# **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
```

ut[3]:		RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Ten
	0	1	15634602	Hargrave	619	France	Female	42	
9	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	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								
•	1¢	2ms/sten	_	accuracy:	0 8611	_	1055.	0 3361
Epoch 2/250	13	211137 3 CCP		accuracy.	0.0011		1033.	0.5501
250/250 ————	1s	2ms/step	_	accuracy:	0.8728	_	loss:	0.3191
Epoch 3/250		, ,		,				
250/250	<b>1</b> s	2ms/step	-	accuracy:	0.8666	-	loss:	0.3296
Epoch 4/250								
	<b>1</b> s	2ms/step	-	accuracy:	0.8616	-	loss:	0.3369
Epoch 5/250								
	<b>1</b> s	2ms/step	-	accuracy:	0.8669	-	loss:	0.3317
Epoch 6/250 250/250 ————————————————————————————————————	1.	2ms/ston		2661122611	0.000		10001	0 2264
Epoch 7/250	12	ziis/step	-	accuracy:	0.8098	-	1055:	0.3264
•	15	2ms/sten	_	accuracy:	0.8656	_	loss:	0.3324
Epoch 8/250		о, о о о р						
•	<b>1</b> s	2ms/step	-	accuracy:	0.8736	-	loss:	0.3235
Epoch 9/250								
	<b>1</b> s	2ms/step	-	accuracy:	0.8658	-	loss:	0.3313
Epoch 10/250							_	
250/250	<b>1</b> s	2ms/step	-	accuracy:	0.8689	-	loss:	0.3270
Epoch 11/250 250/250 ————————————————————————————————————	1.	2ms/ston		2661122611	0.000		10001	0 2202
Epoch 12/250	12	ziis/step	-	accuracy:	0.8080	-	1055:	0.3293
•	15	2ms/sten	_	accuracy:	0.8655	_	loss:	0.3275
Epoch 13/250		23, 3 ccp		accai acy.	0.0033		1033.	0.32,3
•	<b>1</b> s	2ms/step	_	accuracy:	0.8663	-	loss:	0.3342
Epoch 14/250				-				
250/250 —————	<b>1</b> s	2ms/step	-	accuracy:	0.8621	-	loss:	0.3328
Epoch 15/250								
250/250	<b>1</b> s	2ms/step	-	accuracy:	0.8568	-	loss:	0.3463
Epoch 16/250	4.	2			0.0643		1	0 2207
<b>250/250</b> ————————————————————————————————————	15	zms/step	-	accuracy:	0.8643	_	1055:	0.3307
250/250	1ς	3ms/sten	_	accuracy:	0 8615	_	1055.	0 3332
Epoch 18/250		33, 3 ccp		accai acy.	0.0015		1033.	0.3332
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8707	-	loss:	0.3267
Epoch 19/250								
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8657	-	loss:	0.3316
Epoch 20/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8680	-	loss:	0.3247
Epoch 21/250	1.	2ms/ston		2661122611	0 9676		10001	0 2272
<b>250/250</b> ————————————————————————————————————	12	ollis/step	-	accuracy.	0.0070	_	1055.	0.32/2
250/250	1s	3ms/step	_	accuracv:	0.8663	_	loss:	0.3282
Epoch 23/250		т, т.т.р						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8601	-	loss:	0.3371
Epoch 24/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8602	-	loss:	0.3335
Epoch 25/250		_					_	
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8657	-	loss:	0.3299
Epoch 26/250 250/250 ————————————————————————————————————	1.0	2ms/s+on		2661102611	0 9606		1000	a 2220
Epoch 27/250	12	siis/step	-	accuracy:	0.8606	-	1055:	0.3328
250/250	15	3ms/sten	_	accuracy:	0.8628	_	loss:	0.3250
Epoch 28/250		-, - cop						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8599	-	loss:	0.3410
Epoch 29/250				-				
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8747	-	loss:	0.3120
Epoch 30/250	_						,	0.54
250/250	15	3ms/step	-	accuracy:	0.8575	-	TOSS:	0.3401

Epoch 31/250	4.	2			0.0653		1	0 2222
<b>250/250</b> ————————————————————————————————————	. 12	3ms/step	-	accuracy:	0.8653	-	1088:	0.3232
250/250	. 15	3ms/sten	_	accuracy:	0 8583	_	1055.	0 3389
Epoch 33/250		3.1137 3 ccp		accar acy.	0.0303		1033.	0.3303
-	<b>1</b> s	3ms/step	_	accuracy:	0.8643	_	loss:	0.3348
Epoch 34/250				•				
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8617	-	loss:	0.3362
Epoch 35/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8622	-	loss:	0.3361
Epoch 36/250	1.	2/			0.0631		1	0 2210
<b>250/250</b> ————————————————————————————————————	. 12	siis/scep	-	accuracy:	0.8621	-	1022:	0.3319
250/250	· 1s	3ms/sten	_	accuracy:	0.8646	_	loss:	0.3362
Epoch 38/250		т, т тор		,				
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8633	-	loss:	0.3254
Epoch 39/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8673	-	loss:	0.3293
Epoch 40/250 250/250 ————————————————————————————————————	1.	2/			0.0016		1	0 2267
Epoch 41/250	. 12	3ms/step	-	accuracy:	0.8616	-	1055:	0.3367
250/250	· 1s	3ms/step	_	accuracv:	0.8652	_	loss:	0.3306
Epoch 42/250		,						
250/250 —————	<b>1</b> s	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 ————————————————————————————————————	1 c	3mc/ctan	_	accuracy:	0 8624	_	1000	0 3350
Epoch 45/250	13	Jiii3/ 3 cep		accuracy.	0.0024		1033.	0.5550
250/250	<b>1</b> s	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 ————————————————————————————————————	. 1 c	2mc/ston		accuracy:	0 0500		1000	0 2250
Epoch 48/250	13	Jiii3/3 Cep	_	accuracy.	0.0303	_	1033.	0.5558
250/250 ————	<b>1</b> s	3ms/step	_	accuracy:	0.8608	_	loss:	0.3388
Epoch 49/250								
	<b>1</b> s	3ms/step	-	accuracy:	0.8649	-	loss:	0.3314
Epoch 50/250	1.	2/			0.0000		1	0 2250
<b>250/250</b> ————————————————————————————————————	. 12	3ms/step	-	accuracy:	0.8666	_	1055:	0.3350
-	· 1s	3ms/step	_	accuracy:	0.8671	_	loss:	0.3256
Epoch 52/250				•				
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8607	-	loss:	0.3304
Epoch 53/250		2 / 1					,	
<b>250/250</b> ————————————————————————————————————	· 1s	3ms/step	-	accuracy:	0.8686	-	loss:	0.3224
-	- 15	3ms/sten	_	accuracy:	0.8682	_	loss:	0.3222
Epoch 55/250		ээ, эсср		accai acy.	0.0002		1033.	0.3222
•	<b>1</b> s	3ms/step	-	accuracy:	0.8669	-	loss:	0.3218
Epoch 56/250								
	1s	3ms/step	-	accuracy:	0.8621	-	loss:	0.3331
Epoch 57/250 250/250 ————————————————————————————————————	. 1 c	2mc/c+on		accuracy:	0 9663		1000	0 2200
Epoch 58/250	τ2	step / داااد	-	accuracy:	0.0003	-	TO22:	0.3203
-	<b>1</b> s	3ms/step	_	accuracy:	0.8750	_	loss:	0.3205
Epoch 59/250		·		•				
	<b>1</b> s	3ms/step	-	accuracy:	0.8666	-	loss:	0.3270
Epoch 60/250	4 -	2 m = 1 = 1			0.0505		1	0.2244
250/250	TS	sms/step	-	accuracy:	0.8595	-	TO22:	0.3341

5 1 64 (050								
Epoch 61/250	1.	2/			0.0630		1	0 2272
<b>250/250</b> ————————————————————————————————————	. 12	3ms/step	-	accuracy:	0.8628	-	1088:	0.33/2
250/250	. 1c	3mc/ctan	_	accuracy:	0 8651	_	1000	0 3320
Epoch 63/250	13	Jiii3/ 3 CCP		accuracy.	0.0051		1033.	0.3320
-	<b>1</b> s	3ms/step	_	accuracy:	0.8599	_	loss:	0.3411
Epoch 64/250		т, т тор		,				
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8664	_	loss:	0.3263
Epoch 65/250								
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8697	-	loss:	0.3253
Epoch 66/250							-	
250/250 ————————————————————————————————————	· 1s	3ms/step	-	accuracy:	0.86/9	-	loss:	0.3219
Epoch 67/250 250/250 ————————————————————————————————————	. 1c	3ms/sten	_	accuracy:	0 8650	_	1055.	0 3257
Epoch 68/250		3.1137 3 ccp		accar acy.	0.0050		1033.	0.3237
250/250 ————	<b>1</b> s	3ms/step	_	accuracy:	0.8707	_	loss:	0.3199
Epoch 69/250		•		-				
250/250	<b>1</b> s	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 ————————————————————————————————————	. 1.	2mc/c+on		2661102614	0 0716		1000	0 2252
Epoch 72/250	. 12	ollis/step	-	accuracy.	0.0/10	_	1055.	0.3232
250/250 ————	· 1s	3ms/step	_	accuracy:	0.8663	_	loss:	0.3206
Epoch 73/250				•				
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8703	-	loss:	0.3222
Epoch 74/250		2 / 1					,	0 2242
250/250 ————————————————————————————————————	· 1s	3ms/step	-	accuracy:	0.8655	-	loss:	0.3313
Epoch 75/250 250/250 ————————————————————————————————————	. 15	3ms/sten	_	accuracy:	0 8674	_	loss.	0 3307
Epoch 76/250		3.1137 3 ccp		accar acy.	0.0074		1033.	0.3307
250/250 ————	<b>1</b> s	3ms/step	-	accuracy:	0.8715	_	loss:	0.3225
Epoch 77/250								
	<b>1</b> s	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 ————————————————————————————————————	. 1c	3ms/sten	_	accuracy:	0 8630	_	1055.	0 3268
Epoch 80/250		ээ, эсер		accai acy.	0.0050		1033.	0.3200
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8678	-	loss:	0.3273
Epoch 81/250								
	<b>1</b> s	3ms/step	-	accuracy:	0.8722	-	loss:	0.3188
Epoch 82/250 250/250 ————————————————————————————————————	. 1 c	2mc/ston		2661102611	0 9670		1000	0 2202
Epoch 83/250	13	Jiii3/3 Cep	_	accuracy.	0.8070	_	1033.	0.5505
•	<b>1</b> s	3ms/step	_	accuracy:	0.8573	_	loss:	0.3381
Epoch 84/250				-				
	<b>1</b> s	3ms/step	-	accuracy:	0.8638	-	loss:	0.3299
Epoch 85/250							_	
	1s	3ms/step	-	accuracy:	0.8685	-	loss:	0.3265
Epoch 86/250 250/250 ————————————————————————————————————	1 c	3mc/ctan	_	accuracy:	0 8582	_	1000	0 3370
Epoch 87/250	13	эшэ/ эсср		accuracy.	0.0302		1033.	0.3370
-	<b>1</b> s	3ms/step	_	accuracy:	0.8602	-	loss:	0.3397
Epoch 88/250				-				
	<b>1</b> s	3ms/step	-	accuracy:	0.8584	-	loss:	0.3413
Epoch 89/250	4 -	2 m = 1 = 1			0.0613		1	0 2255
<b>250/250</b> ————————————————————————————————————	TS	sms/step	-	accuracy:	0.8613	-	TO22:	Ø.3355
•	<b>1</b> s	3ms/sten	_	accuracy:	0.8658	_	loss:	0.3343
		zz, z ccp						

5 b 01 /250								
Epoch 91/250 250/250 ————————————————————————————————————	. 1 c	2mc/ston		accupacy:	0 0505		10551	0 2/22
Epoch 92/250	13	Jilis/step	_	accuracy.	0.0333	_	1055.	0.3422
	15	3ms/sten	_	accuracy:	0.8666	_	loss:	0.3270
Epoch 93/250		ээ, э сер						0.027.0
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8641	_	loss:	0.3268
Epoch 94/250		·						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8589	-	loss:	0.3397
Epoch 95/250								
	<b>1</b> s	3ms/step	-	accuracy:	0.8697	-	loss:	0.3292
Epoch 96/250							-	
	15	3ms/step	-	accuracy:	0.8657	-	loss:	0.3232
Epoch 97/250 250/250 ————————————————————————————————————	. 1 c	2mc/ston		accupacy:	0 9655		10551	0 2220
Epoch 98/250	13	Jilis/step	_	accuracy.	0.0033	_	1055.	0.3333
250/250	1s	3ms/step	_	accuracv:	0.8672	_	loss:	0.3325
Epoch 99/250		ээ, э зэр						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8672	-	loss:	0.3226
Epoch 100/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8661	-	loss:	0.3251
Epoch 101/250							_	
	<b>1</b> s	3ms/step	-	accuracy:	0.8590	-	loss:	0.3382
Epoch 102/250 250/250 ————————————————————————————————————	1.	2mc/ston		accuracy:	0 9611		1000	0 2207
Epoch 103/250	12	3ms/scep	-	accuracy:	0.8644	-	1055:	0.3297
250/250	15	3ms/sten	_	accuracy:	0.8686	_	loss:	0.3225
Epoch 104/250		эшэ, эсср		accai acy.	0.0000		1055.	0.3223
250/250 ————	<b>1</b> s	3ms/step	_	accuracy:	0.8555	-	loss:	0.3441
Epoch 105/250				-				
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8675	-	loss:	0.3245
Epoch 106/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8574	-	loss:	0.3404
Epoch 107/250	1.	2			0.0640		1	0 2242
<b>250/250</b> ————————————————————————————————————	12	3ms/scep	-	accuracy:	0.8640	-	1055:	0.3343
	<b>1</b> s	3ms/sten	_	accuracy:	0.8708	_	loss:	0.3209
Epoch 109/250		эшэ, эсср		accai acy.	0.0700		1055.	0.3203
•	<b>1</b> s	3ms/step	_	accuracy:	0.8637	-	loss:	0.3331
Epoch 110/250								
	<b>1</b> s	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 ————————————————————————————————————	. 1 c	2mc/ston		accuracy:	0 0503		10551	0 2220
Epoch 113/250	12	ollis/step	-	accuracy.	0.0592	-	1055.	0.3329
250/250 ————	1s	3ms/step	_	accuracv:	0.8631	_	loss:	0.3306
Epoch 114/250		ээ, э зэр						
•	<b>1</b> s	3ms/step	_	accuracy:	0.8615	-	loss:	0.3332
Epoch 115/250								
	<b>1</b> s	3ms/step	-	accuracy:	0.8675	-	loss:	0.3329
Epoch 116/250							_	
	<b>1</b> s	3ms/step	-	accuracy:	0.8574	-	loss:	0.3473
Epoch 117/250	1.	2mc/ston		2661102611	0 0622		1000	0 2252
<b>250/250</b> ————————————————————————————————————	12	oms/step	-	accuracy:	v.8023	-	1022;	۵.5555
•	15	3ms/sten	_	accuracy:	0.8632	_	loss:	0.3283
Epoch 119/250		зэ, эсер			2.0002			
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8641	-	loss:	0.3318
Epoch 120/250				-				
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8645	-	loss:	0.3316

Enach 121/250								
Epoch 121/250 250/250 ————————————————————————————————————	1 c	3mc/ston		accuracy:	0 8675		1000	0 3380
Epoch 122/250	12	Jilis/step	_	accuracy.	0.8073	_	1055.	0.3200
250/250	1 c	3ms/sten	_	accuracy:	0 8666	_	1055.	0 3208
Epoch 123/250	13	эшэ/ эсср		accuracy.	0.0000		1033.	0.3200
•	15	3ms/sten	_	accuracy:	0.8676	_	loss:	0.3264
Epoch 124/250		ээ, э сер		accai acy i	0.007.0			
•	1s	3ms/step	_	accuracy:	0.8642	_	loss:	0.3312
Epoch 125/250		,						
•	1s	3ms/step	_	accuracy:	0.8630	_	loss:	0.3383
Epoch 126/250		·						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8658	-	loss:	0.3268
Epoch 127/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8640	-	loss:	0.3343
Epoch 128/250								
	<b>1</b> s	3ms/step	-	accuracy:	0.8725	-	loss:	0.3171
Epoch 129/250							_	
	<b>1</b> s	3ms/step	-	accuracy:	0.8709	-	loss:	0.3201
Epoch 130/250	4.	2 / 1			0.0640		,	0 2246
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8649	-	loss:	0.3316
Epoch 131/250 250/250 ————————————————————————————————————	1.0	2ms/ston		accuracy:	0 0621		10551	0 2200
Epoch 132/250	12	ollis/step	-	accuracy.	0.0031	_	1055.	0.3309
•	1ς	3ms/sten	_	accuracy:	0 8649	_	1055.	0 3299
Epoch 133/250		эшэ, эсср		accar acy.	0.0043		1033.	0.3233
•	<b>1</b> s	3ms/step	_	accuracy:	0.8694	_	loss:	0.3219
Epoch 134/250		,						
•	<b>1</b> s	3ms/step	_	accuracy:	0.8678	_	loss:	0.3260
Epoch 135/250		·						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8603	-	loss:	0.3364
Epoch 136/250								
	<b>1</b> s	4ms/step	-	accuracy:	0.8649	-	loss:	0.3341
Epoch 137/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8660	-	loss:	0.3335
Epoch 138/250	4.	2 / 1			0 0700		,	0 2404
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8/20	-	1055:	0.3191
Epoch 139/250 250/250 ————————————————————————————————————	1.	2mc/ston		2661102611	0 0600		1000	0 2170
Epoch 140/250	12	Jilis/step	_	accuracy.	0.0000	_	1055.	0.3170
250/250 ————	15	3ms/sten	_	accuracy:	0.8545	_	loss:	0.3373
Epoch 141/250		ээ, э сер						0.007.0
250/250 ————	<b>1</b> s	3ms/step	_	accuracy:	0.8694	_	loss:	0.3192
Epoch 142/250		·						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8648	-	loss:	0.3302
Epoch 143/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8622	-	loss:	0.3318
Epoch 144/250							_	
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8638	-	loss:	0.3270
Epoch 145/250 250/250 ————————————————————————————————————	1.	2ms/ston		200112011	0.000		10001	0 2270
Epoch 146/250	15	3ms/step	-	accuracy:	0.8638	-	1088:	0.32/9
250/250	1 c	3mc/stan	_	accuracy:	0 8710	_	1000	0 3218
Epoch 147/250	13	Jiii3/3CEP		accuracy.	0.0710		1033.	0.5210
250/250 ————	1s	3ms/step	_	accuracv:	0.8688	_	loss:	0.3287
Epoch 148/250		. э, - сер						
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8561	-	loss:	0.3485
Epoch 149/250		•		•				
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8649	-	loss:	0.3273
Epoch 150/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8692	-	loss:	0.3305

Epoch 151/250								
•	1 c	3mc/stan	_	accuracy:	0 8696	_	1000	0 3251
Epoch 152/250	13	Jiii3/3Cep		accuracy.	0.8050		1033.	0.5251
250/250	15	4ms/sten	_	accuracy:	0.8683	_	loss:	0.3308
Epoch 153/250		ттэ, эсср		accai acy.	0.0003		1055.	0.3300
•	1s	3ms/step	_	accuracy:	0.8686	_	loss:	0.3206
Epoch 154/250		,						
•	<b>1</b> s	3ms/step	_	accuracy:	0.8689	_	loss:	0.3263
Epoch 155/250								
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8645	_	loss:	0.3264
Epoch 156/250								
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8601	-	loss:	0.3329
Epoch 157/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8681	-	loss:	0.3316
Epoch 158/250								
	<b>1</b> s	4ms/step	-	accuracy:	0.8624	-	loss:	0.3358
Epoch 159/250							-	
	1s	3ms/step	-	accuracy:	0.8630	-	loss:	0.3318
Epoch 160/250	4.	2/-+			0 0707		1	0 2227
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8/0/	-	1055:	0.3237
Epoch 161/250 250/250 ————————————————————————————————————	1.	Ams/ston		accuracy:	0 0620		10551	0 2227
Epoch 162/250	12	4111S/Step	-	accuracy.	0.0020	_	1055.	0.3327
•	15	4ms/sten	_	accuracy:	0 8635	_	loss	0 3388
Epoch 163/250		-шэ, эсср		accar acy.	0.0033		1033.	0.5500
•	1s	3ms/step	_	accuracy:	0.8560	_	loss:	0.3359
Epoch 164/250		,						
•	<b>1</b> s	4ms/step	-	accuracy:	0.8717	_	loss:	0.3236
Epoch 165/250		·						
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8554	-	loss:	0.3437
Epoch 166/250								
250/250 —————	<b>1</b> s	4ms/step	-	accuracy:	0.8717	-	loss:	0.3177
Epoch 167/250								
250/250	<b>1</b> s	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 ————————————————————————————————————	1.	2			0.0655		1	0 2265
Epoch 170/250	12	3ms/step	-	accuracy:	0.8055	-	1022:	0.3203
250/250	1 c	1mc/stan	_	accuracy:	0 8699	_	1000	0 3167
Epoch 171/250	13	-шэ/ эсср		accuracy.	0.0055		1033.	0.5107
250/250 ————	<b>1</b> s	4ms/step	_	accuracv:	0.8639	_	loss:	0.3322
Epoch 172/250								
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8710	-	loss:	0.3156
Epoch 173/250								
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8672	-	loss:	0.3201
Epoch 174/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8639	-	loss:	0.3349
Epoch 175/250							-	
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8708	-	loss:	0.3177
Epoch 176/250	4.	2/-+			0.0660		1	0 2210
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8669	-	1055:	0.3318
Epoch 177/250 250/250 ————————————————————————————————————	1 c	1mc/ston	_	accuracy:	0 8618		1000	0 3334
Epoch 178/250	Τ2	-m3/3cep	-	accuracy:	0.0040	-	TO22:	0.3334
250/250	15	4ms/sten	_	accuracy.	0.8659	_	1055.	0.3306
Epoch 179/250		э, эсср		accar acy.	0.0055			2.3300
250/250 ————	<b>1</b> s	4ms/step	_	accuracy:	0.8708	_	loss:	0.3147
Epoch 180/250	_	, <b>r</b>					- 1	
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8653	-	loss:	0.3323

Epoch 181/250								
•	1 c	1mc/ston	_	accuracy:	0 8702	_	1000	0 33/13
Epoch 182/250	13	41113/3 ССР		accuracy.	0.0702		1033.	0.5245
250/250	15	4ms/sten	_	accuracy:	0.8733	_	loss:	0.3168
Epoch 183/250		о, о сер			0.07.00			0.0200
•	1s	4ms/step	_	accuracy:	0.8615	_	loss:	0.3389
Epoch 184/250		-,						
•	<b>1</b> s	3ms/step	_	accuracy:	0.8681	_	loss:	0.3238
Epoch 185/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8674	-	loss:	0.3204
Epoch 186/250								
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8606	-	loss:	0.3362
Epoch 187/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8684	-	loss:	0.3253
Epoch 188/250								
	<b>1</b> s	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	4.	2/-+			0.0613		1	0 2257
<b>250/250</b> ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8613	-	1055:	0.335/
•	1.	2mc/ston		accuracy:	0 0610		1055	0 2202
Epoch 192/250	13	Jilis/step	_	accuracy.	0.0040	_	1055.	0.3293
•	15	3ms/sten	_	accuracy:	0 8660	_	loss	0 3247
Epoch 193/250		эшэ, эсср		accar acy.	0.0000		1033.	0.3247
•	1s	4ms/step	_	accuracy:	0.8739	_	loss:	0.3122
Epoch 194/250		-,						
•	<b>1</b> s	3ms/step	_	accuracy:	0.8650	_	loss:	0.3321
Epoch 195/250		·						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8621	-	loss:	0.3335
Epoch 196/250								
250/250 ————	<b>1</b> s	3ms/step	-	accuracy:	0.8630	-	loss:	0.3315
Epoch 197/250								
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8662	-	loss:	0.3234
Epoch 198/250							_	
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8658	-	loss:	0.3259
Epoch 199/250	4.	2 / 1			0.0665		,	0 2266
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8665	-	1055:	0.3266
Epoch 200/250 250/250 ————————————————————————————————————	1.	2mc/ston		accupacy:	0 0607		1055	0 2101
Epoch 201/250	13	Jilis/step	_	accuracy.	0.8087	_	1033.	0.5104
250/250 ————	15	3ms/sten	_	accuracy:	0.8696	_	loss:	0.3145
Epoch 202/250		,						
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8682	-	loss:	0.3227
Epoch 203/250								
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8675	-	loss:	0.3306
Epoch 204/250								
250/250 ————	<b>1</b> s	3ms/step	-	accuracy:	0.8694	-	loss:	0.3213
Epoch 205/250							_	
250/250	<b>1</b> s	4ms/step	-	accuracy:	0.8628	-	loss:	0.3327
Epoch 206/250	4.	2 / 1			0.0600		,	0 2242
250/250 ————————————————————————————————————	15	3ms/step	-	accuracy:	0.8622	-	loss:	0.3312
Epoch 207/250 250/250 ————————————————————————————————————	1.	2mc/ston		26611026111	0 0702		1000	0 2242
Epoch 208/250	12	oms/step	-	accuracy:	0.0/02	-	1022:	v.3243
250/250 ————————————————————————————————————	1 c	3ms/stan	_	accuracy	0 2770	_	1055.	0 3121
Epoch 209/250	13	21113/3 CEh	_	accuracy.	0.0723	-	1033.	0.9121
250/250 ————	<b>1</b> s	4ms/sten	_	accuracv:	0.8663	_	loss:	0.3289
Epoch 210/250		∍, = <b>55</b> P		·				
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8632	-	loss:	0.3329
		•		-				

Fnach 311/350								
Epoch 211/250 250/250 ————————————————————————————————————	. 1 c	2mc/ston		accuracy:	0 9627		1000	0 2250
Epoch 212/250	12	Jilis/step	_	accuracy.	0.8037	_	1055.	0.3330
250/250	. 1c	3mc/stan	_	accuracy:	0 86/18	_	1000	0 3262
Epoch 213/250	13	Jiiis/scep	_	accuracy.	0.8048	_	1033.	0.3202
•	. 1c	3mc/stan	_	accuracy:	0 8608	_	1000	0 3372
Epoch 214/250	13	Jiiis/scep	_	accuracy.	0.8008	_	1033.	0.3372
•	. 1c	1mc/stan	_	accuracy:	a 8639	_	1000	0 3350
Epoch 215/250		-шэ/ эсср		accuracy.	0.0055		1033.	0.5550
•	. 15	3ms/sten	_	accuracy:	0 8604	_	1055.	0 3325
Epoch 216/250		эшэ, эсср		accar acy.	0.0004		1033.	0.3323
•	. 15	3ms/sten	_	accuracy:	0 8615	_	1055.	0 3366
Epoch 217/250		эшэ, эсср		accar acy.	0.0013		1033.	0.3300
250/250 ————	· 1s	3ms/sten	_	accuracy:	0.8676	_	loss:	0.3294
Epoch 218/250		ээ, э сер						
•	· 1s	3ms/sten	_	accuracy:	0.8703	_	loss:	0.3253
Epoch 219/250		эшэ, эсср		accai acy.	0.0703		1055.	0.3233
250/250 ————	15	3ms/sten	_	accuracy:	0.8634	_	loss:	0.3323
Epoch 220/250		ээ, э сер						0.000
250/250 —————	15	3ms/sten	_	accuracy:	0.8687	_	loss:	0.3221
Epoch 221/250		эшэ, эсср		accai acy.	0.0007		1055.	0.3222
•	15	3ms/sten	_	accuracy:	0.8691	_	loss:	0.3235
Epoch 222/250		эшэ, эсср		accai acy.	0.0031		1055.	0.3233
•	15	3ms/sten	_	accuracy:	0.8646	_	loss:	0.3286
Epoch 223/250		эшэ, эсср		accai acy.	0.00.0		1055.	0.3200
•	15	3ms/sten	_	accuracy:	0.8604	_	loss:	0.3319
Epoch 224/250		эшэ, эсср		accai acy.	0.0001		1055.	0.3323
•	15	4ms/sten	_	accuracy:	0.8687	_	loss:	0.3284
Epoch 225/250		-шэ, эсср		accar acy.	0.0007		1033.	0.3204
250/250 —————	- 15	3ms/sten	_	accuracy:	0.8692	_	loss:	0.3240
Epoch 226/250		эшэ, эсср		accar acy.	0.0032		1033.	0.3240
•	- 15	3ms/sten	_	accuracy:	0.8650	_	loss:	0.3245
Epoch 227/250		эшэ, эсср		accai acy.	0.0050		1055.	0.32.3
250/250 —————	· 1s	3ms/sten	_	accuracy:	0.8570	_	loss:	0.3388
Epoch 228/250		ээ, э сер						0.000
250/250 ————	· 1s	3ms/sten	_	accuracy:	0.8661	_	loss:	0.3294
Epoch 229/250		т, т т т г						
250/250 ————	<b>1</b> s	3ms/step	_	accuracy:	0.8716	_	loss:	0.3126
Epoch 230/250		т, т т т г						
250/250 ————	· 1s	3ms/step	_	accuracy:	0.8714	_	loss:	0.3230
Epoch 231/250		,						
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8722	_	loss:	0.3203
Epoch 232/250		·		-				
250/250	<b>1</b> s	3ms/step	_	accuracy:	0.8635	_	loss:	0.3302
Epoch 233/250		·		-				
250/250	<b>1</b> s	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	<b>1</b> s	3ms/step	-	accuracy:	0.8744	-	loss:	0.3128
Epoch 237/250								
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8674	-	loss:	0.3273
Epoch 238/250		•		-				
250/250	<b>1</b> s	3ms/step	-	accuracy:	0.8719	-	loss:	0.3208
Epoch 239/250		•		-				
250/250 —————	<b>1</b> s	3ms/step	-	accuracy:	0.8635	-	loss:	0.3216
Epoch 240/250				-				
250/250 —————	<b>1</b> s	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
                            - 1s 3ms/step - accuracy: 0.8638 - loss: 0.3277
250/250 -
Epoch 245/250
250/250 -
                            - 1s 3ms/step - accuracy: 0.8673 - loss: 0.3215
Epoch 246/250
                           - 1s 3ms/step - accuracy: 0.8602 - loss: 0.3345
250/250 -
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
                            - 1s 3ms/step - accuracy: 0.8599 - loss: 0.3398
250/250 -
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

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

Out[26]: 0.863

In [ ]: