In [1]:
```
pip install keras
```

```
Requirement already satisfied: keras in c:\users\vxlli\anaconda3\lib\site-p
ackages (2.11.0)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:
```
pip install tensorflow
```

```
Requirement already satisfied: tensorflow in c:\users\vxlli\anaconda3\lib\s
ite-packages (2.11.0)
Requirement already satisfied: tensorflow-intel==2.11.0 in c:\users\vxlli\a
naconda3\lib\site-packages (from tensorflow) (2.11.0)
Requirement already satisfied: tensorboard<2.12,>=2.11 in c:\users\vxlli\an
aconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (2.1
1.1)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\vxlli\anaconda3\l
ib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.4.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\vxlli\anaconda3\lib
\site-packages (from tensorflow-intel==2.11.0->tensorflow) (3.7.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\vxlli\anaconda
3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.6.3)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\vxlli\anacon
da3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.51.1)
Requirement already satisfied: wrapt>=1.11.0 in c:\users\vxlli\anaconda3\li
b\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.14.1)
Requirement already satisfied: libclang>=13.0.0 in c:\users\vxlli\anaconda3
\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (15.0.6.1)
Requirement already satisfied: setuptools in c:\users\vxlli\anaconda3\lib\s
ite-packages (from tensorflow-intel==2.11.0->tensorflow) (63.4.1)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\users\vxlli\anacon
da3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (0.4.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\vxlli\anaconda3
\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (2.2.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\vxlli\a
naconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (4.
3.0)
Requirement already satisfied: keras<2.12,>=2.11.0 in c:\users\vxlli\anacon
da3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (2.11.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\vxlli\anacon
da3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (0.2.0)
Requirement already satisfied: tensorflow-estimator<2.12,>=2.11.0 in c:\use
rs\vxlli\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensor
flow) (2.11.0)
Requirement already satisfied: flatbuffers>=2.0 in c:\users\vxlli\anaconda3
\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (23.1.4)
Requirement already satisfied: packaging in c:\users\vxlli\anaconda3\lib\si
te-packages (from tensorflow-intel==2.11.0->tensorflow) (21.3)
Requirement already satisfied: numpy>=1.20 in c:\users\vxlli\anaconda3\lib
\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.21.5)
Requirement already satisfied: six>=1.12.0 in c:\users\vxlli\anaconda3\lib
\site-packages (from tensorflow-intel==2.11.0->tensorflow) (1.16.0)
Requirement already satisfied: protobuf<3.20,>=3.9.2 in c:\users\vxlli\anac
onda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (3.19.
6)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\u
sers\vxlli\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tens
orflow) (0.29.0)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\vxlli\anaconda
3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow) (3.3.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\vxlli\anacond
a3\lib\site-packages (from astunparse>=1.6.0->tensorflow-intel==2.11.0->ten
sorflow) (0.37.1)
```

```
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in c:\users
\vxlli\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflo
w-intel==2.11.0->tensorflow) (0.4.6)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\vxlli\anac
onda3\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflow-intel==2.
11.0->tensorflow) (2.16.0)
Requirement already satisfied: markdown>=2.6.8 in c:\users\vxlli\anaconda3
\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0-
>tensorflow) (3.3.4)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\vxlli\anaconda3
\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0-
>tensorflow) (2.0.3)
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in
c:\users\vxlli\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->t
ensorflow-intel==2.11.0->tensorflow) (0.6.1)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in c:\users\vx
lli\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflow-i
ntel==2.11.0->tensorflow) (1.8.1)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\vxlli\anacon
da3\lib\site-packages (from tensorboard<2.12,>=2.11->tensorflow-intel==2.1
1.0->tensorflow) (2.28.1)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\users\vxlli\a
naconda3\lib\site-packages (from packaging->tensorflow-intel==2.11.0->tenso
rflow) (3.0.9)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\vxlli\anaconda3\li
b\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.12,>=2.11->tenso
rflow-intel==2.11.0->tensorflow) (4.9)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\vxlli\anac
onda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.12,>=2.1
1->tensorflow-intel==2.11.0->tensorflow) (0.2.8)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\vxlli\ana
conda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.12,>=2.
11->tensorflow-intel==2.11.0->tensorflow) (5.2.1)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\vxlli\a
naconda3\lib\site-packages (from google-auth-oauthlib<0.5,>=0.4.1->tensorbo
ard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (1.3.1)
Requirement already satisfied: idna<4,>=2.5 in c:\users\vxlli\anaconda3\lib
\site-packages (from requests<3,>=2.21.0->tensorboard<2.12,>=2.11->tensorfl
ow-intel==2.11.0->tensorflow) (3.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\vxlli\anacond
a3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.12,>=2.11->te
nsorflow-intel==2.11.0->tensorflow) (2022.9.14)
Requirement already satisfied: charset-normalizer<3,>=2 in c:\users\vxlli\a
naconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.12,>=2.
11->tensorflow-intel==2.11.0->tensorflow) (2.0.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in c:\users\vxlli\anac
onda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.12,>=2.11-
>tensorflow-intel==2.11.0->tensorflow) (1.26.11)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\vxlli\anaco
nda3\lib\site-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->
tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\vxlli\anaconda3
\lib\site-packages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<0.
5,>=0.4.1->tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow)
(3.2.2)
Note: you may need to restart the kernel to use updated packages.
```

In [3]:
```
#import activation function in a keras sequential model
from keras.models import Sequential
from keras.layers import Dense, Activation
from keras.optimizers import Adam
from keras.metrics import categorical_crossentropy
```

In [4]:
```
#Import necessary packages
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

In [5]:
```
#Read the training data
data = pd.read_csv(r'C:\Users\vxlli\Downloads\diabetes.csv')
```

In [6]:
```
#show the dataframe
data.head(5)
```

Out[6]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunctio
0	6	148	72	35	0	33.6	0.6
1	1	85	66	29	0	26.6	0.3
2	8	183	64	0	0	23.3	0.6
3	1	89	66	23	94	28.1	0.1
4	0	137	40	35	168	43.1	2.2

In [7]:
```
#separate the features
features = data.drop('Outcome', axis = 'columns')
```

In [8]:
```
#separate the target
target = data['Outcome']
```

In [9]:
```
#Assigning to conventional variables, the features and target
X_train = features
Y_train = target
```

In [10]:
```
#solit the dataset into training and testing
from sklearn.model_selection import train_test_split
X_trian, X_test, Y_train, Y_test = train_test_split(features, target, test_si
#random_state = 0; we get the same train and test sets across different execu
```

In [11]:
```
#print the dimension of train and test data
print(X_train.shape)
print(Y_train.shape)
print(X_test.shape)
print(Y_test.shape)
```

```
(768, 8)
(537,)
(231, 8)
(231,)
```

In [12]:
```
#Define layers
model = Sequential ([
        Dense(units=16,input_shape=(8,), activation='sigmoid'),#input feature
        Dense(units=32, activation= 'relu'), #2nd hidden layer with 32 nodes
        Dense(units=2, activation='sigmoid') #2 outputs
])
```

In [13]:
```
#before training the model, will be compileing it
model.compile(
optimizer=Adam(learning_rate=0.0001), #Adam is a variant of SGD
loss='sparse_categorical_crossentropy',
metrics=['accuracy'])
#to the compile() function, we are passing the optimizer, the loss function,
```

In [14]:
```
model.fit (features,
           target,
           validation_split=0.1,  #10% validation set#
           batch_size=10, #how many training samples should be sent to the mo
           epochs=30, #the complete training set (all of the samples) will be
           shuffle= True,
           verbose=2)
```

```
Epoch 1/30
70/70 - 1s - loss: 0.7871 - accuracy: 0.3632 - val_loss: 0.7307 - val_accur
acy: 0.4156 - 1s/epoch - 15ms/step
Epoch 2/30
70/70 - 0s - loss: 0.7331 - accuracy: 0.3763 - val_loss: 0.6978 - val_accur
acy: 0.5195 - 169ms/epoch - 2ms/step
Epoch 3/30
70/70 - 0s - loss: 0.6946 - accuracy: 0.4805 - val_loss: 0.6804 - val_accur
acy: 0.6234 - 164ms/epoch - 2ms/step
Epoch 4/30
70/70 - 0s - loss: 0.6668 - accuracy: 0.6425 - val_loss: 0.6691 - val_accur
acy: 0.6234 - 154ms/epoch - 2ms/step
Epoch 5/30
70/70 - 0s - loss: 0.6485 - accuracy: 0.6686 - val_loss: 0.6637 - val_accur
acy: 0.6104 - 160ms/epoch - 2ms/step
Epoch 6/30
70/70 - 0s - loss: 0.6357 - accuracy: 0.6686 - val_loss: 0.6620 - val_accur
acy: 0.5974 - 147ms/epoch - 2ms/step
Epoch 7/30
70/70 - 0s - loss: 0.6279 - accuracy: 0.6671 - val_loss: 0.6622 - val_accur
acy: 0.5974 - 152ms/epoch - 2ms/step
Epoch 8/30
70/70 - 0s - loss: 0.6224 - accuracy: 0.6671 - val_loss: 0.6623 - val_accur
acy: 0.5974 - 159ms/epoch - 2ms/step
Epoch 9/30
70/70 - 0s - loss: 0.6182 - accuracy: 0.6671 - val_loss: 0.6624 - val_accur
acy: 0.5974 - 152ms/epoch - 2ms/step
Epoch 10/30
70/70 - 0s - loss: 0.6152 - accuracy: 0.6643 - val_loss: 0.6603 - val_accur
acy: 0.5974 - 152ms/epoch - 2ms/step
Epoch 11/30
70/70 - 0s - loss: 0.6126 - accuracy: 0.6585 - val_loss: 0.6614 - val_accur
acy: 0.5974 - 157ms/epoch - 2ms/step
Epoch 12/30
70/70 - 0s - loss: 0.6106 - accuracy: 0.6585 - val_loss: 0.6590 - val_accur
acy: 0.5974 - 150ms/epoch - 2ms/step
Epoch 13/30
70/70 - 0s - loss: 0.6088 - accuracy: 0.6585 - val_loss: 0.6582 - val_accur
acy: 0.5974 - 148ms/epoch - 2ms/step
Epoch 14/30
70/70 - 0s - loss: 0.6069 - accuracy: 0.6599 - val_loss: 0.6577 - val_accur
acy: 0.5974 - 148ms/epoch - 2ms/step
Epoch 15/30
70/70 - 0s - loss: 0.6053 - accuracy: 0.6599 - val_loss: 0.6586 - val_accur
acy: 0.5974 - 147ms/epoch - 2ms/step
Epoch 16/30
70/70 - 0s - loss: 0.6036 - accuracy: 0.6614 - val_loss: 0.6567 - val_accur
acy: 0.5974 - 156ms/epoch - 2ms/step
```

```
Epoch 17/30
70/70 - 0s - loss: 0.6022 - accuracy: 0.6643 - val_loss: 0.6539 - val_accur
acy: 0.5974 - 151ms/epoch - 2ms/step
Epoch 18/30
70/70 - 0s - loss: 0.6008 - accuracy: 0.6643 - val_loss: 0.6535 - val_accur
acy: 0.5974 - 145ms/epoch - 2ms/step
Epoch 19/30
70/70 - 0s - loss: 0.5994 - accuracy: 0.6614 - val_loss: 0.6520 - val_accur
acy: 0.5974 - 147ms/epoch - 2ms/step
Epoch 20/30
70/70 - 0s - loss: 0.5984 - accuracy: 0.6628 - val_loss: 0.6516 - val_accur
acy: 0.5974 - 134ms/epoch - 2ms/step
Epoch 21/30
70/70 - 0s - loss: 0.5981 - accuracy: 0.6686 - val_loss: 0.6496 - val_accur
acy: 0.5974 - 147ms/epoch - 2ms/step
Epoch 22/30
70/70 - 0s - loss: 0.5962 - accuracy: 0.6614 - val_loss: 0.6506 - val_accur
acy: 0.5974 - 148ms/epoch - 2ms/step
Epoch 23/30
70/70 - 0s - loss: 0.5952 - accuracy: 0.6657 - val_loss: 0.6458 - val_accur
acy: 0.5974 - 150ms/epoch - 2ms/step
Epoch 24/30
70/70 - 0s - loss: 0.5940 - accuracy: 0.6614 - val_loss: 0.6470 - val_accur
acy: 0.5974 - 157ms/epoch - 2ms/step
Epoch 25/30
70/70 - 0s - loss: 0.5934 - accuracy: 0.6628 - val_loss: 0.6479 - val_accur
acy: 0.5974 - 152ms/epoch - 2ms/step
Epoch 26/30
70/70 - 0s - loss: 0.5931 - accuracy: 0.6643 - val_loss: 0.6481 - val_accur
acy: 0.5974 - 151ms/epoch - 2ms/step
Epoch 27/30
70/70 - 0s - loss: 0.5923 - accuracy: 0.6787 - val_loss: 0.6465 - val_accur
acy: 0.5844 - 149ms/epoch - 2ms/step
Epoch 28/30
70/70 - 0s - loss: 0.5912 - accuracy: 0.6787 - val_loss: 0.6458 - val_accur
acy: 0.5974 - 151ms/epoch - 2ms/step
Epoch 29/30
70/70 - 0s - loss: 0.5902 - accuracy: 0.6802 - val_loss: 0.6440 - val_accur
acy: 0.6104 - 153ms/epoch - 2ms/step
Epoch 30/30
70/70 - 0s - loss: 0.5896 - accuracy: 0.6773 - val_loss: 0.6443 - val_accur
acy: 0.6104 - 150ms/epoch - 2ms/step
```

Out[14]: `<keras.callbacks.History at 0x11b04885ee0>`

In [15]:
```
#predict the response for test dataset
#Y_pred = model.predict(X_test)
Y_pred = np.argmax(model.predict(X_test),axis=1)
```

```
8/8 [==============================] - 0s 2ms/step
```

In [16]:
```
pip install sklearn
```

```
Requirement already satisfied: sklearn in c:\users\vxlli\anaconda3\lib\site
-packages (0.0.post1)
Note: you may need to restart the kernel to use updated packages.
```

In [17]:
```
#np.round(model.predict(X_test))
```

In [18]:
```
#model Accuracy, how often is classifier correct
from sklearn import metrics
from sklearn.metrics import accuracy_score
print ("Accuracy:", accuracy_score(Y_test, Y_pred))
```

```
Accuracy: 0.7186147186147186
```

In [19]:
```
#confusion matirix
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(Y_test, Y_pred)
print (cm)
```

```
[[148   9]
 [ 56  18]]
```

In [20]:
```
TN = cm [0][0]
FN = cm [1][0]
FP = cm [0][1]
TP = cm [1][1]
```

In [21]:
```
print ('TP = ', TP)
print ('TN = ', TN)
print ('FP = ', FP)
print ('FN = ', FN)
```

```
TP =  18
TN =  148
FP =  9
FN =  56
```

In [22]:
```
#specificity quantifies the ability to avoid false positive
print ('Specificity = ', TN / (TN +FP))
```

```
Specificity =  0.9426751592356688
```

In [23]:
```
#specificity quantifies the ability to avoid false nigative
print ('Specificity = ', TP / (TP +FN))
```

```
Specificity =  0.24324324324324326
```

In [24]:
```
#Precision
from sklearn.metrics import precision_score
print ("Precision:", precision_score(Y_test, Y_pred, average = None))
```

```
Precision: [0.7254902  0.66666667]
```

In [25]:
```
#Recall
from sklearn.metrics import recall_score
print ("Recall:", recall_score(Y_test, Y_pred, average = None))
```

```
Recall: [0.94267516 0.24324324]
```

In [26]:
```
#F1 score
from sklearn.metrics import f1_score
print ("F-score:", f1_score(Y_test, Y_pred, average = None))
```

```
F-score: [0.8199446  0.35643564]
```

In [27]:
```
#print classification report
from sklearn.metrics import classification_report
print (classification_report(Y_test, Y_pred))
```

```
              precision    recall  f1-score   support

           0       0.73      0.94      0.82       157
           1       0.67      0.24      0.36        74

    accuracy                           0.72       231
   macro avg       0.70      0.59      0.59       231
weighted avg       0.71      0.72      0.67       231
```

In [ ]:
```

```