


artificial-neural-network

December 5, 2023

[3]:  pip install tensorflow

```
Requirement already satisfied: tensorflow in c:\users\nikee\anaconda3\lib\site-  
packages (2.15.0)  
Requirement already satisfied: tensorflow-intel==2.15.0 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow) (2.15.0)  
Requirement already satisfied: absl-py>=1.0.0 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (2.0.0)  
Requirement already satisfied: astunparse>=1.6.0 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (1.6.3)  
Requirement already satisfied: flatbuffers>=23.5.26 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (23.5.26)  
Requirement already satisfied: gast!=0.5.0,!0.5.1,!0.5.2,>=0.2.1 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (0.5.4)  
Requirement already satisfied: google-pasta>=0.1.1 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (0.2.0)  
Requirement already satisfied: h5py>=2.9.0 in c:\users\nikee\anaconda3\lib\site-  
packages (from tensorflow-intel==2.15.0->tensorflow) (3.7.0)  
Requirement already satisfied: libclang>=13.0.0 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (16.0.6)  
Requirement already satisfied: ml-dtypes~=0.2.0 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (0.2.0)  
Requirement already satisfied: numpy<2.0.0,>=1.23.5 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (1.24.3)  
Requirement already satisfied: opt-einsum>=2.3.2 in  
c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-  
intel==2.15.0->tensorflow) (3.3.0)  
Requirement already satisfied: packaging in c:\users\nikee\anaconda3\lib\site-  
packages (from tensorflow-intel==2.15.0->tensorflow) (23.0)  
Requirement already satisfied:
```

protobuf!=4.21.0,!4.21.1,!4.21.2,!4.21.3,!4.21.4,!4.21.5,<5.0.0dev,>=3.20.3
 in c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (4.23.4)
 Requirement already satisfied: setuptools in c:\users\nikee\anaconda3\lib\site-
 packages (from tensorflow-intel==2.15.0->tensorflow) (68.0.0)
 Requirement already satisfied: six>=1.12.0 in c:\users\nikee\anaconda3\lib\site-
 packages (from tensorflow-intel==2.15.0->tensorflow) (1.16.0)
 Requirement already satisfied: termcolor>=1.1.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (2.4.0)
 Requirement already satisfied: typing-extensions>=3.6.6 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (4.7.1)
 Requirement already satisfied: wrapt<1.15,>=1.11.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (1.14.1)
 Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (0.31.0)
 Requirement already satisfied: grpcio<2.0,>=1.24.3 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (1.59.3)
 Requirement already satisfied: tensorboard<2.16,>=2.15 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (2.15.1)
 Requirement already satisfied: tensorflow-estimator<2.16,>=2.15.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (2.15.0)
 Requirement already satisfied: keras<2.16,>=2.15.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from tensorflow-
 intel==2.15.0->tensorflow) (2.15.0)
 Requirement already satisfied: wheel<1.0,>=0.23.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from astunparse>=1.6.0->tensorflow-
 intel==2.15.0->tensorflow) (0.38.4)
 Requirement already satisfied: google-auth<3,>=1.6.3 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.24.0)
 Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (1.1.0)
 Requirement already satisfied: markdown>=2.6.8 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (3.4.1)
 Requirement already satisfied: requests<3,>=2.21.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.31.0)
 Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from

tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (0.7.2)
 Requirement already satisfied: werkzeug>=1.0.1 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.2.3)
 Requirement already satisfied: cachetools<6.0,>=2.0.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from google-
 auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (5.3.2)
 Requirement already satisfied: pyasn1-modules>=0.2.1 in
 c:\users\nikee\anaconda3\lib\site-packages (from google-
 auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (0.2.8)
 Requirement already satisfied: rsa<5,>=3.1.4 in
 c:\users\nikee\anaconda3\lib\site-packages (from google-
 auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (4.9)
 Requirement already satisfied: requests-oauthlib>=0.7.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from google-auth-
 oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (1.3.1)
 Requirement already satisfied: charset-normalizer<4,>=2 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-
 intel==2.15.0->tensorflow) (2.0.4)
 Requirement already satisfied: idna<4,>=2.5 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-
 intel==2.15.0->tensorflow) (3.4)
 Requirement already satisfied: urllib3<3,>=1.21.1 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-
 intel==2.15.0->tensorflow) (1.26.16)
 Requirement already satisfied: certifi>=2017.4.17 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-
 intel==2.15.0->tensorflow) (2023.7.22)
 Requirement already satisfied: MarkupSafe>=2.1.1 in
 c:\users\nikee\anaconda3\lib\site-packages (from
 werkzeug>=1.0.1->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (2.1.1)
 Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in
 c:\users\nikee\anaconda3\lib\site-packages (from pyasn1-modules>=0.2.1->google-
 auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)
 (0.4.8)
 Requirement already satisfied: oauthlib>=3.0.0 in
 c:\users\nikee\anaconda3\lib\site-packages (from requests-
 oauthlib>=0.7.0->google-auth-
 oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow)

(3.2.2)

```
[2]: #Importing necessary Libraries
import numpy as np
import pandas as pd
import tensorflow as tf
import keras
from keras.models import Sequential # for all deep learning neural network
from keras.layers import Dense #for hidden layer
from keras.layers import LeakyReLU, PReLU, ELU # for Activation function
from keras.layers import Dropout # to avoid overfittin---> if neural network is too deep we usually used this
```

```
[3]: #Import data set
dataset= pd.read_csv('Churn_Modelling.csv')
dataset.head()
```

```
[3]:
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	\
0	1	15634602	Hargrave	619	France	Female	42	
1	2	15647311	Hill	608	Spain	Female	41	
2	3	15619304	Onio	502	France	Female	42	
3	4	15701354	Boni	699	France	Female	39	
4	5	15737888	Mitchell	850	Spain	Female	43	

	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember	\
0	2	0.00	1	1	1	
1	1	83807.86	1	0	1	
2	8	159660.80	3	1	0	
3	1	0.00	2	0	0	
4	2	125510.82	1	1	1	

	EstimatedSalary	Exited
0	101348.88	1
1	112542.58	0
2	113931.57	1
3	93826.63	0
4	79084.10	0

```
[4]: X= dataset.iloc[:,3:-1]
y=dataset.iloc[:,-1]
X.head()
```

```
[4]:
```

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	\
0	619	France	Female	42	2	0.00	1	
1	608	Spain	Female	41	1	83807.86	1	
2	502	France	Female	42	8	159660.80	3	
3	699	France	Female	39	1	0.00	2	

4	850	Spain	Female	43	2	125510.82	1
---	-----	-------	--------	----	---	-----------	---

	HasCrCard	IsActiveMember	EstimatedSalary
0	1	1	101348.88
1	0	1	112542.58
2	1	0	113931.57
3	0	0	93826.63
4	1	1	79084.10

```
[5]: geography=pd.get_dummies(X["Geography"],drop_first=True)
gender= pd.get_dummies(X['Gender'],drop_first=True)
```

```
[6]: # concat
X=pd.concat([X,geography,gender],axis=1)
# Dropping
X.drop(['Geography','Gender'],axis=1,inplace=True)
X.head()
```

```
[6]:
```

	CreditScore	Age	Tenure	Balance	NumOfProducts	HasCrCard	\
0	619	42	2	0.00	1	1	
1	608	41	1	83807.86	1	0	
2	502	42	8	159660.80	3	1	
3	699	39	1	0.00	2	0	
4	850	43	2	125510.82	1	1	

	IsActiveMember	EstimatedSalary	Germany	Spain	Male
0	1	101348.88	False	False	False
1	1	112542.58	False	True	False
2	0	113931.57	False	False	False
3	0	93826.63	False	False	False
4	1	79084.10	False	True	False

```
[7]: #splitting into training and test
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.
↪20,random_state=0)
```

```
[8]: from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
X_train=sc.fit_transform(X_train)
X_test=sc.transform(X_test)
```

```
[9]: classifier= Sequential()
```

```
[10]: # Adding the input layer and the first hidden layer
classifier.
↪add(Dense(units=6,kernel_initializer='he_uniform',activation='relu',input_dim=11))
```

```
# Adding the second hidden layer
classifier.add(Dense(units=6,kernel_initializer='he_uniform',activation='relu'))

# Adding the output layer
classifier.
    ↪add(Dense(units=1,kernel_initializer='glorot_uniform',activation='sigmoid'))
classifier.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
dense (Dense)	(None, 6)	72
dense_1 (Dense)	(None, 6)	42
dense_2 (Dense)	(None, 1)	7

=====
 Total params: 121 (484.00 Byte)
 Trainable params: 121 (484.00 Byte)
 Non-trainable params: 0 (0.00 Byte)
 =====

```
[11]: # compiling ANN
classifier.
    ↪compile(loss='binary_crossentropy',optimizer='adam',metrics=['accuracy'])
```

```
[12]: #fitting the ANN to the training set
model_history=classifier.fit(X_train,y_train,validation_split=0.
    ↪33,batch_size=10,epochs=100)
```

```
Epoch 1/100
536/536 [=====] - 2s 2ms/step - loss: 0.6029 -
accuracy: 0.7132 - val_loss: 0.5116 - val_accuracy: 0.7959
Epoch 2/100
536/536 [=====] - 1s 2ms/step - loss: 0.4900 -
accuracy: 0.7964 - val_loss: 0.4766 - val_accuracy: 0.7959
Epoch 3/100
536/536 [=====] - 1s 2ms/step - loss: 0.4580 -
accuracy: 0.7972 - val_loss: 0.4527 - val_accuracy: 0.7970
Epoch 4/100
536/536 [=====] - 1s 2ms/step - loss: 0.4345 -
accuracy: 0.8093 - val_loss: 0.4328 - val_accuracy: 0.8164
Epoch 5/100
536/536 [=====] - 1s 3ms/step - loss: 0.4198 -
accuracy: 0.8169 - val_loss: 0.4220 - val_accuracy: 0.8217
```

Epoch 6/100
536/536 [=====] - 2s 4ms/step - loss: 0.4119 - accuracy: 0.8205 - val_loss: 0.4156 - val_accuracy: 0.8239

Epoch 7/100
536/536 [=====] - 1s 2ms/step - loss: 0.4064 - accuracy: 0.8212 - val_loss: 0.4105 - val_accuracy: 0.8243

Epoch 8/100
536/536 [=====] - 1s 3ms/step - loss: 0.4021 - accuracy: 0.8268 - val_loss: 0.4071 - val_accuracy: 0.8217

Epoch 9/100
536/536 [=====] - 1s 3ms/step - loss: 0.3982 - accuracy: 0.8263 - val_loss: 0.4035 - val_accuracy: 0.8239

Epoch 10/100
536/536 [=====] - 1s 2ms/step - loss: 0.3944 - accuracy: 0.8278 - val_loss: 0.4005 - val_accuracy: 0.8251

Epoch 11/100
536/536 [=====] - 1s 2ms/step - loss: 0.3911 - accuracy: 0.8287 - val_loss: 0.3978 - val_accuracy: 0.8228

Epoch 12/100
536/536 [=====] - 1s 2ms/step - loss: 0.3885 - accuracy: 0.8293 - val_loss: 0.3945 - val_accuracy: 0.8281

Epoch 13/100
536/536 [=====] - 1s 2ms/step - loss: 0.3854 - accuracy: 0.8304 - val_loss: 0.3925 - val_accuracy: 0.8307

Epoch 14/100
536/536 [=====] - 1s 2ms/step - loss: 0.3830 - accuracy: 0.8313 - val_loss: 0.3908 - val_accuracy: 0.8285

Epoch 15/100
536/536 [=====] - 1s 2ms/step - loss: 0.3804 - accuracy: 0.8326 - val_loss: 0.3896 - val_accuracy: 0.8266

Epoch 16/100
536/536 [=====] - 1s 2ms/step - loss: 0.3787 - accuracy: 0.8336 - val_loss: 0.3880 - val_accuracy: 0.8273

Epoch 17/100
536/536 [=====] - 1s 2ms/step - loss: 0.3763 - accuracy: 0.8354 - val_loss: 0.3860 - val_accuracy: 0.8281

Epoch 18/100
536/536 [=====] - 1s 2ms/step - loss: 0.3744 - accuracy: 0.8336 - val_loss: 0.3832 - val_accuracy: 0.8304

Epoch 19/100
536/536 [=====] - 1s 2ms/step - loss: 0.3732 - accuracy: 0.8330 - val_loss: 0.3821 - val_accuracy: 0.8285

Epoch 20/100
536/536 [=====] - 1s 2ms/step - loss: 0.3711 - accuracy: 0.8341 - val_loss: 0.3814 - val_accuracy: 0.8285

Epoch 21/100
536/536 [=====] - 1s 2ms/step - loss: 0.3694 - accuracy: 0.8332 - val_loss: 0.3811 - val_accuracy: 0.8273

Epoch 22/100
536/536 [=====] - 1s 2ms/step - loss: 0.3678 - accuracy: 0.8384 - val_loss: 0.3804 - val_accuracy: 0.8398
Epoch 23/100
536/536 [=====] - 1s 2ms/step - loss: 0.3665 - accuracy: 0.8418 - val_loss: 0.3794 - val_accuracy: 0.8391
Epoch 24/100
536/536 [=====] - 1s 2ms/step - loss: 0.3649 - accuracy: 0.8436 - val_loss: 0.3794 - val_accuracy: 0.8387
Epoch 25/100
536/536 [=====] - 1s 2ms/step - loss: 0.3632 - accuracy: 0.8474 - val_loss: 0.3768 - val_accuracy: 0.8413
Epoch 26/100
536/536 [=====] - 1s 2ms/step - loss: 0.3623 - accuracy: 0.8485 - val_loss: 0.3773 - val_accuracy: 0.8421
Epoch 27/100
536/536 [=====] - 1s 2ms/step - loss: 0.3611 - accuracy: 0.8494 - val_loss: 0.3766 - val_accuracy: 0.8421
Epoch 28/100
536/536 [=====] - 1s 2ms/step - loss: 0.3595 - accuracy: 0.8494 - val_loss: 0.3773 - val_accuracy: 0.8482
Epoch 29/100
536/536 [=====] - 1s 2ms/step - loss: 0.3578 - accuracy: 0.8520 - val_loss: 0.3771 - val_accuracy: 0.8444
Epoch 30/100
536/536 [=====] - 1s 2ms/step - loss: 0.3575 - accuracy: 0.8496 - val_loss: 0.3754 - val_accuracy: 0.8482
Epoch 31/100
536/536 [=====] - 1s 2ms/step - loss: 0.3568 - accuracy: 0.8511 - val_loss: 0.3729 - val_accuracy: 0.8482
Epoch 32/100
536/536 [=====] - 1s 2ms/step - loss: 0.3554 - accuracy: 0.8518 - val_loss: 0.3732 - val_accuracy: 0.8478
Epoch 33/100
536/536 [=====] - 1s 2ms/step - loss: 0.3543 - accuracy: 0.8509 - val_loss: 0.3716 - val_accuracy: 0.8497
Epoch 34/100
536/536 [=====] - 1s 2ms/step - loss: 0.3535 - accuracy: 0.8509 - val_loss: 0.3725 - val_accuracy: 0.8482
Epoch 35/100
536/536 [=====] - 1s 2ms/step - loss: 0.3518 - accuracy: 0.8543 - val_loss: 0.3721 - val_accuracy: 0.8463
Epoch 36/100
536/536 [=====] - 1s 2ms/step - loss: 0.3504 - accuracy: 0.8552 - val_loss: 0.3706 - val_accuracy: 0.8493
Epoch 37/100
536/536 [=====] - 1s 2ms/step - loss: 0.3491 - accuracy: 0.8565 - val_loss: 0.3726 - val_accuracy: 0.8463

Epoch 38/100
536/536 [=====] - 1s 2ms/step - loss: 0.3483 -
accuracy: 0.8550 - val_loss: 0.3679 - val_accuracy: 0.8516
Epoch 39/100
536/536 [=====] - 1s 3ms/step - loss: 0.3469 -
accuracy: 0.8554 - val_loss: 0.3685 - val_accuracy: 0.8508
Epoch 40/100
536/536 [=====] - 1s 2ms/step - loss: 0.3453 -
accuracy: 0.8580 - val_loss: 0.3696 - val_accuracy: 0.8504
Epoch 41/100
536/536 [=====] - 1s 2ms/step - loss: 0.3446 -
accuracy: 0.8589 - val_loss: 0.3675 - val_accuracy: 0.8504
Epoch 42/100
536/536 [=====] - 1s 2ms/step - loss: 0.3433 -
accuracy: 0.8604 - val_loss: 0.3657 - val_accuracy: 0.8474
Epoch 43/100
536/536 [=====] - 1s 2ms/step - loss: 0.3424 -
accuracy: 0.8574 - val_loss: 0.3671 - val_accuracy: 0.8504
Epoch 44/100
536/536 [=====] - 1s 2ms/step - loss: 0.3413 -
accuracy: 0.8600 - val_loss: 0.3666 - val_accuracy: 0.8493
Epoch 45/100
536/536 [=====] - 1s 2ms/step - loss: 0.3404 -
accuracy: 0.8586 - val_loss: 0.3722 - val_accuracy: 0.8410
Epoch 46/100
536/536 [=====] - 1s 2ms/step - loss: 0.3410 -
accuracy: 0.8610 - val_loss: 0.3664 - val_accuracy: 0.8455
Epoch 47/100
536/536 [=====] - 1s 2ms/step - loss: 0.3401 -
accuracy: 0.8610 - val_loss: 0.3649 - val_accuracy: 0.8463
Epoch 48/100
536/536 [=====] - 1s 2ms/step - loss: 0.3399 -
accuracy: 0.8606 - val_loss: 0.3651 - val_accuracy: 0.8489
Epoch 49/100
536/536 [=====] - 1s 2ms/step - loss: 0.3396 -
accuracy: 0.8623 - val_loss: 0.3654 - val_accuracy: 0.8519
Epoch 50/100
536/536 [=====] - 1s 2ms/step - loss: 0.3397 -
accuracy: 0.8623 - val_loss: 0.3659 - val_accuracy: 0.8489
Epoch 51/100
536/536 [=====] - 1s 2ms/step - loss: 0.3393 -
accuracy: 0.8612 - val_loss: 0.3653 - val_accuracy: 0.8485
Epoch 52/100
536/536 [=====] - 1s 2ms/step - loss: 0.3385 -
accuracy: 0.8628 - val_loss: 0.3648 - val_accuracy: 0.8497
Epoch 53/100
536/536 [=====] - 1s 2ms/step - loss: 0.3389 -
accuracy: 0.8608 - val_loss: 0.3634 - val_accuracy: 0.8508

Epoch 54/100
536/536 [=====] - 1s 2ms/step - loss: 0.3382 -
accuracy: 0.8628 - val_loss: 0.3649 - val_accuracy: 0.8512
Epoch 55/100
536/536 [=====] - 2s 3ms/step - loss: 0.3376 -
accuracy: 0.8610 - val_loss: 0.3637 - val_accuracy: 0.8489
Epoch 56/100
536/536 [=====] - 1s 2ms/step - loss: 0.3371 -
accuracy: 0.8653 - val_loss: 0.3644 - val_accuracy: 0.8493
Epoch 57/100
536/536 [=====] - 1s 2ms/step - loss: 0.3374 -
accuracy: 0.8623 - val_loss: 0.3639 - val_accuracy: 0.8485
Epoch 58/100
536/536 [=====] - 1s 2ms/step - loss: 0.3369 -
accuracy: 0.8632 - val_loss: 0.3638 - val_accuracy: 0.8523
Epoch 59/100
536/536 [=====] - 1s 2ms/step - loss: 0.3370 -
accuracy: 0.8617 - val_loss: 0.3636 - val_accuracy: 0.8527
Epoch 60/100
536/536 [=====] - 1s 2ms/step - loss: 0.3367 -
accuracy: 0.8640 - val_loss: 0.3636 - val_accuracy: 0.8497
Epoch 61/100
536/536 [=====] - 1s 2ms/step - loss: 0.3364 -
accuracy: 0.8628 - val_loss: 0.3637 - val_accuracy: 0.8504
Epoch 62/100
536/536 [=====] - 1s 2ms/step - loss: 0.3363 -
accuracy: 0.8634 - val_loss: 0.3650 - val_accuracy: 0.8459
Epoch 63/100
536/536 [=====] - 1s 2ms/step - loss: 0.3356 -
accuracy: 0.8643 - val_loss: 0.3658 - val_accuracy: 0.8470
Epoch 64/100
536/536 [=====] - 1s 2ms/step - loss: 0.3358 -
accuracy: 0.8612 - val_loss: 0.3644 - val_accuracy: 0.8523
Epoch 65/100
536/536 [=====] - 1s 2ms/step - loss: 0.3357 -
accuracy: 0.8640 - val_loss: 0.3634 - val_accuracy: 0.8527
Epoch 66/100
536/536 [=====] - 1s 2ms/step - loss: 0.3358 -
accuracy: 0.8608 - val_loss: 0.3646 - val_accuracy: 0.8493
Epoch 67/100
536/536 [=====] - 1s 2ms/step - loss: 0.3347 -
accuracy: 0.8658 - val_loss: 0.3643 - val_accuracy: 0.8504
Epoch 68/100
536/536 [=====] - 1s 2ms/step - loss: 0.3350 -
accuracy: 0.8630 - val_loss: 0.3639 - val_accuracy: 0.8519
Epoch 69/100
536/536 [=====] - 1s 2ms/step - loss: 0.3349 -
accuracy: 0.8640 - val_loss: 0.3676 - val_accuracy: 0.8474

Epoch 70/100
536/536 [=====] - 1s 2ms/step - loss: 0.3342 -
accuracy: 0.8630 - val_loss: 0.3650 - val_accuracy: 0.8501
Epoch 71/100
536/536 [=====] - 1s 2ms/step - loss: 0.3341 -
accuracy: 0.8612 - val_loss: 0.3640 - val_accuracy: 0.8523
Epoch 72/100
536/536 [=====] - 1s 2ms/step - loss: 0.3340 -
accuracy: 0.8647 - val_loss: 0.3657 - val_accuracy: 0.8504
Epoch 73/100
536/536 [=====] - 1s 2ms/step - loss: 0.3337 -
accuracy: 0.8617 - val_loss: 0.3655 - val_accuracy: 0.8474
Epoch 74/100
536/536 [=====] - 1s 2ms/step - loss: 0.3330 -
accuracy: 0.8647 - val_loss: 0.3632 - val_accuracy: 0.8489
Epoch 75/100
536/536 [=====] - 1s 2ms/step - loss: 0.3334 -
accuracy: 0.8643 - val_loss: 0.3645 - val_accuracy: 0.8485
Epoch 76/100
536/536 [=====] - 1s 2ms/step - loss: 0.3331 -
accuracy: 0.8645 - val_loss: 0.3662 - val_accuracy: 0.8512
Epoch 77/100
536/536 [=====] - 1s 2ms/step - loss: 0.3333 -
accuracy: 0.8606 - val_loss: 0.3632 - val_accuracy: 0.8535
Epoch 78/100
536/536 [=====] - 1s 2ms/step - loss: 0.3339 -
accuracy: 0.8612 - val_loss: 0.3632 - val_accuracy: 0.8519
Epoch 79/100
536/536 [=====] - 1s 2ms/step - loss: 0.3332 -
accuracy: 0.8642 - val_loss: 0.3627 - val_accuracy: 0.8554
Epoch 80/100
536/536 [=====] - 1s 2ms/step - loss: 0.3326 -
accuracy: 0.8614 - val_loss: 0.3636 - val_accuracy: 0.8512
Epoch 81/100
536/536 [=====] - 1s 2ms/step - loss: 0.3322 -
accuracy: 0.8600 - val_loss: 0.3668 - val_accuracy: 0.8455
Epoch 82/100
536/536 [=====] - 1s 2ms/step - loss: 0.3331 -
accuracy: 0.8630 - val_loss: 0.3652 - val_accuracy: 0.8519
Epoch 83/100
536/536 [=====] - 1s 2ms/step - loss: 0.3327 -
accuracy: 0.8628 - val_loss: 0.3647 - val_accuracy: 0.8489
Epoch 84/100
536/536 [=====] - 1s 2ms/step - loss: 0.3329 -
accuracy: 0.8634 - val_loss: 0.3632 - val_accuracy: 0.8504
Epoch 85/100
536/536 [=====] - 1s 2ms/step - loss: 0.3329 -
accuracy: 0.8638 - val_loss: 0.3643 - val_accuracy: 0.8516

Epoch 86/100
536/536 [=====] - 1s 2ms/step - loss: 0.3323 -
accuracy: 0.8612 - val_loss: 0.3637 - val_accuracy: 0.8497
Epoch 87/100
536/536 [=====] - 1s 2ms/step - loss: 0.3323 -
accuracy: 0.8627 - val_loss: 0.3629 - val_accuracy: 0.8519
Epoch 88/100
536/536 [=====] - 1s 2ms/step - loss: 0.3328 -
accuracy: 0.8612 - val_loss: 0.3625 - val_accuracy: 0.8550
Epoch 89/100
536/536 [=====] - 1s 2ms/step - loss: 0.3323 -
accuracy: 0.8632 - val_loss: 0.3654 - val_accuracy: 0.8489
Epoch 90/100
536/536 [=====] - 1s 2ms/step - loss: 0.3321 -
accuracy: 0.8617 - val_loss: 0.3640 - val_accuracy: 0.8527
Epoch 91/100
536/536 [=====] - 1s 2ms/step - loss: 0.3320 -
accuracy: 0.8638 - val_loss: 0.3646 - val_accuracy: 0.8504
Epoch 92/100
536/536 [=====] - 1s 2ms/step - loss: 0.3319 -
accuracy: 0.8623 - val_loss: 0.3638 - val_accuracy: 0.8493
Epoch 93/100
536/536 [=====] - 1s 2ms/step - loss: 0.3320 -
accuracy: 0.8621 - val_loss: 0.3627 - val_accuracy: 0.8538
Epoch 94/100
536/536 [=====] - 1s 2ms/step - loss: 0.3316 -
accuracy: 0.8621 - val_loss: 0.3644 - val_accuracy: 0.8516
Epoch 95/100
536/536 [=====] - 1s 2ms/step - loss: 0.3319 -
accuracy: 0.8617 - val_loss: 0.3637 - val_accuracy: 0.8501
Epoch 96/100
536/536 [=====] - 1s 2ms/step - loss: 0.3313 -
accuracy: 0.8647 - val_loss: 0.3654 - val_accuracy: 0.8493
Epoch 97/100
536/536 [=====] - 1s 2ms/step - loss: 0.3314 -
accuracy: 0.8645 - val_loss: 0.3656 - val_accuracy: 0.8497
Epoch 98/100
536/536 [=====] - 1s 2ms/step - loss: 0.3307 -
accuracy: 0.8630 - val_loss: 0.3638 - val_accuracy: 0.8527
Epoch 99/100
536/536 [=====] - 1s 2ms/step - loss: 0.3321 -
accuracy: 0.8619 - val_loss: 0.3626 - val_accuracy: 0.8523
Epoch 100/100
536/536 [=====] - 1s 2ms/step - loss: 0.3313 -
accuracy: 0.8623 - val_loss: 0.3624 - val_accuracy: 0.8550

```
[13]: # predicting the model
y_pred= classifier.predict(X_test)
y_pred= (y_pred>0.5)
y_pred
```

63/63 [=====] - 0s 1ms/step

```
[13]: array([[False],
            [False],
            [False],
            ...,
            [False],
            [False],
            [False]])
```

```
[14]: from sklearn.metrics import
      ↪ accuracy_score, confusion_matrix, classification_report

cm= confusion_matrix(y_test,y_pred)
print(cm)
accuracy=accuracy_score(y_test,y_pred)
print('The accuracy of the model is',accuracy)
cl_report = classification_report(y_test,y_pred)
print(cl_report)
```

```
[[1515  80]
 [ 200 205]]
```

The accuracy of the model is 0.86

	precision	recall	f1-score	support
0	0.88	0.95	0.92	1595
1	0.72	0.51	0.59	405
accuracy			0.86	2000
macro avg	0.80	0.73	0.75	2000
weighted avg	0.85	0.86	0.85	2000

```
[16]: import matplotlib.pyplot as plt
print(model_history.history.keys())
# summarize history for accuracy
plt.plot(model_history.history['accuracy'])
plt.plot(model_history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
```

```
plt.show()
```

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

