61/600
14/14 [=====] - 0s 5ms/step - loss: 0.0563 - val_loss: 0.1070
Epoch 62/600
14/14 [=====] - 0s 5ms/step - loss: 0.0570 - val_loss: 0.1157
Epoch 63/600
14/14 [=====] - 0s 6ms/step - loss: 0.0556 - val_loss: 0.1048
Epoch 64/600
14/14 [=====] - 0s 5ms/step - loss: 0.0551 - val_loss: 0.1145
Epoch 65/600
14/14 [=====] - 0s 5ms/step - loss: 0.0540 - val_loss: 0.1099
Epoch 66/600
14/14 [=====] - 0s 5ms/step - loss: 0.0531 - val_loss: 0.1120
Epoch 67/600
14/14 [=====] - 0s 5ms/step - loss: 0.0540 - val_loss: 0.1091
Epoch 68/600
14/14 [=====] - 0s 6ms/step - loss: 0.0534 - val_loss: 0.1115
Epoch 69/600
14/14 [=====] - 0s 5ms/step - loss: 0.0528 - val_loss: 0.1059
Epoch 70/600
14/14 [=====] - 0s 5ms/step - loss: 0.0521 - val_loss: 0.1124
Epoch 71/600
14/14 [=====] - 0s 5ms/step - loss: 0.0516 - val_loss: 0.1109
Epoch 72/600
14/14 [=====] - 0s 4ms/step - loss: 0.0540 - val_loss: 0.1089
Epoch 73/600
14/14 [=====] - 0s 5ms/step - loss: 0.0507 - val_loss: 0.1080
Epoch 74/600
14/14 [=====] - 0s 6ms/step - loss: 0.0529 - val_loss: 0.1118
Epoch 75/600
14/14 [=====] - 0s 5ms/step - loss: 0.0541 - val_loss: 0.1165
Epoch 76/600
14/14 [=====] - 0s 5ms/step - loss: 0.0542 - val_loss: 0.1072
Epoch 77/600
14/14 [=====] - 0s 5ms/step - loss: 0.0498 - val_loss: 0.1108
Epoch 78/600
14/14 [=====] - 0s 6ms/step - loss: 0.0509 - val_loss: 0.1085
Epoch 79/600
14/14 [=====] - 0s 5ms/step - loss: 0.0514 - val_loss: 0.1325
Epoch 80/600
14/14 [=====] - 0s 5ms/step - loss: 0.0512 - val_loss: 0.1064
Epoch 81/600
14/14 [=====] - 0s 5ms/step - loss: 0.0553 - val_loss: 0.1046
Epoch 82/600
14/14 [=====] - 0s 5ms/step - loss: 0.0490 - val_loss: 0.1138
Epoch 83/600
14/14 [=====] - 0s 5ms/step - loss: 0.0489 - val_loss: 0.1106
Epoch 84/600
14/14 [=====] - 0s 5ms/step - loss: 0.0509 - val_loss: 0.1102
Epoch 85/600
14/14 [=====] - 0s 5ms/step - loss: 0.0534 - val_loss: 0.1186
Epoch 86/600
14/14 [=====] - 0s 5ms/step - loss: 0.0481 - val_loss: 0.1077
Epoch 87/600
14/14 [=====] - 0s 5ms/step - loss: 0.0488 - val_loss: 0.1141
Epoch 88/600
14/14 [=====] - 0s 5ms/step - loss: 0.0470 - val_loss: 0.1125
Epoch 89/600
14/14 [=====] - 0s 5ms/step - loss: 0.0461 - val_loss: 0.1171
Epoch 90/600
14/14 [=====] - 0s 5ms/step - loss: 0.0466 - val_loss: 0.1119
Epoch 91/600
14/14 [=====] - 0s 5ms/step - loss: 0.0474 - val_loss: 0.1092
Epoch 92/600
14/14 [=====] - 0s 5ms/step - loss: 0.0456 - val_loss: 0.1156
Epoch 93/600
14/14 [=====] - 0s 5ms/step - loss: 0.0449 - val_loss: 0.1138
Epoch 94/600
14/14 [=====] - 0s 5ms/step - loss: 0.0461 - val_loss: 0.1074
Epoch 95/600

```

14/14 [=====] - 0s 5ms/step - loss: 0.0430 - val_loss: 0.1224
Epoch 96/600
14/14 [=====] - 0s 5ms/step - loss: 0.0452 - val_loss: 0.1089
Epoch 97/600
14/14 [=====] - 0s 5ms/step - loss: 0.0445 - val_loss: 0.1187
Epoch 98/600
14/14 [=====] - 0s 5ms/step - loss: 0.0472 - val_loss: 0.1103
Epoch 99/600
14/14 [=====] - 0s 5ms/step - loss: 0.0467 - val_loss: 0.1141
Epoch 100/600
14/14 [=====] - 0s 5ms/step - loss: 0.0446 - val_loss: 0.1176
Epoch 101/600
14/14 [=====] - 0s 5ms/step - loss: 0.0436 - val_loss: 0.1148
Epoch 102/600
14/14 [=====] - 0s 5ms/step - loss: 0.0446 - val_loss: 0.1253
Epoch 103/600
14/14 [=====] - 0s 5ms/step - loss: 0.0425 - val_loss: 0.1136
Epoch 104/600
14/14 [=====] - 0s 5ms/step - loss: 0.0426 - val_loss: 0.1157
Epoch 105/600
14/14 [=====] - 0s 5ms/step - loss: 0.0428 - val_loss: 0.1109
Epoch 106/600
14/14 [=====] - 0s 5ms/step - loss: 0.0436 - val_loss: 0.1247
Epoch 106: early stopping
Out[29]: <keras.callbacks.History at 0x13c30a87ac0>

```

```

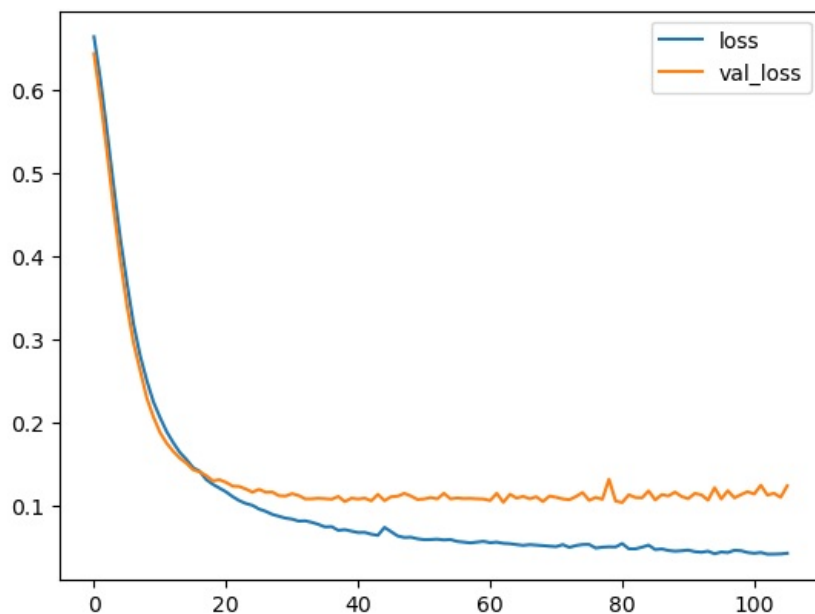
In [30]: model_loss = pd.DataFrame(model.history.history)
         model_loss.plot()

```

```

Out[30]: <AxesSubplot:>

```



Example Three: Adding in DropOut Layers

```

In [31]: from tensorflow.keras.layers import Dropout

```

```

In [32]: model = Sequential()
         model.add(Dense(units=30,activation='relu'))
         model.add(Dropout(0.5)) #0.2 - 0.5 common (20 to 50%) will be turned off

         model.add(Dense(units=15,activation='relu'))
         model.add(Dropout(0.5))

         model.add(Dense(units=1,activation='sigmoid'))
         model.compile(loss='binary_crossentropy', optimizer='adam')

```

```

In [33]: model.fit(x=X_train,
                  y=y_train,
                  epochs=600,
                  validation_data=(X_test, y_test), verbose=1,
                  callbacks=[early_stop]
                  )

```

```

Epoch 1/600
14/14 [=====] - 1s 20ms/step - loss: 0.6815 - val_loss: 0.6579
Epoch 2/600
14/14 [=====] - 0s 6ms/step - loss: 0.6486 - val_loss: 0.6300
Epoch 3/600
14/14 [=====] - 0s 7ms/step - loss: 0.6448 - val_loss: 0.6053
Epoch 4/600

```

```
14/14 [=====] - 0s 7ms/step - loss: 0.6261 - val_loss: 0.5792
Epoch 5/600
14/14 [=====] - 0s 7ms/step - loss: 0.5739 - val_loss: 0.5478
Epoch 6/600
14/14 [=====] - 0s 7ms/step - loss: 0.5693 - val_loss: 0.5116
Epoch 7/600
14/14 [=====] - 0s 8ms/step - loss: 0.5409 - val_loss: 0.4745
Epoch 8/600
14/14 [=====] - 0s 8ms/step - loss: 0.5081 - val_loss: 0.4492
Epoch 9/600
14/14 [=====] - 0s 7ms/step - loss: 0.5019 - val_loss: 0.4186
Epoch 10/600
14/14 [=====] - 0s 7ms/step - loss: 0.4543 - val_loss: 0.3879
Epoch 11/600
14/14 [=====] - 0s 6ms/step - loss: 0.4444 - val_loss: 0.3595
Epoch 12/600
14/14 [=====] - 0s 6ms/step - loss: 0.4564 - val_loss: 0.3420
Epoch 13/600
14/14 [=====] - 0s 7ms/step - loss: 0.4024 - val_loss: 0.3251
Epoch 14/600
14/14 [=====] - 0s 7ms/step - loss: 0.4092 - val_loss: 0.3038
Epoch 15/600
14/14 [=====] - 0s 7ms/step - loss: 0.3902 - val_loss: 0.2885
Epoch 16/600
14/14 [=====] - 0s 7ms/step - loss: 0.3505 - val_loss: 0.2710
Epoch 17/600
14/14 [=====] - 0s 7ms/step - loss: 0.3467 - val_loss: 0.2564
Epoch 18/600
14/14 [=====] - 0s 7ms/step - loss: 0.3443 - val_loss: 0.2380
Epoch 19/600
14/14 [=====] - 0s 6ms/step - loss: 0.3617 - val_loss: 0.2314
Epoch 20/600
14/14 [=====] - 0s 8ms/step - loss: 0.3256 - val_loss: 0.2189
Epoch 21/600
14/14 [=====] - 0s 7ms/step - loss: 0.3208 - val_loss: 0.2081
Epoch 22/600
14/14 [=====] - 0s 7ms/step - loss: 0.2962 - val_loss: 0.2002
Epoch 23/600
14/14 [=====] - 0s 6ms/step - loss: 0.2835 - val_loss: 0.1889
Epoch 24/600
14/14 [=====] - 0s 6ms/step - loss: 0.2575 - val_loss: 0.1788
Epoch 25/600
14/14 [=====] - 0s 6ms/step - loss: 0.2733 - val_loss: 0.1812
Epoch 26/600
14/14 [=====] - 0s 6ms/step - loss: 0.2757 - val_loss: 0.1707
Epoch 27/600
14/14 [=====] - 0s 6ms/step - loss: 0.2507 - val_loss: 0.1611
Epoch 28/600
14/14 [=====] - 0s 6ms/step - loss: 0.2432 - val_loss: 0.1694
Epoch 29/600
14/14 [=====] - 0s 7ms/step - loss: 0.2614 - val_loss: 0.1572
Epoch 30/600
14/14 [=====] - 0s 6ms/step - loss: 0.2687 - val_loss: 0.1498
Epoch 31/600
14/14 [=====] - 0s 6ms/step - loss: 0.2454 - val_loss: 0.1509
Epoch 32/600
14/14 [=====] - 0s 5ms/step - loss: 0.2353 - val_loss: 0.1460
Epoch 33/600
14/14 [=====] - 0s 5ms/step - loss: 0.2269 - val_loss: 0.1428
Epoch 34/600
14/14 [=====] - 0s 6ms/step - loss: 0.2383 - val_loss: 0.1454
Epoch 35/600
14/14 [=====] - 0s 5ms/step - loss: 0.2121 - val_loss: 0.1373
Epoch 36/600
14/14 [=====] - 0s 5ms/step - loss: 0.2103 - val_loss: 0.1268
Epoch 37/600
14/14 [=====] - 0s 6ms/step - loss: 0.1981 - val_loss: 0.1246
Epoch 38/600
14/14 [=====] - 0s 5ms/step - loss: 0.2056 - val_loss: 0.1265
Epoch 39/600
14/14 [=====] - 0s 5ms/step - loss: 0.2007 - val_loss: 0.1152
Epoch 40/600
14/14 [=====] - 0s 5ms/step - loss: 0.1918 - val_loss: 0.1165
Epoch 41/600
14/14 [=====] - 0s 5ms/step - loss: 0.1694 - val_loss: 0.1107
Epoch 42/600
14/14 [=====] - 0s 5ms/step - loss: 0.2139 - val_loss: 0.1107
Epoch 43/600
14/14 [=====] - 0s 5ms/step - loss: 0.1870 - val_loss: 0.1129
Epoch 44/600
14/14 [=====] - 0s 5ms/step - loss: 0.1837 - val_loss: 0.1121
Epoch 45/600
14/14 [=====] - 0s 5ms/step - loss: 0.1859 - val_loss: 0.1115
Epoch 46/600
14/14 [=====] - 0s 5ms/step - loss: 0.1868 - val_loss: 0.1101
Epoch 47/600
14/14 [=====] - 0s 5ms/step - loss: 0.1532 - val_loss: 0.1149
Epoch 48/600
14/14 [=====] - 0s 5ms/step - loss: 0.1724 - val_loss: 0.1064
```

Epoch 49/600
14/14 [=====] - 0s 5ms/step - loss: 0.1557 - val_loss: 0.1035
Epoch 50/600
14/14 [=====] - 0s 6ms/step - loss: 0.1723 - val_loss: 0.1073
Epoch 51/600
14/14 [=====] - 0s 5ms/step - loss: 0.1777 - val_loss: 0.1057
Epoch 52/600
14/14 [=====] - 0s 5ms/step - loss: 0.1505 - val_loss: 0.1016
Epoch 53/600
14/14 [=====] - 0s 5ms/step - loss: 0.1669 - val_loss: 0.1031
Epoch 54/600
14/14 [=====] - 0s 5ms/step - loss: 0.1394 - val_loss: 0.1031
Epoch 55/600
14/14 [=====] - 0s 5ms/step - loss: 0.1567 - val_loss: 0.1100
Epoch 56/600
14/14 [=====] - 0s 5ms/step - loss: 0.1661 - val_loss: 0.1015
Epoch 57/600
14/14 [=====] - 0s 5ms/step - loss: 0.1656 - val_loss: 0.1004
Epoch 58/600
14/14 [=====] - 0s 5ms/step - loss: 0.1245 - val_loss: 0.1045
Epoch 59/600
14/14 [=====] - 0s 5ms/step - loss: 0.1450 - val_loss: 0.0992
Epoch 60/600
14/14 [=====] - 0s 5ms/step - loss: 0.1554 - val_loss: 0.1115
Epoch 61/600
14/14 [=====] - 0s 6ms/step - loss: 0.1361 - val_loss: 0.1027
Epoch 62/600
14/14 [=====] - 0s 6ms/step - loss: 0.1401 - val_loss: 0.0962
Epoch 63/600
14/14 [=====] - 0s 5ms/step - loss: 0.1282 - val_loss: 0.0985
Epoch 64/600
14/14 [=====] - 0s 5ms/step - loss: 0.1530 - val_loss: 0.1038
Epoch 65/600
14/14 [=====] - 0s 5ms/step - loss: 0.1205 - val_loss: 0.1029
Epoch 66/600
14/14 [=====] - 0s 6ms/step - loss: 0.1493 - val_loss: 0.0973
Epoch 67/600
14/14 [=====] - 0s 5ms/step - loss: 0.1096 - val_loss: 0.1012
Epoch 68/600
14/14 [=====] - 0s 5ms/step - loss: 0.1170 - val_loss: 0.0949
Epoch 69/600
14/14 [=====] - 0s 5ms/step - loss: 0.1230 - val_loss: 0.0926
Epoch 70/600
14/14 [=====] - 0s 5ms/step - loss: 0.1201 - val_loss: 0.0951
Epoch 71/600
14/14 [=====] - 0s 5ms/step - loss: 0.1144 - val_loss: 0.1006
Epoch 72/600
14/14 [=====] - 0s 5ms/step - loss: 0.1327 - val_loss: 0.0894
Epoch 73/600
14/14 [=====] - 0s 5ms/step - loss: 0.1158 - val_loss: 0.0916
Epoch 74/600
14/14 [=====] - 0s 5ms/step - loss: 0.1229 - val_loss: 0.1012
Epoch 75/600
14/14 [=====] - 0s 5ms/step - loss: 0.1213 - val_loss: 0.0919
Epoch 76/600
14/14 [=====] - 0s 5ms/step - loss: 0.1217 - val_loss: 0.0901
Epoch 77/600
14/14 [=====] - 0s 5ms/step - loss: 0.1111 - val_loss: 0.0945
Epoch 78/600
14/14 [=====] - 0s 5ms/step - loss: 0.1047 - val_loss: 0.0934
Epoch 79/600
14/14 [=====] - 0s 5ms/step - loss: 0.1237 - val_loss: 0.0883
Epoch 80/600
14/14 [=====] - 0s 5ms/step - loss: 0.1129 - val_loss: 0.1013
Epoch 81/600
14/14 [=====] - 0s 5ms/step - loss: 0.1076 - val_loss: 0.0931
Epoch 82/600
14/14 [=====] - 0s 6ms/step - loss: 0.1145 - val_loss: 0.0951
Epoch 83/600
14/14 [=====] - 0s 6ms/step - loss: 0.1191 - val_loss: 0.0952
Epoch 84/600
14/14 [=====] - 0s 6ms/step - loss: 0.1417 - val_loss: 0.1039
Epoch 85/600
14/14 [=====] - 0s 5ms/step - loss: 0.1298 - val_loss: 0.1012
Epoch 86/600
14/14 [=====] - 0s 5ms/step - loss: 0.1218 - val_loss: 0.0943
Epoch 87/600
14/14 [=====] - 0s 5ms/step - loss: 0.1138 - val_loss: 0.0970
Epoch 88/600
14/14 [=====] - 0s 5ms/step - loss: 0.0927 - val_loss: 0.0886
Epoch 89/600
14/14 [=====] - 0s 5ms/step - loss: 0.1125 - val_loss: 0.0934
Epoch 90/600
14/14 [=====] - 0s 11ms/step - loss: 0.1107 - val_loss: 0.1021
Epoch 91/600
14/14 [=====] - 0s 7ms/step - loss: 0.1244 - val_loss: 0.0895
Epoch 92/600
14/14 [=====] - 0s 6ms/step - loss: 0.1024 - val_loss: 0.0934
Epoch 93/600

```
14/14 [=====] - 0s 5ms/step - loss: 0.1133 - val_loss: 0.0990
Epoch 94/600
14/14 [=====] - 0s 5ms/step - loss: 0.1196 - val_loss: 0.0983
Epoch 95/600
14/14 [=====] - 0s 5ms/step - loss: 0.1007 - val_loss: 0.0926
Epoch 96/600
14/14 [=====] - 0s 5ms/step - loss: 0.1135 - val_loss: 0.0915
Epoch 97/600
14/14 [=====] - 0s 6ms/step - loss: 0.0987 - val_loss: 0.0884
Epoch 98/600
14/14 [=====] - 0s 5ms/step - loss: 0.1089 - val_loss: 0.0966
Epoch 99/600
14/14 [=====] - 0s 5ms/step - loss: 0.0954 - val_loss: 0.0908
Epoch 100/600
14/14 [=====] - 0s 5ms/step - loss: 0.0941 - val_loss: 0.0960
Epoch 101/600
14/14 [=====] - 0s 5ms/step - loss: 0.1085 - val_loss: 0.1026
Epoch 102/600
14/14 [=====] - 0s 5ms/step - loss: 0.0905 - val_loss: 0.0933
Epoch 103/600
14/14 [=====] - 0s 5ms/step - loss: 0.0964 - val_loss: 0.0876
Epoch 104/600
14/14 [=====] - 0s 5ms/step - loss: 0.1093 - val_loss: 0.0995
Epoch 105/600
14/14 [=====] - 0s 5ms/step - loss: 0.1070 - val_loss: 0.1046
Epoch 106/600
14/14 [=====] - 0s 5ms/step - loss: 0.0932 - val_loss: 0.0923
Epoch 107/600
14/14 [=====] - 0s 5ms/step - loss: 0.0984 - val_loss: 0.0917
Epoch 108/600
14/14 [=====] - 0s 5ms/step - loss: 0.1193 - val_loss: 0.1081
Epoch 109/600
14/14 [=====] - 0s 5ms/step - loss: 0.1083 - val_loss: 0.0941
Epoch 110/600
14/14 [=====] - 0s 5ms/step - loss: 0.0984 - val_loss: 0.0914
Epoch 111/600
14/14 [=====] - 0s 5ms/step - loss: 0.0798 - val_loss: 0.1021
Epoch 112/600
14/14 [=====] - 0s 5ms/step - loss: 0.1177 - val_loss: 0.0987
Epoch 113/600
14/14 [=====] - 0s 5ms/step - loss: 0.0914 - val_loss: 0.0880
Epoch 114/600
14/14 [=====] - 0s 5ms/step - loss: 0.1045 - val_loss: 0.0896
Epoch 115/600
14/14 [=====] - 0s 5ms/step - loss: 0.0982 - val_loss: 0.1097
Epoch 116/600
14/14 [=====] - 0s 5ms/step - loss: 0.0858 - val_loss: 0.0879
Epoch 117/600
14/14 [=====] - 0s 5ms/step - loss: 0.0854 - val_loss: 0.1041
Epoch 118/600
14/14 [=====] - 0s 5ms/step - loss: 0.0948 - val_loss: 0.1147
Epoch 119/600
14/14 [=====] - 0s 5ms/step - loss: 0.0959 - val_loss: 0.0947
Epoch 120/600
14/14 [=====] - 0s 5ms/step - loss: 0.0992 - val_loss: 0.0883
Epoch 121/600
14/14 [=====] - 0s 5ms/step - loss: 0.1023 - val_loss: 0.1170
Epoch 122/600
14/14 [=====] - 0s 5ms/step - loss: 0.1095 - val_loss: 0.1026
Epoch 123/600
14/14 [=====] - 0s 5ms/step - loss: 0.0848 - val_loss: 0.0873
Epoch 124/600
14/14 [=====] - 0s 5ms/step - loss: 0.1042 - val_loss: 0.0902
Epoch 125/600
14/14 [=====] - 0s 5ms/step - loss: 0.0882 - val_loss: 0.0918
Epoch 126/600
14/14 [=====] - 0s 5ms/step - loss: 0.0907 - val_loss: 0.0937
Epoch 127/600
14/14 [=====] - 0s 5ms/step - loss: 0.0887 - val_loss: 0.0909
Epoch 128/600
14/14 [=====] - 0s 5ms/step - loss: 0.0887 - val_loss: 0.0934
Epoch 129/600
14/14 [=====] - 0s 5ms/step - loss: 0.0759 - val_loss: 0.0951
Epoch 130/600
14/14 [=====] - 0s 5ms/step - loss: 0.1030 - val_loss: 0.1039
Epoch 131/600
14/14 [=====] - 0s 5ms/step - loss: 0.0988 - val_loss: 0.1141
Epoch 132/600
14/14 [=====] - 0s 5ms/step - loss: 0.0890 - val_loss: 0.1135
Epoch 133/600
14/14 [=====] - 0s 5ms/step - loss: 0.0849 - val_loss: 0.0936
Epoch 134/600
14/14 [=====] - 0s 5ms/step - loss: 0.1073 - val_loss: 0.0999
Epoch 135/600
14/14 [=====] - 0s 5ms/step - loss: 0.0956 - val_loss: 0.1087
Epoch 136/600
14/14 [=====] - 0s 5ms/step - loss: 0.0835 - val_loss: 0.0995
Epoch 137/600
14/14 [=====] - 0s 5ms/step - loss: 0.0849 - val_loss: 0.0972
```

```

Epoch 138/600
14/14 [=====] - 0s 5ms/step - loss: 0.0771 - val_loss: 0.0985
Epoch 139/600
14/14 [=====] - 0s 5ms/step - loss: 0.0740 - val_loss: 0.0945
Epoch 140/600
14/14 [=====] - 0s 6ms/step - loss: 0.0772 - val_loss: 0.0944
Epoch 141/600
14/14 [=====] - 0s 6ms/step - loss: 0.1022 - val_loss: 0.0993
Epoch 142/600
14/14 [=====] - 0s 5ms/step - loss: 0.0758 - val_loss: 0.1122
Epoch 143/600
14/14 [=====] - 0s 5ms/step - loss: 0.0549 - val_loss: 0.1039
Epoch 144/600
14/14 [=====] - 0s 5ms/step - loss: 0.0965 - val_loss: 0.0927
Epoch 145/600
14/14 [=====] - 0s 5ms/step - loss: 0.0728 - val_loss: 0.1198
Epoch 146/600
14/14 [=====] - 0s 5ms/step - loss: 0.0854 - val_loss: 0.0878
Epoch 147/600
14/14 [=====] - 0s 5ms/step - loss: 0.0807 - val_loss: 0.1093
Epoch 148/600
14/14 [=====] - 0s 5ms/step - loss: 0.0762 - val_loss: 0.0906
Epoch 148: early stopping
<keras.callbacks.History at 0x13c31c73a60>

```

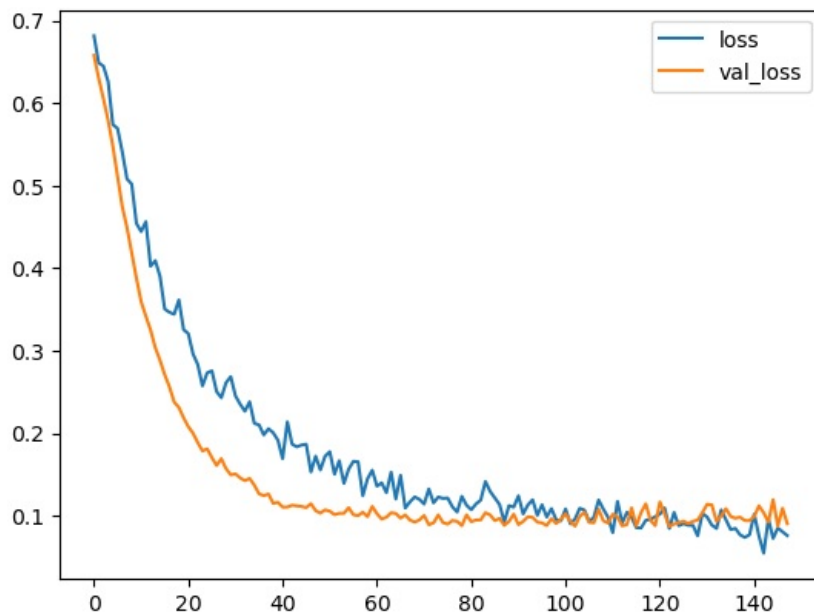
Out[33]:

```

In [34]: model_loss = pd.DataFrame(model.history.history)
         model_loss.plot()

```

Out[34]: <AxesSubplot:>



Model Evaluation

```

In [36]: predictions = (model.predict(X_test) > 0.5)*1

```

```

5/5 [=====] - 0s 2ms/step

```

```

In [38]: from sklearn.metrics import classification_report, confusion_matrix

```

```

In [39]: # https://en.wikipedia.org/wiki/Precision_and_recall
         print(classification_report(y_test, predictions))

```

```

              precision    recall  f1-score   support

     0       0.98      0.98      0.98         55
     1       0.99      0.99      0.99         88

   accuracy          0.99
  macro avg       0.99      0.99      0.99
 weighted avg     0.99      0.99      0.99

```

```

In [40]: print(confusion_matrix(y_test, predictions))

```

```

[[54  1]
 [ 1 87]]

```

In []: