1- Reading the Data

```
# Primary libraries

from google.colab import drive
drive.mount('/content/drive/')
```

```
Drive already mounted at /content/drive/; to attempt to forcibly remount, call drive.mou
```

```
# regular EDA and ML libraries

import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

from sklearn.model_selection import train_test_split
from sklearn import preprocessing
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score, recall_score,
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning:
  import pandas.util.testing as tm
```

```
# loading the dataframe

file_path = '/content/drive/My Drive/NN/project/bank.csv'
df = pd.read_csv(file_path)
```

```
# Shape,size,datatypes,null values

df.shape
```

```
(10000, 14)
```

```
df.info()

# Problematic columns of type 'object' :    Surname, Geography, Gender   --> to change into 1

# Noise columns : RowNumber , CustomerID
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 14 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   RowNumber        10000 non-null  int64  
 1   CustomerId       10000 non-null  int64  
 2   Surname          10000 non-null  object 
 3   CreditScore      10000 non-null  int64  
 4   Geography        10000 non-null  object 
 5   Gender           10000 non-null  object 
 6   Age              10000 non-null  int64  
 7   Tenure           10000 non-null  int64  
 8   Balance          10000 non-null  float64
 9   NumOfProducts    10000 non-null  int64  
 10  HasCrCard        10000 non-null  int64  
 11  IsActiveMember   10000 non-null  int64  
 12  EstimatedSalary  10000 non-null  float64
 13  Exited           10000 non-null  int64  
dtypes: float64(2), int64(9), object(3)
memory usage: 1.1+ MB
```

```
df.isna().sum()
# no missing values
```

```
RowNumber          0
CustomerId         0
Surname            0
CreditScore        0
Geography          0
Gender             0
Age                0
Tenure             0
Balance            0
NumOfProducts      0
HasCrCard          0
IsActiveMember     0
EstimatedSalary    0
Exited             0
dtype: int64
```

```
#checking the numerical columns' Descriptive statistics

df.describe().transpose()

# skewness can be seen ( mean > median ) for some attributes and normalisation should be imp
```

	count	mean	std	min	25%	50%	
RowNumber	10000.0	5.000500e+03	2886.895680	1.00	2500.75	5.000500e+03	7.500:
CustomerId	10000.0	1.569094e+07	71936.186123	15565701.00	15628528.25	1.569074e+07	1.575:
CreditScore	10000.0	6.505288e+02	96.653299	350.00	584.00	6.520000e+02	7.180(
Age	10000.0	3.892180e+01	10.487806	18.00	32.00	3.700000e+01	4.400(
Tenure	10000.0	5.012800e+00	2.892174	0.00	3.00	5.000000e+00	7.000(
Balance	10000.0	7.648589e+04	62397.405202	0.00	0.00	9.719854e+04	1.276
NumOfProducts	10000.0	1.530200e+00	0.581654	1.00	1.00	1.000000e+00	2.000(
HasCrCard	10000.0	7.055000e-01	0.455840	0.00	0.00	1.000000e+00	1.000(
IsActiveMember	10000.0	5.151000e-01	0.499797	0.00	0.00	1.000000e+00	1.000(
EstimatedSalary	10000.0	1.000902e+05	57510.492818	11.58	51002.11	1.001939e+05	1.493
Exited	10000.0	2.037000e-01	0.402769	0.00	0.00	0.000000e+00	0.000(

```
df.head()
```

	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
4	5	15737888	Mitchell	850	Spain	Female	43	2	125510.82

2- Dropping and casting columns

```
df  = df.drop(["RowNumber", "CustomerId", "Surname"] , axis=1)
```

```
df.head()
```

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActi
0	619	France	Female	42	2	0.00	1	1	
1	608	Spain	Female	41	1	83807.86	1	0	
2	502	France	Female	42	8	159660.80	3	1	
3	699	France	Female	39	1	0.00	2	0	
4	850	Spain	Female	43	2	125510.82	1	1	

```
df.Geography.value_counts()
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   CreditScore      10000 non-null  int64
 1   Geography        10000 non-null  object
 2   Gender           10000 non-null  object
 3   Age              10000 non-null  int64
 4   Tenure           10000 non-null  int64
 5   Balance          10000 non-null  float64
 6   NumOfProducts    10000 non-null  int64
 7   HasCrCard        10000 non-null  int64
 8   IsActiveMember   10000 non-null  int64
 9   EstimatedSalary  10000 non-null  float64
 10  Exited           10000 non-null  int64
dtypes: float64(2), int64(7), object(2)
memory usage: 859.5+ KB
```

```
df['Geography'] = df['Geography'].astype('string')
```

```
df['Gender'] = df['Gender'].astype('string')
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   CreditScore      10000 non-null  int64
 1   Geography        10000 non-null  string
 2   Gender           10000 non-null  string
 3   Age              10000 non-null  int64
 4   Tenure           10000 non-null  int64
 5   Balance          10000 non-null  float64
 6   NumOfProducts    10000 non-null  int64
 7   HasCrCard        10000 non-null  int64
 8   IsActiveMember   10000 non-null  int64
 9   EstimatedSalary  10000 non-null  float64
 10  Exited           10000 non-null  int64
dtypes: float64(2), int64(7), string(2)
memory usage: 859.5 KB
```

```
# Creating Dummy variables for 'Geography' and 'Gender'

df= pd.get_dummies(df,columns=['Geography','Gender'])
```

```
df.head()
```

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

3- Features X and Target y

```
X = df.drop(columns='Exited')
```

```
X.shape
```

```
(10000, 13)
```

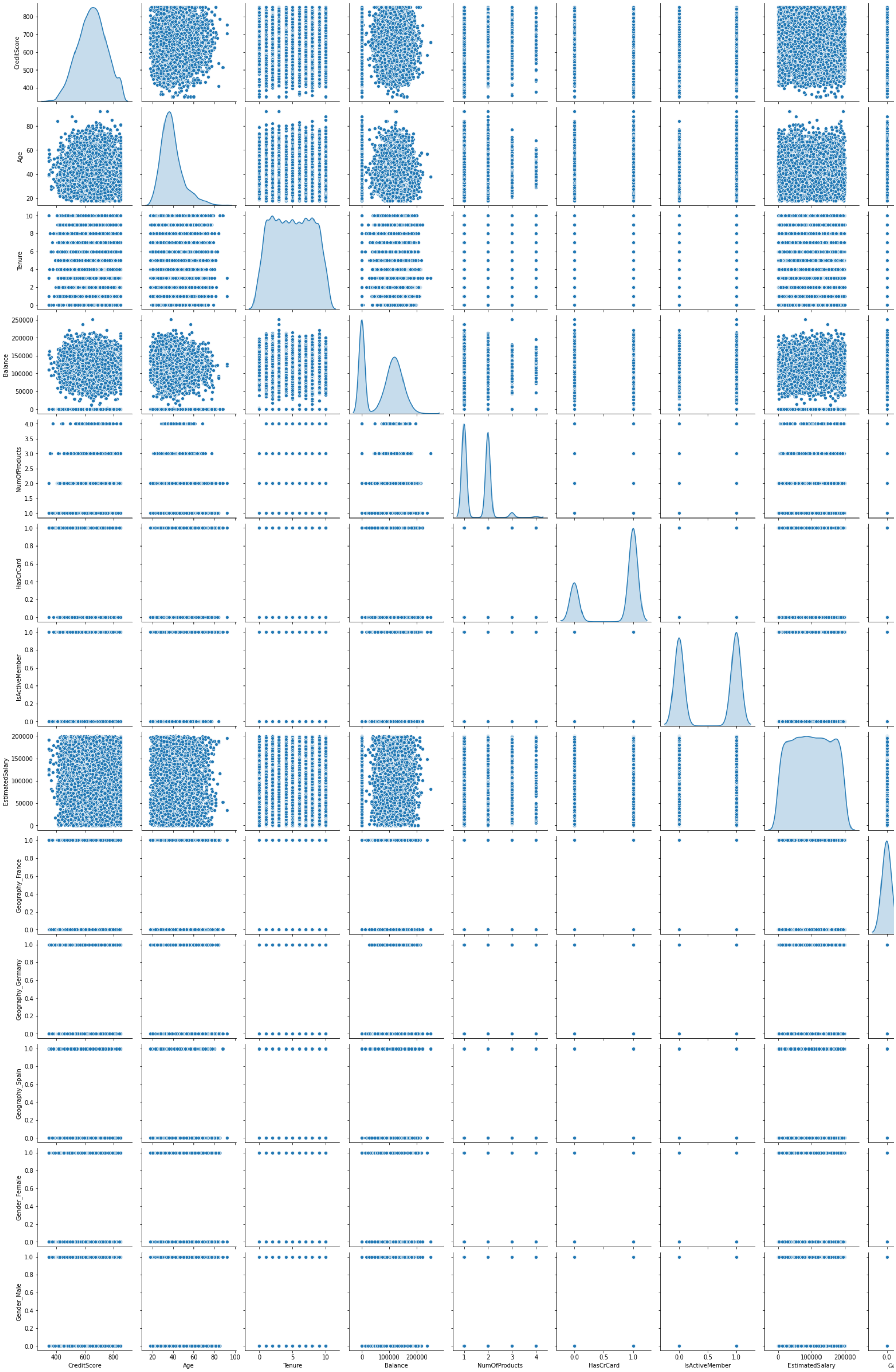
```
y=df['Exited']
```

```
y.shape
```

```
(10000,)
```

```
sns.pairplot(X ,diag_kind='kde')
```

<seaborn.axisgrid.PairGrid at 0x7fedab2a2a90>



4- Train and test split

```
(X_train, X_test, y_train, y_test)= train_test_split(X, y, test_size=0.30, random_state=1)
```

```
X_train.shape
```

```
(7000, 13)
```

```
X_test.shape
```

```
(3000, 13)
```

5-Normalisation of X_train and X_test

```
from sklearn.preprocessing import StandardScaler

X_train = preprocessing.normalize(X_train)
X_test  = preprocessing.normalize(X_test)
```

6.1- NN Model_A

```
# Tf libraries

import tensorflow as tf


from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

from tensorflow.keras import optimizers


# empty shell
model_A = Sequential()


# adding the layers
model_A.add(Dense(13, input_shape = (13,), activation = 'relu'))
model_A.add(Dense(16, activation = 'tanh'))
model_A.add(Dense(1, activation = 'sigmoid'))


# Optimiser and loss function
sgd = optimizers.Adam(lr = 0.001)
model_A.compile(optimizer = sgd, loss = 'binary_crossentropy', metrics=['accuracy'])


model_A.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 13)                182
_________________________________________________________________
dense_1 (Dense)              (None, 16)                224
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 17
=================================================================
Total params: 423
Trainable params: 423
Non-trainable params: 0
_________________________________________________________________
```

```
model_A.fit(X_train, y_train.values, batch_size = 500, epochs = 10, verbose = 1)
# Accuracy for Model_1--> 0.7986
```

```
Epoch 1/10
14/14 [==============================] - 0s 2ms/step - loss: 0.7416 - accuracy: 0.2064
Epoch 2/10
14/14 [==============================] - 0s 2ms/step - loss: 0.6843 - accuracy: 0.6159
Epoch 3/10
14/14 [==============================] - 0s 2ms/step - loss: 0.6363 - accuracy: 0.7986
Epoch 4/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5952 - accuracy: 0.7986
Epoch 5/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5593 - accuracy: 0.7986
Epoch 6/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5323 - accuracy: 0.7986
Epoch 7/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5148 - accuracy: 0.7986
Epoch 8/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5073 - accuracy: 0.7986
Epoch 9/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5042 - accuracy: 0.7986
Epoch 10/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5022 - accuracy: 0.7986
<tensorflow.python.keras.callbacks.History at 0x7fed08073e48>
```

6.2- NN Model_B

```
# An extra dense layer with more nodes and smaller lr ---> same end accuracy as before but w:
model_B = Sequential()

model_B.add(Dense(32, input_shape = (13,), activation = 'relu'))
model_B.add(Dense(64, activation = 'relu'))
model_B.add(Dense(16, activation = 'relu'))
model_B.add(Dense(1, activation = 'sigmoid'))

sgd = optimizers.Adam(lr = 0.001)
model_B.compile(optimizer = sgd, loss = 'binary_crossentropy', metrics=['accuracy'])
model_B.summary()

model_B.fit(X_train, y_train.values, batch_size = 500, epochs = 10, verbose = 1)
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_3 (Dense)              (None, 32)                448
_________________________________________________________________
dense_4 (Dense)              (None, 64)                2112
_________________________________________________________________
dense_5 (Dense)              (None, 16)                1040
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 17
=================================================================
Total params: 3,617
Trainable params: 3,617
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
14/14 [==============================] - 0s 3ms/step - loss: 0.6406 - accuracy: 0.7714
Epoch 2/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5650 - accuracy: 0.7986
Epoch 3/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5170 - accuracy: 0.7986
Epoch 4/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5039 - accuracy: 0.7986
Epoch 5/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5005 - accuracy: 0.7986
Epoch 6/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4979 - accuracy: 0.7986
Epoch 7/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4965 - accuracy: 0.7986
Epoch 8/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4957 - accuracy: 0.7986
Epoch 9/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4952 - accuracy: 0.7986
Epoch 10/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4950 - accuracy: 0.7986
<tensorflow.python.keras.callbacks.History at 0x7fecf1653128>
```

6.3- NN Model_C

```
model_C = Sequential()

model_C.add(Dense(13, input_shape = (13,), activation = 'relu'))
model_C.add(Dense(32, activation = 'relu'))
model_C.add(Dense(16, activation = 'tanh'))
model_C.add(Dense(1, activation = 'sigmoid'))

sgd = optimizers.Adam(lr = 0.01)
model_C.compile(optimizer = sgd, loss = 'binary_crossentropy', metrics=['accuracy'])
model_C.summary()

model_C.fit(X_train, y_train.values, batch_size = 500, epochs = 10, verbose = 1)
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense_7 (Dense)              (None, 13)                182       
_________________________________________________________________
dense_8 (Dense)              (None, 32)                448       
_________________________________________________________________
dense_9 (Dense)              (None, 16)                528       
_________________________________________________________________
dense_10 (Dense)             (None, 1)                 17        
=================================================================
Total params: 1,175
Trainable params: 1,175
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5321 - accuracy: 0.7884
Epoch 2/10
14/14 [==============================] - 0s 2ms/step - loss: 0.5002 - accuracy: 0.7986
Epoch 3/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4963 - accuracy: 0.7986
Epoch 4/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4946 - accuracy: 0.7986
Epoch 5/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4942 - accuracy: 0.7986
Epoch 6/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4947 - accuracy: 0.7986
Epoch 7/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4942 - accuracy: 0.7986
Epoch 8/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4950 - accuracy: 0.7986
Epoch 9/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4945 - accuracy: 0.7986
Epoch 10/10
14/14 [==============================] - 0s 2ms/step - loss: 0.4940 - accuracy: 0.7986
<tensorflow.python.keras.callbacks.History at 0x7fecf15557b8>
```

the Accuracy seems stalled at at 80% ---- let's try all three Model s for evaluation.

7- Prediction using X_test and y_test

```
results = model_A.evaluate(X_test, y_test.values)
```

```
94/94 [==============================] - 0s 2ms/step - loss: 0.5115 - accuracy: 0.7910
```

```
results = model_B.evaluate(X_test, y_test.values)
```

```
94/94 [==============================] - 0s 2ms/step - loss: 0.5079 - accuracy: 0.7910
```

```
results = model_C.evaluate(X_test, y_test.values)
```

```
94/94 [==============================] - 0s 1ms/step - loss: 0.5074 - accuracy: 0.7910
```

```
# All same results : but Model_A is simpler  on resources.
```

8- Confusion matrix

```
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score, recall_score,

y_pred = model_A.predict_classes(X_test, batch_size=200, verbose=0)

print('Accuracy Model (Dropout):'+ str(model_A.evaluate(X_test,y_test.values)[1]))
print('Recall_score: '           + str(recall_score(y_test.values,y_pred)))
print('Precision_score: '        + str(precision_score(y_test.values, y_pred)))
print('F-score: '                + str(f1_score(y_test.values,y_pred)))
confusion_matrix(y_test.values, y_pred)
```

```
94/94 [==============================] - 0s 2ms/step - loss: 0.5115 - accuracy: 0.7910
Accuracy Model (Dropout):0.7910000085830688
Recall_score: 0.0
Precision_score: 0.0
F-score: 0.0
/usr/local/lib/python3.6/dist-packages/sklearn/metrics/_classification.py:1272: Undefine
  _warn_prf(average, modifier, msg_start, len(result))
array([[2373,    0],
       [ 627,    0]])
```

Conclusion : Not my best project . Still lost on how to decide the number of layers and neurones and activatior

It seems we are just correctly predicting around 80% of the clients that decide to leave the bank or not . Better it can improve with further elaboaration and engineering of the layering ... something that needs further study

Edouard Toutounji - April 30 2020.