```
from pyspark.sql import SparkSession
spark =
SparkSession.builder.appName('CheckPyspark').master("local").getOrCrea
te()
#spark
sdf = spark.read.csv("Churn_modelling.csv", header=True,
inferSchema=True)
#pd.DataFrame(df.take(5), columns=df.columns).transpose()
sdf.show(1)
```

```
+---------+----------+--------+-----------+---------+------+---+------
+-------+-------------+---------+--------------+---------------+------
+
|RowNumber|CustomerId| Surname|CreditScore|Geography|Gender|Age|
Tenure|Balance|NumOfProducts|HasCrCard|IsActiveMember|EstimatedSalary|
Exited|
+---------+----------+--------+-----------+---------+------+---+------
+-------+-------------+---------+--------------+---------------+------
+
|        1|  15634602|Hargrave|        619|   France|Female| 42|
2|    0.0|            1|        1|              1|      101348.88|
1|
+---------+----------+--------+-----------+---------+------+---+------
+-------+-------------+---------+--------------+---------------+------
+
only showing top 1 row
```

Use Spark SQL to filter data

```
sdf.createOrReplaceTempView("sales")
output =  spark.sql("SELECT Geography,CreditScore,CustomerId,Age from
sales where   CreditScore<600 ")
output.show()
```

```
+---------+-----------+----------+---+
|Geography|CreditScore|CustomerId|Age|
+---------+-----------+----------+---+
|   France|        502|  15619304| 42|
|  Germany|        376|  15656148| 29|
|   France|        501|  15792365| 44|
|   France|        528|  15767821| 31|
|    Spain|        497|  15737173| 24|
|   France|        476|  15632264| 34|
|   France|        549|  15691483| 25|
|    Spain|        549|  15788218| 24|
|    Spain|        587|  15661507| 45|
|    Spain|        510|  15699309| 38|
|   France|        577|  15738191| 25|
|   France|        571|  15700772| 44|
```

```
|  Germany|        574|  15728693| 43|
|   France|        411|  15656300| 29|
|    Spain|        591|  15589475| 39|
|   France|        533|  15706552| 36|
|  Germany|        553|  15750181| 41|
|    Spain|        520|  15659428| 42|
|   France|        475|  15794171| 45|
|    Spain|        490|  15788448| 31|
+---------+-----------+----------+---+
only showing top 20 rows
```

```
output =  spark.sql("SELECT Geography,CreditScore from sales where
CreditScore<600 group by 1,2")
output.show()
```

```
+---------+-----------+
|Geography|CreditScore|
+---------+-----------+
|   France|        567|
|   France|        410|
|  Germany|        578|
|  Germany|        425|
|  Germany|        471|
|  Germany|        455|
|  Germany|        520|
|    Spain|        489|
|   France|        373|
|    Spain|        597|
|    Spain|        595|
|    Spain|        596|
|   France|        447|
|  Germany|        436|
|   France|        515|
|   France|        461|
|  Germany|        548|
|    Spain|        559|
|  Germany|        598|
|  Germany|        565|
+---------+-----------+
only showing top 20 rows
```

```
bh1 = sdf.groupBy('Geography').count()
print(bh1.show())
```

```
+---------+-----+
|Geography|count|
+---------+-----+
|  Germany| 2509|
|   France| 5014|
```

```
|    Spain| 2477|
+---------+-----+

None
```

```
sdf.select("Geography", "CreditScore").filter("CreditScore =
619").show(1)
#or
# sdf.select(sdf.Geography, sdf.CreditScore).filter("CreditScore =
619").show()
```

```
+---------+-----------+
|Geography|CreditScore|
+---------+-----------+
|   France|        619|
+---------+-----------+
only showing top 1 row


sdf.select("Geography", "CreditScore").filter("CreditScore like
'%4%'").show(5)

+---------+-----------+
|Geography|CreditScore|
+---------+-----------+
|    Spain|        645|
|   France|        684|
|    Spain|        497|
|   France|        476|
|   France|        549|
+---------+-----------+
only showing top 5 rows


#IT WILL SHOW ALL COLUMN
sdf.filter((sdf.Geography.like('%F%')) &
(sdf.CreditScore=='619')).show(3)

+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
|RowNumber|CustomerId|  Surname|CreditScore|Geography|Gender|Age|
Tenure|  Balance|NumOfProducts|HasCrCard|IsActiveMember|
EstimatedSalary|Exited|
+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
|        1|  15634602| Hargrave|        619|   France|Female| 42|
2|      0.0|            1|        1|             1|      101348.88|
1|
|       56|  15760861|Phillipps|        619|   France|  Male| 43|
```

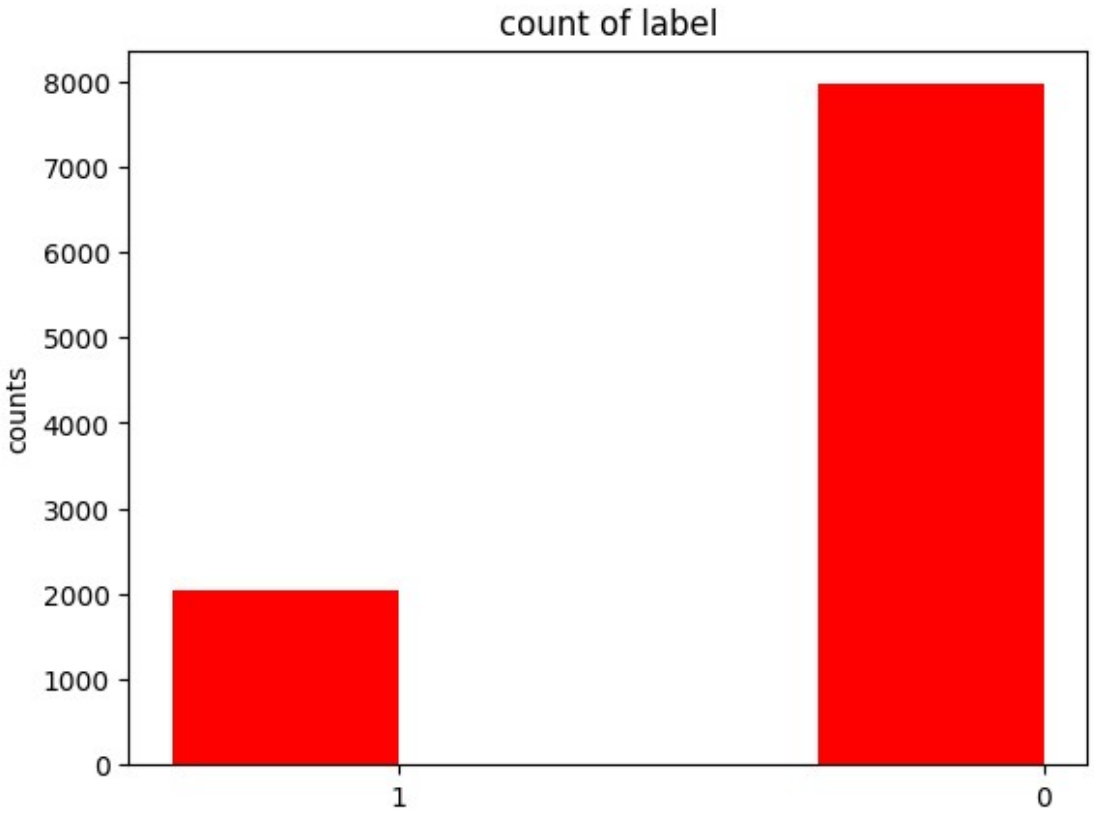
```
1|125211.92|            1|        1|             1|      113410.49|
0|
|      936|  15675316|  Avdeeva|        619|   France|Female| 38|
3|      0.0|            2|        0|             1|      116467.35|
0|
+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
only showing top 3 rows
```

```
from pyspark.sql.functions import *
count_df = sdf.groupBy('Exited').count()  # to check balance vs
unbalanced dataset
count_df.show()
```

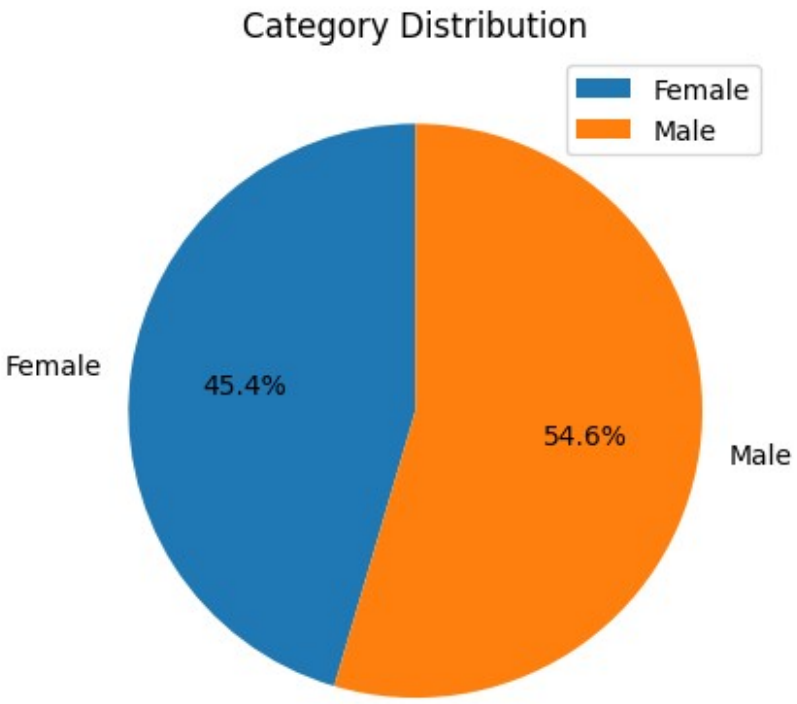
```
+------+-----+
|Exited|count|
+------+-----+
|     1| 2037|
|     0| 7963|
+------+-----+
```

```
import numpy as np
import matplotlib.pyplot as plt
#pip install matplotlib

label_count = sdf.groupBy('Exited').count().collect()
categories = [i[0] for i in label_count]
counts = [i[1] for i in label_count]

ind = np.array(range(len(categories)))
width = 0.35
plt.bar(ind, counts, width=width, color='r')

plt.ylabel('counts')
plt.title('count of label')
plt.xticks(ind + width/2., categories)

# label_counts = sdf.groupBy("Exited").count().orderBy("count",
ascending=False).collect()
# category_names = [row[0] for row in label_counts]
# category_values = [row[1] for row in label_counts]
# plt.bar(category_names, category_values)
# plt.xlabel("Exited")
# plt.ylabel("Count")
# plt.title("label Counts")
# plt.show()
```

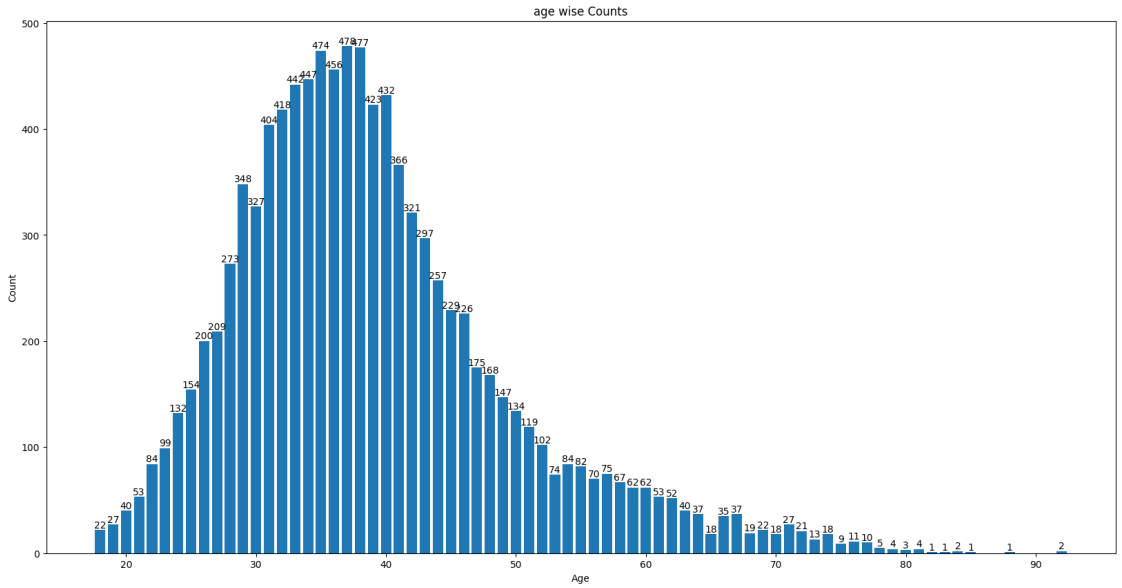
```
([<matplotlib.axis.XTick at 0x1eec0dcbfa0>,
  <matplotlib.axis.XTick at 0x1eec0dcbf70>],
 [Text(0.175, 0, '1'), Text(1.175, 0, '0')])
```




```
gender_count = sdf.groupBy("Gender").count().collect()
labels = [str(row[0]) for row in gender_count]     # Convert
category_counts to two separate lists for labels and values
values = [int(row[1]) for row in gender_count]
plt.pie(values, labels=labels, autopct='%1.1f%%', startangle=90)
plt.title("Category Distribution")
plt.legend()
plt.show()
```




```
age_counts = sdf.groupBy("Age").count().orderBy("count",
ascending=False).collect()
category_names = [row[0] for row in age_counts]
category_values = [row[1] for row in age_counts]
fig, ax = plt.subplots(figsize=(20, 10))           # to change width n
height of graph
bar=plt.bar(category_names, category_values)
ax.set_xlabel("Age")
ax.set_ylabel("Count")
ax.set_title("age wise Counts")
for b in bar:
    height = b.get_height()
    ax.text(b.get_x() + b.get_width() / 2, height, str(int(height)),
ha="center", va="bottom")
plt.show()
```




```
#sdf.na.drop(how="any").show(truncate=False)
sdf.dropna().show(truncate=False)
```

```
+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
|RowNumber|CustomerId|Surname  |CreditScore|Geography|Gender|Age|
Tenure|Balance  |NumOfProducts|HasCrCard|IsActiveMember|
EstimatedSalary|Exited|
+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
|1        |15634602  |Hargrave |619        |France   |Female|42 |2
|0.0      |1            |1        |1             |101348.88      |1
|
|2        |15647311  |Hill     |608        |Spain    |Female|41 |1
|83807.86 |1            |0        |1             |112542.58      |0
|
|3        |15619304  |Onio     |502        |France   |Female|42 |8
|159660.8 |3            |1        |0             |113931.57      |1
|
|4        |15701354  |Boni     |699        |France   |Female|39 |1
|0.0      |2            |0        |0             |93826.63       |0
|
|5        |15737888  |Mitchell |850        |Spain    |Female|43 |2
|125510.82|1            |1        |1             |79084.1        |0
|
|6        |15574012  |Chu      |645        |Spain    |Male  |44 |8
|113755.78|2            |1        |0             |149756.71      |1
|
|7        |15592531  |Bartlett |822        |France   |Male  |50 |7
|0.0      |2            |1        |1             |10062.8        |0
```

```
|
|8         |15656148  |Obinna   |376         |Germany  |Female|29 |4
|115046.74|4            |1        |0             |119346.88      |1
|
|9         |15792365  |He       |501         |France   |Male  |44 |4
|142051.07|2            |0        |1             |74940.5        |0
|
|10        |15592389  |H?       |684         |France   |Male  |27 |2
|134603.88|1            |1        |1             |71725.73       |0
|
|11        |15767821  |Bearce   |528         |France   |Male  |31 |6
|102016.72|2            |0        |0             |80181.12       |0
|
|12        |15737173  |Andrews  |497         |Spain    |Male  |24 |3
|0.0       |2            |1        |0             |76390.01       |0
|
|13        |15632264  |Kay      |476         |France   |Female|34 |10
|0.0       |2            |1        |0             |26260.98       |0
|
|14        |15691483  |Chin     |549         |France   |Female|25 |5
|0.0       |2            |0        |0             |190857.79      |0
|
|15        |15600882  |Scott    |635         |Spain    |Female|35 |7
|0.0       |2            |1        |1             |65951.65       |0
|
|16        |15643966  |Goforth  |616         |Germany  |Male  |45 |3
|143129.41|2            |0        |1             |64327.26       |0
|
|17        |15737452  |Romeo    |653         |Germany  |Male  |58 |1
|132602.88|1            |1        |0             |5097.67        |1
|
|18        |15788218  |Henderson|549         |Spain    |Female|24 |9
|0.0       |2            |1        |1             |14406.41       |0
|
|19        |15661507  |Muldrow  |587         |Spain    |Male  |45 |6
|0.0       |1            |0        |0             |158684.81      |0
|
|20        |15568982  |Hao      |726         |France   |Female|24 |6
|0.0       |2            |1        |1             |54724.03       |0
|
+---------+----------+---------+-----------+---------+------+---
+------+---------+-------------+---------+--------------
+---------------+------+
only showing top 20 rows
```

```
#from pyspark.sql.functions import col, when, count
#sdf.select([count(when(col(c).isNotNull() , c)).alias(c) for c in
sdf.columns]).show()
```

```
sdf.printSchema()
```

```
root
 |-- RowNumber: integer (nullable = true)
 |-- CustomerId: integer (nullable = true)
 |-- Surname: string (nullable = true)
 |-- CreditScore: integer (nullable = true)
 |-- Geography: string (nullable = true)
 |-- Gender: string (nullable = true)
 |-- Age: integer (nullable = true)
 |-- Tenure: integer (nullable = true)
 |-- Balance: double (nullable = true)
 |-- NumOfProducts: integer (nullable = true)
 |-- HasCrCard: integer (nullable = true)
 |-- IsActiveMember: integer (nullable = true)
 |-- EstimatedSalary: double (nullable = true)
 |-- Exited: integer (nullable = true)
```

convert categorical data into vector

```
from pyspark.ml.feature import StringIndexer

categoricalColumns = ["Geography"]
l = []

for categoricalCol in categoricalColumns:
    stringIndexer = StringIndexer(inputCol = categoricalCol, outputCol
= categoricalCol+"_encoded").fit(sdf)

sdf = stringIndexer.transform(sdf)

sdf = sdf.withColumn(categoricalCol+"_encoded",
sdf[categoricalCol+"_encoded"].cast('int')) #StringIndexer returns the
data in float format, so in the next step, we have Performed casting
and converted float values into Numerical.


encoded_df =
sdf.select('CreditScore',"Geography_encoded",'CreditScore','Age','Tenu
re','Balance','NumOfProducts','HasCrCard','IsActiveMember','EstimatedS
alary','Exited')
encoded_df.show()
```

```
+-----------+-----------------+-----------+---+------+---------
+-------------+---------+--------------+---------------+------+
|CreditScore|Geography_encoded|CreditScore|Age|Tenure|  Balance|
NumOfProducts|HasCrCard|IsActiveMember|EstimatedSalary|Exited|
+-----------+-----------------+-----------+---+------+---------
+-------------+---------+--------------+---------------+------+
```

```
|        619|                  0|         619| 42|     2|      0.0|
1|         1|              1|       101348.88|     1|
|        608|                  2|         608| 41|     1| 83807.86|
1|         0|              1|       112542.58|     0|
|        502|                  0|         502| 42|     8| 159660.8|
3|         1|              0|       113931.57|     1|
|        699|                  0|         699| 39|     1|      0.0|
2|         0|              0|        93826.63|     0|
|        850|                  2|         850| 43|     2|125510.82|
1|         1|              1|         79084.1|     0|
|        645|                  2|         645| 44|     8|113755.78|
2|         1|              0|       149756.71|     1|
|        822|                  0|         822| 50|     7|      0.0|
2|         1|              1|         10062.8|     0|
|        376|                  1|         376| 29|     4|115046.74|
4|         1|              0|       119346.88|     1|
|        501|                  0|         501| 44|     4|142051.07|
2|         0|              1|         74940.5|     0|
|        684|                  0|         684| 27|     2|134603.88|
1|         1|              1|        71725.73|     0|
|        528|                  0|         528| 31|     6|102016.72|
2|         0|              0|        80181.12|     0|
|        497|                  2|         497| 24|     3|      0.0|
2|         1|              0|        76390.01|     0|
|        476|                  0|         476| 34|    10|      0.0|
2|         1|              0|        26260.98|     0|
|        549|                  0|         549| 25|     5|      0.0|
2|         0|              0|       190857.79|     0|
|        635|                  2|         635| 35|     7|      0.0|
2|         1|              1|        65951.65|     0|
|        616|                  1|         616| 45|     3|143129.41|
2|         0|              1|        64327.26|     0|
|        653|                  1|         653| 58|     1|132602.88|
1|         1|              0|         5097.67|     1|
|        549|                  2|         549| 24|     9|      0.0|
2|         1|              1|        14406.41|     0|
|        587|                  2|         587| 45|     6|      0.0|
1|         0|              0|       158684.81|     0|
|        726|                  0|         726| 24|     6|      0.0|
2|         1|              1|        54724.03|     0|
+-----------+-----------------+-----------+---+------+---------
+-------------+---------+--------------+---------------+------+
only showing top 20 rows
```

feature extraction using VectorAssembler

convert all the independent columns into one feature using VectorAssembler. The feature created is used for training.

```
from pyspark.ml.feature import
VectorAssembler,Normalizer,StandardScaler

bholuAssembler =
VectorAssembler(inputCols=['CreditScore',"Geography_encoded",'CreditSc
ore','Age','Tenure','Balance','NumOfProducts','HasCrCard','IsActiveMem
ber','EstimatedSalary'],outputCol="features")
bholu = bholuAssembler.transform(encoded_df)
bholu.select("features","Exited").show(5)
```

```
+--------------------+------+
|            features|Exited|
+--------------------+------+
|[619.0,0.0,619.0,...|     1|
|[608.0,2.0,608.0,...|     0|
|[502.0,0.0,502.0,...|     1|
|[699.0,0.0,699.0,...|     0|
|[850.0,2.0,850.0,...|     0|
+--------------------+------+
only showing top 5 rows
```

```
#scaler = StandardScaler(inputCol="features",
outputCol="normalized_features", withStd=True, withMean=True)
#scalerModel = scaler.fit(sdf)
#scaledData = scalerModel.transform(sdf)

normalizer = Normalizer(inputCol="features",
outputCol="normalized_features", p=2.0)
df_normalized = normalizer.transform(bholu)
df_normalized.select("normalized_features").show(5)
```

```
+--------------------+
| normalized_features|
+--------------------+
|[0.00610738724885...|
|[0.00433288411597...|
|[0.00255934379577...|
|[0.00744949645256...|
|[0.00572956505309...|
+--------------------+
only showing top 5 rows
```

split the data for training and testing.

```
train, test = df_normalized.randomSplit([0.9, 0.1], seed=1700)

print('size of training data',train.count())
print('size of testing data',test.count())
```

```
size of training data 9025
size of testing data 975
```

```
from pyspark.ml.classification import LogisticRegression

lr = LogisticRegression(featuresCol = 'normalized_features', labelCol
= 'Exited', maxIter=10)
lrModel = lr.fit(train)

predictions23 = lrModel.transform(test)        #predict the test data
predictions_train=lrModel.transform(train)   ##predict the train data
#predictions.show(truncate=2)                  #print prediction of
test data
#predictions_train.show(truncate=2)
predictions23.select('CreditScore',"Geography_encoded",'CreditScore','
Age','Tenure','Balance','NumOfProducts','HasCrCard','IsActiveMember','
EstimatedSalary','Exited','features','rawPrediction','probability','pr
ediction').toPandas().head(1)
```

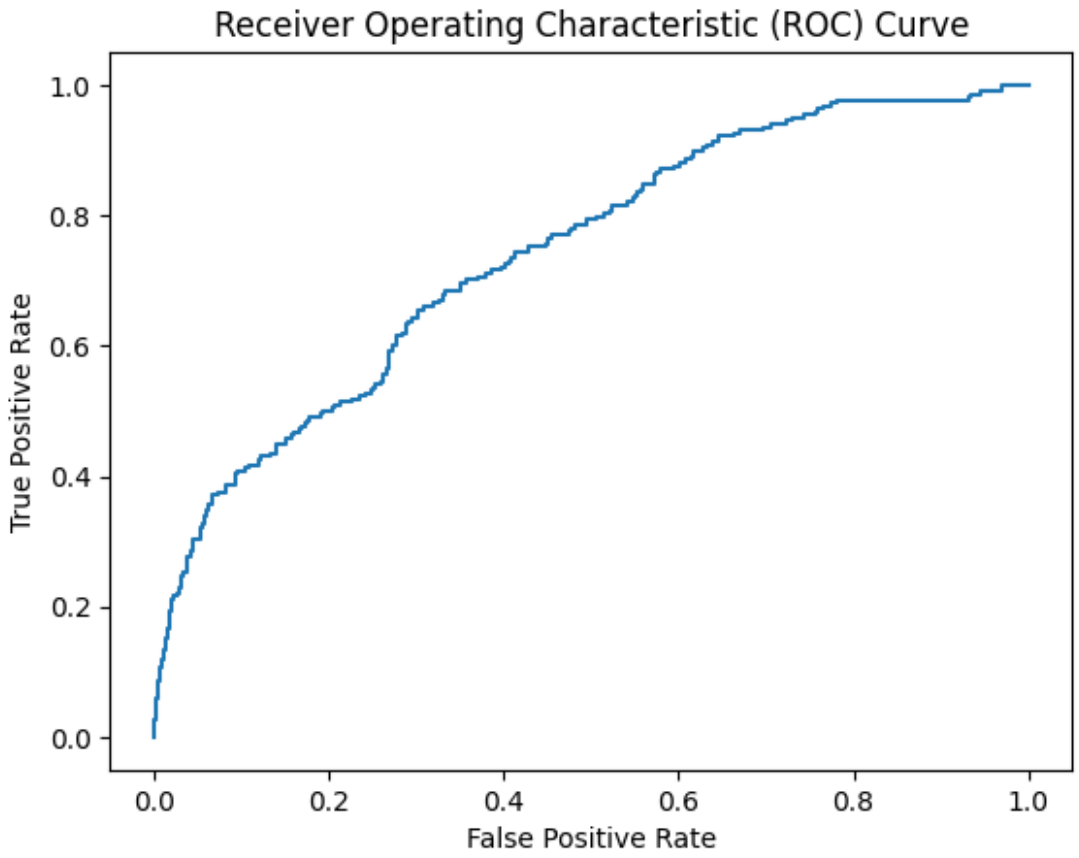
```
   CreditScore  Geography_encoded  CreditScore  Age  Tenure    Balance
\
0          363                  2          363   28       6  146098.43


   NumOfProducts  HasCrCard  IsActiveMember  EstimatedSalary
Exited  \
0              3          1               0        100615.14       1


                                             features  \
0  [363.0, 2.0, 363.0, 28.0, 6.0, 146098.43, 3.0,...

                                rawPrediction  \
0  [1.1898468834838123, -1.1898468834838123]

                                  probability  prediction
0  [0.7667136783429497, 0.23328632165705032]         0.0
```

```
from pyspark.ml.evaluation import BinaryClassificationEvaluator   #
from pyspark.ml.evaluation import MulticlassClassificationEvaluator

evaluator40 = BinaryClassificationEvaluator(labelCol="Exited",
rawPredictionCol="prediction",metricName='areaUnderROC')
```

```
auc = evaluator40.evaluate(predictions23)
print('AUC:', auc)
```

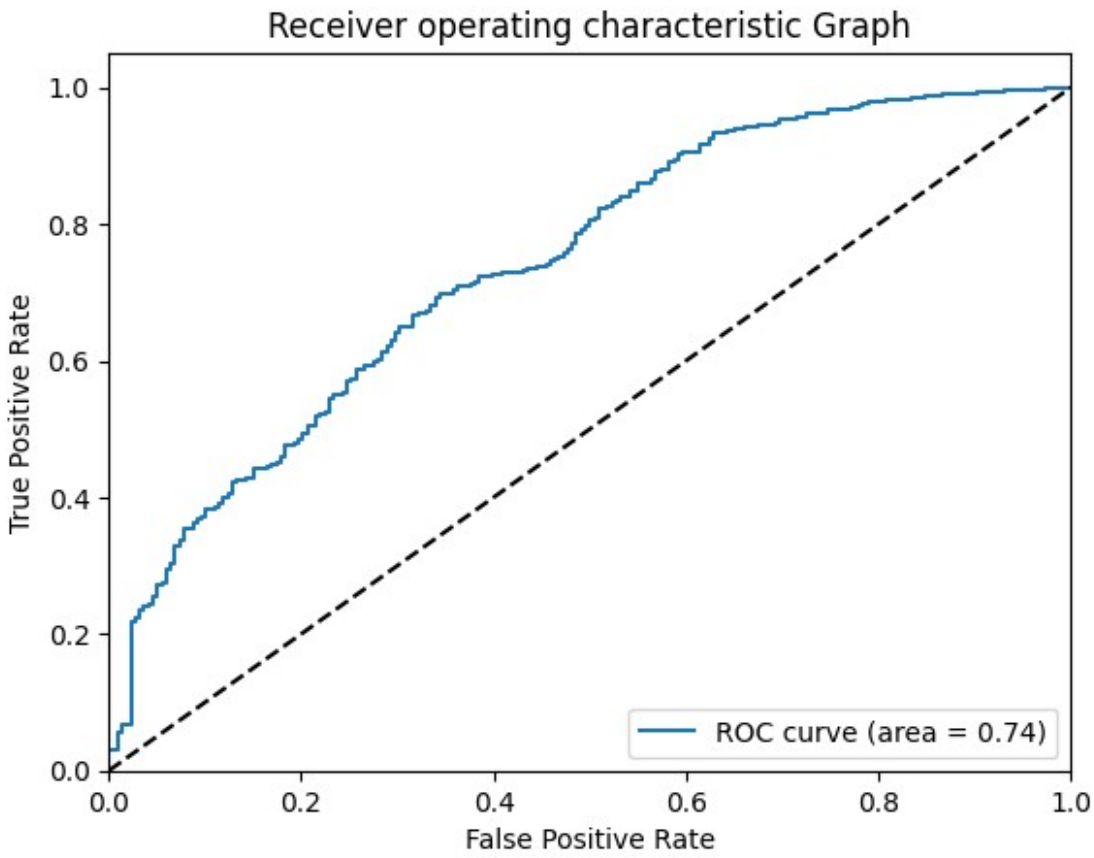
```
AUC: 0.5062202319634481
```

```
from sklearn.metrics import roc_curve
import matplotlib.pyplot as plt
import pandas as pd

preds = predictions23.select('Exited', 'probability').toPandas() #
convert PySpark DataFrame to Pandas DataFrame
fpr, tpr, thresholds = roc_curve(preds['Exited'],
preds['probability'].apply(lambda x: x[1]))# compute false positive
rate, true positive rate, and thresholds
plt.plot(fpr, tpr)
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```




```
from sklearn.metrics import roc_curve, auc
from pyspark.mllib.evaluation import BinaryClassificationMetrics as
metric
```

```
results = predictions23.select(['probability', 'Exited'])
results_collect = results.collect()
results_list = [(float(i[0][0]), 1.0-float(i[1])) for i in
results_collect]

fpr = dict()
tpr = dict()
roc_auc = dict()

y_test = [i[1] for i in results_list]
y_score = [i[0] for i in results_list]

fpr, tpr, _ = roc_curve(y_test, y_score)
roc_auc = auc(fpr, tpr)

%matplotlib inline
plt.figure()
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], 'k--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic Graph')
plt.legend(loc="lower right")
plt.show()
```




```
evaluator12 =
MulticlassClassificationEvaluator(predictionCol="prediction",
labelCol="Exited", metricName="f1")
f1_score = evaluator12.evaluate(predictions23)  #because data is
highly un-balanced
print("F1 score: %.4f" % f1_score)
```

```
F1 score: 0.6854
```

```
accuracy = predictions23.filter(predictions23.Exited ==
predictions23.prediction).count() / float(predictions23.count())
print("Accuracy : ",accuracy)
```

```
Accuracy :  0.7784615384615384
```

check which algo is best on our dataset

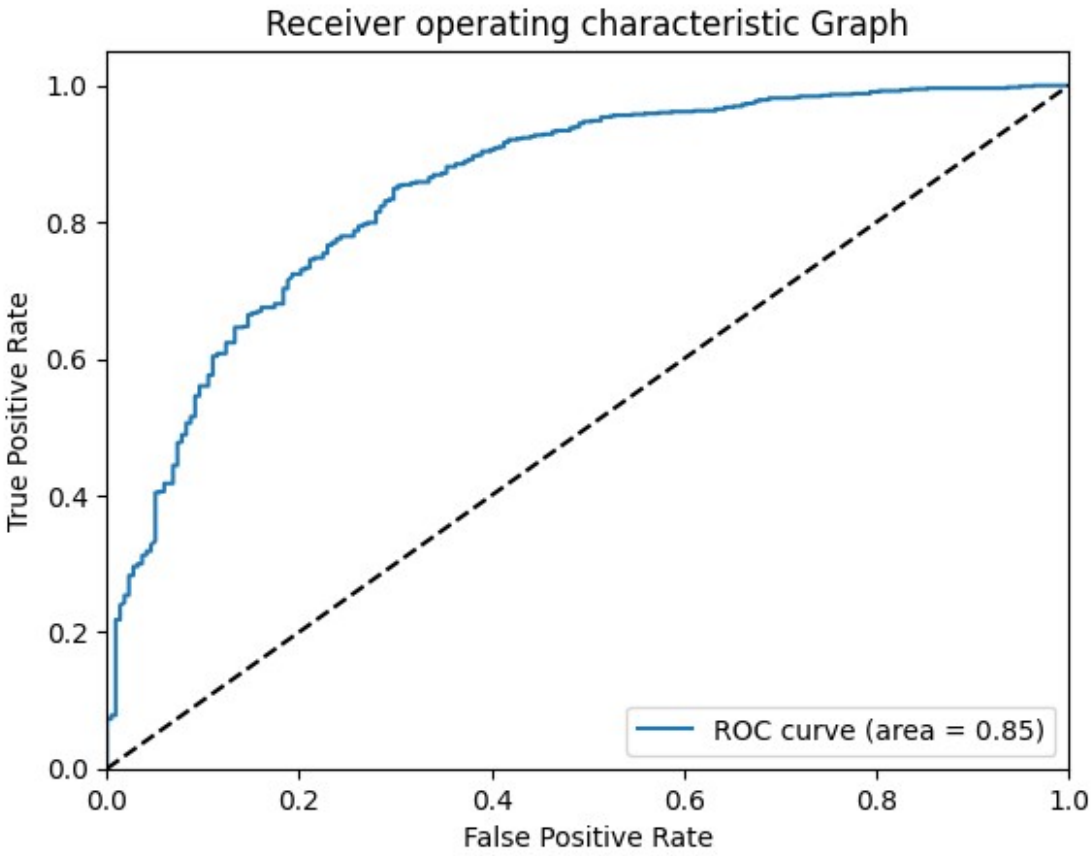
```
from pyspark.ml.classification import LogisticRegression,
DecisionTreeClassifier, RandomForestClassifier, GBTClassifier,
NaiveBayes
#from pyspark.ml.classification import
AdaBoostClassifier,XGBoostClassifier,XGBRFClassifier
```

```
models={'Logistic_regression': LogisticRegression(),
       'Tree': DecisionTreeClassifier(),
       'Random_forest': RandomForestClassifier(),
        'GBT': GBTClassifier(),
        'NB': NaiveBayes() }


model1 = LogisticRegression(featuresCol = 'normalized_features',
labelCol = 'Exited', maxIter=10).fit(train)
model2=DecisionTreeClassifier(featuresCol = 'normalized_features',
labelCol = 'Exited').fit(train)
model3=RandomForestClassifier(featuresCol = 'normalized_features',
labelCol = 'Exited').fit(train)
model4=GBTClassifier(featuresCol = 'normalized_features', labelCol =
'Exited').fit(train)
model5=NaiveBayes(featuresCol = 'normalized_features', labelCol =
'Exited').fit(train)

predictions1 = model1.transform(test)              # Make predictions
on test set
predictions2 = model2.transform(test)
predictions3 = model3.transform(test)
predictions4 = model4.transform(test)
predictions5 = model5.transform(test)
#predictions1.show(truncate=2)

predictions1_train = model1.transform(train)        # Make predictions
on train set
predictions2_train = model2.transform(train)
predictions3_train = model3.transform(train)
predictions4_train = model4.transform(train)
predictions5_train = model5.transform(train)
#predictions1_train.show(truncate=2)

#evaluator1 = BinaryClassificationEvaluator(labelCol="Exited",
rawPredictionCol="predictions")    #for ROC
#print( 'test area under ROC',evaluator1.evaluate(predictions1))

accuracy1 = predictions1.filter(predictions1.Exited ==
predictions1.prediction).count() / float(predictions1.count())
accuracy2 = predictions2.filter(predictions2.Exited ==
predictions2.prediction).count() / float(predictions2.count())
accuracy3 = predictions3.filter(predictions3.Exited ==
predictions3.prediction).count() / float(predictions3.count())
accuracy4 = predictions4.filter(predictions4.Exited ==
predictions4.prediction).count() / float(predictions4.count())
accuracy5 = predictions5.filter(predictions5.Exited ==
```

```
predictions5.prediction).count() / float(predictions5.count())
print("Accuracy of LogisticRegression : ",accuracy1)
print("Accuracy of DecisionTreeClassifier: ",accuracy2)
print("Accuracy of RandomForestClassifier: ",accuracy3)
print("Accuracy of GBTClassifier: ",accuracy4)
print("Accuracy of NaiveBayes: ",accuracy5)
```

```
Accuracy of LogisticRegression :  0.7784615384615384
Accuracy of DecisionTreeClassifier:  0.8174358974358974
Accuracy of RandomForestClassifier:  0.7979487179487179
Accuracy of GBTClassifier:  0.8338461538461538
Accuracy of NaiveBayes:  0.7764102564102564
```

```
results = predictions4.select(['probability', 'Exited'])
results_collect = results.collect()
results_list = [(float(i[0][0]), 1.0-float(i[1])) for i in
results_collect]

fpr = dict()
tpr = dict()
roc_auc = dict()

y_test = [i[1] for i in results_list]
y_score = [i[0] for i in results_list]

fpr, tpr, _ = roc_curve(y_test, y_score)
roc_auc = auc(fpr, tpr)

%matplotlib inline
plt.figure()
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], 'k--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic Graph')
plt.legend(loc="lower right")
plt.show()
```


Receiver operating characteristic Graph
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.85)