Churn model

October 30, 2023

[1]:
```
import pandas as pd
from sklearn.model_selection import train_test_split
```

[3]:
```
data=pd.read_csv("churn.csv")
```

[4]:
```
data.head()
```

[4]:

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	…	DeviceProtection	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	PaymentMethod	MonthlyCharges	TotalCharges	Churn
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	No	No	No	No	Month-to-month	Yes	Electronic check	29.85	29.85	No
1	5575-GNVDE	Male	0	No	No	34	Yes	No	Yes	No	No	No	One year	No	Mailed check	56.95	1889.5	No
2	3668-QPYBK	Male	0	No	No	2	Yes	No	No	No	No	No	Month-to-month	Yes	Mailed check	53.85	108.15	Yes
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	Yes	Yes	No	No	One year	No	Bank transfer (automatic)	42.30	1840.75	No
4	9237-HQITU	Female	0	No	No	2	Yes	No	No	No	No	No	Month-to-month	Yes	Electronic check	70.70	151.65	Yes

[5 rows x 21 columns]

[11]:
```
x=pd.get_dummies(data.drop(['Churn','customerID'],axis=1))
y=data['Churn'].apply(lambda x: 1 if x=='Yes'else 0)
```

[15]:
```
y.head()
```

[15]:
```
0    0
1    0
2    1
3    0
4    1
Name: Churn, dtype: int64
```

[16]:
```
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2)
```

[17]:
```
x_train.head()
```

[17]:

	SeniorCitizen	tenure	MonthlyCharges	gender_Female	gender_Male	\
6768	0	72	117.50	1	0	
924	1	22	81.70	1	0	
3668	0	22	59.75	0	1	
6016	0	68	108.45	0	1	
2857	0	47	63.80	1	0	

	Partner_No	Partner_Yes	Dependents_No	Dependents_Yes	PhoneService_No	\
6768	0	1	0	1	0	
924	1	0	1	0	0	
3668	0	1	1	0	0	
6016	1	0	1	0	0	
2857	0	1	0	1	0	

	…	TotalCharges_995.35	TotalCharges_996.45	TotalCharges_996.85	\
6768	…	0	0	0	
924	…	0	0	0	
3668	…	0	0	0	
6016	…	0	0	0	
2857	…	0	0	0	

	TotalCharges_996.95	TotalCharges_997.65	TotalCharges_997.75	\
6768	0	0	0	
924	0	0	0	
3668	0	0	0	
6016	0	0	0	
2857	0	0	0	

	TotalCharges_998.1	TotalCharges_999.45	TotalCharges_999.8	\
6768	0	0	0	
924	0	0	0	

```
3668                    0                    0                    0
6016                    0                    0                    0
2857                    0                    0                    0

      TotalCharges_999.9
6768                    0
924                     0
3668                    0
6016                    0
2857                    0

[5 rows x 6575 columns]
```

[18]:
```
y_train.head()
```

[18]:
```
6768    0
924     0
3668    0
6016    1
2857    0
Name: Churn, dtype: int64
```

[19]:
```
from tensorflow.keras.models import Sequential,load_model
from tensorflow.keras.layers import Dense # Weighted sum and activation␣
 ↪function
from sklearn.metrics import accuracy_score
```

Sequential is a type of model in TensorFlow used to create a linear stack of layers for building neural networks.
load_model is a function that allows you to load a pre-trained model from a file
The Dense layer is used to create fully connected layers in a neural network, where every neuron is connected to every neuron in the previous and subsequent layers.

[20]:
```
model= Sequential()
model.add(Dense(units=32,activation='relu',input_dim=len(x_train.columns)))
model.add(Dense(units=64,activation='relu'))
model.add(Dense(units=1,activation='sigmoid')) #output

# activation='relu': The activation function for this layer is
# Rectified Linear Unit (ReLU), which is commonly used in hidden layers
# of neural networks. It introduces non-linearity by outputting the input
# if it's positive and 0 if it's negative.
```

[21]:
```
model.compile(loss='binary_crossentropy',optimizer='sgd',metrics='accuracy')
```

[30]:
```
model.fit(x_train,y_train,epochs=300,batch_size=32)
```

```
Epoch 1/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4164 -
accuracy: 0.8058
Epoch 2/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4185 -
accuracy: 0.8048
Epoch 3/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4171 -
accuracy: 0.7998
Epoch 4/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4178 -
accuracy: 0.8023
Epoch 5/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4166 -
accuracy: 0.8028
Epoch 6/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4171 -
accuracy: 0.8049
Epoch 7/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4152 -
accuracy: 0.8088
Epoch 8/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4146 -
accuracy: 0.8040
Epoch 9/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4180 -
accuracy: 0.8056
Epoch 10/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4161 -
accuracy: 0.8051
Epoch 11/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4169 -
accuracy: 0.8055
Epoch 12/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4222 -
accuracy: 0.8019
Epoch 13/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4183 -
accuracy: 0.8035
Epoch 14/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4190 -
accuracy: 0.8012
Epoch 15/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4154 -
accuracy: 0.8016
Epoch 16/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4121 -
accuracy: 0.8049
Epoch 17/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4158 -
accuracy: 0.8009
Epoch 18/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4145 -
accuracy: 0.8053
Epoch 19/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4161 -
accuracy: 0.8053
Epoch 20/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4175 -
accuracy: 0.8024
Epoch 21/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4167 -
accuracy: 0.8042
Epoch 22/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4150 -
accuracy: 0.8035
Epoch 23/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4165 -
accuracy: 0.8046
Epoch 24/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4132 -
accuracy: 0.8055
Epoch 25/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4140 -
accuracy: 0.8069
Epoch 26/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4178 -
accuracy: 0.7996
Epoch 27/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4157 -
accuracy: 0.8062
Epoch 28/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4139 -
accuracy: 0.8083
Epoch 29/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4140 -
accuracy: 0.8051
Epoch 30/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4137 -
accuracy: 0.8067
Epoch 31/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4210 -
accuracy: 0.8010
Epoch 32/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4181 -
accuracy: 0.8007
Epoch 33/300
```

```
177/177 [==============================] - 1s 4ms/step - loss: 0.4146 -
accuracy: 0.8049
Epoch 34/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4165 -
accuracy: 0.8032
Epoch 35/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4169 -
accuracy: 0.8035
Epoch 36/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4168 -
accuracy: 0.8019
Epoch 37/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4160 -
accuracy: 0.8039
Epoch 38/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4130 -
accuracy: 0.8081
Epoch 39/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4143 -
accuracy: 0.8051
Epoch 40/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4158 -
accuracy: 0.8003
Epoch 41/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4160 -
accuracy: 0.8039
Epoch 42/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4152 -
accuracy: 0.8040
Epoch 43/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4153 -
accuracy: 0.8056
Epoch 44/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4167 -
accuracy: 0.8056
Epoch 45/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4129 -
accuracy: 0.8056
Epoch 46/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4142 -
accuracy: 0.8055
Epoch 47/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4139 -
accuracy: 0.8071
Epoch 48/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4154 -
accuracy: 0.8030
Epoch 49/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4157 -
accuracy: 0.8064
Epoch 50/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4146 -
accuracy: 0.8014
Epoch 51/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4131 -
accuracy: 0.8048
Epoch 52/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4150 -
accuracy: 0.8033
Epoch 53/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4125 -
accuracy: 0.8072
Epoch 54/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4156 -
accuracy: 0.8005
Epoch 55/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4173 -
accuracy: 0.8035
Epoch 56/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4155 -
accuracy: 0.8074
Epoch 57/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4250 -
accuracy: 0.7930
Epoch 58/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4137 -
accuracy: 0.8033
Epoch 59/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4128 -
accuracy: 0.8051
Epoch 60/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4135 -
accuracy: 0.8081
Epoch 61/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4115 -
accuracy: 0.8039
Epoch 62/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4123 -
accuracy: 0.8055
Epoch 63/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4141 -
accuracy: 0.8049
Epoch 64/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4140 -
accuracy: 0.8062
Epoch 65/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4154 -
accuracy: 0.8051
Epoch 66/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4132 -
accuracy: 0.8076
Epoch 67/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4158 -
accuracy: 0.8003
Epoch 68/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4175 -
accuracy: 0.8014
Epoch 69/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4137 -
accuracy: 0.8062
Epoch 70/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4146 -
accuracy: 0.8042
Epoch 71/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4131 -
accuracy: 0.8032
Epoch 72/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4141 -
accuracy: 0.8044
Epoch 73/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4152 -
accuracy: 0.8032
Epoch 74/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4142 -
accuracy: 0.8064
Epoch 75/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4142 -
accuracy: 0.7994
Epoch 76/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4146 -
accuracy: 0.8039
Epoch 77/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4188 -
accuracy: 0.7996
Epoch 78/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4149 -
accuracy: 0.8024
Epoch 79/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4123 -
accuracy: 0.8076
Epoch 80/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4175 -
accuracy: 0.8021
Epoch 81/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4144 -
accuracy: 0.8078
Epoch 82/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4148 -
accuracy: 0.8033
Epoch 83/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4118 -
accuracy: 0.8046
Epoch 84/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4127 -
accuracy: 0.8071
Epoch 85/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4140 -
accuracy: 0.8049
Epoch 86/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4132 -
accuracy: 0.8076
Epoch 87/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4148 -
accuracy: 0.8032
Epoch 88/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4153 -
accuracy: 0.8064
Epoch 89/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4121 -
accuracy: 0.8062
Epoch 90/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4144 -
accuracy: 0.8049
Epoch 91/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4105 -
accuracy: 0.8069
Epoch 92/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4138 -
accuracy: 0.8062
Epoch 93/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4198 -
accuracy: 0.8035
Epoch 94/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4156 -
accuracy: 0.8071
Epoch 95/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4121 -
accuracy: 0.8076
Epoch 96/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4120 -
accuracy: 0.8058
Epoch 97/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4129 -
accuracy: 0.8053
Epoch 98/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4110 -
accuracy: 0.8055
Epoch 99/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4121 -
accuracy: 0.8055
Epoch 100/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4142 -
accuracy: 0.8064
Epoch 101/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4138 -
accuracy: 0.8046
Epoch 102/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4114 -
accuracy: 0.8080
Epoch 103/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4138 -
accuracy: 0.8023
Epoch 104/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4128 -
accuracy: 0.8053
Epoch 105/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4135 -
accuracy: 0.8069
Epoch 106/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4129 -
accuracy: 0.8049
Epoch 107/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4138 -
accuracy: 0.8044
Epoch 108/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4118 -
accuracy: 0.8065
Epoch 109/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4113 -
accuracy: 0.8069
Epoch 110/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4121 -
accuracy: 0.8085
Epoch 111/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4122 -
accuracy: 0.8067
Epoch 112/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4104 -
accuracy: 0.8072
Epoch 113/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4123 -
accuracy: 0.8049
Epoch 114/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4106 -
accuracy: 0.8071
Epoch 115/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4120 -
accuracy: 0.8064
Epoch 116/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4117 -
accuracy: 0.8030
Epoch 117/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4116 -
accuracy: 0.8051
Epoch 118/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4116 -
accuracy: 0.8049
Epoch 119/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4123 -
accuracy: 0.8019
Epoch 120/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4126 -
accuracy: 0.8033
Epoch 121/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4166 -
accuracy: 0.8032
Epoch 122/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4121 -
accuracy: 0.8087
Epoch 123/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4112 -
accuracy: 0.8040
Epoch 124/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4080 -
accuracy: 0.8083
Epoch 125/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4128 -
accuracy: 0.8051
Epoch 126/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4117 -
accuracy: 0.8044
Epoch 127/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4124 -
accuracy: 0.8024
Epoch 128/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4126 -
accuracy: 0.8046
Epoch 129/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4114 -
accuracy: 0.8069
Epoch 130/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4127 -
accuracy: 0.8078
Epoch 131/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4114 -
accuracy: 0.8080
Epoch 132/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4118 -
accuracy: 0.8021
Epoch 133/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4131 -
accuracy: 0.8046
Epoch 134/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8044
Epoch 135/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4102 -
accuracy: 0.8076
Epoch 136/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4111 -
accuracy: 0.8076
Epoch 137/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4112 -
accuracy: 0.8056
Epoch 138/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4144 -
accuracy: 0.8033
Epoch 139/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4097 -
accuracy: 0.8051
Epoch 140/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4115 -
accuracy: 0.8056
Epoch 141/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4125 -
accuracy: 0.8060
Epoch 142/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4113 -
accuracy: 0.8051
Epoch 143/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4104 -
accuracy: 0.8055
Epoch 144/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4081 -
accuracy: 0.8055
Epoch 145/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4118 -
accuracy: 0.8071
Epoch 146/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4095 -
accuracy: 0.8104
Epoch 147/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4109 -
accuracy: 0.8087
Epoch 148/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8060
Epoch 149/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4127 -
accuracy: 0.8035
Epoch 150/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4123 -
accuracy: 0.8033
Epoch 151/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4137 -
accuracy: 0.8053
Epoch 152/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4117 -
accuracy: 0.8039
Epoch 153/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4091 -
accuracy: 0.8058
Epoch 154/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4085 -
accuracy: 0.8078
Epoch 155/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4083 -
accuracy: 0.8081
Epoch 156/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4116 -
accuracy: 0.8064
Epoch 157/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4081 -
accuracy: 0.8078
Epoch 158/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4093 -
accuracy: 0.8076
Epoch 159/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4103 -
accuracy: 0.8072
Epoch 160/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4103 -
accuracy: 0.8037
Epoch 161/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4109 -
accuracy: 0.8067
Epoch 162/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8067
Epoch 163/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4105 -
accuracy: 0.8064
Epoch 164/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4093 -
accuracy: 0.8044
Epoch 165/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4122 -
accuracy: 0.8048
Epoch 166/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4103 -
accuracy: 0.8064
Epoch 167/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8088
Epoch 168/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4102 -
accuracy: 0.8051
Epoch 169/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4098 -
accuracy: 0.8051
Epoch 170/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4099 -
accuracy: 0.8035
Epoch 171/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4073 -
accuracy: 0.8072
Epoch 172/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4112 -
accuracy: 0.8071
Epoch 173/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4097 -
accuracy: 0.8053
Epoch 174/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4118 -
accuracy: 0.8060
Epoch 175/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4107 -
accuracy: 0.8058
Epoch 176/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4125 -
accuracy: 0.8046
Epoch 177/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4096 -
accuracy: 0.8078
Epoch 178/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4125 -
accuracy: 0.8021
Epoch 179/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4102 -
accuracy: 0.8085
Epoch 180/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4099 -
accuracy: 0.8053
Epoch 181/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4101 -
accuracy: 0.8081
Epoch 182/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4095 -
accuracy: 0.8117
Epoch 183/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8072
Epoch 184/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4094 -
accuracy: 0.8080
Epoch 185/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4078 -
accuracy: 0.8095
Epoch 186/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4099 -
accuracy: 0.8080
Epoch 187/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4089 -
accuracy: 0.8062
Epoch 188/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4103 -
accuracy: 0.8058
Epoch 189/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8044
Epoch 190/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4107 -
accuracy: 0.8028
Epoch 191/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4105 -
accuracy: 0.8053
Epoch 192/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4092 -
accuracy: 0.8080
Epoch 193/300
```

```
177/177 [==============================] - 1s 3ms/step - loss: 0.4103 -
accuracy: 0.8053
Epoch 194/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4098 -
accuracy: 0.8076
Epoch 195/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4083 -
accuracy: 0.8103
Epoch 196/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4087 -
accuracy: 0.8092
Epoch 197/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8071
Epoch 198/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4085 -
accuracy: 0.8065
Epoch 199/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4109 -
accuracy: 0.8080
Epoch 200/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4086 -
accuracy: 0.8087
Epoch 201/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4119 -
accuracy: 0.8062
Epoch 202/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8039
Epoch 203/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4093 -
accuracy: 0.8000
Epoch 204/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4104 -
accuracy: 0.8053
Epoch 205/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4105 -
accuracy: 0.8037
Epoch 206/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4104 -
accuracy: 0.8120
Epoch 207/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4106 -
accuracy: 0.8032
Epoch 208/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4096 -
accuracy: 0.8060
Epoch 209/300
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177/177 [==============================] - 1s 3ms/step - loss: 0.4078 -
accuracy: 0.8092
Epoch 210/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4091 -
accuracy: 0.8088
Epoch 211/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4097 -
accuracy: 0.8094
Epoch 212/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4159 -
accuracy: 0.8037
Epoch 213/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4089 -
accuracy: 0.8074
Epoch 214/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4091 -
accuracy: 0.8037
Epoch 215/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4078 -
accuracy: 0.8092
Epoch 216/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4091 -
accuracy: 0.8021
Epoch 217/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4083 -
accuracy: 0.8055
Epoch 218/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4086 -
accuracy: 0.8078
Epoch 219/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4087 -
accuracy: 0.8108
Epoch 220/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4087 -
accuracy: 0.8099
Epoch 221/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4099 -
accuracy: 0.8067
Epoch 222/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4064 -
accuracy: 0.8083
Epoch 223/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4097 -
accuracy: 0.8069
Epoch 224/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8087
Epoch 225/300
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177/177 [==============================] - 1s 3ms/step - loss: 0.4075 -
accuracy: 0.8080
Epoch 226/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4092 -
accuracy: 0.8069
Epoch 227/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4071 -
accuracy: 0.8074
Epoch 228/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4101 -
accuracy: 0.8037
Epoch 229/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4101 -
accuracy: 0.8083
Epoch 230/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4086 -
accuracy: 0.8099
Epoch 231/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4092 -
accuracy: 0.8053
Epoch 232/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4079 -
accuracy: 0.8040
Epoch 233/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4077 -
accuracy: 0.8074
Epoch 234/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4090 -
accuracy: 0.8048
Epoch 235/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4082 -
accuracy: 0.8048
Epoch 236/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4093 -
accuracy: 0.8069
Epoch 237/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4088 -
accuracy: 0.8053
Epoch 238/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4116 -
accuracy: 0.8046
Epoch 239/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4075 -
accuracy: 0.8049
Epoch 240/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4074 -
accuracy: 0.8074
Epoch 241/300
```

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177/177 [==============================] - 1s 3ms/step - loss: 0.4076 -
accuracy: 0.8104
Epoch 242/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4089 -
accuracy: 0.8060
Epoch 243/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4075 -
accuracy: 0.8080
Epoch 244/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4070 -
accuracy: 0.8076
Epoch 245/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4072 -
accuracy: 0.8003
Epoch 246/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4079 -
accuracy: 0.8074
Epoch 247/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4099 -
accuracy: 0.8106
Epoch 248/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4073 -
accuracy: 0.8048
Epoch 249/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4128 -
accuracy: 0.8048
Epoch 250/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4086 -
accuracy: 0.8097
Epoch 251/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4082 -
accuracy: 0.8062
Epoch 252/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4076 -
accuracy: 0.8067
Epoch 253/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4096 -
accuracy: 0.8064
Epoch 254/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4068 -
accuracy: 0.8048
Epoch 255/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4081 -
accuracy: 0.8097
Epoch 256/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4080 -
accuracy: 0.8097
Epoch 257/300
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177/177 [==============================] - 1s 4ms/step - loss: 0.4087 -
accuracy: 0.8083
Epoch 258/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4085 -
accuracy: 0.8065
Epoch 259/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4078 -
accuracy: 0.8076
Epoch 260/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8080
Epoch 261/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4089 -
accuracy: 0.8065
Epoch 262/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4106 -
accuracy: 0.8069
Epoch 263/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4072 -
accuracy: 0.8051
Epoch 264/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4091 -
accuracy: 0.8062
Epoch 265/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4083 -
accuracy: 0.8055
Epoch 266/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4110 -
accuracy: 0.8026
Epoch 267/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4113 -
accuracy: 0.8064
Epoch 268/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4096 -
accuracy: 0.8067
Epoch 269/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4111 -
accuracy: 0.8042
Epoch 270/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4093 -
accuracy: 0.8080
Epoch 271/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4071 -
accuracy: 0.8069
Epoch 272/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4086 -
accuracy: 0.8071
Epoch 273/300
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177/177 [==============================] - 1s 3ms/step - loss: 0.4047 -
accuracy: 0.8076
Epoch 274/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4077 -
accuracy: 0.8042
Epoch 275/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4092 -
accuracy: 0.8095
Epoch 276/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4087 -
accuracy: 0.8033
Epoch 277/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4073 -
accuracy: 0.8104
Epoch 278/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4107 -
accuracy: 0.8071
Epoch 279/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4100 -
accuracy: 0.8080
Epoch 280/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4094 -
accuracy: 0.8080
Epoch 281/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4080 -
accuracy: 0.8076
Epoch 282/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4063 -
accuracy: 0.8087
Epoch 283/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4075 -
accuracy: 0.8097
Epoch 284/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4095 -
accuracy: 0.8062
Epoch 285/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4087 -
accuracy: 0.8056
Epoch 286/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4070 -
accuracy: 0.8030
Epoch 287/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4069 -
accuracy: 0.8088
Epoch 288/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4107 -
accuracy: 0.8065
Epoch 289/300
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177/177 [==============================] - 1s 3ms/step - loss: 0.4065 -
accuracy: 0.8049
Epoch 290/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4085 -
accuracy: 0.8069
Epoch 291/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4059 -
accuracy: 0.8087
Epoch 292/300
177/177 [==============================] - 1s 4ms/step - loss: 0.4092 -
accuracy: 0.8090
Epoch 293/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4098 -
accuracy: 0.8101
Epoch 294/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4076 -
accuracy: 0.8078
Epoch 295/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4074 -
accuracy: 0.8067
Epoch 296/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4094 -
accuracy: 0.8048
Epoch 297/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4075 -
accuracy: 0.8074
Epoch 298/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4085 -
accuracy: 0.8037
Epoch 299/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4071 -
accuracy: 0.8092
Epoch 300/300
177/177 [==============================] - 1s 3ms/step - loss: 0.4065 -
accuracy: 0.8083
```

[30]:
```
<keras.src.callbacks.History at 0x1abf4a22f90>
```

[31]:
```
y_hat= model.predict(x_test)
y_hat=[0 if val <0.5 else 1 for val in y_hat]
```

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45/45 [==============================] - 0s 2ms/step
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y_hat
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[33]:
```
accuracy_score(y_test,y_hat)
```

[33]:
```
0.7877927608232789
```

[34]:
```
model.save('tfmodel')
```

```
INFO:tensorflow:Assets written to: tfmodel\assets

INFO:tensorflow:Assets written to: tfmodel\assets
```

[28]:
```
model=load_model('tfmodel') # reloading the model after deleting (del model)
```

[29]:
```
model
```

[29]:
```
<keras.src.engine.sequential.Sequential at 0x1ab81caab50>
```

[ ]:
```

```