Churn Modelling

In [1]:
```
import pandas as pd
import numpy as np
import tensorflow as tf
```

In [3]:
```
df = pd.read_csv(r"C:\Users\JANHAVI\Desktop\Churn_Modelling.csv")
```

In [4]:
```
df
```

Out[4]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Bala
0	1	15634602	Hargrave	619	France	Female	42	2	(
1	2	15647311	Hill	608	Spain	Female	41	1	83807
2	3	15619304	Onio	502	France	Female	42	8	15966(
3	4	15701354	Boni	699	France	Female	39	1	(
4	5	15737888	Mitchell	850	Spain	Female	43	2	12551(
...	...	...	...	...	...	...	...	...	
9995	9996	15606229	Obijiaku	771	France	Male	39	5	(
9996	9997	15569892	Johnstone	516	France	Male	35	10	5736
9997	9998	15584532	Liu	709	France	Female	36	7	(
9998	9999	15682355	Sabbatini	772	Germany	Male	42	3	7507
9999	10000	15628319	Walker	792	France	Female	28	4	13014

10000 rows × 14 columns

In [5]:
```
df.head(4)
```

Out[5]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance
0	1	15634602	Hargrave	619	France	Female	42	2	0.00
1	2	15647311	Hill	608	Spain	Female	41	1	83807.86
2	3	15619304	Onio	502	France	Female	42	8	159660.80
3	4	15701354	Boni	699	France	Female	39	1	0.00

In [6]:
```
X = df.iloc[:,3:-1].values
y = df.iloc[:,-1].values
```

In [7]:
```
X
```

Out[7]:
```
array([[619, 'France', 'Female', ..., 1, 1, 101348.88],
       [608, 'Spain', 'Female', ..., 0, 1, 112542.58],
       [502, 'France', 'Female', ..., 1, 0, 113931.57],
       ...,
       [709, 'France', 'Female', ..., 0, 1, 42085.58],
       [772, 'Germany', 'Male', ..., 1, 0, 92888.52],
       [792, 'France', 'Female', ..., 1, 0, 38190.78]], dtype=object)
```

In [8]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
X[:,2] = le.fit_transform(X[:,2])
```

In [9]:
```
X
```

Out[9]:
```
array([[619, 'France', 0, ..., 1, 1, 101348.88],
       [608, 'Spain', 0, ..., 0, 1, 112542.58],
       [502, 'France', 0, ..., 1, 0, 113931.57],
       ...,
       [709, 'France', 0, ..., 0, 1, 42085.58],
       [772, 'Germany', 1, ..., 1, 0, 92888.52],
       [792, 'France', 0, ..., 1, 0, 38190.78]], dtype=object)
```

In [10]:
```
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import OneHotEncoder

ct = ColumnTransformer(transformers=[('encoder',OneHotEncoder(),[1])],remainder='pa
X = np.array(ct.fit_transform(X))
```

In [11]:
```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X = sc.fit_transform(X)
```

In [12]:
```
X
```

Out[12]:
```
array([[ 0.99720391, -0.57873591, -0.57380915, ...,  0.64609167,
         0.97024255,  0.02188649],
       [-1.00280393, -0.57873591,  1.74273971, ..., -1.54776799,
         0.97024255,  0.21653375],
       [ 0.99720391, -0.57873591, -0.57380915, ...,  0.64609167,
        -1.03067011,  0.2406869 ],
       ...,
       [ 0.99720391, -0.57873591, -0.57380915, ..., -1.54776799,
         0.97024255, -1.00864308],
       [-1.00280393,  1.72790383, -0.57380915, ...,  0.64609167,
        -1.03067011, -0.12523071],
       [ 0.99720391, -0.57873591, -0.57380915, ...,  0.64609167,
        -1.03067011, -1.07636976]])
```

In [13]:
```
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
```

In [14]:
```
ann = tf.keras.models.Sequential()

ann.add(tf.keras.layers.Dense(units = 6,activation = 'relu'))
ann.add(tf.keras.layers.Dense(units = 6,activation = 'relu'))
ann.add(tf.keras.layers.Dense(units = 5,activation = 'relu'))
ann.add(tf.keras.layers.Dense(units = 4,activation = 'relu'))
ann.add(tf.keras.layers.Dense(units = 1,activation = 'sigmoid'))
```

In [15]:
```
ann.compile(optimizer = 'adam',loss = 'binary_crossentropy',metrics = ['accuracy'])
```

In [16]:
```
ann.fit(X_train,y_train,batch_size = 32,epochs = 150,validation_data=(X_test,y_test
```

```
Epoch 1/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 3s 3ms/step - accuracy: 0.7879 - loss: 0.5276 - val_a
ccuracy: 0.7975 - val_loss: 0.4635
Epoch 2/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.7971 - loss: 0.4515 - val_a
ccuracy: 0.8145 - val_loss: 0.4325
Epoch 3/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8114 - loss: 0.4306 - val_a
ccuracy: 0.8220 - val_loss: 0.4127
Epoch 4/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8165 - loss: 0.4173 - val_a
ccuracy: 0.8355 - val_loss: 0.3995
Epoch 5/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8298 - loss: 0.4025 - val_a
ccuracy: 0.8450 - val_loss: 0.3822
Epoch 6/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8400 - loss: 0.3871 - val_a
ccuracy: 0.8545 - val_loss: 0.3658
Epoch 7/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8482 - loss: 0.3751 - val_a
ccuracy: 0.8595 - val_loss: 0.3583
Epoch 8/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8505 - loss: 0.3668 - val_a
ccuracy: 0.8570 - val_loss: 0.3554
Epoch 9/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8534 - loss: 0.3600 - val_a
ccuracy: 0.8645 - val_loss: 0.3485
Epoch 10/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8550 - loss: 0.3553 - val_a
ccuracy: 0.8615 - val_loss: 0.3476
Epoch 11/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8568 - loss: 0.3531 - val_a
ccuracy: 0.8625 - val_loss: 0.3441
Epoch 12/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8570 - loss: 0.3512 - val_a
ccuracy: 0.8555 - val_loss: 0.3490
Epoch 13/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8583 - loss: 0.3501 - val_a
ccuracy: 0.8615 - val_loss: 0.3439
Epoch 14/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8576 - loss: 0.3481 - val_a
ccuracy: 0.8625 - val_loss: 0.3421
Epoch 15/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8566 - loss: 0.3467 - val_a
ccuracy: 0.8610 - val_loss: 0.3423
Epoch 16/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8585 - loss: 0.3460 - val_a
ccuracy: 0.8630 - val_loss: 0.3402
Epoch 17/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8600 - loss: 0.3446 - val_a
ccuracy: 0.8545 - val_loss: 0.3484
Epoch 18/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8551 - loss: 0.3444 - val_a
ccuracy: 0.8615 - val_loss: 0.3415
Epoch 19/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8593 - loss: 0.3440 - val_a
ccuracy: 0.8595 - val_loss: 0.3410
Epoch 20/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8590 - loss: 0.3437 - val_a
ccuracy: 0.8590 - val_loss: 0.3391
Epoch 21/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8596 - loss: 0.3426 - val_a
ccuracy: 0.8565 - val_loss: 0.3409
Epoch 22/150
```

```
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8596 - loss: 0.3423 - val_a
ccuracy: 0.8600 - val_loss: 0.3395
Epoch 23/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8611 - loss: 0.3417 - val_a
ccuracy: 0.8600 - val_loss: 0.3382
Epoch 24/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8596 - loss: 0.3417 - val_a
ccuracy: 0.8575 - val_loss: 0.3443
Epoch 25/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8602 - loss: 0.3409 - val_a
ccuracy: 0.8575 - val_loss: 0.3392
Epoch 26/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8595 - loss: 0.3410 - val_a
ccuracy: 0.8595 - val_loss: 0.3377
Epoch 27/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8609 - loss: 0.3401 - val_a
ccuracy: 0.8580 - val_loss: 0.3419
Epoch 28/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8646 - loss: 0.3400 - val_a
ccuracy: 0.8580 - val_loss: 0.3389
Epoch 29/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8605 - loss: 0.3396 - val_a
ccuracy: 0.8565 - val_loss: 0.3419
Epoch 30/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8619 - loss: 0.3400 - val_a
ccuracy: 0.8595 - val_loss: 0.3364
Epoch 31/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8606 - loss: 0.3402 - val_a
ccuracy: 0.8605 - val_loss: 0.3378
Epoch 32/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8610 - loss: 0.3389 - val_a
ccuracy: 0.8605 - val_loss: 0.3380
Epoch 33/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8622 - loss: 0.3382 - val_a
ccuracy: 0.8575 - val_loss: 0.3403
Epoch 34/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8621 - loss: 0.3383 - val_a
ccuracy: 0.8590 - val_loss: 0.3372
Epoch 35/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8620 - loss: 0.3385 - val_a
ccuracy: 0.8560 - val_loss: 0.3384
Epoch 36/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8627 - loss: 0.3381 - val_a
ccuracy: 0.8605 - val_loss: 0.3375
Epoch 37/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8635 - loss: 0.3378 - val_a
ccuracy: 0.8575 - val_loss: 0.3383
Epoch 38/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8635 - loss: 0.3377 - val_a
ccuracy: 0.8575 - val_loss: 0.3383
Epoch 39/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8626 - loss: 0.3382 - val_a
ccuracy: 0.8595 - val_loss: 0.3384
Epoch 40/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8634 - loss: 0.3369 - val_a
ccuracy: 0.8610 - val_loss: 0.3404
Epoch 41/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8643 - loss: 0.3375 - val_a
ccuracy: 0.8565 - val_loss: 0.3367
Epoch 42/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8640 - loss: 0.3365 - val_a
ccuracy: 0.8590 - val_loss: 0.3358
Epoch 43/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8631 - loss: 0.3367 - val_a
```

```
ccuracy: 0.8595 - val_loss: 0.3364
Epoch 44/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8637 - loss: 0.3362 - val_a
ccuracy: 0.8650 - val_loss: 0.3353
Epoch 45/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8639 - loss: 0.3362 - val_a
ccuracy: 0.8595 - val_loss: 0.3346
Epoch 46/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8637 - loss: 0.3362 - val_a
ccuracy: 0.8550 - val_loss: 0.3383
Epoch 47/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8634 - loss: 0.3363 - val_a
ccuracy: 0.8625 - val_loss: 0.3352
Epoch 48/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8645 - loss: 0.3352 - val_a
ccuracy: 0.8580 - val_loss: 0.3369
Epoch 49/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8630 - loss: 0.3351 - val_a
ccuracy: 0.8635 - val_loss: 0.3354
Epoch 50/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8650 - loss: 0.3351 - val_a
ccuracy: 0.8565 - val_loss: 0.3356
Epoch 51/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8636 - loss: 0.3350 - val_a
ccuracy: 0.8575 - val_loss: 0.3356
Epoch 52/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8646 - loss: 0.3344 - val_a
ccuracy: 0.8585 - val_loss: 0.3378
Epoch 53/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8637 - loss: 0.3350 - val_a
ccuracy: 0.8585 - val_loss: 0.3360
Epoch 54/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8654 - loss: 0.3340 - val_a
ccuracy: 0.8580 - val_loss: 0.3367
Epoch 55/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8639 - loss: 0.3339 - val_a
ccuracy: 0.8620 - val_loss: 0.3359
Epoch 56/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8630 - loss: 0.3339 - val_a
ccuracy: 0.8550 - val_loss: 0.3397
Epoch 57/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8659 - loss: 0.3334 - val_a
ccuracy: 0.8590 - val_loss: 0.3357
Epoch 58/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8649 - loss: 0.3332 - val_a
ccuracy: 0.8590 - val_loss: 0.3352
Epoch 59/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8659 - loss: 0.3331 - val_a
ccuracy: 0.8565 - val_loss: 0.3361
Epoch 60/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8649 - loss: 0.3327 - val_a
ccuracy: 0.8625 - val_loss: 0.3365
Epoch 61/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8643 - loss: 0.3333 - val_a
ccuracy: 0.8570 - val_loss: 0.3385
Epoch 62/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8650 - loss: 0.3323 - val_a
ccuracy: 0.8575 - val_loss: 0.3355
Epoch 63/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8630 - loss: 0.3323 - val_a
ccuracy: 0.8610 - val_loss: 0.3360
Epoch 64/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8651 - loss: 0.3324 - val_a
ccuracy: 0.8550 - val_loss: 0.3368
```

```
Epoch 65/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8666 - loss: 0.3325 - val_a
ccuracy: 0.8570 - val_loss: 0.3362
Epoch 66/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8641 - loss: 0.3315 - val_a
ccuracy: 0.8595 - val_loss: 0.3351
Epoch 67/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8646 - loss: 0.3321 - val_a
ccuracy: 0.8585 - val_loss: 0.3356
Epoch 68/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8659 - loss: 0.3315 - val_a
ccuracy: 0.8630 - val_loss: 0.3348
Epoch 69/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8661 - loss: 0.3318 - val_a
ccuracy: 0.8580 - val_loss: 0.3375
Epoch 70/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8645 - loss: 0.3322 - val_a
ccuracy: 0.8580 - val_loss: 0.3391
Epoch 71/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8659 - loss: 0.3321 - val_a
ccuracy: 0.8620 - val_loss: 0.3354
Epoch 72/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8651 - loss: 0.3315 - val_a
ccuracy: 0.8575 - val_loss: 0.3389
Epoch 73/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8643 - loss: 0.3317 - val_a
ccuracy: 0.8565 - val_loss: 0.3363
Epoch 74/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8651 - loss: 0.3314 - val_a
ccuracy: 0.8560 - val_loss: 0.3356
Epoch 75/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8660 - loss: 0.3316 - val_a
ccuracy: 0.8585 - val_loss: 0.3374
Epoch 76/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8643 - loss: 0.3313 - val_a
ccuracy: 0.8575 - val_loss: 0.3379
Epoch 77/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8654 - loss: 0.3309 - val_a
ccuracy: 0.8600 - val_loss: 0.3363
Epoch 78/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8644 - loss: 0.3313 - val_a
ccuracy: 0.8585 - val_loss: 0.3369
Epoch 79/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8668 - loss: 0.3311 - val_a
ccuracy: 0.8555 - val_loss: 0.3385
Epoch 80/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8668 - loss: 0.3308 - val_a
ccuracy: 0.8610 - val_loss: 0.3362
Epoch 81/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8669 - loss: 0.3311 - val_a
ccuracy: 0.8545 - val_loss: 0.3388
Epoch 82/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8666 - loss: 0.3311 - val_a
ccuracy: 0.8585 - val_loss: 0.3354
Epoch 83/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8625 - loss: 0.3314 - val_a
ccuracy: 0.8610 - val_loss: 0.3353
Epoch 84/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8658 - loss: 0.3310 - val_a
ccuracy: 0.8610 - val_loss: 0.3362
Epoch 85/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8664 - loss: 0.3318 - val_a
ccuracy: 0.8580 - val_loss: 0.3358
Epoch 86/150
```

```
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8675 - loss: 0.3311 - val_a
ccuracy: 0.8580 - val_loss: 0.3368
Epoch 87/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8655 - loss: 0.3316 - val_a
ccuracy: 0.8585 - val_loss: 0.3367
Epoch 88/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8650 - loss: 0.3311 - val_a
ccuracy: 0.8540 - val_loss: 0.3393
Epoch 89/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8640 - loss: 0.3316 - val_a
ccuracy: 0.8600 - val_loss: 0.3351
Epoch 90/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8670 - loss: 0.3306 - val_a
ccuracy: 0.8560 - val_loss: 0.3367
Epoch 91/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8679 - loss: 0.3311 - val_a
ccuracy: 0.8585 - val_loss: 0.3352
Epoch 92/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8646 - loss: 0.3311 - val_a
ccuracy: 0.8585 - val_loss: 0.3357
Epoch 93/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8659 - loss: 0.3313 - val_a
ccuracy: 0.8560 - val_loss: 0.3388
Epoch 94/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8666 - loss: 0.3308 - val_a
ccuracy: 0.8580 - val_loss: 0.3355
Epoch 95/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8674 - loss: 0.3306 - val_a
ccuracy: 0.8555 - val_loss: 0.3383
Epoch 96/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8654 - loss: 0.3313 - val_a
ccuracy: 0.8575 - val_loss: 0.3362
Epoch 97/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8658 - loss: 0.3310 - val_a
ccuracy: 0.8545 - val_loss: 0.3380
Epoch 98/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8675 - loss: 0.3307 - val_a
ccuracy: 0.8575 - val_loss: 0.3351
Epoch 99/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8659 - loss: 0.3308 - val_a
ccuracy: 0.8560 - val_loss: 0.3361
Epoch 100/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8687 - loss: 0.3303 - val_a
ccuracy: 0.8520 - val_loss: 0.3403
Epoch 101/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8670 - loss: 0.3304 - val_a
ccuracy: 0.8540 - val_loss: 0.3397
Epoch 102/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8659 - loss: 0.3303 - val_a
ccuracy: 0.8625 - val_loss: 0.3353
Epoch 103/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8650 - loss: 0.3307 - val_a
ccuracy: 0.8575 - val_loss: 0.3379
Epoch 104/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8658 - loss: 0.3307 - val_a
ccuracy: 0.8630 - val_loss: 0.3345
Epoch 105/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8656 - loss: 0.3304 - val_a
ccuracy: 0.8605 - val_loss: 0.3345
Epoch 106/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8661 - loss: 0.3308 - val_a
ccuracy: 0.8595 - val_loss: 0.3366
Epoch 107/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8651 - loss: 0.3310 - val_a
```

```
ccuracy: 0.8640 - val_loss: 0.3347
Epoch 108/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8634 - loss: 0.3299 - val_a
ccuracy: 0.8610 - val_loss: 0.3342
Epoch 109/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8658 - loss: 0.3306 - val_a
ccuracy: 0.8590 - val_loss: 0.3367
Epoch 110/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8669 - loss: 0.3305 - val_a
ccuracy: 0.8555 - val_loss: 0.3393
Epoch 111/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8684 - loss: 0.3301 - val_a
ccuracy: 0.8590 - val_loss: 0.3352
Epoch 112/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8656 - loss: 0.3303 - val_a
ccuracy: 0.8565 - val_loss: 0.3386
Epoch 113/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8656 - loss: 0.3298 - val_a
ccuracy: 0.8565 - val_loss: 0.3386
Epoch 114/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8668 - loss: 0.3301 - val_a
ccuracy: 0.8590 - val_loss: 0.3372
Epoch 115/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8662 - loss: 0.3302 - val_a
ccuracy: 0.8595 - val_loss: 0.3363
Epoch 116/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8666 - loss: 0.3301 - val_a
ccuracy: 0.8630 - val_loss: 0.3357
Epoch 117/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8685 - loss: 0.3302 - val_a
ccuracy: 0.8580 - val_loss: 0.3365
Epoch 118/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8671 - loss: 0.3299 - val_a
ccuracy: 0.8610 - val_loss: 0.3356
Epoch 119/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8679 - loss: 0.3299 - val_a
ccuracy: 0.8600 - val_loss: 0.3352
Epoch 120/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8676 - loss: 0.3299 - val_a
ccuracy: 0.8625 - val_loss: 0.3344
Epoch 121/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8650 - loss: 0.3304 - val_a
ccuracy: 0.8630 - val_loss: 0.3335
Epoch 122/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8674 - loss: 0.3301 - val_a
ccuracy: 0.8585 - val_loss: 0.3345
Epoch 123/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8656 - loss: 0.3298 - val_a
ccuracy: 0.8600 - val_loss: 0.3353
Epoch 124/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8679 - loss: 0.3298 - val_a
ccuracy: 0.8600 - val_loss: 0.3359
Epoch 125/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8655 - loss: 0.3302 - val_a
ccuracy: 0.8600 - val_loss: 0.3359
Epoch 126/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8675 - loss: 0.3300 - val_a
ccuracy: 0.8570 - val_loss: 0.3378
Epoch 127/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8655 - loss: 0.3301 - val_a
ccuracy: 0.8615 - val_loss: 0.3357
Epoch 128/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8648 - loss: 0.3297 - val_a
ccuracy: 0.8645 - val_loss: 0.3351
```

```
Epoch 129/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8666 - loss: 0.3299 - val_a
ccuracy: 0.8615 - val_loss: 0.3343
Epoch 130/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8643 - loss: 0.3295 - val_a
ccuracy: 0.8590 - val_loss: 0.3356
Epoch 131/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8665 - loss: 0.3301 - val_a
ccuracy: 0.8590 - val_loss: 0.3355
Epoch 132/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8673 - loss: 0.3308 - val_a
ccuracy: 0.8630 - val_loss: 0.3356
Epoch 133/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8670 - loss: 0.3297 - val_a
ccuracy: 0.8590 - val_loss: 0.3360
Epoch 134/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8673 - loss: 0.3303 - val_a
ccuracy: 0.8580 - val_loss: 0.3355
Epoch 135/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8660 - loss: 0.3296 - val_a
ccuracy: 0.8640 - val_loss: 0.3345
Epoch 136/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8679 - loss: 0.3294 - val_a
ccuracy: 0.8575 - val_loss: 0.3383
Epoch 137/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8652 - loss: 0.3303 - val_a
ccuracy: 0.8585 - val_loss: 0.3395
Epoch 138/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8674 - loss: 0.3297 - val_a
ccuracy: 0.8625 - val_loss: 0.3351
Epoch 139/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8664 - loss: 0.3294 - val_a
ccuracy: 0.8620 - val_loss: 0.3347
Epoch 140/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8673 - loss: 0.3299 - val_a
ccuracy: 0.8605 - val_loss: 0.3351
Epoch 141/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8661 - loss: 0.3302 - val_a
ccuracy: 0.8595 - val_loss: 0.3362
Epoch 142/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8654 - loss: 0.3295 - val_a
ccuracy: 0.8610 - val_loss: 0.3355
Epoch 143/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8662 - loss: 0.3295 - val_a
ccuracy: 0.8615 - val_loss: 0.3338
Epoch 144/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8676 - loss: 0.3296 - val_a
ccuracy: 0.8570 - val_loss: 0.3366
Epoch 145/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8649 - loss: 0.3298 - val_a
ccuracy: 0.8645 - val_loss: 0.3339
Epoch 146/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8662 - loss: 0.3297 - val_a
ccuracy: 0.8595 - val_loss: 0.3348
Epoch 147/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8680 - loss: 0.3294 - val_a
ccuracy: 0.8615 - val_loss: 0.3341
Epoch 148/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8670 - loss: 0.3297 - val_a
ccuracy: 0.8605 - val_loss: 0.3345
Epoch 149/150
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8659 - loss: 0.3293 - val_a
ccuracy: 0.8585 - val_loss: 0.3361
Epoch 150/150
```

```
250/250 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8671 - loss: 0.3293 - val_a
ccuracy: 0.8570 - val_loss: 0.3389
```

Out[16]:
```
<keras.src.callbacks.history.History at 0x238cbc2c210>
```

In [17]:
```
y_pred = ann.predict(X_test)
```

```
63/63 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
```

In [18]:
```
y_pred = (y_pred > 0.5)
```

In [19]:
```
print(np.concatenate((y_pred.reshape(len(y_pred),1),y_test.reshape(len(y_test),1)),
```

```
[[0 0]
 [0 1]
 [0 0]
 ...
 [0 0]
 [0 0]
 [0 0]]
```

In [20]:
```
from sklearn.metrics import accuracy_score,confusion_matrix

ac = accuracy_score(y_test,y_pred)
ac
```

Out[20]:
```
0.857
```

In [21]:
```
cm = confusion_matrix(y_test,y_pred)
cm
```

Out[21]:
```
array([[1495,  100],
       [ 186,  219]], dtype=int64)
```

In [ ]:
```

```