Artificial Neural Network

Importing the libraries

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

In [2]:
```
tf.__version__
```

Out[2]:
```
'2.18.0'
```

Part 1 - Data Preprocessing

Importing the dataset

In [3]:
```
dataset = pd.read_csv('Churn_Modelling.csv')
dataset
```

Out[3]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Ten
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	
...	...	...	...	...	...	...	...	
9995	9996	15606229	Obijiaku	771	France	Male	39	
9996	9997	15569892	Johnstone	516	France	Male	35	
9997	9998	15584532	Liu	709	France	Female	36	
9998	9999	15682355	Sabbatini	772	Germany	Male	42	
9999	10000	15628319	Walker	792	France	Female	28	

10000 rows × 14 columns

In [4]:
```
X = dataset.iloc[:, 3:-1].values
y = dataset.iloc[:, -1].values
```

In [5]:
```
print(X)
```

```
[[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]]
```

In [6]:
```
print(y)
```

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

Encoding categorical data

Label Encoding the "Gender" column

In [7]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
X[:, 2] = le.fit_transform(X[:, 2])
```

In [8]:
```
print(X)
```

```
[[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]]
```

One Hot Encoding the "Geography" column

In [9]:
```
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import OneHotEncoder
ct = ColumnTransformer(transformers=[('encoder', OneHotEncoder(), [1])], remaind
X = np.array(ct.fit_transform(X))
```

In [10]:
```
print(X)
```

```
[[1.0 0.0 0.0 ... 1 1 101348.88]
 [0.0 0.0 1.0 ... 0 1 112542.58]
 [1.0 0.0 0.0 ... 1 0 113931.57]
 ...
 [1.0 0.0 0.0 ... 0 1 42085.58]
 [0.0 1.0 0.0 ... 1 0 92888.52]
 [1.0 0.0 0.0 ... 1 0 38190.78]]
```

Feature Scaling

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

In [12]:
```
print(X)
```

```
[[ 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]]
```

Splitting the dataset into the Training set and Test set

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 = 0.2, rando
```

Part 2 - Building the ANN

Initializing the ANN

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

Adding the input layer and the first hidden layer

In [15]:
```
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))
```

Adding the second hidden layer

In [16]:
```
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))
```

Adding the output layer

In [17]:
```
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))
```

Training the ANN

Compiling the ANN

In [18]:
```
ann.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accura
```

Training the ANN on the Training set

In [23]:
```
ann.fit(X_train, y_train, batch_size = 32, epochs = 250)
```

```
Epoch 1/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8611 - loss: 0.3361
Epoch 2/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8728 - loss: 0.3191
Epoch 3/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8666 - loss: 0.3296
Epoch 4/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8616 - loss: 0.3369
Epoch 5/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8669 - loss: 0.3317
Epoch 6/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8698 - loss: 0.3264
Epoch 7/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8656 - loss: 0.3324
Epoch 8/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8736 - loss: 0.3235
Epoch 9/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8658 - loss: 0.3313
Epoch 10/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8689 - loss: 0.3270
Epoch 11/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8686 - loss: 0.3293
Epoch 12/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8655 - loss: 0.3275
Epoch 13/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8663 - loss: 0.3342
Epoch 14/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8621 - loss: 0.3328
Epoch 15/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8568 - loss: 0.3463
Epoch 16/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8643 - loss: 0.3307
Epoch 17/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8615 - loss: 0.3332
Epoch 18/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8707 - loss: 0.3267
Epoch 19/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8657 - loss: 0.3316
Epoch 20/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8680 - loss: 0.3247
Epoch 21/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8676 - loss: 0.3272
Epoch 22/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8663 - loss: 0.3282
Epoch 23/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8601 - loss: 0.3371
Epoch 24/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8602 - loss: 0.3335
Epoch 25/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8657 - loss: 0.3299
Epoch 26/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8606 - loss: 0.3328
Epoch 27/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8628 - loss: 0.3250
Epoch 28/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8599 - loss: 0.3410
Epoch 29/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8747 - loss: 0.3120
Epoch 30/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8575 - loss: 0.3401
```

```
Epoch 31/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8653 - loss: 0.3232
Epoch 32/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8583 - loss: 0.3389
Epoch 33/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8643 - loss: 0.3348
Epoch 34/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8617 - loss: 0.3362
Epoch 35/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8622 - loss: 0.3361
Epoch 36/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8621 - loss: 0.3319
Epoch 37/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8646 - loss: 0.3362
Epoch 38/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8633 - loss: 0.3254
Epoch 39/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8673 - loss: 0.3293
Epoch 40/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8616 - loss: 0.3367
Epoch 41/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8652 - loss: 0.3306
Epoch 42/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8632 - loss: 0.3342
Epoch 43/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8667 - loss: 0.3254
Epoch 44/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8624 - loss: 0.3350
Epoch 45/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8623 - loss: 0.3430
Epoch 46/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8621 - loss: 0.3391
Epoch 47/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8589 - loss: 0.3358
Epoch 48/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8608 - loss: 0.3388
Epoch 49/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8649 - loss: 0.3314
Epoch 50/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8666 - loss: 0.3350
Epoch 51/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8671 - loss: 0.3256
Epoch 52/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8607 - loss: 0.3304
Epoch 53/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8686 - loss: 0.3224
Epoch 54/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8682 - loss: 0.3222
Epoch 55/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8669 - loss: 0.3218
Epoch 56/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8621 - loss: 0.3331
Epoch 57/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8663 - loss: 0.3209
Epoch 58/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8750 - loss: 0.3205
Epoch 59/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8666 - loss: 0.3270
Epoch 60/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8595 - loss: 0.3341
```

```
Epoch 61/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8628 - loss: 0.3372
Epoch 62/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8651 - loss: 0.3320
Epoch 63/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8599 - loss: 0.3411
Epoch 64/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8664 - loss: 0.3263
Epoch 65/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8697 - loss: 0.3253
Epoch 66/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8679 - loss: 0.3219
Epoch 67/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8650 - loss: 0.3257
Epoch 68/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8707 - loss: 0.3199
Epoch 69/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8656 - loss: 0.3308
Epoch 70/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8675 - loss: 0.3235
Epoch 71/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8716 - loss: 0.3252
Epoch 72/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8663 - loss: 0.3206
Epoch 73/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8703 - loss: 0.3222
Epoch 74/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8655 - loss: 0.3313
Epoch 75/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8674 - loss: 0.3307
Epoch 76/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8715 - loss: 0.3225
Epoch 77/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8684 - loss: 0.3242
Epoch 78/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8607 - loss: 0.3376
Epoch 79/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8630 - loss: 0.3268
Epoch 80/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8678 - loss: 0.3273
Epoch 81/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8722 - loss: 0.3188
Epoch 82/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8670 - loss: 0.3303
Epoch 83/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8573 - loss: 0.3381
Epoch 84/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8638 - loss: 0.3299
Epoch 85/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8685 - loss: 0.3265
Epoch 86/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8582 - loss: 0.3370
Epoch 87/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8602 - loss: 0.3397
Epoch 88/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8584 - loss: 0.3413
Epoch 89/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8613 - loss: 0.3355
Epoch 90/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8658 - loss: 0.3343
```

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Epoch 91/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8595 - loss: 0.3422
Epoch 92/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8666 - loss: 0.3270
Epoch 93/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8641 - loss: 0.3268
Epoch 94/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8589 - loss: 0.3397
Epoch 95/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8697 - loss: 0.3292
Epoch 96/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8657 - loss: 0.3232
Epoch 97/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8655 - loss: 0.3339
Epoch 98/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8672 - loss: 0.3325
Epoch 99/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8672 - loss: 0.3226
Epoch 100/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8661 - loss: 0.3251
Epoch 101/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8590 - loss: 0.3382
Epoch 102/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8644 - loss: 0.3297
Epoch 103/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8686 - loss: 0.3225
Epoch 104/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8555 - loss: 0.3441
Epoch 105/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8675 - loss: 0.3245
Epoch 106/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8574 - loss: 0.3404
Epoch 107/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8640 - loss: 0.3343
Epoch 108/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8708 - loss: 0.3209
Epoch 109/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8637 - loss: 0.3331
Epoch 110/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8694 - loss: 0.3211
Epoch 111/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8636 - loss: 0.3311
Epoch 112/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8592 - loss: 0.3329
Epoch 113/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8631 - loss: 0.3306
Epoch 114/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8615 - loss: 0.3332
Epoch 115/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8675 - loss: 0.3329
Epoch 116/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8574 - loss: 0.3473
Epoch 117/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8623 - loss: 0.3353
Epoch 118/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8632 - loss: 0.3283
Epoch 119/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8641 - loss: 0.3318
Epoch 120/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8645 - loss: 0.3316
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Epoch 121/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8675 - loss: 0.3280
Epoch 122/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8666 - loss: 0.3208
Epoch 123/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8676 - loss: 0.3264
Epoch 124/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8642 - loss: 0.3312
Epoch 125/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8630 - loss: 0.3383
Epoch 126/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8658 - loss: 0.3268
Epoch 127/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8640 - loss: 0.3343
Epoch 128/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8725 - loss: 0.3171
Epoch 129/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8709 - loss: 0.3201
Epoch 130/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8649 - loss: 0.3316
Epoch 131/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8631 - loss: 0.3309
Epoch 132/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8649 - loss: 0.3299
Epoch 133/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8694 - loss: 0.3219
Epoch 134/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8678 - loss: 0.3260
Epoch 135/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8603 - loss: 0.3364
Epoch 136/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8649 - loss: 0.3341
Epoch 137/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8660 - loss: 0.3335
Epoch 138/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8720 - loss: 0.3191
Epoch 139/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8688 - loss: 0.3170
Epoch 140/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8545 - loss: 0.3373
Epoch 141/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8694 - loss: 0.3192
Epoch 142/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8648 - loss: 0.3302
Epoch 143/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8622 - loss: 0.3318
Epoch 144/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8638 - loss: 0.3270
Epoch 145/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8638 - loss: 0.3279
Epoch 146/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8710 - loss: 0.3218
Epoch 147/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8688 - loss: 0.3287
Epoch 148/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8561 - loss: 0.3485
Epoch 149/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8649 - loss: 0.3273
Epoch 150/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8692 - loss: 0.3305
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Epoch 151/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8696 - loss: 0.3251
Epoch 152/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8683 - loss: 0.3308
Epoch 153/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8686 - loss: 0.3206
Epoch 154/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8689 - loss: 0.3263
Epoch 155/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8645 - loss: 0.3264
Epoch 156/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8601 - loss: 0.3329
Epoch 157/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8681 - loss: 0.3316
Epoch 158/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8624 - loss: 0.3358
Epoch 159/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8630 - loss: 0.3318
Epoch 160/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8707 - loss: 0.3237
Epoch 161/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8620 - loss: 0.3327
Epoch 162/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8635 - loss: 0.3388
Epoch 163/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8560 - loss: 0.3359
Epoch 164/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8717 - loss: 0.3236
Epoch 165/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8554 - loss: 0.3437
Epoch 166/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8717 - loss: 0.3177
Epoch 167/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8644 - loss: 0.3265
Epoch 168/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8711 - loss: 0.3166
Epoch 169/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8655 - loss: 0.3265
Epoch 170/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8699 - loss: 0.3167
Epoch 171/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8639 - loss: 0.3322
Epoch 172/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8710 - loss: 0.3156
Epoch 173/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8672 - loss: 0.3201
Epoch 174/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8639 - loss: 0.3349
Epoch 175/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8708 - loss: 0.3177
Epoch 176/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8669 - loss: 0.3318
Epoch 177/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8648 - loss: 0.3334
Epoch 178/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8659 - loss: 0.3306
Epoch 179/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8708 - loss: 0.3147
Epoch 180/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8653 - loss: 0.3323
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Epoch 181/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8702 - loss: 0.3243
Epoch 182/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8733 - loss: 0.3168
Epoch 183/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8615 - loss: 0.3389
Epoch 184/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8681 - loss: 0.3238
Epoch 185/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8674 - loss: 0.3204
Epoch 186/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8606 - loss: 0.3362
Epoch 187/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8684 - loss: 0.3253
Epoch 188/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8620 - loss: 0.3341
Epoch 189/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8644 - loss: 0.3267
Epoch 190/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8613 - loss: 0.3357
Epoch 191/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8648 - loss: 0.3293
Epoch 192/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8660 - loss: 0.3247
Epoch 193/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8739 - loss: 0.3122
Epoch 194/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8650 - loss: 0.3321
Epoch 195/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8621 - loss: 0.3335
Epoch 196/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8630 - loss: 0.3315
Epoch 197/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8662 - loss: 0.3234
Epoch 198/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8658 - loss: 0.3259
Epoch 199/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8665 - loss: 0.3266
Epoch 200/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8687 - loss: 0.3184
Epoch 201/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8696 - loss: 0.3145
Epoch 202/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8682 - loss: 0.3227
Epoch 203/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8675 - loss: 0.3306
Epoch 204/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8694 - loss: 0.3213
Epoch 205/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8628 - loss: 0.3327
Epoch 206/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8622 - loss: 0.3312
Epoch 207/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8702 - loss: 0.3243
Epoch 208/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8729 - loss: 0.3121
Epoch 209/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8663 - loss: 0.3289
Epoch 210/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8632 - loss: 0.3329
```

```
Epoch 211/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8637 - loss: 0.3350
Epoch 212/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8648 - loss: 0.3262
Epoch 213/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8608 - loss: 0.3372
Epoch 214/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8639 - loss: 0.3350
Epoch 215/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8604 - loss: 0.3325
Epoch 216/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8615 - loss: 0.3366
Epoch 217/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8676 - loss: 0.3294
Epoch 218/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8703 - loss: 0.3253
Epoch 219/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8634 - loss: 0.3323
Epoch 220/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8687 - loss: 0.3221
Epoch 221/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8691 - loss: 0.3235
Epoch 222/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8646 - loss: 0.3286
Epoch 223/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8604 - loss: 0.3319
Epoch 224/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step - accuracy: 0.8687 - loss: 0.3284
Epoch 225/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8692 - loss: 0.3240
Epoch 226/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8650 - loss: 0.3245
Epoch 227/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8570 - loss: 0.3388
Epoch 228/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8661 - loss: 0.3294
Epoch 229/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8716 - loss: 0.3126
Epoch 230/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8714 - loss: 0.3230
Epoch 231/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8722 - loss: 0.3203
Epoch 232/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8635 - loss: 0.3302
Epoch 233/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8616 - loss: 0.3282
Epoch 234/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8582 - loss: 0.3396
Epoch 235/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8668 - loss: 0.3234
Epoch 236/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8744 - loss: 0.3128
Epoch 237/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8674 - loss: 0.3273
Epoch 238/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8719 - loss: 0.3208
Epoch 239/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8635 - loss: 0.3216
Epoch 240/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8576 - loss: 0.3399
```

```
Epoch 241/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8656 - loss: 0.3279
Epoch 242/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8644 - loss: 0.3299
Epoch 243/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8607 - loss: 0.3370
Epoch 244/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8638 - loss: 0.3277
Epoch 245/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8673 - loss: 0.3215
Epoch 246/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8602 - loss: 0.3345
Epoch 247/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8635 - loss: 0.3274
Epoch 248/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8694 - loss: 0.3230
Epoch 249/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8599 - loss: 0.3398
Epoch 250/250
250/250 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.8706 - loss: 0.3139
```

Out[23]: <keras.src.callbacks.history.History at 0x20638cd4fa0>

Part 4 - Making the predictions and evaluating the model

Predicting the Test set results

In [24]:
```
y_pred = ann.predict(X_test)
y_pred = (y_pred > 0.5)
print(np.concatenate((y_pred.reshape(len(y_pred),1), y_test.reshape(len(y_test),
```

```
63/63 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step
[[0 0]
 [0 1]
 [0 0]
 ...
 [0 0]
 [0 0]
 [0 0]]
```

Making the Confusion Matrix

In [25]:
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
```

```
[[1516   79]
 [ 195  210]]
```

Accuracy

In [26]:
```
from sklearn.metrics import accuracy_score
acc = accuracy_score(y_test, y_pred)
acc
```

Out[26]: 0.863

In [ ]: