In [5]:

```
from keras.models import Sequential
from keras.layers import Dense
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

In [2]:

```
!pip install keras
```

```
Collecting keras
  Downloading Keras-2.4.3-py2.py3-none-any.whl (36 kB)
Requirement already satisfied: pyyaml in c:\users\acer\anaconda3\lib\site-packages (from keras) (5.3.1)
Requirement already satisfied: numpy>=1.9.1 in c:\users\acer\anaconda3\lib\site-packages (from keras) (1.
19.2)
Requirement already satisfied: scipy>=0.14 in c:\users\acer\anaconda3\lib\site-packages (from keras) (1.5
.2)
Requirement already satisfied: h5py in c:\users\acer\anaconda3\lib\site-packages (from keras) (2.10.0)
Requirement already satisfied: six in c:\users\acer\anaconda3\lib\site-packages (from h5py->keras) (1.15.
0)
Installing collected packages: keras
Successfully installed keras-2.4.3
```

In [4]:

```
!pip install tensorflow
```

```
Collecting tensorflow
  Downloading tensorflow-2.5.0-cp38-cp38-win_amd64.whl (422.6 MB)
Collecting gast==0.4.0
  Downloading gast-0.4.0-py3-none-any.whl (9.8 kB)
Collecting tensorflow-estimator<2.6.0,>=2.5.0rc0
  Downloading tensorflow_estimator-2.5.0-py2.py3-none-any.whl (462 kB)
Requirement already satisfied: typing-extensions~=3.7.4 in c:\users\acer\anaconda3\lib\site-packages (fro
m tensorflow) (3.7.4.3)
Collecting keras-nightly~=2.5.0.dev
  Downloading keras_nightly-2.5.0.dev2021032900-py2.py3-none-any.whl (1.2 MB)
Collecting h5py~=3.1.0
  Downloading h5py-3.1.0-cp38-cp38-win_amd64.whl (2.7 MB)
Collecting opt-einsum~=3.3.0
  Downloading opt_einsum-3.3.0-py3-none-any.whl (65 kB)
Collecting wrapt~=1.12.1
  Downloading wrapt-1.12.1.tar.gz (27 kB)
Collecting grpcio~=1.34.0
  Downloading grpcio-1.34.1-cp38-cp38-win_amd64.whl (2.9 MB)
Collecting tensorboard~=2.5
  Downloading tensorboard-2.5.0-py3-none-any.whl (6.0 MB)
Collecting keras-preprocessing~=1.1.2
  Downloading Keras_Preprocessing-1.1.2-py2.py3-none-any.whl (42 kB)
Requirement already satisfied: numpy~=1.19.2 in c:\users\acer\anaconda3\lib\site-packages (from tensorflo
w) (1.19.2)
Collecting google-pasta~=0.2
  Downloading google_pasta-0.2.0-py3-none-any.whl (57 kB)
Requirement already satisfied: protobuf>=3.9.2 in c:\users\acer\anaconda3\lib\site-packages (from tensorf
low) (3.14.0)
Collecting termcolor~=1.1.0
  Downloading termcolor-1.1.0.tar.gz (3.9 kB)
Collecting flatbuffers~=1.12.0
  Downloading flatbuffers-1.12-py2.py3-none-any.whl (15 kB)
Requirement already satisfied: wheel~=0.35 in c:\users\acer\anaconda3\lib\site-packages (from tensorflow)
(0.35.1)
Collecting astunparse~=1.6.3
  Downloading astunparse-1.6.3-py2.py3-none-any.whl (12 kB)
Requirement already satisfied: six~=1.15.0 in c:\users\acer\anaconda3\lib\site-packages (from tensorflow)
(1.15.0)
Collecting absl-py~=0.10
  Downloading absl_py-0.13.0-py3-none-any.whl (132 kB)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\acer\anaconda3\lib\site-packages (from ten
sorboard~=2.5->tensorflow) (2.24.0)
Requirement already satisfied: google-auth<2,>=1.6.3 in c:\users\acer\anaconda3\lib\site-packages (from t
ensorboard~=2.5->tensorflow) (1.25.0)
Collecting google-auth-oauthlib<0.5,>=0.4.1
  Downloading google_auth_oauthlib-0.4.4-py2.py3-none-any.whl (18 kB)
Collecting tensorboard-plugin-wit>=1.6.0
  Downloading tensorboard_plugin_wit-1.8.0-py3-none-any.whl (781 kB)
Requirement already satisfied: setuptools>=41.0.0 in c:\users\acer\anaconda3\lib\site-packages (from tens
orboard~=2.5->tensorflow) (50.3.1.post20201107)
Collecting tensorboard-data-server<0.7.0,>=0.6.0
```

```
  Downloading tensorboard_data_server-0.6.1-py3-none-any.whl (2.4 kB)
Collecting markdown>=2.6.8
  Downloading Markdown-3.3.4-py3-none-any.whl (97 kB)
Requirement already satisfied: werkzeug>=0.11.15 in c:\users\acer\anaconda3\lib\site-packages (from tenso
rboard~=2.5->tensorflow) (1.0.1)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
c:\users\acer\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard~=2.5->tensorflow)
(1.25.11)
Requirement already satisfied: idna<3,>=2.5 in c:\users\acer\anaconda3\lib\site-packages (from requests<3
,>=2.21.0->tensorboard~=2.5->tensorflow) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\acer\anaconda3\lib\site-packages (from requ
ests<3,>=2.21.0->tensorboard~=2.5->tensorflow) (2020.6.20)
Requirement already satisfied: chardet<4,>=3.0.2 in c:\users\acer\anaconda3\lib\site-packages (from reque
sts<3,>=2.21.0->tensorboard~=2.5->tensorflow) (3.0.4)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\acer\anaconda3\lib\site-packages (from g
oogle-auth<2,>=1.6.3->tensorboard~=2.5->tensorflow) (0.2.8)
Requirement already satisfied: rsa<5,>=3.1.4; python_version >= "3.6" in
c:\users\acer\anaconda3\lib\site-packages (from google-auth<2,>=1.6.3->tensorboard~=2.5->tensorflow)
(4.7.2)
Requirement already satisfied: cachetools<5.0,>=2.0.0 in c:\users\acer\anaconda3\lib\site-packages (from
google-auth<2,>=1.6.3->tensorboard~=2.5->tensorflow) (4.2.2)
Collecting requests-oauthlib>=0.7.0
  Downloading requests_oauthlib-1.3.0-py2.py3-none-any.whl (23 kB)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\acer\anaconda3\lib\site-packages (from py
asn1-modules>=0.2.1->google-auth<2,>=1.6.3->tensorboard~=2.5->tensorflow) (0.4.8)
Collecting oauthlib>=3.0.0
  Downloading oauthlib-3.1.1-py2.py3-none-any.whl (146 kB)
Building wheels for collected packages: wrapt, termcolor
  Building wheel for wrapt (setup.py): started
  Building wheel for wrapt (setup.py): finished with status 'done'
  Created wheel for wrapt: filename=wrapt-1.12.1-py3-none-any.whl size=19558
sha256=60b8cba234fdeb0d3f021939239cabfb8aeda32c408d25609c36d89b64fbe8c3
  Stored in directory:
c:\users\acer\appdata\local\pip\cache\wheels\5f\fd\9e\b6cf5890494cb8ef0b5eaff72e5d55a70fb56316007d6dfe73
  Building wheel for termcolor (setup.py): started
  Building wheel for termcolor (setup.py): finished with status 'done'
  Created wheel for termcolor: filename=termcolor-1.1.0-py3-none-any.whl size=4835
sha256=13047748e5152c6967c11a7b50c066349739dff1f223052cdf5a9011807901ae
  Stored in directory:
c:\users\acer\appdata\local\pip\cache\wheels\a0\16\9c\5473df82468f958445479c59e784896fa24f4a5fc024b0f501
Successfully built wrapt termcolor
Installing collected packages: gast, tensorflow-estimator, keras-nightly, h5py, opt-einsum, wrapt,
grpcio, oauthlib, requests-oauthlib, google-auth-oauthlib, tensorboard-plugin-wit, absl-py, tensorboard-
data-server, markdown, tensorboard, keras-preprocessing, google-pasta, termcolor, flatbuffers, astunparse
, tensorflow
  Attempting uninstall: h5py
    Found existing installation: h5py 2.10.0
    Uninstalling h5py-2.10.0:
      Successfully uninstalled h5py-2.10.0
  Attempting uninstall: wrapt
    Found existing installation: wrapt 1.11.2
    Uninstalling wrapt-1.11.2:
      Successfully uninstalled wrapt-1.11.2
Successfully installed absl-py-0.13.0 astunparse-1.6.3 flatbuffers-1.12 gast-0.4.0 google-auth-oauthlib-
0.4.4 google-pasta-0.2.0 grpcio-1.34.1 h5py-3.1.0 keras-nightly-2.5.0.dev2021032900 keras-preprocessing-1
.1.2 markdown-3.3.4 oauthlib-3.1.1 opt-einsum-3.3.0 requests-oauthlib-1.3.0 tensorboard-2.5.0
tensorboard-data-server-0.6.1 tensorboard-plugin-wit-1.8.0 tensorflow-2.5.0 tensorflow-estimator-2.5.0 t
ermcolor-1.1.0 wrapt-1.12.1
```

In [6]:

```
df = pd.read_csv('/Users/acer/Sandesh Pal/Data Science Assgn/Neural Network/forestfires.csv')
```

In [7]:

```
df
```

Out[7]:

	month	day	FFMC	DMC	DC	ISI	temp	RH	wind	rain	...	monthfeb	monthjan	monthjul	monthjun	monthmar	monthmay	month
0	mar	fri	86.2	26.2	94.3	5.1	8.2	51	6.7	0.0	...	0	0	0	0	1	0	
1	oct	tue	90.6	35.4	669.1	6.7	18.0	33	0.9	0.0	...	0	0	0	0	0	0	
2	oct	sat	90.6	43.7	686.9	6.7	14.6	33	1.3	0.0	...	0	0	0	0	0	0	
3	mar	fri	91.7	33.3	77.5	9.0	8.3	97	4.0	0.2	...	0	0	0	0	1	0	
4	mar	sun	89.3	51.3	102.2	9.6	11.4	99	1.8	0.0	...	0	0	0	0	1	0	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
512	aug	sun	81.6	56.7	665.6	1.9	27.8	32	2.7	0.0	...	0	0	0	0	0	0	
513	aug	sun	81.6	56.7	665.6	1.9	21.9	71	5.8	0.0	...	0	0	0	0	0	0	
514	aug	sun	81.6	56.7	665.6	1.9	21.2	70	6.7	0.0	...	0	0	0	0	0	0	
515	aug	sat	94.4	146.0	614.7	11.3	25.6	42	4.0	0.0	...	0	0	0	0	0	0	
516	nov	tue	79.5	3.0	106.7	1.1	11.8	31	4.5	0.0	...	0	0	0	0	0	0	

517 rows × 31 columns

In [8]:

```
#Checking for null values & data types
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 517 entries, 0 to 516
Data columns (total 31 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   month          517 non-null    object 
 1   day            517 non-null    object 
 2   FFMC           517 non-null    float64
 3   DMC            517 non-null    float64
 4   DC             517 non-null    float64
 5   ISI            517 non-null    float64
 6   temp           517 non-null    float64
 7   RH             517 non-null    int64  
 8   wind           517 non-null    float64
 9   rain           517 non-null    float64
 10  area           517 non-null    float64
 11  dayfri         517 non-null    int64  
 12  daymon         517 non-null    int64  
 13  daysat         517 non-null    int64  
 14  daysun         517 non-null    int64  
 15  daythu         517 non-null    int64  
 16  daytue         517 non-null    int64  
 17  daywed         517 non-null    int64  
 18  monthapr       517 non-null    int64  
 19  monthaug       517 non-null    int64  
 20  monthdec       517 non-null    int64  
 21  monthfeb       517 non-null    int64  
 22  monthjan       517 non-null    int64  
 23  monthjul       517 non-null    int64  
 24  monthjun       517 non-null    int64  
 25  monthmar       517 non-null    int64  
 26  monthmay       517 non-null    int64  
 27  monthnov       517 non-null    int64  
 28  monthoct       517 non-null    int64  
 29  monthsep       517 non-null    int64  
 30  size_category  517 non-null    object 
dtypes: float64(8), int64(20), object(3)
memory usage: 125.3+ KB
```

In [9]:

```
#Scaling the data (leaving out the target variable, and the taking only the numerical data for input)
df1= df.iloc[:,2:30]
```

In [10]:

```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
```

In [11]:

```
sc.fit(df1)
df_norm = sc.transform(df1)
```

```
df_norm
```

Out[11]:

```
array([[-8.05959472e-01, -1.32332557e+00, -1.83047676e+00, ...,
        -4.40225453e-02, -1.72859706e-01, -7.06081245e-01],
       [-8.10203395e-03, -1.17954077e+00,  4.88890915e-01, ...,
        -4.40225453e-02,  5.78503817e+00, -7.06081245e-01],
       [-8.10203395e-03, -1.04982188e+00,  5.60715454e-01, ...,
        -4.40225453e-02,  5.78503817e+00, -7.06081245e-01],
       ...,
       [-1.64008316e+00, -8.46647711e-01,  4.74768113e-01, ...,
        -4.40225453e-02, -1.72859706e-01, -7.06081245e-01],
       [ 6.80956663e-01,  5.49002541e-01,  2.69382214e-01, ...,
        -4.40225453e-02, -1.72859706e-01, -7.06081245e-01],
       [-2.02087875e+00, -1.68591332e+00, -1.78044169e+00, ...,
         2.27156334e+01, -1.72859706e-01, -7.06081245e-01]])
```

In [12]:

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 28)
pca_values = pca.fit_transform(df_norm)
pca_values
```

Out[12]:

```
array([[ 3.76670947e+00, -1.32025451e+00, -8.43971398e-01, ...,
        -6.53345819e-02,  1.02062582e-14,  8.43633968e-16],
       [ 3.90786263e-01,  8.31061522e-01, -1.10136513e+00, ...,
         3.42618601e-02,  4.71409252e-15,  2.25999472e-16],
       [ 6.90415596e-01,  1.17774562e+00, -1.22199841e+00, ...,
         2.63235187e-02,  4.28072464e-15,  1.86480662e-16],
       ...,
       [ 9.21634000e-01, -2.64543072e-01,  2.71921606e+00, ...,
        -2.97865814e-01,  3.40869735e-16,  4.52552927e-17],
       [-1.62054896e+00, -9.78838231e-01,  3.31987355e-01, ...,
         3.91949863e-02,  2.86075370e-16,  1.07765779e-16],
       [ 4.07590654e+00, -3.67440726e-01, -2.47151775e-01, ...,
        -2.50420726e-02, -4.56772859e-17,  6.90662122e-17]])
```

In [13]:

```
# The amount of variance that each PCA explains is
var = pca.explained_variance_ratio_
var
```

Out[13]:

```
array([1.35522746e-01, 6.85788793e-02, 6.23572652e-02, 5.32713255e-02,
       4.75942360e-02, 4.68009902e-02, 4.37490015e-02, 4.28025164e-02,
       4.08875728e-02, 4.01633268e-02, 3.92926854e-02, 3.83232321e-02,
       3.64221503e-02, 3.63217289e-02, 3.57856782e-02, 3.50087806e-02,
       3.35447704e-02, 3.24777366e-02, 3.04490902e-02, 3.00246758e-02,
       2.37167400e-02, 2.08329788e-02, 1.18357869e-02, 8.88449559e-03,
       4.55347471e-03, 7.98135931e-04, 2.67271490e-32, 1.28276240e-33])
```

In [14]:

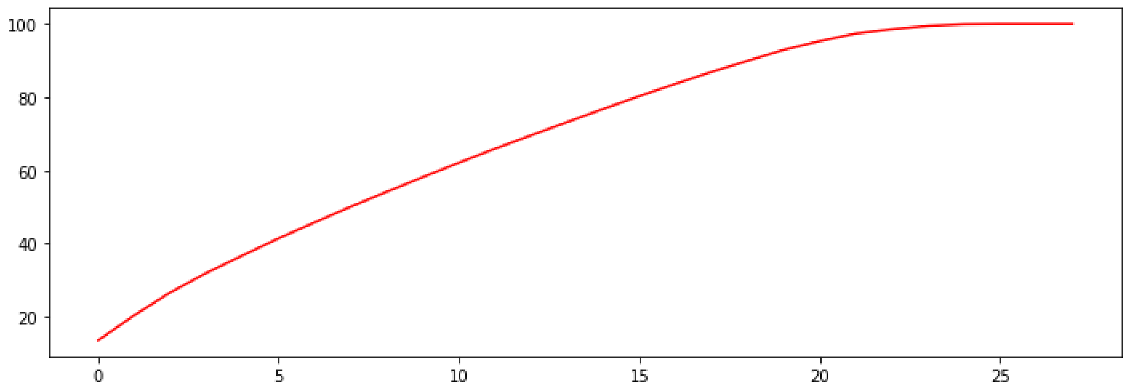
```
# Cumulative variance
var1 = np.cumsum(np.round(var,decimals = 4)*100)
var1
```

Out[14]:

```
array([13.55, 20.41, 26.65, 31.98, 36.74, 41.42, 45.79, 50.07, 54.16,
       58.18, 62.11, 65.94, 69.58, 73.21, 76.79, 80.29, 83.64, 86.89,
       89.93, 92.93, 95.3 , 97.38, 98.56, 99.45, 99.91, 99.99, 99.99,
       99.99])
```

In [15]:

```
# Variance plot for PCA components obtained
plt.figure(figsize=(12,4))
plt.plot(var1,color="red");
```



In [17]:

```
finalDf = pd.concat([pd.DataFrame(pca_values[:,0:24],columns=['pc1','pc2','pc3','pc4','pc5','pc6','pc7',
 'pc8','pc9','pc10','pc11','pc12','pc13','pc14',
 'pc15','pc16','pc17','pc18','pc19','pc20','pc21',
 'pc22','pc23','pc24']),
 df[['size_category']]], axis = 1)
finalDf.size_category.replace(('large','small'),(1,0),inplace=True)
finalDf
```

Out[17]:

	pc1	pc2	pc3	pc4	pc5	pc6	pc7	pc8	pc9	pc10	...	pc16	pc17	pc18
0	3.766709	-1.320255	-0.843971	-1.994738	-1.453359	0.693985	0.308104	-0.019764	0.010161	-0.437314	...	-0.197543	-0.021839	0.688958
1	0.390786	0.831062	-1.101365	1.400671	2.869388	0.965898	-2.795574	0.041095	-0.548879	0.104500	...	-2.503167	0.499649	0.563706
2	0.690416	1.177746	-1.221998	2.442038	1.090630	0.390801	-1.586675	-2.159336	-0.090580	0.260888	...	-2.545144	-0.658411	-0.423618
3	3.359951	-1.161443	0.385728	-2.118328	-1.949601	1.027664	-0.179422	-0.250227	-0.620329	-1.343189	...	-0.040887	0.017843	0.332572
4	2.974329	-0.842626	1.327788	0.038086	-1.124763	-0.574676	-0.777155	0.303635	0.861126	-2.024719	...	0.844431	1.014944	-0.618231
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
512	-0.087560	0.153964	1.241810	1.536581	0.372425	-1.133422	-0.362287	0.766946	0.818745	-0.289632	...	0.300522	0.513876	0.539642
513	0.794366	-0.083966	2.670485	0.284995	0.223323	-0.904232	-0.014849	0.107226	1.340049	-0.147246	...	0.342367	0.485571	0.580150
514	0.921634	-0.264543	2.719216	-0.019643	0.242195	-0.966939	-0.118080	0.123010	1.290364	-0.177553	...	0.332816	0.344047	0.122409
515	-1.620549	-0.978838	0.331987	1.256638	-0.408164	0.735698	0.815510	-1.398344	0.076379	-0.005814	...	-0.011739	-1.035533	-0.774382
516	4.075907	-0.367441	-0.247152	0.979966	6.792273	5.943666	-1.639583	8.121827	-0.627980	4.953722	...	10.467443	-7.333036	0.377340

517 rows × 25 columns

In [18]:

```
# split into input (X) and output (Y) variables
array = finalDf.values
X = array[:,0:24]
Y = array[:,24]
```

In [19]:

```
X.reshape(-1,1)
Y.reshape(-1,1)
```

Out[19]:

```
array([[0.],
       [0.],
       [0.],
       [0.],
       [0.],
       [0.],
       [0.],
       [0.],
       [0.],
```

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```

In [20]:

```
# create model
model = Sequential()
model.add(Dense(12, input_dim=24, activation='relu'))
model.add(Dense(8,activation='relu'))
model.add(Dense(1,activation='sigmoid'))
```

In [21]:

```
# Compile model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
# Fit the model
model.fit(X, Y, validation_split=0.3, epochs=150, batch_size=10)
```

```
Epoch 1/150
37/37 [==============================] - 14s 15ms/step - loss: 0.7368 - accuracy: 0.5511 - val_loss: 0.7
815 - val_accuracy: 0.5513
Epoch 2/150
37/37 [==============================] - 0s 2ms/step - loss: 0.6252 - accuracy: 0.6321 - val_loss:
0.7765 - val_accuracy: 0.6410
Epoch 3/150
37/37 [==============================] - 0s 2ms/step - loss: 0.5862 - accuracy: 0.7249 - val_loss:
0.7721 - val_accuracy: 0.6667
Epoch 4/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5401 - accuracy: 0.7862 - val_loss:
0.7695 - val_accuracy: 0.6731
Epoch 5/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5654 - accuracy: 0.7394 - val_loss:
0.7646 - val_accuracy: 0.6859
Epoch 6/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5378 - accuracy: 0.7416 - val_loss:
0.7576 - val_accuracy: 0.6731
```

```
Epoch 7/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5212 - accuracy: 0.7672 - val_loss: 0.7517 - val_accuracy: 0.6795
Epoch 8/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5252 - accuracy: 0.7605 - val_loss: 0.7485 - val_accuracy: 0.6795
Epoch 9/150
37/37 [==============================] - 0s 3ms/step - loss: 0.5080 - accuracy: 0.7533 - val_loss: 0.7456 - val_accuracy: 0.6795
Epoch 10/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4716 - accuracy: 0.7782 - val_loss: 0.7426 - val_accuracy: 0.6859
Epoch 11/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4788 - accuracy: 0.7828 - val_loss: 0.7370 - val_accuracy: 0.6859
Epoch 12/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4699 - accuracy: 0.7788 - val_loss: 0.7313 - val_accuracy: 0.6859
Epoch 13/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4486 - accuracy: 0.7949 - val_loss: 0.7266 - val_accuracy: 0.6859
Epoch 14/150
37/37 [==============================] - 0s 4ms/step - loss: 0.4466 - accuracy: 0.7949 - val_loss: 0.7252 - val_accuracy: 0.6859
Epoch 15/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4579 - accuracy: 0.7976 - val_loss: 0.7239 - val_accuracy: 0.6859
Epoch 16/150
37/37 [==============================] - 0s 2ms/step - loss: 0.4309 - accuracy: 0.8016 - val_loss: 0.7238 - val_accuracy: 0.6987
Epoch 17/150
37/37 [==============================] - 0s 3ms/step - loss: 0.4320 - accuracy: 0.8065 - val_loss: 0.7173 - val_accuracy: 0.6987
Epoch 18/150
37/37 [==============================] - 0s 2ms/step - loss: 0.4328 - accuracy: 0.7800 - val_loss: 0.7221 - val_accuracy: 0.7051
Epoch 19/150
37/37 [==============================] - 0s 2ms/step - loss: 0.4012 - accuracy: 0.8177 - val_loss: 0.7220 - val_accuracy: 0.7051
Epoch 20/150
37/37 [==============================] - 0s 2ms/step - loss: 0.4214 - accuracy: 0.8234 - val_loss: 0.7169 - val_accuracy: 0.7051
Epoch 21/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3859 - accuracy: 0.8475 - val_loss: 0.7244 - val_accuracy: 0.7115
Epoch 22/150
37/37 [==============================] - 0s 2ms/step - loss: 0.4023 - accuracy: 0.8135 - val_loss: 0.7211 - val_accuracy: 0.7051
Epoch 23/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3636 - accuracy: 0.8533 - val_loss: 0.7319 - val_accuracy: 0.7179
Epoch 24/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3787 - accuracy: 0.8348 - val_loss: 0.7305 - val_accuracy: 0.7179
Epoch 25/150
37/37 [==============================] - 0s 3ms/step - loss: 0.3842 - accuracy: 0.8162 - val_loss: 0.7300 - val_accuracy: 0.7179
Epoch 26/150
37/37 [==============================] - 0s 3ms/step - loss: 0.3772 - accuracy: 0.8289 - val_loss: 0.7255 - val_accuracy: 0.7308
Epoch 27/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3845 - accuracy: 0.8162 - val_loss: 0.7296 - val_accuracy: 0.7308
Epoch 28/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3370 - accuracy: 0.8403 - val_loss: 0.7362 - val_accuracy: 0.7308
Epoch 29/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3520 - accuracy: 0.8370 - val_loss: 0.7358 - val_accuracy: 0.7308
Epoch 30/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3582 - accuracy: 0.8374 - val_loss: 0.7346 - val_accuracy: 0.7372
Epoch 31/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3599 - accuracy: 0.8349 - val_loss: 0.7386 - val_accuracy: 0.7372
Epoch 32/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3406 - accuracy: 0.8483 - val_loss:
```

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0.7443 - val_accuracy: 0.7372
Epoch 33/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3135 - accuracy: 0.8893 - val_loss: 0.7418 - val_accuracy: 0.7564
Epoch 34/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3350 - accuracy: 0.8610 - val_loss: 0.7502 - val_accuracy: 0.7564
Epoch 35/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3728 - accuracy: 0.8245 - val_loss: 0.7497 - val_accuracy: 0.7564
Epoch 36/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3452 - accuracy: 0.8531 - val_loss: 0.7424 - val_accuracy: 0.7564
Epoch 37/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3414 - accuracy: 0.8558 - val_loss: 0.7554 - val_accuracy: 0.7628
Epoch 38/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3134 - accuracy: 0.8548 - val_loss: 0.7635 - val_accuracy: 0.7628
Epoch 39/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3510 - accuracy: 0.8441 - val_loss: 0.7666 - val_accuracy: 0.7564
Epoch 40/150
37/37 [==============================] - 0s 2ms/step - loss: 0.3292 - accuracy: 0.8523 - val_loss: 0.7724 - val_accuracy: 0.7564
Epoch 41/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2824 - accuracy: 0.8760 - val_loss: 0.7775 - val_accuracy: 0.7628
Epoch 42/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2733 - accuracy: 0.9004 - val_loss: 0.7747 - val_accuracy: 0.7628
Epoch 43/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2929 - accuracy: 0.8834 - val_loss: 0.7822 - val_accuracy: 0.7628
Epoch 44/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2884 - accuracy: 0.8937 - val_loss: 0.7857 - val_accuracy: 0.7628
Epoch 45/150
37/37 [==============================] - 0s 5ms/step - loss: 0.2983 - accuracy: 0.8870 - val_loss: 0.7914 - val_accuracy: 0.7692
Epoch 46/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2652 - accuracy: 0.9096 - val_loss: 0.7842 - val_accuracy: 0.7564
Epoch 47/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2641 - accuracy: 0.9045 - val_loss: 0.7916 - val_accuracy: 0.7692
Epoch 48/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2655 - accuracy: 0.9219 - val_loss: 0.7962 - val_accuracy: 0.7692
Epoch 49/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2773 - accuracy: 0.9183 - val_loss: 0.8030 - val_accuracy: 0.7628
Epoch 50/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2625 - accuracy: 0.8988 - val_loss: 0.8114 - val_accuracy: 0.7628
Epoch 51/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2566 - accuracy: 0.9135 - val_loss: 0.8174 - val_accuracy: 0.7628
Epoch 52/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2781 - accuracy: 0.8956 - val_loss: 0.8227 - val_accuracy: 0.7564
Epoch 53/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2510 - accuracy: 0.9173 - val_loss: 0.8248 - val_accuracy: 0.7564
Epoch 54/150
37/37 [==============================] - 0s 6ms/step - loss: 0.2598 - accuracy: 0.9096 - val_loss: 0.8316 - val_accuracy: 0.7564
Epoch 55/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2027 - accuracy: 0.9465 - val_loss: 0.8312 - val_accuracy: 0.7500
Epoch 56/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2489 - accuracy: 0.9128 - val_loss: 0.8415 - val_accuracy: 0.7692
Epoch 57/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2477 - accuracy: 0.8958 - val_loss: 0.8457 - val_accuracy: 0.7692
Epoch 58/150
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Epoch 58/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2283 - accuracy: 0.9217 - val_loss:
0.8545 - val_accuracy: 0.7628
Epoch 59/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2196 - accuracy: 0.9202 - val_loss:
0.8616 - val_accuracy: 0.7628
Epoch 60/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2226 - accuracy: 0.9178 - val_loss:
0.8626 - val_accuracy: 0.7692
Epoch 61/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2168 - accuracy: 0.9279 - val_loss:
0.8729 - val_accuracy: 0.7885
Epoch 62/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2374 - accuracy: 0.9022 - val_loss:
0.8783 - val_accuracy: 0.7821
Epoch 63/150
37/37 [==============================] - 0s 3ms/step - loss: 0.2141 - accuracy: 0.9237 - val_loss:
0.8822 - val_accuracy: 0.7821
Epoch 64/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2212 - accuracy: 0.9133 - val_loss:
0.8892 - val_accuracy: 0.7756
Epoch 65/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1944 - accuracy: 0.9330 - val_loss:
0.8864 - val_accuracy: 0.7692
Epoch 66/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1951 - accuracy: 0.9242 - val_loss:
0.8938 - val_accuracy: 0.7628
Epoch 67/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1628 - accuracy: 0.9497 - val_loss:
0.8993 - val_accuracy: 0.7692
Epoch 68/150
37/37 [==============================] - 0s 2ms/step - loss: 0.2092 - accuracy: 0.8992 - val_loss:
0.9015 - val_accuracy: 0.7821
Epoch 69/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1848 - accuracy: 0.9416 - val_loss:
0.9052 - val_accuracy: 0.7756
Epoch 70/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1696 - accuracy: 0.9474 - val_loss:
0.9128 - val_accuracy: 0.7564
Epoch 71/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1936 - accuracy: 0.9335 - val_loss:
0.9087 - val_accuracy: 0.7821
Epoch 72/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1887 - accuracy: 0.9324 - val_loss:
0.9205 - val_accuracy: 0.7756
Epoch 73/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1628 - accuracy: 0.9461 - val_loss:
0.9296 - val_accuracy: 0.7628
Epoch 74/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1944 - accuracy: 0.9281 - val_loss:
0.9358 - val_accuracy: 0.7692
Epoch 75/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1901 - accuracy: 0.9279 - val_loss:
0.9400 - val_accuracy: 0.7628
Epoch 76/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1621 - accuracy: 0.9280 - val_loss:
0.9501 - val_accuracy: 0.7564
Epoch 77/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1585 - accuracy: 0.9565 - val_loss:
0.9523 - val_accuracy: 0.7564
Epoch 78/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1564 - accuracy: 0.9462 - val_loss:
0.9603 - val_accuracy: 0.7500
Epoch 79/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1718 - accuracy: 0.9428 - val_loss:
0.9681 - val_accuracy: 0.7564
Epoch 80/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1477 - accuracy: 0.9396 - val_loss:
0.9812 - val_accuracy: 0.7692
Epoch 81/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1553 - accuracy: 0.9479 - val_loss:
0.9791 - val_accuracy: 0.7628
Epoch 82/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1574 - accuracy: 0.9415 - val_loss:
0.9838 - val_accuracy: 0.7500
Epoch 83/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1533 - accuracy: 0.9434 - val_loss:
1.0002 - val_accuracy: 0.7500
```

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1.0002 - val_accuracy: 0.7500
Epoch 84/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1670 - accuracy: 0.9380 - val_loss: 0.9912 - val_accuracy: 0.7564
Epoch 85/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1650 - accuracy: 0.9375 - val_loss: 1.0017 - val_accuracy: 0.7628
Epoch 86/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1402 - accuracy: 0.9570 - val_loss: 1.0066 - val_accuracy: 0.7628
Epoch 87/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1581 - accuracy: 0.9498 - val_loss: 1.0121 - val_accuracy: 0.7564
Epoch 88/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1542 - accuracy: 0.9611 - val_loss: 1.0117 - val_accuracy: 0.7628
Epoch 89/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1122 - accuracy: 0.9719 - val_loss: 1.0182 - val_accuracy: 0.7372
Epoch 90/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1464 - accuracy: 0.9549 - val_loss: 1.0221 - val_accuracy: 0.7628
Epoch 91/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1263 - accuracy: 0.9626 - val_loss: 1.0276 - val_accuracy: 0.7500
Epoch 92/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1395 - accuracy: 0.9555 - val_loss: 1.0271 - val_accuracy: 0.7692
Epoch 93/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1148 - accuracy: 0.9693 - val_loss: 1.0407 - val_accuracy: 0.7628
Epoch 94/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1118 - accuracy: 0.9732 - val_loss: 1.0429 - val_accuracy: 0.7500
Epoch 95/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1353 - accuracy: 0.9544 - val_loss: 1.0431 - val_accuracy: 0.7564
Epoch 96/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1233 - accuracy: 0.9530 - val_loss: 1.0554 - val_accuracy: 0.7564
Epoch 97/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1196 - accuracy: 0.9713 - val_loss: 1.0474 - val_accuracy: 0.7436
Epoch 98/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1426 - accuracy: 0.9395 - val_loss: 1.0601 - val_accuracy: 0.7436
Epoch 99/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1222 - accuracy: 0.9640 - val_loss: 1.0618 - val_accuracy: 0.7500
Epoch 100/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0991 - accuracy: 0.9668 - val_loss: 1.0674 - val_accuracy: 0.7436
Epoch 101/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1230 - accuracy: 0.9429 - val_loss: 1.0619 - val_accuracy: 0.7500
Epoch 102/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1217 - accuracy: 0.9515 - val_loss: 1.0735 - val_accuracy: 0.7564
Epoch 103/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1234 - accuracy: 0.9555 - val_loss: 1.0854 - val_accuracy: 0.7500
Epoch 104/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1202 - accuracy: 0.9559 - val_loss: 1.0878 - val_accuracy: 0.7500
Epoch 105/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1006 - accuracy: 0.9690 - val_loss: 1.0975 - val_accuracy: 0.7436
Epoch 106/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0946 - accuracy: 0.9682 - val_loss: 1.1053 - val_accuracy: 0.7564
Epoch 107/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1073 - accuracy: 0.9530 - val_loss: 1.1002 - val_accuracy: 0.7628
Epoch 108/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0922 - accuracy: 0.9648 - val_loss: 1.1247 - val_accuracy: 0.7500
Epoch 109/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1064 - accuracy: 0.9684 - val_loss:
```

```
37/37 [==============================] - 0s 2ms/step - loss: 0.1064 - accuracy: 0.9664 - val_loss:
1.1169 - val_accuracy: 0.7500
Epoch 110/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0893 - accuracy: 0.9702 - val_loss:
1.1137 - val_accuracy: 0.7500
Epoch 111/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0831 - accuracy: 0.9754 - val_loss:
1.1261 - val_accuracy: 0.7436
Epoch 112/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0876 - accuracy: 0.9697 - val_loss:
1.1241 - val_accuracy: 0.7500
Epoch 113/150
37/37 [==============================] - 0s 2ms/step - loss: 0.1089 - accuracy: 0.9607 - val_loss:
1.1466 - val_accuracy: 0.7308
Epoch 114/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0922 - accuracy: 0.9715 - val_loss:
1.1446 - val_accuracy: 0.7308
Epoch 115/150
37/37 [==============================] - 0s 3ms/step - loss: 0.1027 - accuracy: 0.9557 - val_loss:
1.1503 - val_accuracy: 0.7500
Epoch 116/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0908 - accuracy: 0.9694 - val_loss:
1.1690 - val_accuracy: 0.7244
Epoch 117/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0771 - accuracy: 0.9789 - val_loss:
1.1739 - val_accuracy: 0.7244
Epoch 118/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0949 - accuracy: 0.9730 - val_loss:
1.1685 - val_accuracy: 0.7564
Epoch 119/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0850 - accuracy: 0.9752 - val_loss:
1.1686 - val_accuracy: 0.7500
Epoch 120/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0669 - accuracy: 0.9821 - val_loss:
1.1864 - val_accuracy: 0.7372
Epoch 121/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0836 - accuracy: 0.9672 - val_loss:
1.1904 - val_accuracy: 0.7308
Epoch 122/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0745 - accuracy: 0.9811 - val_loss:
1.1797 - val_accuracy: 0.7372
Epoch 123/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0775 - accuracy: 0.9711 - val_loss:
1.1874 - val_accuracy: 0.7500
Epoch 124/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0828 - accuracy: 0.9680 - val_loss:
1.2064 - val_accuracy: 0.7179
Epoch 125/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0886 - accuracy: 0.9569 - val_loss:
1.1995 - val_accuracy: 0.7372
Epoch 126/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0570 - accuracy: 0.9719 - val_loss:
1.2139 - val_accuracy: 0.7244
Epoch 127/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0580 - accuracy: 0.9815 - val_loss:
1.2113 - val_accuracy: 0.7372
Epoch 128/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0632 - accuracy: 0.9848 - val_loss:
1.2125 - val_accuracy: 0.7372
Epoch 129/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0676 - accuracy: 0.9737 - val_loss:
1.2300 - val_accuracy: 0.7244
Epoch 130/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0637 - accuracy: 0.9825 - val_loss:
1.2279 - val_accuracy: 0.7308
Epoch 131/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0556 - accuracy: 0.9900 - val_loss:
1.2449 - val_accuracy: 0.7436
Epoch 132/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0570 - accuracy: 0.9935 - val_loss:
1.2479 - val_accuracy: 0.7500
Epoch 133/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0650 - accuracy: 0.9810 - val_loss:
1.2506 - val_accuracy: 0.7372
Epoch 134/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0709 - accuracy: 0.9850 - val_loss:
1.2543 - val_accuracy: 0.7436
Epoch 135/150
```

```
Epoch 135/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0654 - accuracy: 0.9729 - val_loss:
1.2564 - val_accuracy: 0.7564
Epoch 136/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0593 - accuracy: 0.9852 - val_loss:
1.2796 - val_accuracy: 0.7308
Epoch 137/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0609 - accuracy: 0.9871 - val_loss:
1.2845 - val_accuracy: 0.7436
Epoch 138/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0575 - accuracy: 0.9874 - val_loss:
1.2927 - val_accuracy: 0.7436
Epoch 139/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0532 - accuracy: 0.9887 - val_loss:
1.2956 - val_accuracy: 0.7500
Epoch 140/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0524 - accuracy: 0.9946 - val_loss:
1.3027 - val_accuracy: 0.7436
Epoch 141/150
37/37 [==============================] - 0s 4ms/step - loss: 0.0680 - accuracy: 0.9819 - val_loss:
1.2955 - val_accuracy: 0.7500
Epoch 142/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0610 - accuracy: 0.9755 - val_loss:
1.3188 - val_accuracy: 0.7372
Epoch 143/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0449 - accuracy: 0.9928 - val_loss:
1.3178 - val_accuracy: 0.7436
Epoch 144/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0641 - accuracy: 0.9847 - val_loss:
1.3323 - val_accuracy: 0.7372
Epoch 145/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0402 - accuracy: 0.9927 - val_loss:
1.3477 - val_accuracy: 0.7436
Epoch 146/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0417 - accuracy: 0.9960 - val_loss:
1.3394 - val_accuracy: 0.7372
Epoch 147/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0547 - accuracy: 0.9890 - val_loss:
1.3574 - val_accuracy: 0.7436
Epoch 148/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0484 - accuracy: 0.9954 - val_loss:
1.3598 - val_accuracy: 0.7308
Epoch 149/150
37/37 [==============================] - 0s 2ms/step - loss: 0.0376 - accuracy: 0.9952 - val_loss:
1.3606 - val_accuracy: 0.7308
Epoch 150/150
37/37 [==============================] - 0s 3ms/step - loss: 0.0372 - accuracy: 0.9917 - val_loss:
1.4027 - val_accuracy: 0.7244
```

Out[21]:

```
<keras.callbacks.History at 0x2197c40b160>
```

In [22]:

```python
# evaluate the model
scores = model.evaluate(X, Y)
print("%s: %.2f%%" % (model.metrics_names[1], scores[1]*100))
```

```
17/17 [==============================] - 0s 1ms/step - loss: 0.4524 - accuracy: 0.9149
accuracy: 91.49%
```

In [ ]: