Chapter 3: ANN - Demo

In [1]:
```
# from google.colab import drive
# drive.mount("/content/gdrive", force_remount=True)
```

In [2]:
```
# %cd '/content/gdrive/My Drive/LDS8_DeepLearning/Practice/Chapter3/'
```

In [3]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [4]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras
```

In [5]:
```
print(tf.__version__)
print(keras.__version__)
```

```
2.5.0
2.5.0
```

Đọc dữ liệu, Tiền xử lý dữ liệu

In [6]:
```
df = pd.read_csv("Churn_Modelling.csv")
```

In [7]:
```
df.info()
```

```
<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
```

In [8]:
```
df.head()
```

Out[8]:

	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

In [9]:
```
df.groupby(by='Geography').count()
```

Out[9]:

	RowNumber	CustomerId	Surname	CreditScore	Gender	Age	Tenure	Balance	Num
Geography									
France	5014	5014	5014	5014	5014	5014	5014	5014	
Germany	2509	2509	2509	2509	2509	2509	2509	2509	
Spain	2477	2477	2477	2477	2477	2477	2477	2477	

In [10]:
```
X = df.iloc[:, 3:13].values # inputs
y = df.iloc[:, 13].values # output
```

In [11]:
```
# khach hang ra di
exited = np.count_nonzero(y)
exited
```

Out[11]:
```
2037
```

In [12]:
```
# khach hang o lai
no_exited = y.shape[0] - exited
no_exited
```

Out[12]:
```
7963
```

In [13]:
```
from scipy.stats import itemfreq
# khach hang o lai/ra di
itemfreq(y)
```

Out[13]:
```
array([[   0, 7963],
       [   1, 2037]], dtype=int64)
```

In [14]:
```
# in thong tin 10 khach hang dau tien
X[:10]
```

Out[14]:
```
array([[619, 'France', 'Female', 42, 2, 0.0, 1, 1, 1, 101348.88],
       [608, 'Spain', 'Female', 41, 1, 83807.86, 1, 0, 1, 112542.58],
       [502, 'France', 'Female', 42, 8, 159660.8, 3, 1, 0, 113931.57],
       [699, 'France', 'Female', 39, 1, 0.0, 2, 0, 0, 93826.63],
       [850, 'Spain', 'Female', 43, 2, 125510.82, 1, 1, 1, 79084.1],
       [645, 'Spain', 'Male', 44, 8, 113755.78, 2, 1, 0, 149756.71],
       [822, 'France', 'Male', 50, 7, 0.0, 2, 1, 1, 10062.8],
       [376, 'Germany', 'Female', 29, 4, 115046.74, 4, 1, 0, 119346.88],
       [501, 'France', 'Male', 44, 4, 142051.07, 2, 0, 1, 74940.5],
       [684, 'France', 'Male', 27, 2, 134603.88, 1, 1, 1, 71725.73]],
      dtype=object)
```

In [15]:
```
# Encoding categorical data
# Encoding the Independent Variable
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
from sklearn.compose import ColumnTransformer

labelencoder_X_1 = LabelEncoder()
X[:, 1] = labelencoder_X_1.fit_transform(X[:, 1])
labelencoder_X_2 = LabelEncoder()
X[:, 2] = labelencoder_X_2.fit_transform(X[:, 2])

ct = ColumnTransformer([('encoder', OneHotEncoder(), [1])],
                       remainder='passthrough')
X = ct.fit_transform(X.tolist())

# save 3 model nay pickle: labelencoder_X_1, labelencoder_X_2, ct
# Save the Modle to file in the current working directory
# Pkl_Filename = "Pickle_RL_Model.pkl"

# with open(Pkl_Filename, 'wb') as file:
#     pickle.dump(Model, file)

# Load the Model back from file
# with open(Pkl_Filename, 'rb') as file:
#     model_load = pickle.load(file)
```

In [16]:
```
X[:10]
```

Out[16]:
```
array([[1.0, 0.0, 0.0, 619, 0, 42, 2, 0.0, 1, 1, 1, 101348.88],
       [0.0, 0.0, 1.0, 608, 0, 41, 1, 83807.86, 1, 0, 1, 112542.58],
       [1.0, 0.0, 0.0, 502, 0, 42, 8, 159660.8, 3, 1, 0, 113931.57],
       [1.0, 0.0, 0.0, 699, 0, 39, 1, 0.0, 2, 0, 0, 93826.63],
       [0.0, 0.0, 1.0, 850, 0, 43, 2, 125510.82, 1, 1, 1, 79084.1],
       [0.0, 0.0, 1.0, 645, 1, 44, 8, 113755.78, 2, 1, 0, 149756.71],
       [1.0, 0.0, 0.0, 822, 1, 50, 7, 0.0, 2, 1, 1, 10062.8],
       [0.0, 1.0, 0.0, 376, 0, 29, 4, 115046.74, 4, 1, 0, 119346.88],
       [1.0, 0.0, 0.0, 501, 1, 44, 4, 142051.07, 2, 0, 1, 74940.5],
       [1.0, 0.0, 0.0, 684, 1, 27, 2, 134603.88, 1, 1, 1, 71725.73]],
      dtype=object)
```

In [17]:
```
# vì chỉ có 3 quốc gia, nên khi tạo ra ma trận OneHotEncoder quốc gia sẽ như sau:
# France  1, 0, 0
# Germany 0, 1, 0
# Spain   0, 0, 1
# => Theo đó có thể bỏ đi 1 cột đầu thì 2 cột sau là đủ thể hiện mã của 3 quốc gi
# France  0, 0
# Germany 1, 0
# Spain   0, 1
X = X[:, 1:]
```

In [18]:
```
X[:10]
```

Out[18]:
```
array([[0.0, 0.0, 619, 0, 42, 2, 0.0, 1, 1, 1, 101348.88],
       [0.0, 1.0, 608, 0, 41, 1, 83807.86, 1, 0, 1, 112542.58],
       [0.0, 0.0, 502, 0, 42, 8, 159660.8, 3, 1, 0, 113931.57],
       [0.0, 0.0, 699, 0, 39, 1, 0.0, 2, 0, 0, 93826.63],
       [0.0, 1.0, 850, 0, 43, 2, 125510.82, 1, 1, 1, 79084.1],
       [0.0, 1.0, 645, 1, 44, 8, 113755.78, 2, 1, 0, 149756.71],
       [0.0, 0.0, 822, 1, 50, 7, 0.0, 2, 1, 1, 10062.8],
       [1.0, 0.0, 376, 0, 29, 4, 115046.74, 4, 1, 0, 119346.88],
       [0.0, 0.0, 501, 1, 44, 4, 142051.07, 2, 0, 1, 74940.5],
       [0.0, 0.0, 684, 1, 27, 2, 134603.88, 1, 1, 1, 71725.73]],
      dtype=object)
```

In [19]:
```
# scale truoc => split sau
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
sc.fit(X)
X = sc.transform(X)

import pickle
scalerfile = 'sc.sav'
pickle.dump(sc, open(scalerfile, 'wb'))

# Hoac lam 1 pipeline: Lable Encoder => OnhotEncoder => Stadard scaler => model p
# o noi khac: goi model pre
```

In [20]:
```
# Splitting the dataset into the Training set and Test set
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,
                                                    random_state = 0)
```

In [21]:
```
X_train[:5]
```

Out[21]:
```
array([[-0.57873591,  1.74273971,  0.17042381, -1.09598752, -0.4693113 ,
        -0.00442596, -1.22584767,  0.80773656,  0.64609167, -1.03067011,
         1.10838187],
       [ 1.72790383, -0.57380915, -2.31280236,  0.91241915,  0.29351742,
        -1.38753759, -0.01289171, -0.91158349,  0.64609167,  0.97024255,
        -0.74759209],
       [-0.57873591, -0.57380915, -1.19535058, -1.09598752, -0.94607926,
        -1.04175968,  0.57507592, -0.91158349,  0.64609167, -1.03067011,
         1.48746417],
       [-0.57873591,  1.74273971,  0.03591573,  0.91241915,  0.10281024,
        -0.00442596,  0.46795537, -0.91158349,  0.64609167, -1.03067011,
         1.27855845],
       [-0.57873591,  1.74273971,  2.06388377, -1.09598752,  1.72382128,
         1.03290776,  0.80600989,  0.80773656,  0.64609167,  0.97024255,
         0.56006929]])
```

In [22]:
```
X_train[0].shape
```

Out[22]:
```
(11,)
```

Xây dựng model ANN

In [23]:
```
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras import Sequential
```

In [24]:
```
# Intitialing the ANN
classifier = Sequential()
```

- khởi tạo ANN sử dụng keras Sequential class và đặt tên là classifier.
- Tạo một Dense input layer với output_dim là 6 (11 inputs + 1 output)/2, hoặc 12 (11+1). Không có một quy tắc nghiêm ngặt nào cho giá trị này,
- activation function: 'relu' (thường được áp dụng cho input layer và các hidden network layers)
- input_shape = (11,) (có independent input variables trong X matrix)
- => => add vào hidden layer sử dụng classifier.add()

In [25]:
```
# Adding the input layer and the first hidden layer
classifier.add(Dense(units = 6, activation='relu', input_shape=(11,)))
classifier.add(Dropout(rate=0.1))
```

- Tạo Dense hidden layer tiếp theo với cùng tham số mà không cần input_dim (chỉ cần khai báo input_dim ở input layer) => add vào hidden layer sử dụng classifier.add()

In [26]:
```
# Addding the second hidden layer
# lop truoc do da co output => input cua lop sau
classifier.add(Dense(units = 6,
                     activation='relu'))

classifier.add(Dropout(rate=0.1))
```

- Tạo output layer với output_dim = 1 và sigmoid activation function (kết quả chỉ có 1) => add vào network sử dụng classifier.add().

In [27]:
```
# Adding the output layer
classifier.add(Dense(units = 1,
                     activation='sigmoid')) # like logistic regression
```

- Compile neural network sử dụng 'adam' optimizer, 'binary_crossentropy' loss function cho accuracy metrics

In [28]:
```
#compiling ANN
classifier.compile(optimizer='adam', loss='binary_crossentropy', \
                   metrics=['accuracy'])
```

In [29]:
```
classifier.summary()
```

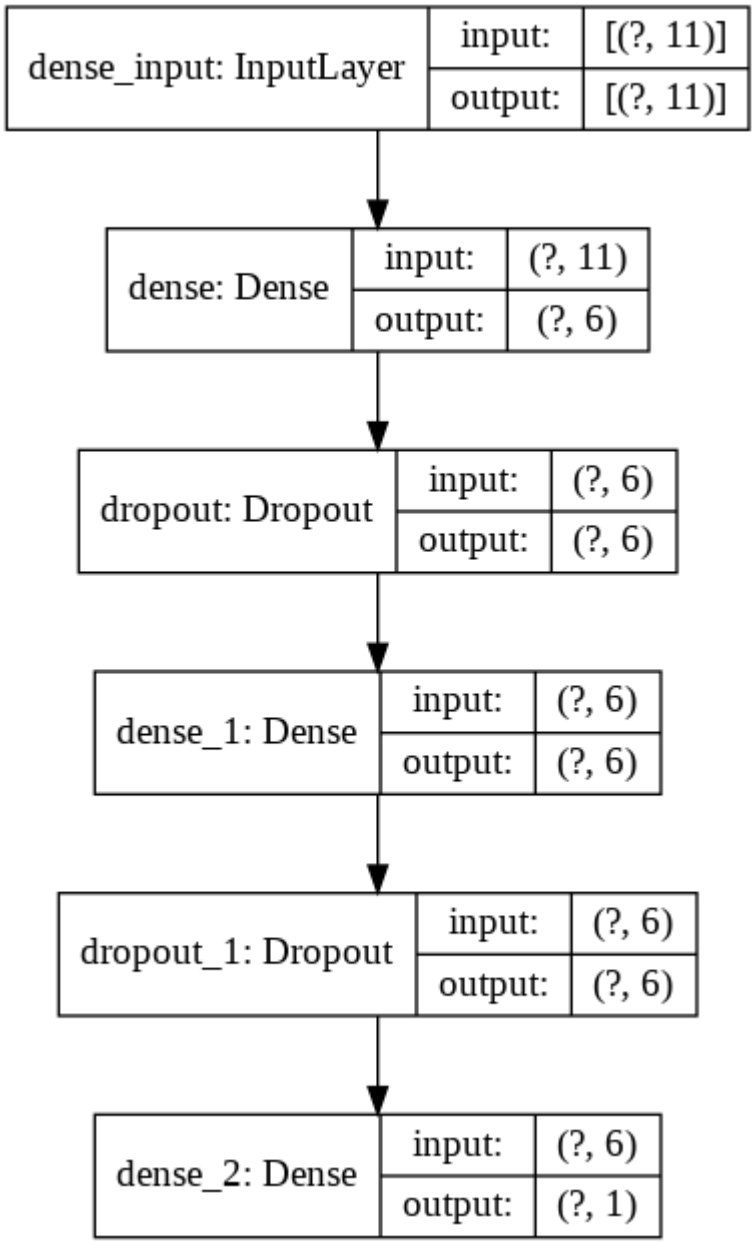
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 6)                 72
_________________________________________________________________
dropout (Dropout)            (None, 6)                 0
_________________________________________________________________
dense_1 (Dense)              (None, 6)                 42
_________________________________________________________________
dropout_1 (Dropout)          (None, 6)                 0
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 7
=================================================================
Total params: 121
Trainable params: 121
Non-trainable params: 0
_________________________________________________________________
```

In [30]:
```
from tensorflow.keras.utils import plot_model
from IPython.display import Image
```

In [31]:
```
plot_model(classifier, to_file='ANN_model.png', show_shapes=True)
Image(filename='ANN_model.png')
```

```
('You must install pydot (`pip install pydot`) and install graphviz (see instru
ctions at https://graphviz.gitlab.io/download/) (https://graphviz.gitlab.io/dow
nload/)) ', 'for plot_model/model_to_dot to work.')
```

Out[31]:



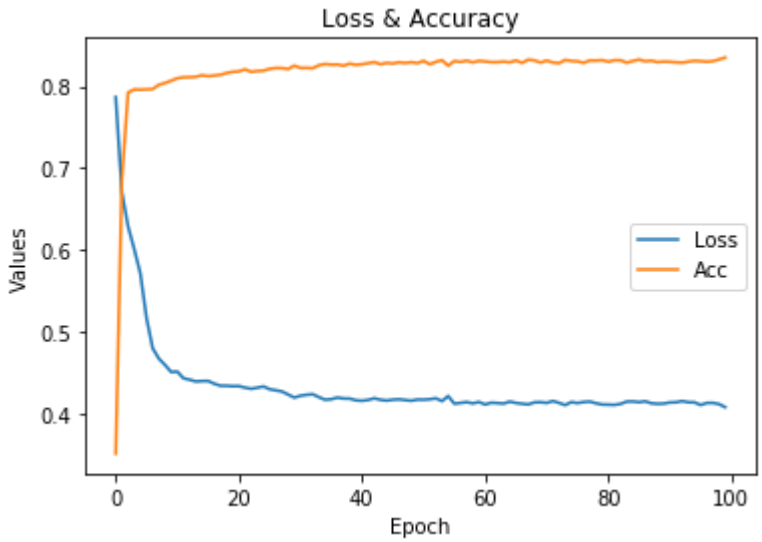
Cách tính params: fully connected: Param # = input * output + output

- dense_input: Input layer: shape(None, 11), Param #=0
- dense:Dense: shape(?, 6), Param # = input * output + output = 11 * 6 + 6 = 72
- dense_1:Dense: shape(?, 6), Param # = input * output + output = 6 * 6 + 6 = 42
- dense_2:Dense: shape(?, 6), Param # = input * output + output = 6 * 1 + 1 = 7

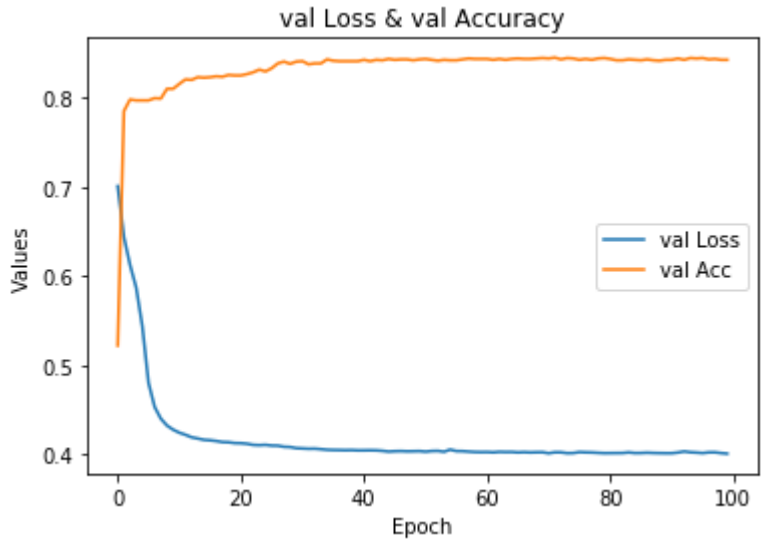
In [32]:
```
# Fitting classifier to the Training set
history = classifier.fit(X_train, y_train,
                         epochs = 100,
                         batch_size=64,
                         validation_data=(X_test, y_test)) # default batch size =
```

```
Epoch 1/100
125/125 [==============================] - 1s 2ms/step - loss: 0.7869 - accur
acy: 0.3510 - val_loss: 0.7013 - val_accuracy: 0.5225
Epoch 2/100
125/125 [==============================] - 0s 965us/step - loss: 0.6706 - acc
uracy: 0.6870 - val_loss: 0.6443 - val_accuracy: 0.7855
Epoch 3/100
125/125 [==============================] - 0s 984us/step - loss: 0.6290 - acc
uracy: 0.7925 - val_loss: 0.6128 - val_accuracy: 0.7985
Epoch 4/100
125/125 [==============================] - 0s 981us/step - loss: 0.6011 - acc
uracy: 0.7964 - val_loss: 0.5874 - val_accuracy: 0.7975
Epoch 5/100
125/125 [==============================] - 0s 989us/step - loss: 0.5713 - acc
uracy: 0.7960 - val_loss: 0.5438 - val_accuracy: 0.7975
Epoch 6/100
125/125 [==============================] - 0s 997us/step - loss: 0.5168 - acc
uracy: 0.7964 - val_loss: 0.4806 - val_accuracy: 0.7975
Epoch 7/100
```

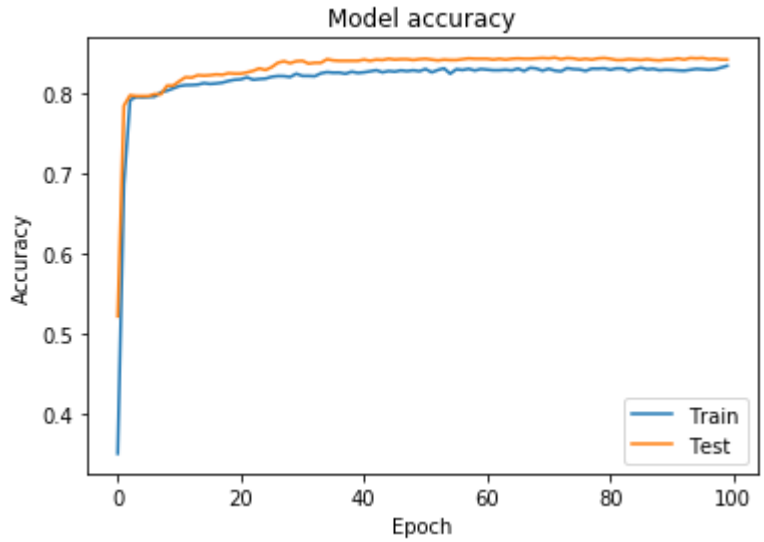
In [33]:
```
plt.figure()
plt.plot(history.history['loss'])
plt.plot(history.history['accuracy'])
plt.title('Loss & Accuracy')
plt.ylabel('Values')
plt.xlabel('Epoch')
plt.legend(['Loss', 'Acc'])
plt.show()
```



In [34]:
```
plt.figure()
plt.plot(history.history['val_loss'])
plt.plot(history.history['val_accuracy'])
plt.title('val Loss & val Accuracy')
plt.ylabel('Values')
plt.xlabel('Epoch')
plt.legend(['val Loss', 'val Acc'])
plt.show()
```



In [35]:
```
# so sanh acc giua train vs test: overfitting? underfitting? => No
plt.figure()
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'])
plt.show()
```



In [36]:
```
# Part 3: Making a predictions and evaluating the models
# Predicting the Test set results
y_pred = classifier.predict(X_test)
```

Đánh giá model và dự đoán dữ liệu mới

In [37]:
```
y_pred[:5]
```

Out[37]:
```
array([[0.26806527],
       [0.29092318],
       [0.1793733 ],
       [0.07376492],
       [0.20785925]], dtype=float32)
```

In [38]:
```
# trên 0.5 => 1, ngược lại => 0
y_pred = y_pred >= 0.5
print(y_pred)
```

```
[[False]
 [False]
 [False]
 ...
 [False]
 [False]
 [False]]
```

In [39]:
```
# Making the Confusion Matrix
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
cm
```

Out[39]:
```
array([[1559,   36],
       [ 278,  127]], dtype=int64)
```

In [40]:
```
acc = (cm[0][0] + cm[1][1])/ (cm[0][0] + cm[1][1] + cm[0][1] + cm[1][0])
print(acc)
```

```
0.843
```

In [41]:
```
# Evaluation
print("Accuracy:", classifier.evaluate(X_test, y_test))
```

```
63/63 [==============================] - 0s 708us/step - loss: 0.4012 - accurac
y: 0.8430
Accuracy: [0.4012296199798584, 0.8429999947547913]
```

In [42]:
```
#Save the result
from tensorflow.keras.models import load_model
# Creates a HDF5 file 'my_model.h5'
classifier.save('ANN_model.h5')
```

Use our ANN model to predict if the customer with the following informations will leave the bank:

- Geography: France
- Credit Score: 600
- Gender: Male
- Age: 40 years old
- Tenure: 3 years
- Balance: 60000
- Number of Products: 2
- Does this customer have a credit card ? Yes
- Is this customer an Active Member: Yes
- Estimated Salary: 50000
- So should we say goodbye to that customer ?

In [43]:
```
new_pred = classifier.predict(sc.transform(np.array([[0, 0, 600, 1, 40, 3, 60000,
                                                      2, 1, 1, 50000]])))
```

In [44]:
```
new_pred  = new_pred  > 0.5
new_pred
```

Out[44]:
```
array([[False]])
```

In [45]:
```
# the customer doesn't leave the bank
```