In [117]:
```
import numpy as np
import pandas as pd

from matplotlib import pyplot as plt

from sklearn.model_selection import train_test_split

from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import load_model
```

In [133]:
```
data = pd.read_csv('Churn.csv')
```

In [134]:
```
data.columns
```

Out[134]:
```
Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
       'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
       'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
       'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
       'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
      dtype='object')
```

In [135]:
```
data.dtypes
```

Out[135]:
```
customerID           object
gender               object
SeniorCitizen         int64
Partner              object
Dependents           object
tenure                int64
PhoneService         object
MultipleLines        object
InternetService      object
OnlineSecurity       object
OnlineBackup         object
DeviceProtection     object
TechSupport          object
StreamingTV          object
StreamingMovies      object
Contract             object
PaperlessBilling     object
PaymentMethod        object
MonthlyCharges      float64
TotalCharges         object
Churn                object
dtype: object
```

In [136]:
```
data.SeniorCitizen.replace([0, 1], ["No", "Yes"], inplace= True)
```

In [138]:
```
for charge in data.TotalCharges:
    try:
      charge = float(charge)
    except:
      print("charge is: %s" % charge)
```

```
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
charge is:
```

In [139]:
```
for i in range(len(data)):
  if data.TotalCharges[i] == " ":
      print("Tenure is %s and Monthly charges are %s" % (data.tenure[i], data.Mon
thlyCharges[i]))
```

```
Tenure is 0 and Monthly charges are 52.55
Tenure is 0 and Monthly charges are 20.25
Tenure is 0 and Monthly charges are 80.85
Tenure is 0 and Monthly charges are 25.75
Tenure is 0 and Monthly charges are 56.05
Tenure is 0 and Monthly charges are 19.85
Tenure is 0 and Monthly charges are 25.35
Tenure is 0 and Monthly charges are 20.0
Tenure is 0 and Monthly charges are 19.7
Tenure is 0 and Monthly charges are 73.35
Tenure is 0 and Monthly charges are 61.9
```

In [140]:
```
data.TotalCharges.replace([" "], ["0"], inplace= True)
data.TotalCharges = data.TotalCharges.astype(float)
```

In [141]:
```
data.dtypes
```

Out[141]:
```
customerID           object
gender               object
SeniorCitizen        object
Partner              object
Dependents           object
tenure                int64
PhoneService         object
MultipleLines        object
InternetService      object
OnlineSecurity       object
OnlineBackup         object
DeviceProtection     object
TechSupport          object
StreamingTV          object
StreamingMovies      object
Contract             object
PaperlessBilling     object
PaymentMethod        object
MonthlyCharges      float64
TotalCharges        float64
Churn                object
dtype: object
```

In [142]:
```
data.drop("customerID", axis= 1, inplace= True)
```

In [143]:
```
for col in data.dtypes[data.dtypes == object].index:
    print(col, data[col].unique())
```

```
gender ['Female' 'Male']
SeniorCitizen ['No' 'Yes']
Partner ['Yes' 'No']
Dependents ['No' 'Yes']
PhoneService ['No' 'Yes']
MultipleLines ['No phone service' 'No' 'Yes']
InternetService ['DSL' 'Fiber optic' 'No']
OnlineSecurity ['No' 'Yes' 'No internet service']
OnlineBackup ['Yes' 'No' 'No internet service']
DeviceProtection ['No' 'Yes' 'No internet service']
TechSupport ['No' 'Yes' 'No internet service']
StreamingTV ['No' 'Yes' 'No internet service']
StreamingMovies ['No' 'Yes' 'No internet service']
Contract ['Month-to-month' 'One year' 'Two year']
PaperlessBilling ['Yes' 'No']
PaymentMethod ['Electronic check' 'Mailed check' 'Bank transfer (automatic)'
 'Credit card (automatic)']
Churn ['No' 'Yes']
```

In [144]:
```
data.Churn.replace(["Yes", "No"], [1, 0], inplace= True)
```

In [150]:
```
data = pd.get_dummies(data)
```

In [151]:
```
X = data.drop(['Churn'],axis=1)
y = data.Churn
```

In [152]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size= 0.57, random
_state= 1234)
```

In [153]:
```
model = Sequential()
model.add(Dense(16, input_dim=X_train.shape[1], activation='relu'))
model.add(Dense(8, activation='relu'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
model.add(Dense(1, activation='sigmoid'))
```

In [154]:
```
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
```

In [157]:
```
model.fit(X_train, y_train, epochs=200, batch_size=50)
```

```
Epoch 1/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3960 - ac
c: 0.8160
Epoch 2/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3920 - ac
c: 0.8173
Epoch 3/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3915 - ac
c: 0.8225
Epoch 4/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3933 - ac
c: 0.8186
Epoch 5/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3939 - ac
c: 0.8160
Epoch 6/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3928 - ac
c: 0.8183
Epoch 7/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3896 - ac
c: 0.8186
Epoch 8/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3882 - ac
c: 0.8241
Epoch 9/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.4001 - ac
c: 0.8089
Epoch 10/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.4024 - ac
c: 0.8108
Epoch 11/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3992 - ac
c: 0.8157
Epoch 12/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3937 - ac
c: 0.8167
Epoch 13/200
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3923 - ac
c: 0.8170
Epoch 14/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3904 - ac
c: 0.8205
Epoch 15/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.4017 - ac
c: 0.8128
Epoch 16/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3928 - ac
c: 0.8183
Epoch 17/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.4126 - ac
c: 0.8096
Epoch 18/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3963 - ac
c: 0.8189
Epoch 19/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.4054 - ac
c: 0.8073
Epoch 20/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3948 - ac
c: 0.8160
Epoch 21/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3994 - ac
c: 0.8138
Epoch 22/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3870 - ac
```

```
c: 0.8238
Epoch 23/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.4046 - ac
c: 0.8086
Epoch 24/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3931 - ac
c: 0.8221
Epoch 25/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3936 - ac
c: 0.8189
Epoch 26/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3914 - ac
c: 0.8170
Epoch 27/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3986 - ac
c: 0.8131
Epoch 28/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3947 - ac
c: 0.8205
Epoch 29/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3964 - ac
c: 0.8189
Epoch 30/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3933 - ac
c: 0.8154
Epoch 31/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3895 - ac
c: 0.8244
Epoch 32/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3923 - ac
c: 0.8186
Epoch 33/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3905 - ac
c: 0.8147
Epoch 34/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3937 - ac
c: 0.8183
Epoch 35/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3971 - ac
c: 0.8189
Epoch 36/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3904 - ac
c: 0.8209
Epoch 37/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.4002 - ac
c: 0.8160
Epoch 38/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3983 - ac
c: 0.8134
Epoch 39/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.4032 - ac
c: 0.8034
Epoch 40/200
3098/3098 [==============================] - 0s 49us/sample - loss: 0.3855 - ac
c: 0.8205
Epoch 41/200
3098/3098 [==============================] - 0s 42us/sample - loss: 0.3857 - ac
c: 0.8276
Epoch 42/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3905 - ac
c: 0.8183
Epoch 43/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3898 - ac
c: 0.8209
Epoch 44/200
```

```
3098/3098 [==============================] - 0s 53us/sample - loss: 0.3856 - ac
c: 0.8228
Epoch 45/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3917 - ac
c: 0.8238
Epoch 46/200
3098/3098 [==============================] - 0s 44us/sample - loss: 0.4063 - ac
c: 0.8121
Epoch 47/200
3098/3098 [==============================] - 0s 51us/sample - loss: 0.3944 - ac
c: 0.8179
Epoch 48/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.4018 - ac
c: 0.8157
Epoch 49/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3948 - ac
c: 0.8170
Epoch 50/200
3098/3098 [==============================] - 0s 59us/sample - loss: 0.4017 - ac
c: 0.8128
Epoch 51/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3948 - ac
c: 0.8154
Epoch 52/200
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3930 - ac
c: 0.8218
Epoch 53/200
3098/3098 [==============================] - 0s 48us/sample - loss: 0.3975 - ac
c: 0.8154
Epoch 54/200
3098/3098 [==============================] - 0s 41us/sample - loss: 0.3977 - ac
c: 0.8150
Epoch 55/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3974 - ac
c: 0.8183
Epoch 56/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3893 - ac
c: 0.8228
Epoch 57/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3844 - ac
c: 0.8221
Epoch 58/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3960 - ac
c: 0.8134
Epoch 59/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3868 - ac
c: 0.8209
Epoch 60/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3957 - ac
c: 0.8167
Epoch 61/200
3098/3098 [==============================] - 0s 35us/sample - loss: 0.3886 - ac
c: 0.8196
Epoch 62/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3967 - ac
c: 0.8189
Epoch 63/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3895 - ac
c: 0.8199
Epoch 64/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.4156 - ac
c: 0.8138
Epoch 65/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3939 - ac
c: 0.8170
```

```
Epoch 66/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3939 - ac
c: 0.8131
Epoch 67/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3846 - ac
c: 0.8244
Epoch 68/200
3098/3098 [==============================] - 0s 41us/sample - loss: 0.4014 - ac
c: 0.8134
Epoch 69/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3873 - ac
c: 0.8215
Epoch 70/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3908 - ac
c: 0.8218
Epoch 71/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3844 - ac
c: 0.8238
Epoch 72/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3877 - ac
c: 0.8147
Epoch 73/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3946 - ac
c: 0.8173
Epoch 74/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3882 - ac
c: 0.8218
Epoch 75/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.4022 - ac
c: 0.8099
Epoch 76/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3949 - ac
c: 0.8144
Epoch 77/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3901 - ac
c: 0.8225
Epoch 78/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3903 - ac
c: 0.8205
Epoch 79/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3983 - ac
c: 0.8170
Epoch 80/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3957 - ac
c: 0.8170
Epoch 81/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3899 - ac
c: 0.8160
Epoch 82/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.4127 - ac
c: 0.8041
Epoch 83/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3859 - ac
c: 0.8199
Epoch 84/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3898 - ac
c: 0.8176
Epoch 85/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.4072 - ac
c: 0.8150
Epoch 86/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3888 - ac
c: 0.8189
Epoch 87/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3861 - ac
```

```
c: 0.8241
Epoch 88/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3908 - ac
c: 0.8199
Epoch 89/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.4071 - ac
c: 0.8173
Epoch 90/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3990 - ac
c: 0.8173
Epoch 91/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3973 - ac
c: 0.8167
Epoch 92/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3858 - ac
c: 0.8244
Epoch 93/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3947 - ac
c: 0.8147
Epoch 94/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3862 - ac
c: 0.8283
Epoch 95/200
3098/3098 [==============================] - 0s 35us/sample - loss: 0.3866 - ac
c: 0.8231
Epoch 96/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3886 - ac
c: 0.8238
Epoch 97/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3845 - ac
c: 0.8250
Epoch 98/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3965 - ac
c: 0.8212
Epoch 99/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3937 - ac
c: 0.8231
Epoch 100/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3897 - ac
c: 0.8173
Epoch 101/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.4012 - ac
c: 0.8150
Epoch 102/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3930 - ac
c: 0.8154
Epoch 103/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3840 - ac
c: 0.8202
Epoch 104/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.4016 - ac
c: 0.8163
Epoch 105/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3892 - ac
c: 0.8212
Epoch 106/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3931 - ac
c: 0.8196
Epoch 107/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3906 - ac
c: 0.8131
Epoch 108/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3837 - ac
c: 0.8202
Epoch 109/200
```

```
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3849 - ac
c: 0.8241
Epoch 110/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.4054 - ac
c: 0.8147
Epoch 111/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.4003 - ac
c: 0.8150
Epoch 112/200
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3835 - ac
c: 0.8189
Epoch 113/200
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3918 - ac
c: 0.8199
Epoch 114/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3892 - ac
c: 0.8173
Epoch 115/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3863 - ac
c: 0.8225
Epoch 116/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3897 - ac
c: 0.8186
Epoch 117/200
3098/3098 [==============================] - 0s 35us/sample - loss: 0.3950 - ac
c: 0.8176
Epoch 118/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3785 - ac
c: 0.8283
Epoch 119/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3951 - ac
c: 0.8125
Epoch 120/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3877 - ac
c: 0.8163
Epoch 121/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3960 - ac
c: 0.8173
Epoch 122/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3816 - ac
c: 0.8238
Epoch 123/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3893 - ac
c: 0.8225
Epoch 124/200
3098/3098 [==============================] - 0s 49us/sample - loss: 0.3846 - ac
c: 0.8257
Epoch 125/200
3098/3098 [==============================] - 0s 50us/sample - loss: 0.3870 - ac
c: 0.8209
Epoch 126/200
3098/3098 [==============================] - 0s 52us/sample - loss: 0.3959 - ac
c: 0.8163
Epoch 127/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3819 - ac
c: 0.8250
Epoch 128/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3858 - ac
c: 0.8205
Epoch 129/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3818 - ac
c: 0.8244
Epoch 130/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3849 - ac
c: 0.8260
```

```
Epoch 131/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3862 - ac
c: 0.8196
Epoch 132/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3828 - ac
c: 0.8263
Epoch 133/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3817 - ac
c: 0.8250
Epoch 134/200
3098/3098 [==============================] - 0s 27us/sample - loss: 0.3863 - ac
c: 0.8212
Epoch 135/200
3098/3098 [==============================] - 0s 35us/sample - loss: 0.3852 - ac
c: 0.8183
Epoch 136/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3813 - ac
c: 0.8189
Epoch 137/200
3098/3098 [==============================] - 0s 34us/sample - loss: 0.3927 - ac
c: 0.8163
Epoch 138/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3880 - ac
c: 0.8205
Epoch 139/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3895 - ac
c: 0.8163
Epoch 140/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3836 - ac
c: 0.8244
Epoch 141/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3899 - ac
c: 0.8170
Epoch 142/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3891 - ac
c: 0.8225
Epoch 143/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3831 - ac
c: 0.8189
Epoch 144/200
3098/3098 [==============================] - 0s 41us/sample - loss: 0.3815 - ac
c: 0.8244
Epoch 145/200
3098/3098 [==============================] - 0s 41us/sample - loss: 0.3850 - ac
c: 0.8241
Epoch 146/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3877 - ac
c: 0.8173
Epoch 147/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3835 - ac
c: 0.8202
Epoch 148/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3882 - ac
c: 0.8179
Epoch 149/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3835 - ac
c: 0.8192
Epoch 150/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3869 - ac
c: 0.8173
Epoch 151/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3876 - ac
c: 0.8225
Epoch 152/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.4016 - ac
```

```
c: 0.8099
Epoch 153/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3908 - ac
c: 0.8183
Epoch 154/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3842 - ac
c: 0.8254
Epoch 155/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3822 - ac
c: 0.8225
Epoch 156/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3810 - ac
c: 0.8218
Epoch 157/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3815 - ac
c: 0.8238
Epoch 158/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3859 - ac
c: 0.8241
Epoch 159/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3871 - ac
c: 0.8205
Epoch 160/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3876 - ac
c: 0.8189
Epoch 161/200
3098/3098 [==============================] - 0s 27us/sample - loss: 0.3907 - ac
c: 0.8202
Epoch 162/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3872 - ac
c: 0.8202
Epoch 163/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3867 - ac
c: 0.8228
Epoch 164/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3812 - ac
c: 0.8247
Epoch 165/200
3098/3098 [==============================] - 0s 41us/sample - loss: 0.3816 - ac
c: 0.8234
Epoch 166/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3843 - ac
c: 0.8186
Epoch 167/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3798 - ac
c: 0.8257
Epoch 168/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.4086 - ac
c: 0.8089
Epoch 169/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3967 - ac
c: 0.8212
Epoch 170/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3900 - ac
c: 0.8196
Epoch 171/200
3098/3098 [==============================] - 0s 35us/sample - loss: 0.3838 - ac
c: 0.8244
Epoch 172/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3846 - ac
c: 0.8280
Epoch 173/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3885 - ac
c: 0.8157
Epoch 174/200
```

```
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3847 - ac
c: 0.8238
Epoch 175/200
3098/3098 [==============================] - 0s 39us/sample - loss: 0.3870 - ac
c: 0.8205
Epoch 176/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3793 - ac
c: 0.8234
Epoch 177/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3908 - ac
c: 0.8231
Epoch 178/200
3098/3098 [==============================] - 0s 36us/sample - loss: 0.3842 - ac
c: 0.8199
Epoch 179/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3841 - ac
c: 0.8241
Epoch 180/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3784 - ac
c: 0.8280
Epoch 181/200
3098/3098 [==============================] - 0s 27us/sample - loss: 0.3810 - ac
c: 0.8254
Epoch 182/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3820 - ac
c: 0.8218
Epoch 183/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3886 - ac
c: 0.8173
Epoch 184/200
3098/3098 [==============================] - 0s 30us/sample - loss: 0.3869 - ac
c: 0.8179
Epoch 185/200
3098/3098 [==============================] - 0s 29us/sample - loss: 0.3877 - ac
c: 0.8244
Epoch 186/200
3098/3098 [==============================] - 0s 40us/sample - loss: 0.3808 - ac
c: 0.8234
Epoch 187/200
3098/3098 [==============================] - 0s 48us/sample - loss: 0.3804 - ac
c: 0.8244
Epoch 188/200
3098/3098 [==============================] - 0s 38us/sample - loss: 0.3803 - ac
c: 0.8280
Epoch 189/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3797 - ac
c: 0.8250
Epoch 190/200
3098/3098 [==============================] - 0s 31us/sample - loss: 0.3851 - ac
c: 0.8225
Epoch 191/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3817 - ac
c: 0.8231
Epoch 192/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3863 - ac
c: 0.8247
Epoch 193/200
3098/3098 [==============================] - 0s 42us/sample - loss: 0.3831 - ac
c: 0.8199
Epoch 194/200
3098/3098 [==============================] - 0s 49us/sample - loss: 0.3854 - ac
c: 0.8196
Epoch 195/200
3098/3098 [==============================] - 0s 37us/sample - loss: 0.3916 - ac
c: 0.8189
```

```
Epoch 196/200
3098/3098 [==============================] - 0s 33us/sample - loss: 0.3833 - ac
c: 0.8267
Epoch 197/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3805 - ac
c: 0.8250
Epoch 198/200
3098/3098 [==============================] - 0s 32us/sample - loss: 0.3821 - ac
c: 0.8244
Epoch 199/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3783 - ac
c: 0.8231
Epoch 200/200
3098/3098 [==============================] - 0s 28us/sample - loss: 0.3809 - ac
c: 0.8283
```

Out[157]: <tensorflow.python.keras.callbacks.History at 0x17460d435c0>

In [158]:
```
_, accuracy = model.evaluate(X_test, y_test)
```

```
3945/3945 [==============================] - 0s 25us/sample - loss: 0.5042 - ac
c: 0.7640
```