```
#import necessary libraries
import pandas as pd
import numpy as np
import pickle
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import sklearn
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.model_selection import RandomizedSearchCV
import imblearn
from imblearn.over_sampling import SMOTE
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix, f1_score


#import dataset
data = pd.read_csv(r"Churn_Modelling.csv")
data
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure
			Hargrave	619	France	Female	42	2
1	2	15647311	Hill	608	Spain	Female	41	1
2	3	15619304	Onio	502	France	Female	42	8
3	4	15701354	Boni	699	France	Female	39	1
4	5	15737888	Mitchell	850	Spain	Female	43	2
...	...	...	...	...	...	...	...	...
9995	9996	15606229	Obijiaku	771	France	Male	39	5
9996	9997	15569892	Johnstone	516	France	Male	35	10
9997	9998	15584532	Liu	709	France	Female	36	7
9998	9999	15682355	Sabbatini	772	Germany	Male	42	3
9999	10000	15628319	Walker	792	France	Female	28	4

10000 rows × 14 columns


```
data.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
```

```
#checking for null values
data.CustomerId=pd.to_numeric(data.CustomerId, errors='coerce')
data.isnull().any()
```

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

```
data["CustomerId"].fillna(data["CustomerId"].median(),inplace=True)
data.isnull().sum()
```

```
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
```



```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
data["RowNumber"] = le.fit_transform(data["RowNumber"])
data["CustomerId"] = le.fit_transform(data["CustomerId"])
data["Surname"] = le.fit_transform(data["Surname"])
data["CreditScore"] = le.fit_transform(data["CreditScore"])
data["Geography"] = le.fit_transform(data["Geography"])
data["Gender"] =le.fit_transform(data["Gender"])
data["Age"] = le.fit_transform(data["Age"])
data["Tenure"] =le.fit_transform(data["Tenure"])
data["Balance"]= le.fit_transform(data["Balance"])
data["NumOfProducts"]= le.fit_transform(data["NumOfProducts"])
data["HasCrCard"] = le.fit_transform(data["HasCrCard"])
data["IsActiveMember"] =le.fit_transform(data["IsActiveMember"])
data["EstimatedSalary"] =le.fit_transform(data["EstimatedSalary"])
data["Exited"] = le.fit_transform(data["Exited"])
```

```
data.head()
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Ba
0	0	2736	1115	228	0	0	24	2	
1	1	3258	1177	217	2	0	23	1	
2	2	2104	2040	111	0	0	24	8	
3	3	5435	289	308	0	0	21	1	
4	4	6899	1822	459	2	0	25	2	

```
x=data.iloc[:,0:14].values
y=data.iloc[:,13:14].values
```

```
x
```

```
array([[   0, 2736, 1115, ...,    1, 5068,    1],
       [   1, 3258, 1177, ...,    1, 5639,    0],
       [   2, 2104, 2040, ...,    0, 5707,    1],
       ...,
       [9997,  717, 1570, ...,    1, 2062,    1],
```

```
       [9998, 4656, 2345, ...,    0, 4639,    1],
       [9999, 2497, 2751, ...,    0, 1878,    0]])
```

```
y
```

```
array([[1],
       [0],
       [1],
       ...,
       [1],
       [1],
       [0]])
```

```
from sklearn.preprocessing import OneHotEncoder
one = OneHotEncoder()
a= one.fit_transform(x[:,0:1]).toarray()
b= one.fit_transform(x[:,1:2]).toarray()
c= one.fit_transform(x[:,2:3]).toarray()
d= one.fit_transform(x[:,3:4]).toarray()
e= one.fit_transform(x[:,4:5]).toarray()
f= one.fit_transform(x[:,5:6]).toarray()
g= one.fit_transform(x[:,6:7]).toarray()
h= one.fit_transform(x[:,7:8]).toarray()
i= one.fit_transform(x[:,8:9]).toarray()
j= one.fit_transform(x[:,9:10]).toarray()
x=np.delete(x, [0,1,2,3,4,5,6,7,8,9], axis=1)
x=np.concatenate((a,b,c,d,e,f,g,h,i,j,x), axis=1)
```

Saving...

```
MOTE
```

```
smt = SMOTE()
x_resample,y_resample=smt.fit_resample (x,y)
```

```
x_resample
```

```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, ...,
        1.00000000e+00, 5.06800000e+03, 1.00000000e+00],
       [0.00000000e+00, 1.00000000e+00, 0.00000000e+00, ...,
        1.00000000e+00, 5.63900000e+03, 0.00000000e+00],
       [0.00000000e+00, 0.00000000e+00, 1.00000000e+00, ...,
        0.00000000e+00, 5.70700000e+03, 1.00000000e+00],
       ...,
       [0.00000000e+00, 0.00000000e+00, 0.00000000e+00, ...,
        0.00000000e+00, 9.87599651e+03, 1.00000000e+00],
       [0.00000000e+00, 0.00000000e+00, 0.00000000e+00, ...,
        5.98737695e-01, 6.03421010e+03, 1.00000000e+00],
       [0.00000000e+00, 0.00000000e+00, 0.00000000e+00, ...,
        0.00000000e+00, 9.51229892e+03, 1.00000000e+00]])
```

```
y_resample
```

```
array([1, 0, 1, ..., 1, 1, 1])
```

```
data.describe()
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gen
count	10000.00000	10000.00000	10000.000000	10000.000000	10000.000000	10000.000
mean	4999.50000	4999.50000	1507.774200	259.584600	0.746300	0.545
std	2886.89568	2886.89568	846.204311	96.496107	0.827529	0.497
min	0.00000	0.00000	0.000000	0.000000	0.000000	0.000
25%	2499.75000	2499.75000	773.750000	193.000000	0.000000	0.000
50%	4999.50000	4999.50000	1542.000000	261.000000	0.000000	1.000
75%	7499.25000	7499.25000	2238.250000	327.000000	1.000000	1.000
max	9999.00000	9999.00000	2931.000000	459.000000	2.000000	1.000

```
plt.figure(figsize=(12,5))
plt.subplot(1,2,1)
```

```
sns.distplot(data["Balance"])
plt.subplot(1,2,2)
sns.distplot(data["Tenure"])
```

```
<ipython-input-21-40ad5a6b3819>:3: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

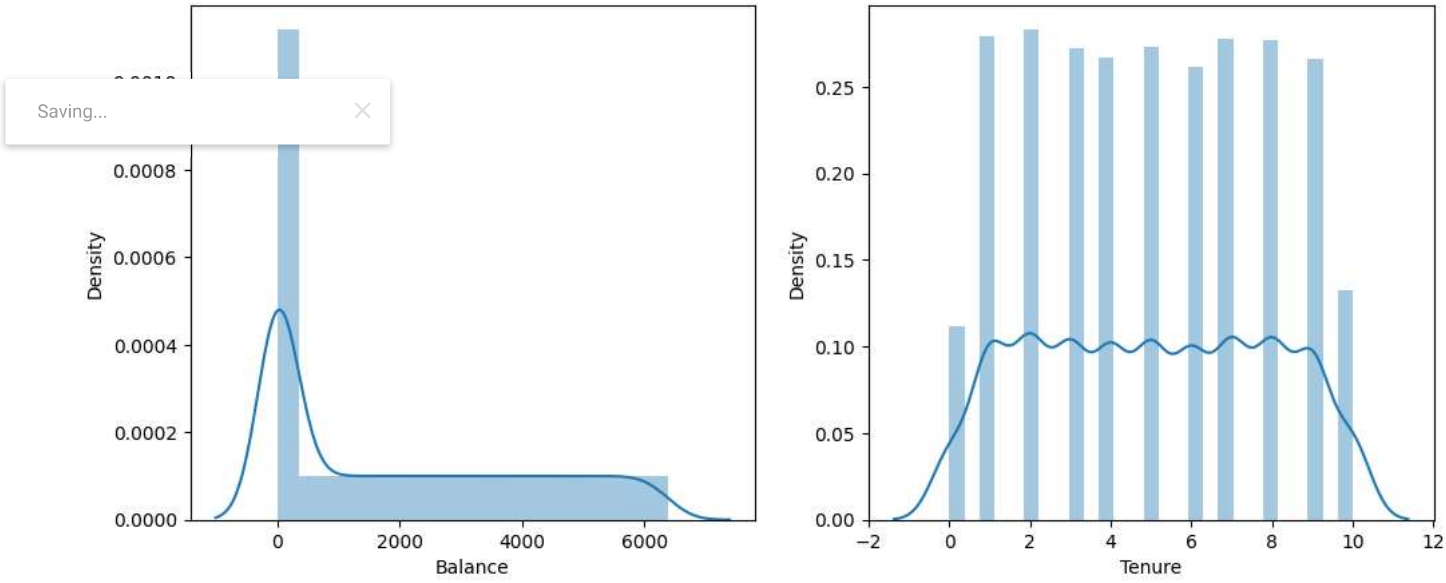
  sns.distplot(data["Balance"])
<ipython-input-21-40ad5a6b3819>:5: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(data["Tenure"])
<Axes: xlabel='Tenure', ylabel='Density'>
```

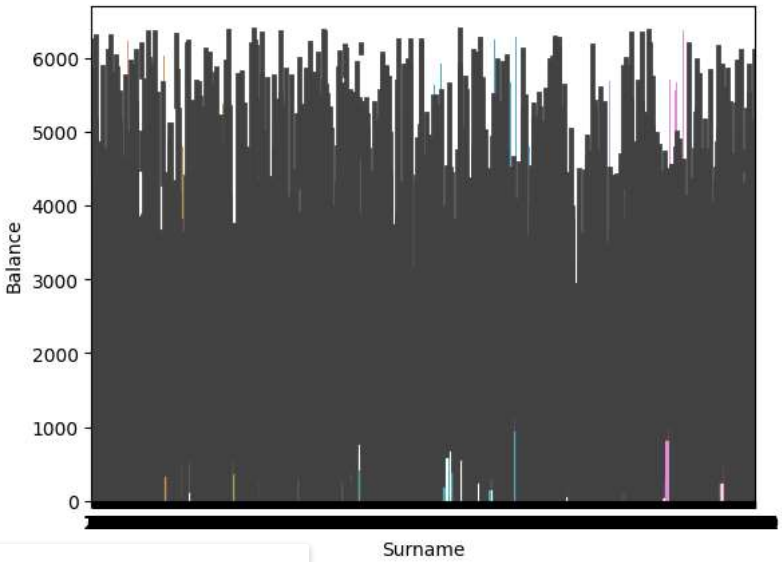



```
plt.figure(figsize=(12,5))
plt.subplot(1,2,1)
sns.countplot(data["Tenure"])
plt.subplot(1,2,1)
sns.countplot(data["Balance"])
```

```
<Axes: ylabel='count'>
```

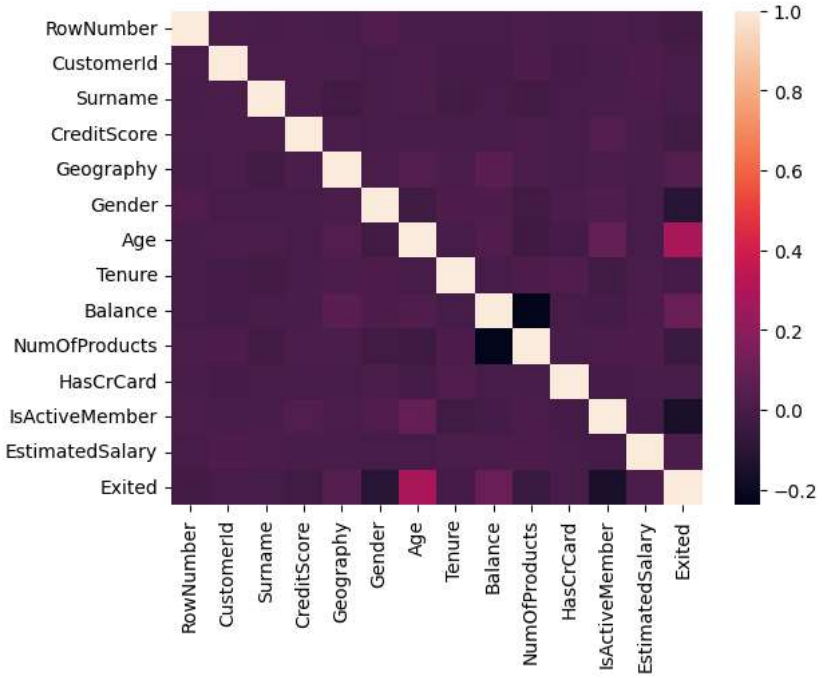

```
sns.barplot(x="Surname", y="Balance",data=data)
```

```
<Axes: xlabel='Surname', ylabel='Balance'>
```




```
sns.heatmap(data.corr(),annot=False)
```

```
<Axes: >
```




```
sns.pairplot(data=data,markers= ["^","v"],palette= "inferno")
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1507: UserWarning: Ignoring `palette` because no `hue` variable has been assi
  func(x=vector, **plot_kwargs)
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```
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```

```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x_resample, y_resample, test_size = 0.2, random_state =0)
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
x_train.ndim
```

```
2
```

```
  func(x=x, y=y, **kwargs)
```

```
x_test.ndim
```

```
2
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
x_train.ndim
```

```
2
```

```
  func(x=x, y=y, **kwargs)
```

```
x_train=pd.DataFrame(x_train)
x_test=pd.DataFrame(x_test)
```

```
  func(x=x, y=y, **kwargs)
```

```
x_train
```

	0	1	2	3	4	5	6	7	8	9	...	29858	29859	29860	29861	29862	29863	29864	29865	29866
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	1.000000	0.000000	0.000000	0.0	0.930159	0.069841	6636.768249
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	1.000000	0.000000	0.000000	0.0	0.000000	0.000000	7113.000000
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.043995	0.956005	0.000000	0.0	0.043995	1.000000	9852.296088
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	1.000000	0.000000	0.000000	0.0	1.000000	0.000000	5534.000000
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	1.000000	0.000000	0.000000	0.0	0.159173	0.000000	4274.522482
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12735	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.209732	0.790268	0.000000	0.0	0.209732	0.000000	6568.951340
12736	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.000000	1.000000	0.000000	0.0	1.000000	0.000000	9083.000000
12737	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.000000	1.000000	0.000000	0.0	1.000000	1.000000	7470.000000
12738	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.123083	0.000000	0.876917	0.0	0.123083	0.000000	391.107750
12739	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	1.000000	0.000000	0.000000	0.0	1.000000	0.000000	5952.000000

12740 rows × 29868 columns

```
from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
x_train = sc.fit_transform(x_train)
x_test = sc.fit_transform(x_test)
```

```
  func(x=x, y=y, **kwargs)
```

```
x_train.shape
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#importing and building the Decision tree model
def logreg(x_train,x_test,y_train,y_test):
  lr = LogisticRegression (random_state=0)
  lr.fit(x_train,y_train)
  y_lr_tr = lr.predict(x_train)
  print(accuracy_score(y_lr_tr,y_train))
  yPred_lr = lr.predict(x_test)
  print(accuracy_score (yPred_lr,y_test))
  print("***Logistic Regression***")
  print("Confusion_Matrix")
  print(confusion_matrix(y_test,yPred_lr))
  print("Classification Report")
  print(classification_report(y_test,yPred_lr))
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#printing the train accuracy and test accuracy respectively
logreg(x_train,x_test,y_train,y_test)
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#importing and building the Decision tree model
def decisionTree(x_train,x_test,y_train,y_test):
  dtc = DecisionTreeClassifier(criterion="entropy", random_state=0)
```

```
  dtc.fit(x_train,y_train)
  y_dt_tr = dtc.predict(x_train)
  print(accuracy_score (y_dt_tr,y_train))
  yPred_dt = dtc.predict(x_test)
  print(accuracy_score (yPred_dt,y_test))
  print("***Decision Tree***")
  print("Confusion_Matrix")
  print(confusion_matrix(y_test,yPred_dt))
  print("Classification Report")
  print(classification_report(y_test,yPred_dt))
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#printing the train accuracy and test accuracy respectively
decisionTree(x_train,x_test,y_train,y_test)
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#importing and building the random forest model
def RandomForest (x_tarin,x_test,y_train,y_test):
  rf = RandomForestClassifier(criterion="entropy",n_estimators=10, random_state=0)
  rf.fit(x_train,y_train) y_rf_tr = rf.predict(x_train)
  print(accuracy_score (y_rf_tr,y_train))
  yPred rf rf.predict(x_test) = print(accuracy_score (yPred_rf,y_test))
  print("***Random Forest***")
  print("Confusion_Matrix")
  print(confusion_matrix(y_test,yPred_rf))
  print("Classification Report")
  print(classification_report(y_test,yPred_rf))
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
t accuracy respectively
y_test)
```

```
ackages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

Saving...

```
#importing and building the KNN model
def KNN(x_train,x_test,y_train,y_test):
  knn = KNeighborsClassifier()
  knn.fit(x_train,y_train)
  y_knn_tr = knn.predict(x_train)
  print(accuracy_score (y_knn_tr,y_train))
  yPred_knn = knn.predict(x_test)
  print(accuracy_score(yPred_knn,y_test))
  print("***KNN***")
  print("Confusion_Matrix")
  print(confusion_matrix(y_test,yPred_knn)
  print("Classification Report")
  print(classification_report(y_test,yPred_knn))
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#printing the train accuracy and test accuracy respectively
KNN(x_train,x_test,y_train,y_test)
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#importing and building the random forest model
def svm(x_tarin, x_test,y_train,y_test):
  svm = SVC (kernel = "linear")
  svm.fit(x_train,y_train)
  y_svm_tr = svm.predict(x_train)
  print(accuracy_score (y_svm_tr,y_train))
  yPred_svm = svm.predict(x_test)
  print(accuracy_score (yPred_svm,y_test))
  print("***Support Vector Machine***")
  print("Confusion_Matrix")
  print(confusion_matrix(y_test,yPred_svm))
  print("Classification Report")
  print(classification_report(y_test,yPred_svm))
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#printing the train accuracy and test accuracy respectively
svm(x_train,x_test,y_train,y_test)
```

```
/usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
# Importing the Keras libraries and packages
import keras
from keras.models import Sequential
from keras.layers import Dense
```

```
    func(x,y, y=y, **kwargs)
```

```
] # Initialising the ANN
classifier Sequential()
```

```
    func(x,y, y=y, **kwargs)
```

```
] # Adding the input layer and the first hidden layer
classifier.add(Dense (units=30, activation='relu', input_dim=40))
```

```
       func(x=x, y=y, **kwargs)
```

```
# Adding the second hidden layer
classifier.add(Dense (units=30, activation='relu'))
```

```
       func(x=x, y=y, **kwargs)
```

```
# Adding the output layer
classifier.add(Dense (units=1, activation='sigmoid'))
```

```
       func(x=x, y=y, **kwargs)
```

```
# Compiling the ANN
classifier.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

```
       func(x=x, y=y, **kwargs)
```

```
#fitting the ANN to the training set
model_history=classifier.fit(x_train,y_train,batch_size=10,validation_split=0.33,epochs=200)
```

```
       func(x=x, y=y, **kwargs)
```

```
ann_pred = classifier.predict(x_test)
ann_pred = (ann_pred>0.5)
ann_pred
```

```
     /usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
print(accuracy_score (ann_pred,y_test))
print("***ANN Model***")
print("Confusion_Matrix")
print(confusion_matrix(y_test, ann_pred))
print("Classification Report")
print(classification_report(y_test, ann_pred))
```

Saving...

```
#testing on randam input values
lr = LogisticRegression(random_state=0)
lr.fit(x_train,y_train)
print("Predicting on random input")
lr_pred_own = lr.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print("output is: ",lr_pred_own)
```

```
       func(x=x, y=y, **kwargs)
```

```
#testing on random input values
dtc = DecisionTreeclassifier (criterion="entropy", random_state=0)
dtc.fit(x_train,y_train)
print("Predicting on random input")
dtc_pred_own = dtc.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print("output is: ",dtc_pred_own)
```

```
       func(x=x, y=y, **kwargs)
```

```
#testing on random input values
rf = RandomForestClassifier (criterion="entropy",n_estimators=10, random_state=0)
rf.fit(x_train,y_train)
print("Predicting on random input")
rf_pred_own = rf.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print("output is: ",rf_pred_own)
```

```
     /usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#testing on random input values
Svc = SVC (kernel = "linear")
svc.fit(x_train,y_train)
print("Predicting on random input")
svm_pred_own = svc.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print("output is: ", svm_pred_own)
```

```
     /usr/local/lib/python3.9/dist-packages/seaborn/axisgrid.py:1609: UserWarning: Ignoring `palette` because no `hue` variable has been assi
```

```
#testing on random input values
knn = KNeighborsClassifier()
knn.fit(x_train,y_train)
print("Predicting on random input")
knn_pred_own = knn.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print("output is: ",knn_pred_own)
```

```
#testing on random input values
print("Predicting on random input")
ann_pred_own = classifier.predict(sc.transform([[0,0,1,1,0,0,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,0,0,1,1,0,0,456,1,0,3245,4567]]))
print (ann_pred_own)
ann_pred_own = (ann_pred_own>0.5)
print("output is: ", ann_pred_own)
```

```
       func(x=x, y=y, **kwargs)
```