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# PREDICT LOAN APPLICATION STATUS

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# Acknowledgement

I take this opportunity to express my profound gratitude and deep regards to my faculty (**Mr. Anubhav Chaturvedi**) for his exemplary guidance, monitoring and constant encouragement throughout the course of this project. The blessing, help and guidance given by him/her time to time shall carry me a long way in the journey of life on which I am about to embark.

I am obliged to my project team members for the valuable information provided by them in their respective fields. I am grateful for their cooperation during the period of my assignment.

*Sayan Dey*

*Surya Ruidas*

*Kuntal Das*

*Shreya Das*

# Project Objective

- **PROBLEM STATEMENT:** Multiclass classification problem for predicting loan application status from a rich dataset. The problem can be reduced to a binary classification problem to build a loan approval pre-check system for potential customers.
- **OBJECTIVE:** The prime objective in banking environment is to invest their assets in safe hands where it is. Today many banks/financial companies approves loan after a regres process of verification and validation but still there is no surety whether the chosen applicant is the deserving right applicant out of all applicants. Through this system we can predict whether that particular applicant is safe or not and the whole process of validation of features is automated by machine learning technique. The disadvantage of this model is that it emphasize different weights to each factor but in real life sometime loan can be approved on the basis of single strong factor only, which is not possible through this system. Loan Prediction is very helpful for employee of banks as well as for the applicant also.

The aim of this Paper is to provide quick, immediate and easy way to choose the deserving applicants. It can provide special advantages to the bank. The Loan Prediction System can automatically calculate the weight of each features taking part in loan processing and on new test data same features are processed with respect to their associated weight .A time limit can be set for the applicant to check whether his/her loan can be sanctioned or not.

# Project Scope

- Loan Prediction is very helpful for employee of banks as well as for the applicant also.
- The aim of this Paper is to provide quick, immediate and easy way to choose the deserving applicants.
- It can provide special advantages to the bank. The Loan Prediction System can automatically calculate the weight of each features taking part in loan processing and on new test data same features are processed with respect to their associated weight .
- Loan Prediction System allows jumping to specific application so that it can be checked on priority basis. This Paper is exclusively for the managing authority of Bank/finance company.

# Data description

- ✓ **Source of data:** The data is available on Kaggle Datasets. In addition to the loan dataset, Kaggle provides a data dictionary explaining the column headers in much more detail allowing much better understanding of the problem at hand.

## Each feature/column description

- **Dependent variable:** 'Loan\_Status' (categorical)
- **Independent variables:** 'Gender'(categorical), 'Married'(categorical), 'ApplicantIncome'(continuous), 'CoapplicantIncome'(continuous), 'LoanAmount'(continuous), 'Loan\_Amount\_Term'(continuous), 'Credit\_History'(categorical), 'Property\_Area'(categorical)
- **Null Percentage:** 2.08

## 5 number statistics:

The **five-number summary** is a set of descriptive statistics that provide information about a dataset. It consists of the five most important sample **percentiles**:

- \* the sample minimum (smallest observation)
- \* the lower quartile or *first quartile*
- \* the median (the middle value)
- \* the upper quartile or *third quartile*
- \* the sample maximum (largest observation)

[?]

# Model Building



Short description of each model used:

- **Linear Regression:** In statistics, linear regression is a linear approach to modelling the relationship between a scalar response (or dependent variable) and one or more explanatory variables (or independent variables).
- **Logistic Regression:** In statistics, the **logistic model** (or **logit model**) is a statistical model that is usually taken to apply to a binary dependent variable. In regression analysis, **logistic regression** or **logit regression** is estimating the parameters of a logistic model.
- **Decision Trees:** The basic algorithm of decision tree requires all attributes or features should be discretized. Feature selection is based on greatest information gain of features. The knowledge depicted in decision tree can be represented in the form of IF-THEN rules. This model is an extension of classification algorithms described by Quinlan.
- **Random Forest (RF):** Random forests are a group learning system for characterization (and relapse) that work by building a large number of Decision trees at preparation time and yielding the class that is the mode of the classes yield by individual trees.
- ***k*-means clustering:** is a method of vector quantization, originally from signal processing, that is popular for cluster analysis in data mining. *k*-means clustering aims to partition  $n$  observations into  $k$  clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.

- **k- Nearest neighbors:** In pattern recognition, the ***k*-nearest neighbors algorithm (*k*-NN)** is a non-parametric method used for classification and regression. In both cases, the input consists of the *k* closest training examples in the feature space.
- **Support Vector Machines:** In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis.
- **Grid Search:** The traditional way of performing hyperparameter optimization has been *grid search*, or a *parameter sweep*, which is simply an exhaustive searching through a manually specified subset of the hyperparameter space of a learning algorithm.
- **K Folds Cross Validator:** Provides train/test indices to split data in train/test sets. Split dataset into *k* consecutive folds (without shuffling by default). Each fold is then used once as a validation while the *k* - 1 remaining folds form the training set.
- **Principal component analysis (PCA)** is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.

## •> For classification

- **Precision**= $TP/(TP + FP)$
- **Recall**= $TP/(TP+FN)$
- **Accuracy**= $(TP+TN)/(TP+TN+FP+FN)$
- **f1-score**= $2*(Precision*Recall)/(Precision+Recall)$

• **ROC curve**: In statistics, a **receiver operating characteristic curve**, i.e. **ROC curve**, is a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied. The ROC curve is created by plotting the true positive rate (TPR) against the false positive rate (FPR) at various threshold settings.

• **AUC**: When using normalized units, the **area under the curve** (often referred to as simply the AUC) is equal to the probability that a classifier will rank a randomly chosen positive instance higher than a randomly chosen negative one (assuming 'positive' ranks higher than 'negative')

## •> For regression

• **RMSE** : The root-mean-square deviation (RMSD) or root-mean-square error (**RMSE**) (or sometimes root-mean-squared error) is a frequently used measure of the differences between **values** (sample and population **values**) predicted by a model or an estimator and the **values** actually observed.

• **R-squared**: It is a statistical measure that represents the proportion of the variance for a dependent variable that's explained by an independent variable.

## •> Finally accepted model

DECISION TREE : ACCURACY=0.85

# Code

## Reading Data

```
In [1]: import pandas as pd  
data=pd.read_excel('project2_train.xlsm')  
data.head()
```

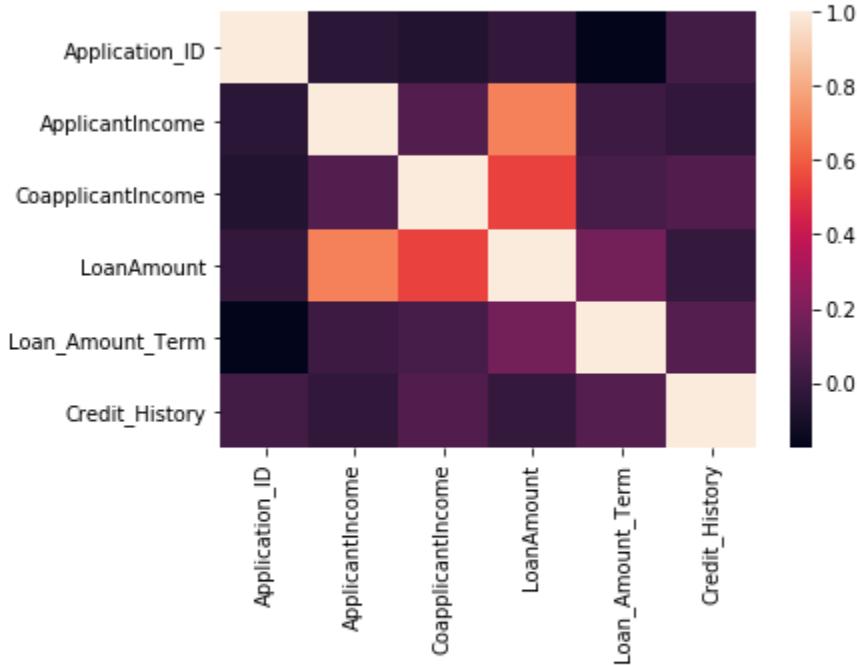
```
Out[1]:
```

	Application_ID	Gender	Married	Dependents	Education	Self_Employed	ApplicantIncome	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_His
0	1002	M	No	0	Graduate	No	5849	0	NaN	360.0	
1	1003	M	Yes	1	Graduate	No	4583	1508	128.0	360.0	
2	1005	M	Yes	0	Graduate	Yes	3000	0	66.0	360.0	
3	1006	M	Yes	0	Not Graduate	No	2583	2358	120.0	360.0	
4	1008	M	No	0	Graduate	No	6000	0	141.0	360.0	

## HEAT MAP

```
In [6]: import seaborn as sns  
sns.heatmap(data.corr())
```

```
Out[6]: <matplotlib.axes._subplots.AxesSubplot at 0x564242a630>
```



```
In [8]: data['Loan_Status'].value_counts()
```

```
Out[8]: Y    64  
N    36  
Name: Loan_Status, dtype: int64
```

## Cleaning data ¶

In [2]:

```
#checking the missing values  
data.isnull().sum()
```

Out[2]:

```
Application_ID      0  
Gender             1  
Married            0  
Dependents         0  
Education          0  
Self_Employed      6  
ApplicantIncome    0  
CoapplicantIncome  0  
LoanAmount         5  
Loan_Amount_Term   5  
Credit_History     8  
Property_Area      0  
Loan_Status         0  
dtype: int64
```

In [3]:

```
data['Loan_Amount_Term'].fillna(value=data['Loan_Amount_Term'].mean(),inplace=True)  
data['LoanAmount'].fillna(value=data['LoanAmount'].mean(),inplace=True)
```

In [4]:

```
#returning the value of 'Credit_History' having highest frequency  
from scipy.stats import mode  
mode(data['Credit_History'])  
mode(data['Credit_History']).mode[0]
```

Out[4]: 1.0

```
In [5]: #Putting the value:  
data['Credit_History'].fillna(mode(data['Credit_History']).mode[0], inplace=True)
```

```
In [6]: def gend(x):  
    if x=='M':  
        return 1  
    elif x=='F':  
        return 0  
data['Gender']=data['Gender'].apply(gend)
```

```
In [7]: #returning the value of 'gender' occurring most frequently  
from scipy.stats import mode  
mode(data['Gender'])  
mode(data['Gender']).mode[0]
```

Out[7]: 1.0

```
In [8]: #Putting the value:  
data['Gender'].fillna(mode(data['Gender']).mode[0], inplace=True)
```

```
In [9]: def emp(x):  
    if x=='Yes':  
        return 1  
    elif x=='No':  
        return 0  
data['Self_Employed']=data['Self_Employed'].apply(emp)
```

```
In [10]: #return the value of 'Self_Employed' occurring most frequently  
mode(data['Self_Employed'])  
mode(data['Self_Employed']).mode[0]
```

```
Out[10]: 0.0
```

```
In [11]: #Putting the value:  
data['Self_Employed'].fillna(mode(data['Self_Employed']).mode[0], inplace=True)
```

```
In [12]: def loan(x):  
    if x=='Y':  
        return 1  
    else:  
        return 0  
data['Loan_Status']=data['Loan_Status'].apply(loan)
```

```
In [13]: def married(t):  
    if t=="Yes":  
        return 1  
    else:  
        return 0  
data['Married']=data['Married'].apply(married)
```

```
In [14]: def area(a):
    if a=='Urban':
        return 0
    elif a=='Semiurban':
        return 1
    else:
        return 2
data[ 'Property_Area']=data[ 'Property_Area'].apply(area)
```

```
In [15]: #checking the missing values once again
data.isnull().sum()
```

```
Out[15]: Application_ID      0
Gender          0
Married         0
Dependents     0
Education       0
Self_Employed   0
ApplicantIncome 0
CoapplicantIncome 0
LoanAmount      0
Loan_Amount_Term 0
Credit_History   0
Property_Area    0
Loan_Status      0
dtype: int64
```

```
In [25]: data.dtypes
```

```
Out[25]: Application_ID      int64
Gender            float64
Married           int64
Dependents        object
Education          object
Self_Employed     float64
ApplicantIncome   int64
CoapplicantIncome int64
LoanAmount        float64
Loan_Amount_Term float64
Credit_History    float64
Property_Area     int64
Loan_Status        int64
dtype: object
```

```
In [16]: data.describe()
```

```
Out[16]:
```

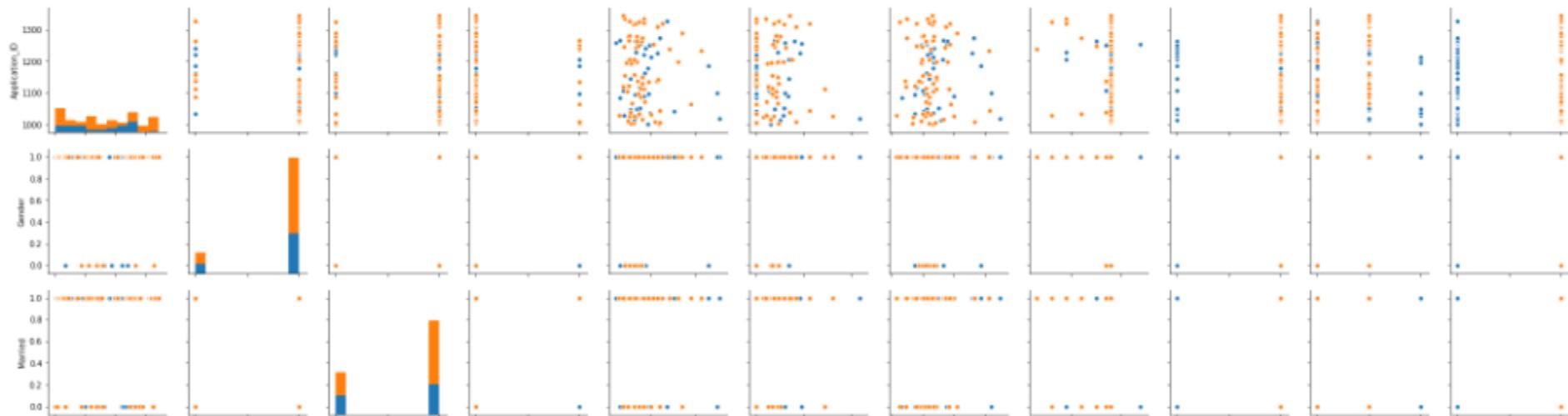
	Application_ID	Gender	Married	Self_Employed	ApplicantIncome	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_History	Property_Area
count	100.000000	100.00000	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000
mean	1160.470000	0.85000	0.690000	0.130000	4122.83000	1700.550000	134.221053	341.684211	0.85000	0.590000
std	104.622212	0.35887	0.464823	0.337998	2258.89434	1947.668891	61.832975	59.741068	0.35887	0.650000
min	1002.000000	0.00000	0.000000	0.000000	1000.00000	0.000000	17.000000	60.000000	0.00000	0.000000
25%	1062.500000	1.00000	0.000000	0.000000	2636.00000	0.000000	100.000000	360.000000	1.00000	0.000000
50%	1153.000000	1.00000	1.000000	0.000000	3598.00000	1558.500000	122.000000	360.000000	1.00000	0.500000
75%	1253.500000	1.00000	1.000000	0.000000	4710.00000	2394.500000	145.750000	360.000000	1.00000	1.000000
max	1343.000000	1.00000	1.000000	1.000000	12841.00000	10968.000000	349.000000	480.000000	1.00000	2.000000

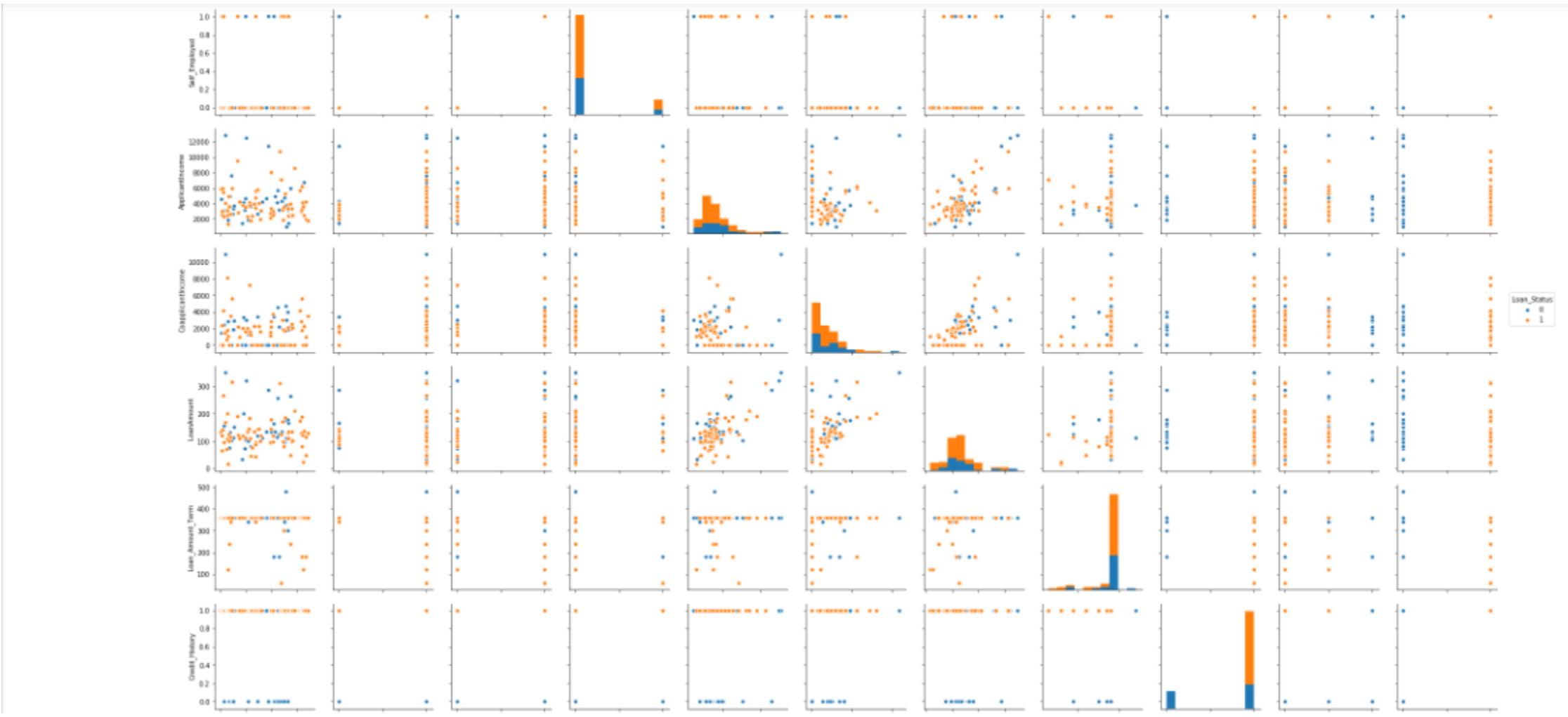
# EDA

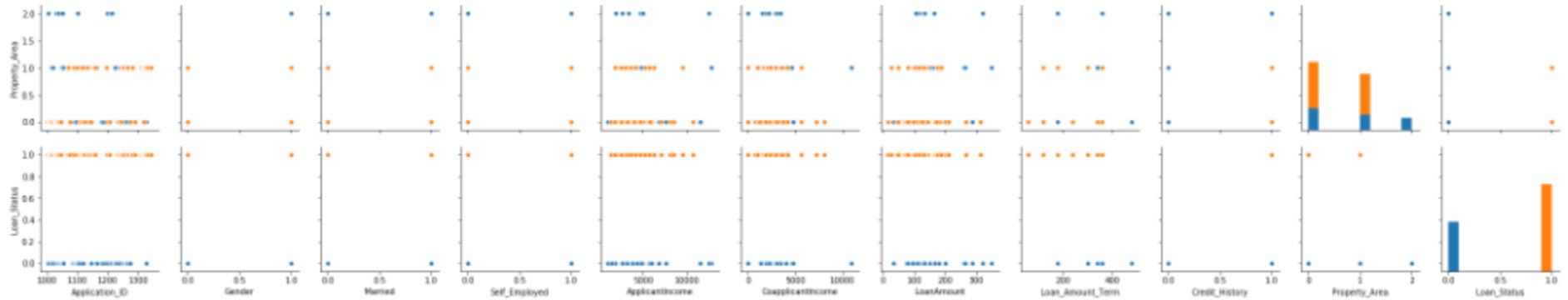
```
In [31]: import numpy as np  
import matplotlib.pyplot as plt  
%matplotlib inline  
import seaborn as sns
```

```
In [28]: sns.pairplot(data,hue='Loan_Status')
```

```
Out[28]: <seaborn.axisgrid.PairGrid at 0x56424d0c50>
```



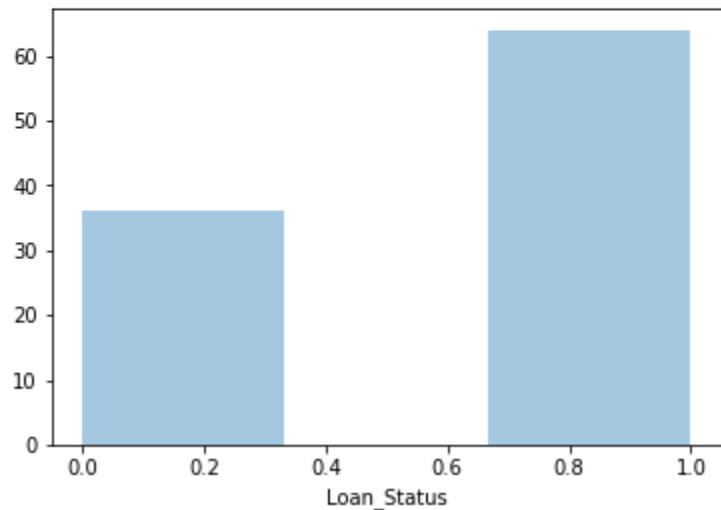




```
In [29]: sns.distplot(data['Loan_Status'],kde=False)
#more people with Loan_Status= 1 ('Y')
```

f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and has been replaced by the 'density' kwarg.  
warnings.warn("The 'normed' kwarg is deprecated, and has been "

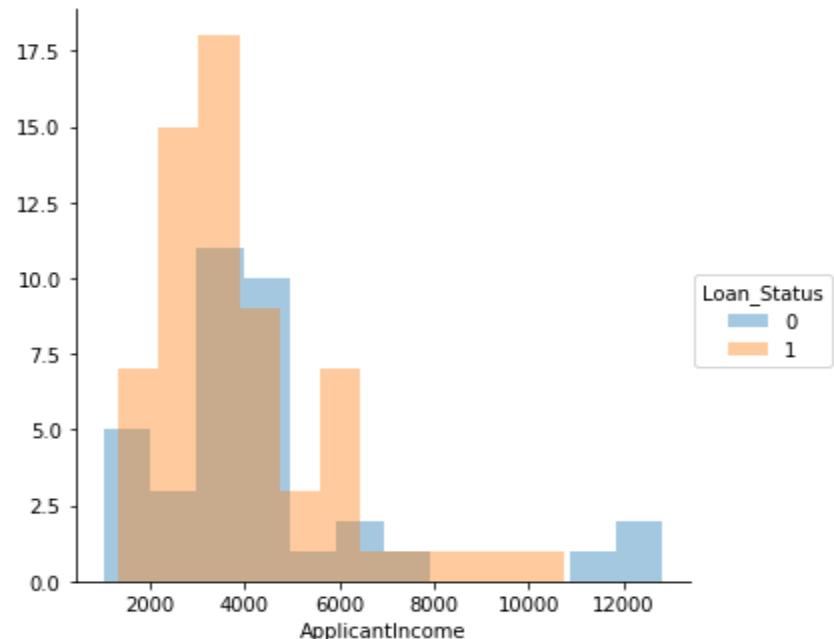
```
Out[29]: <matplotlib.axes._subplots.AxesSubplot at 0x56474325c0>
```



## FACETGRID of APPLICANT INCOME on LOAN STATUS

```
In [30]: sns.FacetGrid(data, hue="Loan_Status", size=5) \
    .map(sns.distplot, "ApplicantIncome", kde=False) \
    .add_legend();
plt.show()
```

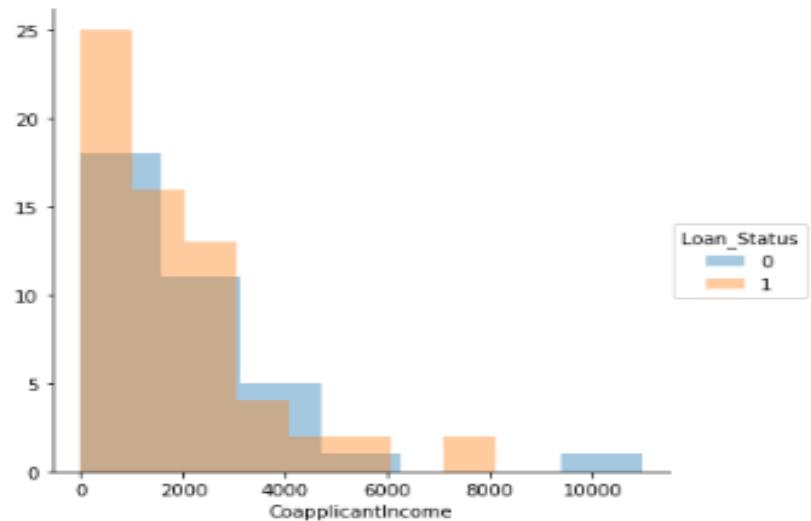
```
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and ha
s been replaced by the 'density' kwarg.
  warnings.warn("The 'normed' kwarg is deprecated, and has been "
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and ha
s been replaced by the 'density' kwarg.
  warnings.warn("The 'normed' kwarg is deprecated, and has been "
```



## FACETGRID of COAPPLICANT INCOME on LOAN STATUS

```
In [31]: sns.FacetGrid(data, hue="Loan_Status", size=5) \
    .map(sns.distplot, "CoapplicantIncome", kde=False) \
    .add_legend();
plt.show()
```

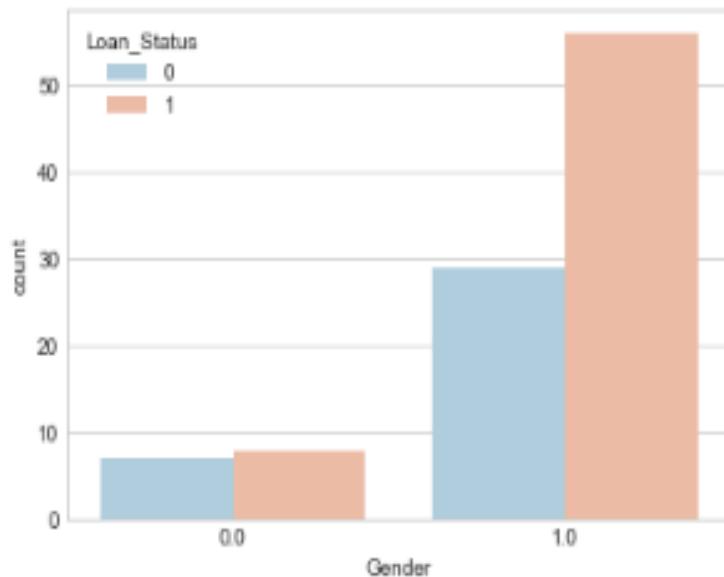
```
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and ha
s been replaced by the 'density' kwarg.
warnings.warn("The 'normed' kwarg is deprecated, and has been "
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and ha
s been replaced by the 'density' kwarg.
warnings.warn("The 'normed' kwarg is deprecated, and has been "
```



## COUNTPLOT of GENDER on LOAN STATUS

```
In [32]: sns.set_style('whitegrid')
sns.countplot(x='Gender',hue='Loan_Status',data=data,palette='RdBu_r')
#conclusion: Males are having higher probability of getting Loan
```

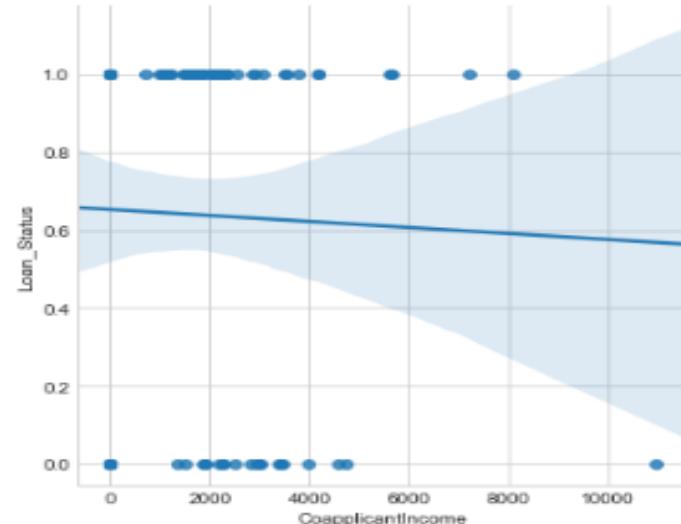
```
Out[32]: <matplotlib.axes._subplots.AxesSubplot at 0x564af8b550>
```



## LMPILOT between COAPPLICANT INCOME and LOAN STATUS

```
In [287]: sns.lmplot(x='CoapplicantIncome',
                   y='Loan_Status', data=data)

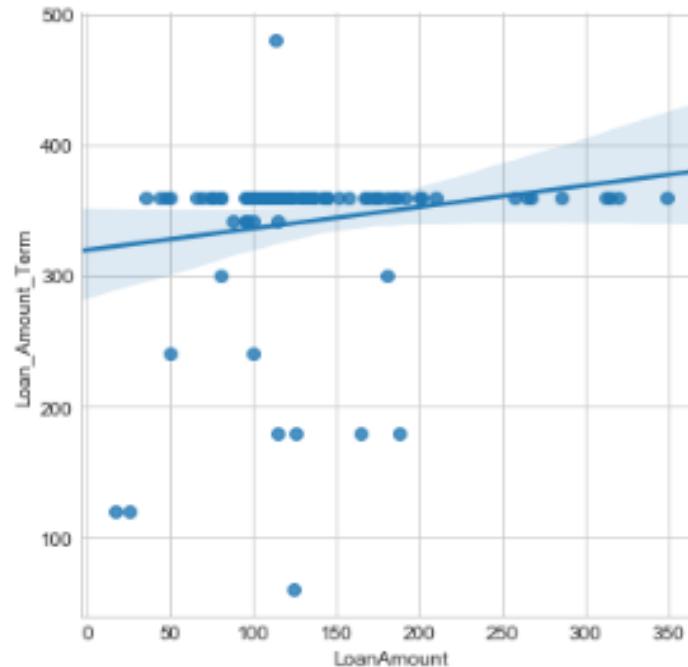
out[287]: <seaborn.axisgrid.FacetGrid at 0xfffff521208>
```



## LMPILOT between LOAN AMOUNT and LOAN AMOUNT TERM

```
In [294]: sns.lmplot(x='LoanAmount',
                   y='Loan_Amount_Term', data=data)
```

```
Out[294]: <seaborn.axisgrid.FacetGrid at 0xffa77a4f28>
```

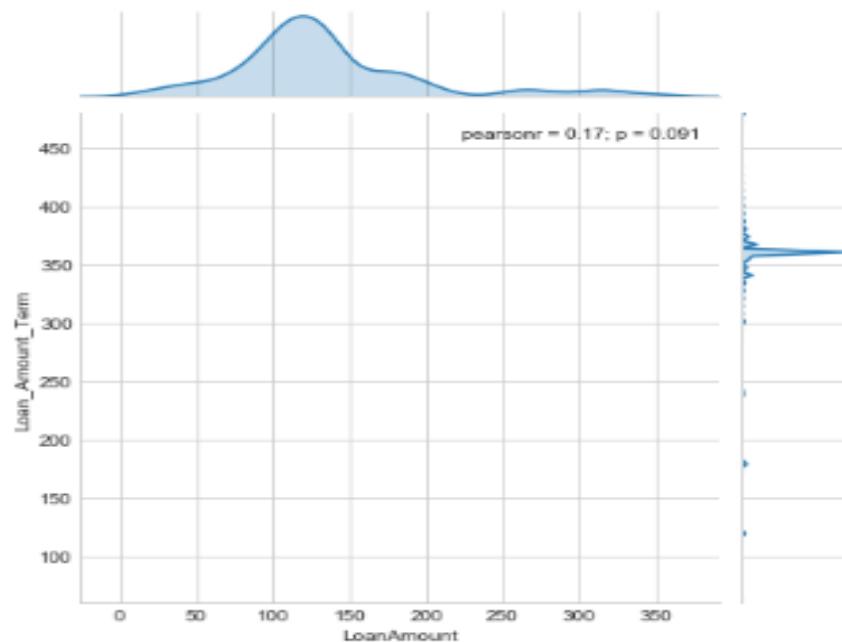


## JOINTPLOT between LOAN AMOUNT and LOAN AMOUNT TERM

```
In [295]: sns.jointplot(x='LoanAmount',y='Loan_Amount_Term',kind='kde',
                     data=data)

f:\ProgramData\Anaconda3\lib\site-packages\statsmodels\nonparametric\kernels.py:128: RuntimeWarning: divide by zero encountered
in true_divide
    return (1. / np.sqrt(2 * np.pi)) * np.exp(-(Xi - x)**2 / (h**2 * 2.))
f:\ProgramData\Anaconda3\lib\site-packages\statsmodels\nonparametric\kernels.py:128: RuntimeWarning: invalid value encountered
in true_divide
    return (1. / np.sqrt(2 * np.pi)) * np.exp(-(Xi - x)**2 / (h**2 * 2.))
f:\ProgramData\Anaconda3\lib\site-packages\statsmodels\nonparametric\_kernel_base.py:513: RuntimeWarning: invalid value encount
ered in true_divide
    dens = Kval.prod(axis=1) / np.prod(bw[iscontinuous])
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\contour.py:1480: UserWarning: Warning: converting a masked element to na
n.
    self.zmax = float(z.max())
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\contour.py:1481: UserWarning: Warning: converting a masked element to na
n.
    self.zmin = float(z.min())

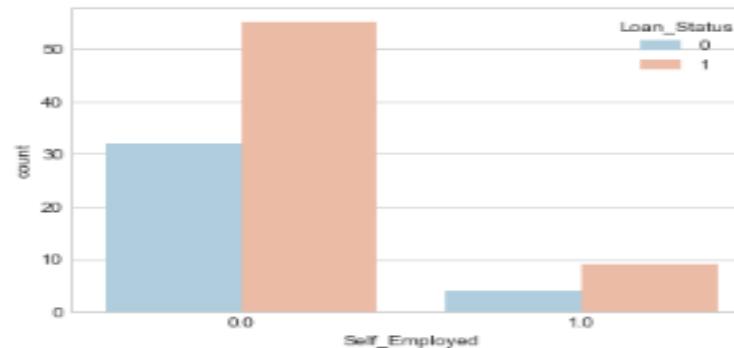
Out[295]: <seaborn.axisgrid.JointGrid at 0xffa7c76c18>
```



## 1.COUNTPLOT of SELF-EMPLOYED on LOAN STATUS;

```
In [34]: sns.set_style('whitegrid')
sns.countplot(x='Self_Employed',hue='Loan_Status',data=data,palette='RdBu_r')

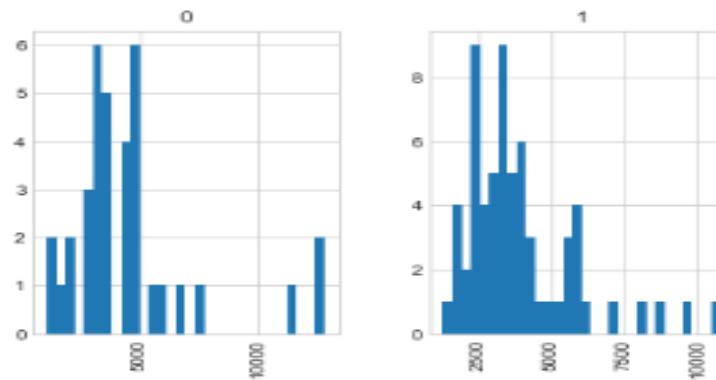
Out[34]: <matplotlib.axes._subplots.AxesSubplot at 0x564b079eb8>
```



## 2.HISTOGRAM between APPLICANT INCOME and LOAN-STATUS

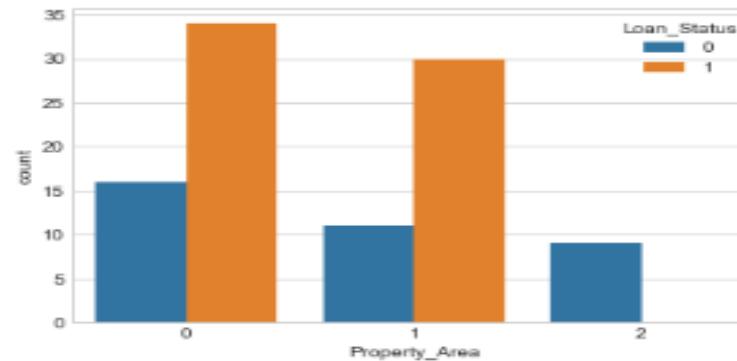
```
In [35]: data.hist(column="ApplicantIncome",by="Loan_Status",bins=30)

Out[35]: array([<matplotlib.axes._subplots.AxesSubplot object at 0x000000564B0C0940>,
   <matplotlib.axes._subplots.AxesSubplot object at 0x000000564B0F06A0>],
  dtype=object)
```

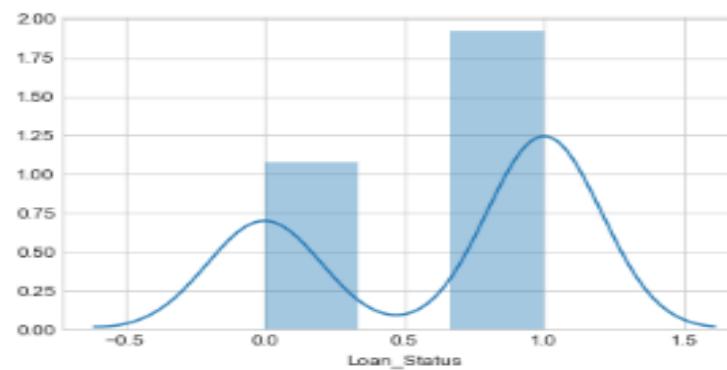


## 1.COUNTPLOT of PROPERTY AREA ON LOAN STATUS; 2.DISTPLOT on LOAN STATUS

```
In [36]: sns.countplot(data['Property_Area'],hue=data['Loan_Status'])  
Out[36]: <matplotlib.axes._subplots.AxesSubplot at 0x564b1d6b00>
```

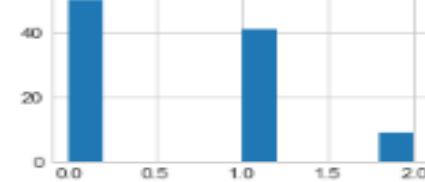
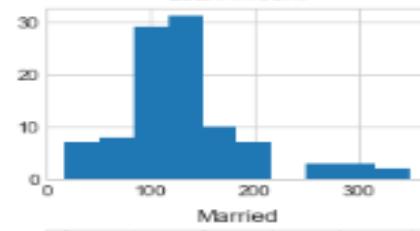
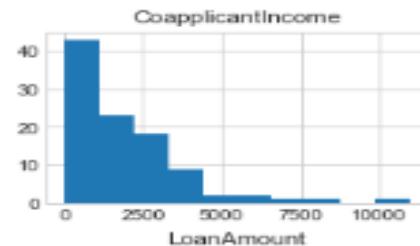
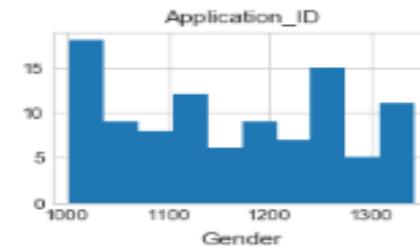
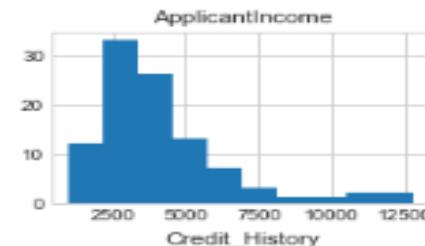


```
In [37]: sns.distplot(data['Loan_Status'])  
f:\ProgramData\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6462: UserWarning: The 'normed' kwarg is deprecated, and ha  
s been replaced by the 'density' kwarg.  
warnings.warn("The 'normed' kwarg is deprecated, and has been "  
Out[37]: <matplotlib.axes._subplots.AxesSubplot at 0x564b3be400>
```

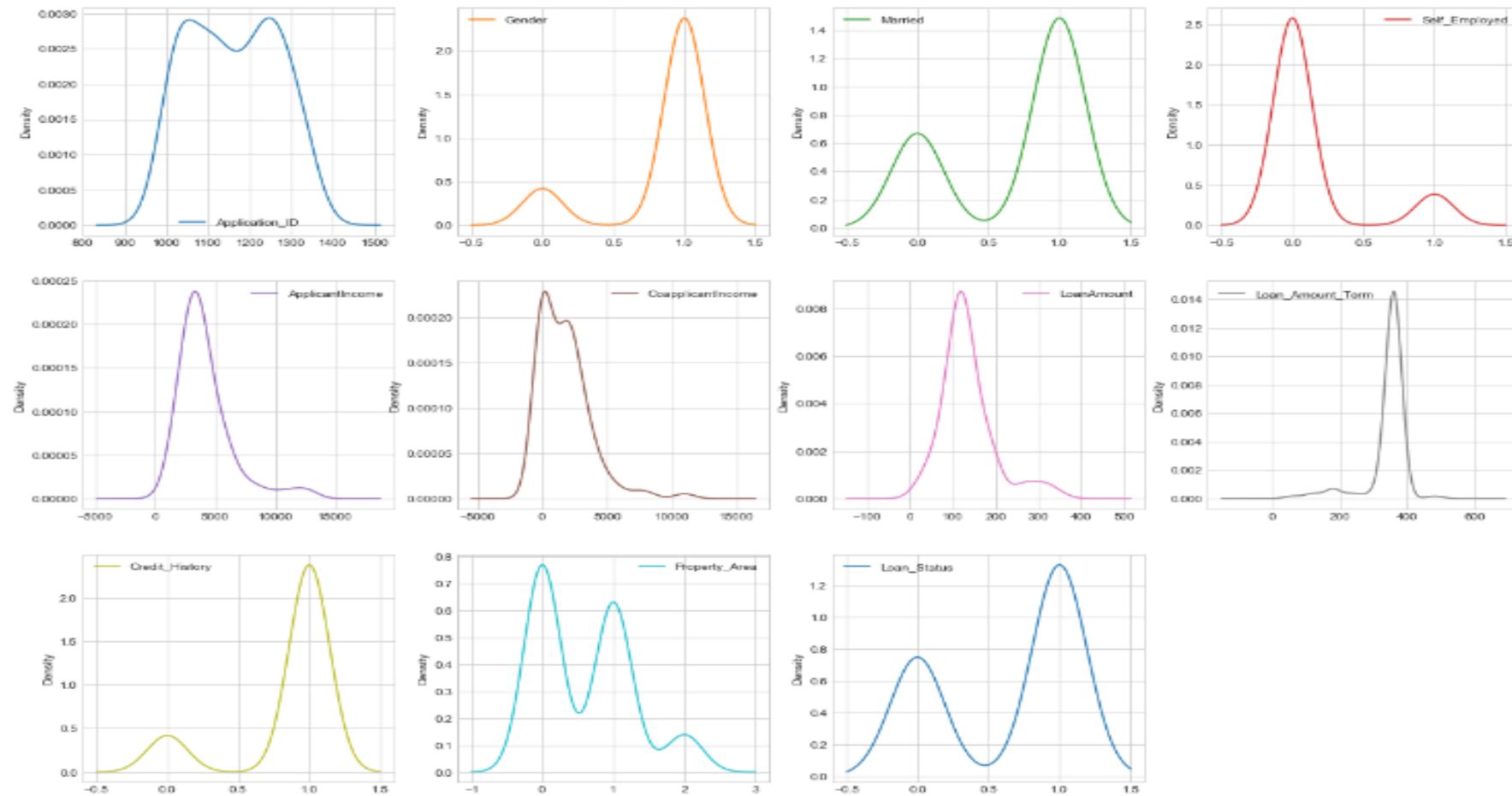


## HISTOGRAMS OF DATA

```
In [38]: data.hist(figsize=(12,10))
plt.show()
```



```
In [39]: data.plot(kind='density',subplots=True,layout=(4,4),sharex=False,figsize=(20,20))  
plt.show()
```



## Linear Regression

```
In [41]: from sklearn.linear_model import LinearRegression
```

```
In [42]: lm=LinearRegression().fit(X_train,y_train)
```

```
In [43]: predictions=lm.predict(X_test)
```

```
In [44]: print(lm.intercept_)
```

```
0.7396534600534846
```

```
In [45]: coeff_df= pd.DataFrame(lm.coef_,X.columns,
                           columns=['Coefficient'])
coeff_df
```

Out[45]:

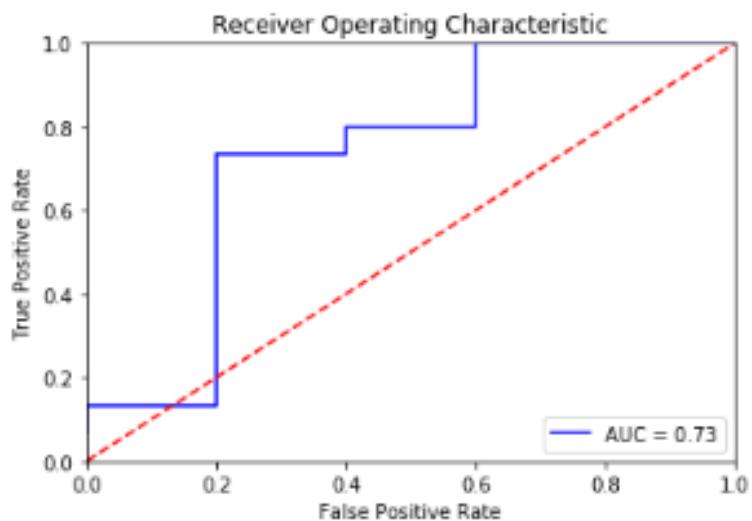
	Coefficient
Gender	-0.214564
Married	0.209605
ApplicantIncome	-0.000004
CoapplicantIncome	0.000003
LoanAmount	-0.001643
Loan_Amount_Term	-0.001247
Credit_History	0.777015
Property_Area	-0.106354

In [46]:

```
#ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



auc = 0.7333333333333334

## Logistic Regression

```
In [65]: from sklearn.linear_model import LogisticRegression
```

```
In [66]: logmodel=LogisticRegression().fit(X_train,y_train)
```

```
In [78]: predictions=logmodel.predict(X_test)
```

```
In [24]: from sklearn.metrics import classification_report,confusion_matrix
```

```
In [25]: print(classification_report(y_test,predictions))
```

	precision	recall	f1-score	support
0	0.50	0.40	0.44	5
1	0.81	0.87	0.84	15
avg / total	0.73	0.75	0.74	20

```
In [26]: print(confusion_matrix(y_test,predictions))
```

```
[[ 2  3]
 [ 2 13]]
```

```
In [68]: from sklearn.metrics import accuracy_score
```

```
In [69]: print('Accuracy : %2f' %accuracy_score(y_test,predictions))
```

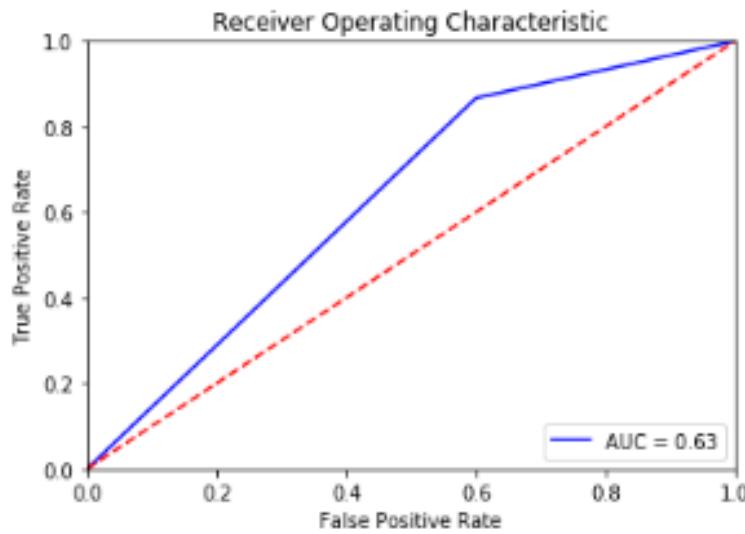
```
Accuracy : 0.750000
```

In [40]:

```
#ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



auc = 0.6333333333333333

# Scalability

```
In [59]: from sklearn.preprocessing import StandardScaler
```

```
In [60]: scaler=StandardScaler()
```

```
In [61]: scaler.fit(X)
```

```
Out[61]: StandardScaler(copy=True, with_mean=True, with_std=True)
```

```
In [62]: scaled_features=scaler.transform(X)
```

```
In [63]: data_feat=pd.DataFrame(scaled_features)
```

```
In [64]: data_feat.head(5)
```

```
Out[64]:
```

	0	1	2	3	4	5	6	7
0	0.420084	-1.491914	0.768016	-0.877519	0.000000	0.308131	0.420084	-0.908338
1	0.420084	0.670280	0.204741	-0.099360	-0.101117	0.308131	0.420084	2.170773
2	0.420084	0.670280	-0.499575	-0.877519	-1.108870	0.308131	0.420084	-0.908338
3	0.420084	0.670280	-0.686108	0.339268	-0.231150	0.308131	0.420084	-0.908338
4	0.420084	-1.491914	0.835199	-0.877519	0.110186	0.308131	0.420084	-0.908338

## KNN ↴

```
In [70]: from sklearn.neighbors import KNeighborsClassifier  
  
In [71]: knn=KNeighborsClassifier(n_neighbors=1)  
  
In [72]: knn.fit(X_train,y_train)  
  
Out[72]: KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',  
    metric_params=None, n_jobs=1, n_neighbors=1, p=2,  
    weights='uniform')
```

```
In [73]: predictions=knn.predict(X_test)
```

```
In [74]: print(classification_report(y_test,predictions))
```

	precision	recall	f1-score	support
0	0.00	0.00	0.00	5
1	0.69	0.73	0.71	15
avg / total	0.52	0.55	0.53	20

```
In [75]: print(confusion_matrix(y_test,predictions))
```

```
[[ 0  5]  
 [ 4 11]]
```

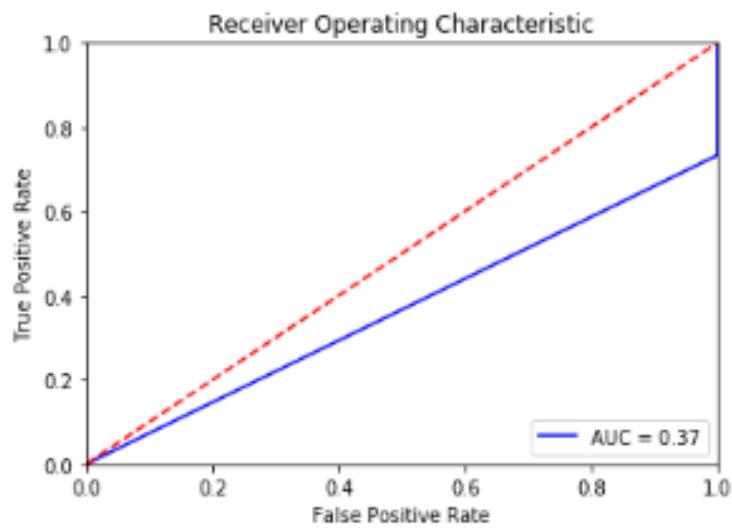
```
In [76]: print('Accuracy : %2f' %accuracy_score(y_test,predictions))
```

```
Accuracy : 0.550000
```

```
In [77]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```

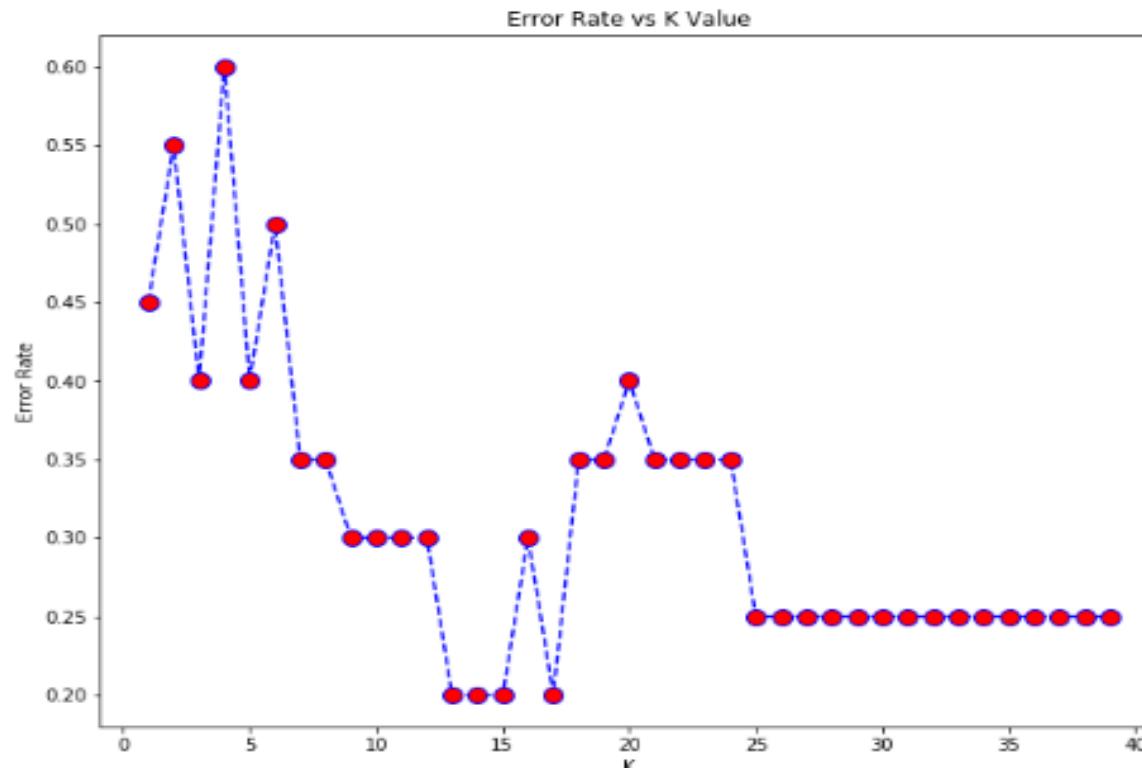


```
auc =  0.36666666666666664
```

```
In [72]: error_rate=[]
for i in range(1,40):
    knn=KNeighborsClassifier(n_neighbors=i)
    knn.fit(X_train,y_train)
    pred_i=knn.predict(X_test)
    error_rate.append(np.mean(pred_i != y_test))
```

```
In [195]: plt.figure(figsize=(10,8))
plt.plot(range(1,40),error_rate,color='blue',linestyle='dashed',
         marker='o',markerfacecolor='red',markersize=10)
plt.title('Error Rate vs K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
```

```
Out[195]: Text(0,0.5,'Error Rate')
```



```
In [73]: print("K value(s) giving minimum error rate: \n")
for i in range(0,39):
    if error_rate[i]==min(error_rate):
        print(i)
```

K value(s) giving minimum error rate:

12  
13  
14  
16

## K Means Clustering

```
In [94]: from sklearn.cluster import KMeans
```

```
In [81]: data['Random']=np.random.randint(0,2,100)  
data.head()
```

```
Out[81]:
```

	Application_ID	Gender	Married	Dependents	Education	Self_Employed	ApplicantIncome	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_His
0	1002	1.0	0	0	Graduate	0.0	5849	0	134.221053	360.0	
1	1003	1.0	1	1	Graduate	0.0	4583	1508	128.000000	360.0	
2	1005	1.0	1	0	Graduate	1.0	3000	0	66.000000	360.0	
3	1006	1.0	1	0	Not Graduate	0.0	2583	2358	120.000000	360.0	
4	1008	1.0	0	0	Graduate	0.0	6000	0	141.000000	360.0	

```
In [95]: kmeans=KMeans(n_clusters=2)
```

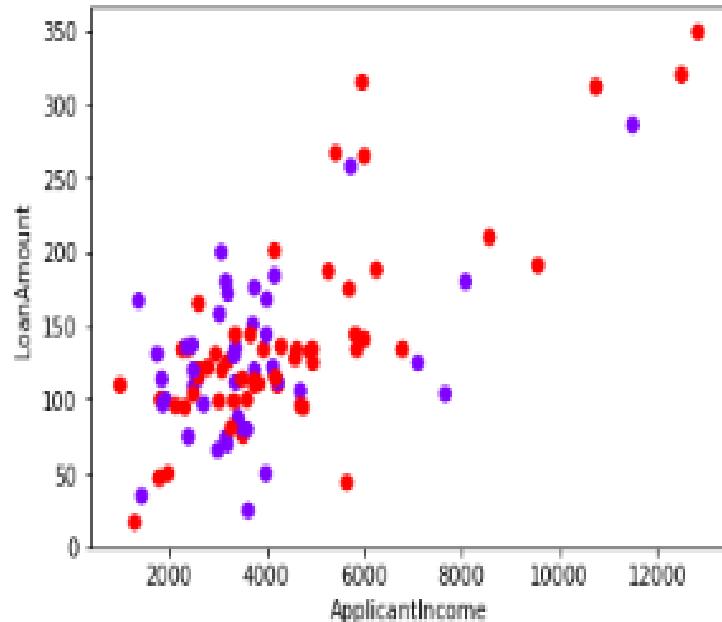
```
In [96]: kmeans.fit(data[['Gender','Married','ApplicantIncome','CoapplicantIncome','LoanAmount','Loan_Amount_Term','Credit_History','Prope  
Out[96]: KMeans(algorithm='auto', copy_x=True, init='k-means++', max_iter=300,  
n_clusters=2, n_init=10, n_jobs=1, precompute_distances='auto',  
random_state=None, tol=0.0001, verbose=0)
```

```
In [97]: kmeans.cluster_centers_
```

```
Out[97]: array([[8.4444444e-01, 6.8888889e-01, 3.52160000e+03, 1.70930000e+03,  
1.24565380e+02, 3.42982456e+02, 8.55555556e-01, 6.1111111e-01],  
[9.00000000e-01, 7.00000000e-01, 9.53390000e+03, 1.62180000e+03,  
2.21122105e+02, 3.30000000e+02, 8.00000000e-01, 4.00000000e-01]])
```

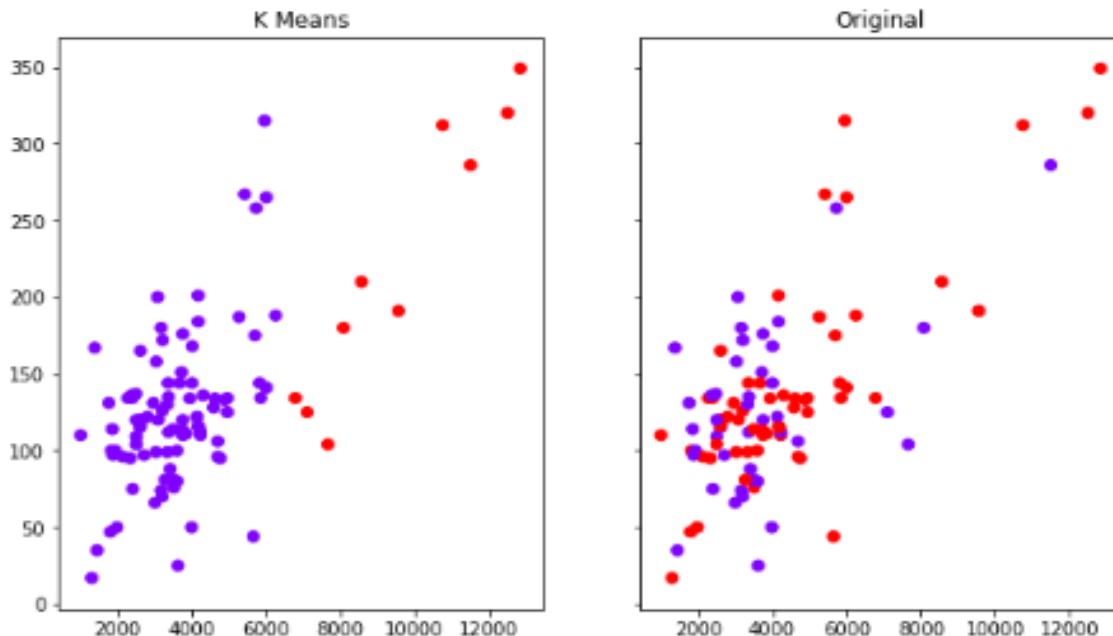
```
In [85]: plt.scatter(data['ApplicantIncome'],data['LoanAmount'],c=data['Random'],cmap='rainbow')
plt.xlabel('ApplicantIncome')
plt.ylabel('LoanAmount')
```

```
Out[85]: Text(0,0.5,'LoanAmount')
```



```
In [86]: f,(ax1,ax2)=plt.subplots(1,2,sharey=True,figsize=(10,6))
        ax1.set_title('K Means')
        ax1.scatter(data["ApplicantIncome"],data["LoanAmount"],c=kmeans.labels_,cmap='rainbow')
        ax2.set_title("Original")
        ax2.scatter(data["ApplicantIncome"],data["LoanAmount"],c=data["Random"],cmap='rainbow')
```

```
out[86]: <matplotlib.collections.PathCollection at 0x87aedbab70>
```



```
In [87]: kmeans.labels_
```

```
In [98]: print("Confusion matrix: \n")
print(confusion_matrix(data['Loan_Status'],kmeans.labels_))

print("\nClassification report: \n")
print(classification_report(data['Loan_Status'],kmeans.labels_))
```

Confusion matrix:

```
[[31  5]
 [59  5]]
```

Classification report:

	precision	recall	f1-score	support
0	0.34	0.86	0.49	36
1	0.50	0.08	0.14	64
avg / total	0.44	0.36	0.26	100

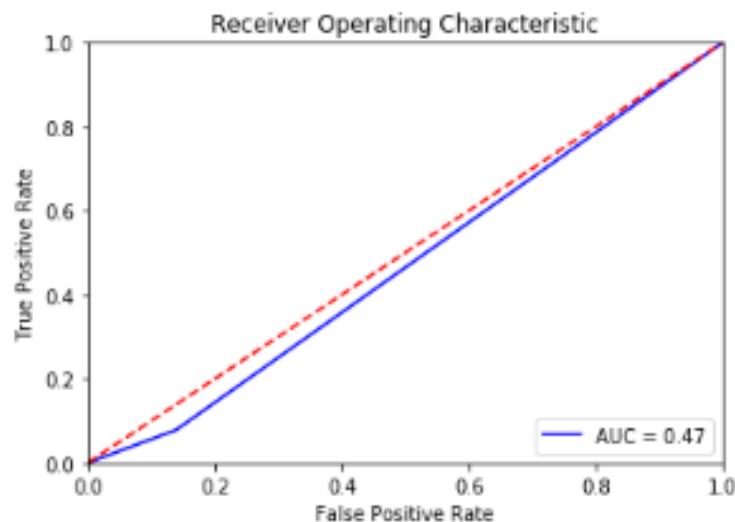
```
In [99]: print('Accuracy : %2f' %accuracy_score(data['Loan_Status'],kmeans.labels_))
```

Accuracy : 0.360000

```
In [100]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(data['Loan_Status'], kmeans.labels_)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



```
auc =  0.4696180555555556
```

## Naive Bayes Classifier

```
In [101]: from sklearn.naive_bayes import GaussianNB
```

```
In [102]: model=GaussianNB()  
model.fit(X_train,y_train)
```

```
Out[102]: GaussianNB(priors=None)
```

```
In [103]: predicted=model.predict(X_test)
```

```
In [104]: print(classification_report(y_test,predicted))
```

	precision	recall	f1-score	support
0	0.25	0.20	0.22	5
1	0.75	0.80	0.77	15
avg / total	0.62	0.65	0.64	20

```
In [105]: print(confusion_matrix(y_test,predicted))
```

```
[[ 1  4]  
 [ 3 12]]
```

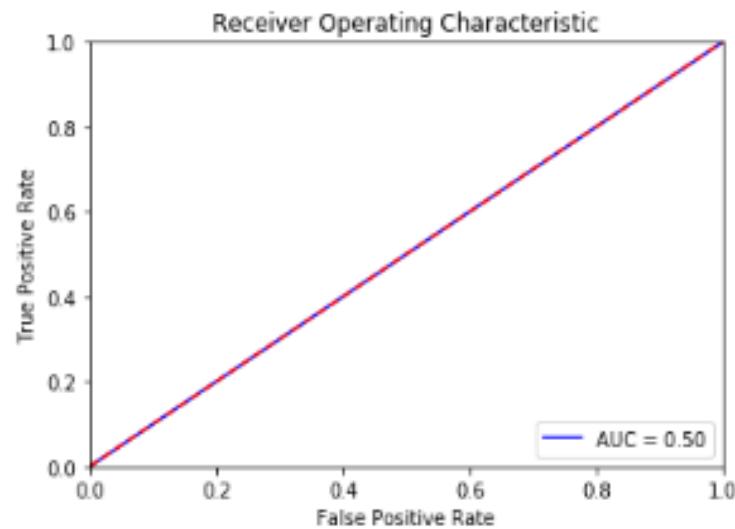
```
In [106]: print('Accuracy : %2f' %accuracy_score(y_test,predicted))
```

```
Accuracy : 0.650000
```

```
In [108]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predicted)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1], 'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



auc = 0.5

```
In [103]: #Entering values of independent variables  
# 'Gender', 'Married', 'ApplicantIncome', 'CoapplicantIncome', 'LoanAmount', 'Loan_Amount_Term', 'Credit_History', 'Property_Area'  
test=np.array([[1,0,4000,2000,150,360,0,1]])
```

```
In [104]: #predicting the value of dependent variable ('Loan_Status')  
predicted=model.predict(test)  
print(predicted)
```

```
[0]
```

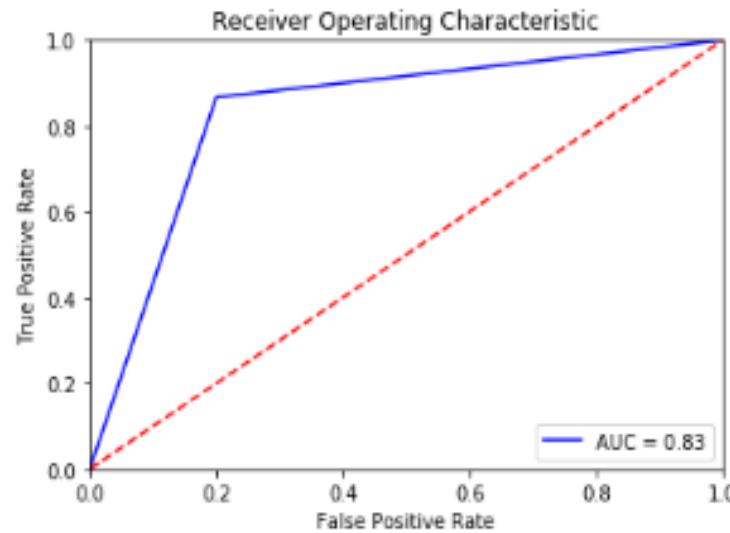
## Decision Tree

```
In [109]: from sklearn.tree import DecisionTreeClassifier  
  
In [110]: dtree=DecisionTreeClassifier()  
  
In [111]: dtree.fit(X_train,y_train)  
  
Out[111]: DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,  
        max_features=None, max_leaf_nodes=None,  
        min_impurity_decrease=0.0, min_impurity_split=None,  
        min_samples_leaf=1, min_samples_split=2,  
        min_weight_fraction_leaf=0.0, presort=False, random_state=None,  
        splitter='best')  
  
In [112]: predictions=dtree.predict(X_test)  
  
In [113]: print(classification_report(y_test,predictions))  
  
          precision    recall  f1-score   support  
  
         0       0.67      0.80      0.73       5  
         1       0.93      0.87      0.90      15  
  
     avg / total       0.86      0.85      0.85      20  
  
In [114]: print(confusion_matrix(y_test,predictions))  
  
[[ 4  1]  
 [ 2 13]]  
  
In [117]: print('Accuracy : %2f' %accuracy_score(y_test,predictions))  
Accuracy : 0.850000
```

```
In [118]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



auc = 0.8333333333333334

```
In [116]: #decision trees
from IPython.display import Image
from sklearn.externals.six import StringIO
from sklearn.tree import export_graphviz
import pydot

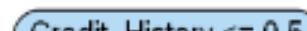
features=['Gender','Married','ApplicantIncome','CoapplicantIncome','LoanAmount','Loan_Amount_Term','Credit_History','Property_Are
features
```

```
Out[116]: ['Gender',
'Married',
'ApplicantIncome',
'CoapplicantIncome',
'LoanAmount',
'Loan_Amount_Term',
'Credit_History',
'Property_Area']
```

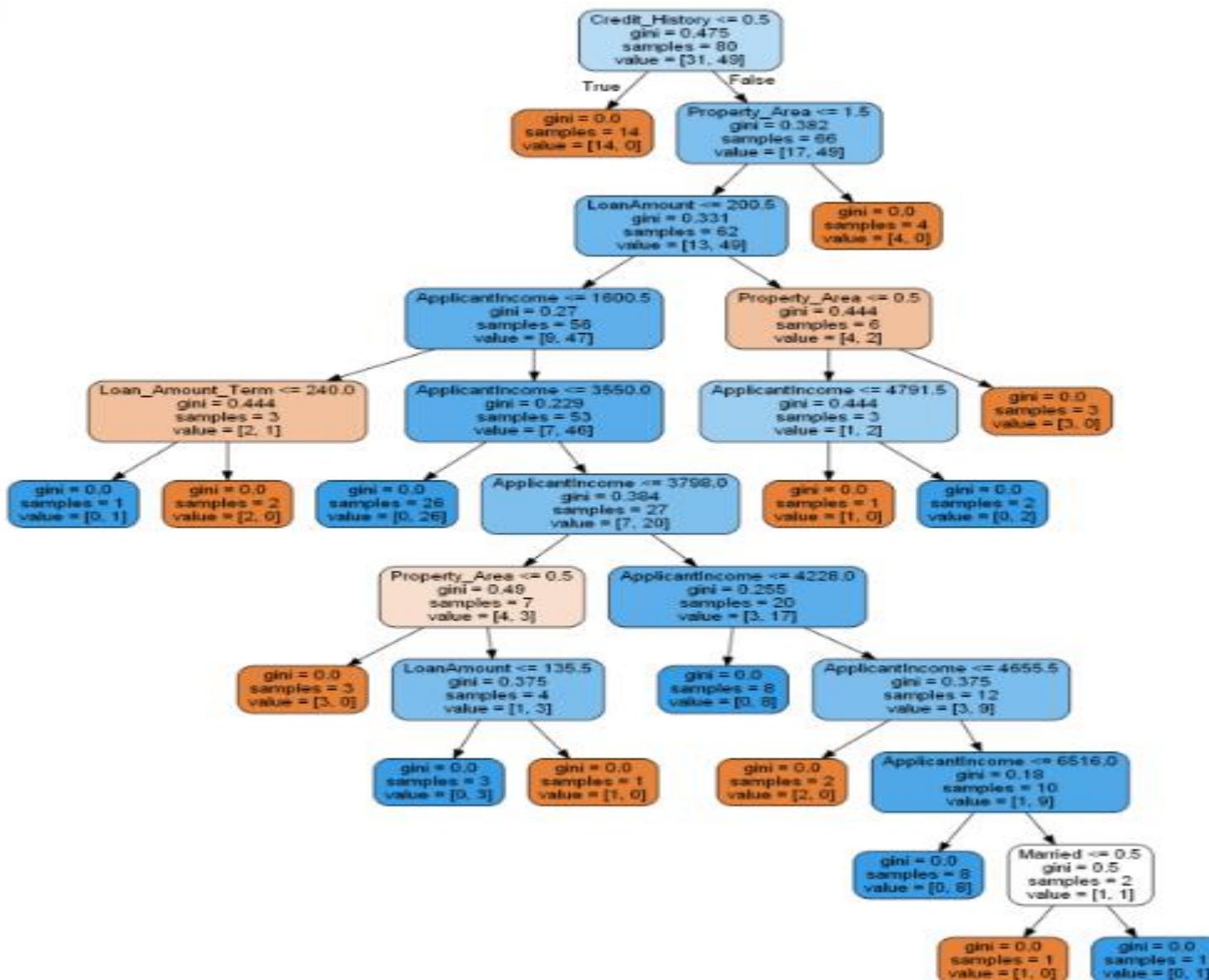
```
In [113]: dot_data=StringIO()
export_graphviz(dtree,out_file=dot_data,feature_names=features,
filled=True,rounded=True)

graph=pydot.graph_from_dot_data(dot_data.getvalue())
Image(graph[0].create_png())
```

```
Out[113]:
```



Out[113]:



## Random Forest Classifier

```
In [119]: from sklearn.ensemble import RandomForestClassifier  
rfc=RandomForestClassifier(n_estimators=100)  
rfc.fit(X_train,y_train)
```

```
out[119]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',  
max_depth=None, max_features='auto', max_leaf_nodes=None,  
min_impurity_decrease=0.0, min_impurity_split=None,  
min_samples_leaf=1, min_samples_split=2,  
min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,  
oob_score=False, random_state=None, verbose=0,  
warm_start=False)
```

```
In [120]: predictions=rfc.predict(X_test)
```

```
In [121]: print(classification_report(y_test,predictions))
```

	precision	recall	f1-score	support
0	0.57	0.80	0.67	5
1	0.92	0.80	0.86	15
avg / total	0.84	0.80	0.81	20

```
In [122]: print(confusion_matrix(y_test,predictions))
```

```
[[ 4  1]  
 [ 3 12]]
```

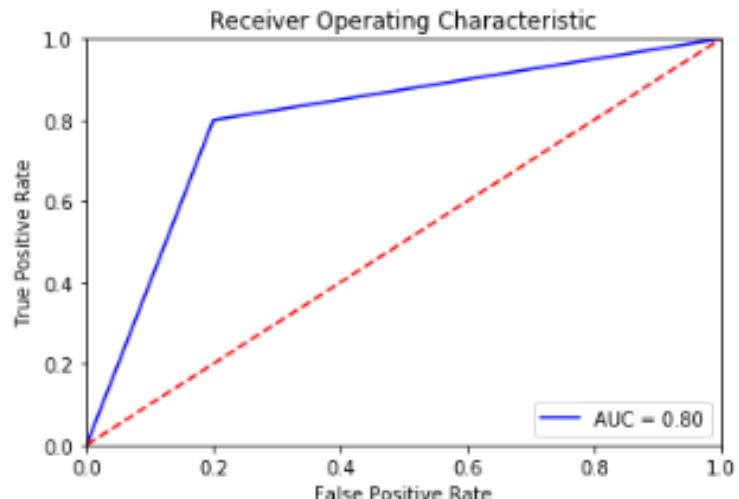
```
In [123]: print('Accuracy : %2f' %accuracy_score(y_test,predictions))
```

```
Accuracy : 0.800000
```

```
In [124]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1], 'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



```
auc =  0.8
```

## Support Vector Classifier

```
In [134]: from sklearn.svm import SVC
In [135]: model=SVC()
In [136]: model.fit(X_train,y_train)
Out[136]: SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
      decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
      max_iter=-1, probability=False, random_state=None, shrinking=True,
      tol=0.001, verbose=False)

In [137]: predictions=model.predict(X_test)
In [138]: print(classification_report(y_test,predictions))
          precision    recall  f1-score   support
          0         0.00     0.00     0.00       5
          1         0.75     1.00     0.86      15
avg / total         0.56     0.75     0.64      20

f:\ProgramData\Anaconda3\lib\site-packages\sklearn\metrics\classification.py:1135: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples.
  'precision', 'predicted', average, warn_for)

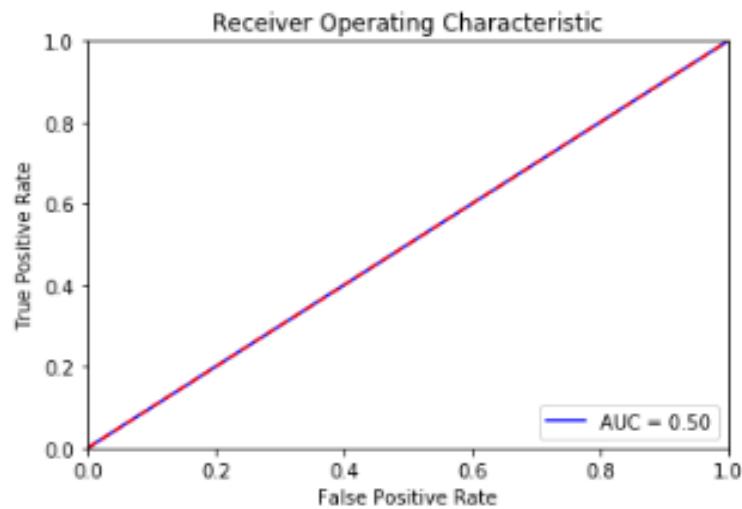
In [139]: print(confusion_matrix(y_test,predictions))
[[ 0  5]
 [ 0 15]]

In [140]: print('Accuracy : %2f' %accuracy_score(y_test,predictions))
Accuracy : 0.750000
```

```
In [141]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1], 'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



```
auc =  0.5
```

## GridSearch

```
In [142]: param_grid={'C':[0.1,1,10,100,1000], 'gamma':[1,0.1,0.01,0.001,0.0001], 'kernel':['rbf']}
```

```
In [143]: from sklearn.model_selection import GridSearchCV
```

```
In [144]: grid=GridSearchCV(SVC(),param_grid,refit=True,verbose=3)
```

```
In [145]: grid.fit(X_train,y_train)
```

```
Fitting 3 folds for each of 25 candidates, totalling 75 fits
[CV] C=0.1, gamma=1, kernel=rbf .....
[CV] C=0.1, gamma=1, kernel=rbf, score=0.6071428571428571, total= 0.0s
[CV] C=0.1, gamma=1, kernel=rbf .....
[CV] C=0.1, gamma=1, kernel=rbf, score=0.6153846153846154, total= 0.0s
[CV] C=0.1, gamma=1, kernel=rbf .....
[CV] C=0.1, gamma=1, kernel=rbf, score=0.6153846153846154, total= 0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf .....
[CV] C=0.1, gamma=0.1, kernel=rbf, score=0.6071428571428571, total= 0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf .....
[CV] C=0.1, gamma=0.1, kernel=rbf, score=0.6153846153846154, total= 0.0s
[CV] C=0.1, gamma=0.1, kernel=rbf .....
[CV] C=0.1, gamma=0.1, kernel=rbf, score=0.6153846153846154, total= 0.0s

[Parallel(n_jobs=1)]: Done  1 out of  1 | elapsed:  0.0s remaining:  0.0s
[Parallel(n_jobs=1)]: Done  2 out of  2 | elapsed:  0.0s remaining:  0.0s
```

```
[CV] C=0.1, gamma=0.01, kernel=rbf .....
[CV] C=0.1, gamma=0.01, kernel=rbf, score=0.6071428571428571, total= 0.0s
[CV] C=0.1, gamma=0.01, kernel=rbf .....
```

```
In [146]: grid.best_params_
```

```
out[146]: {'C': 1, 'gamma': 0.0001, 'kernel': 'rbf'}
```

```
In [147]: grid.best_estimator_
```

```
out[147]: SVC(C=1, cache_size=200, class_weight=None, coef0=0.0,  
    decision_function_shape='ovr', degree=3, gamma=0.0001, kernel='rbf',  
    max_iter=-1, probability=False, random_state=None, shrinking=True,  
    tol=0.001, verbose=False)
```

```
In [148]: grid_predictions=grid.predict(X_test)
```

```
In [149]: print(classification_report(y_test,grid_predictions))
```

	precision	recall	f1-score	support
0	0.00	0.00	0.00	5
1	0.75	1.00	0.86	15
avg / total	0.56	0.75	0.64	20

```
f:\ProgramData\Anaconda3\lib\site-packages\sklearn\metrics\classification.py:1135: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples.  
    'precision', 'predicted', average, warn_for)
```

```
In [150]: print(confusion_matrix(y_test,grid_predictions))
```

```
[[ 0  5]  
 [ 0 15]]
```

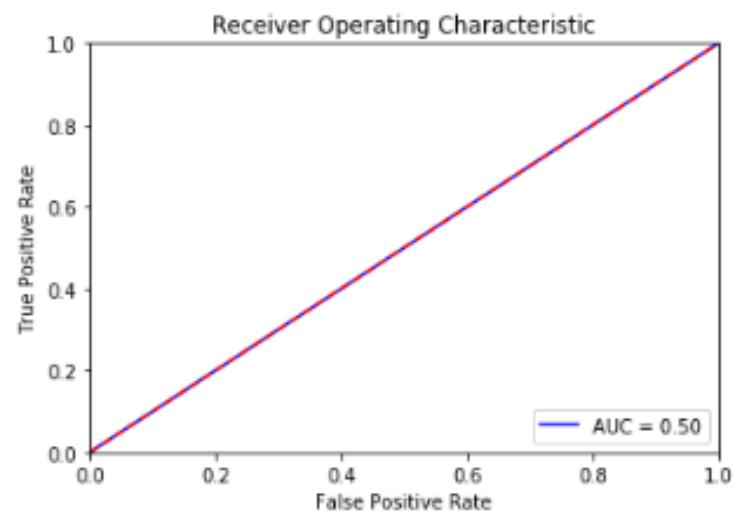
```
In [135]: print('Accuracy : %2f' %accuracy_score(y_test,grid_predictions))
```

```
Accuracy : 0.750000
```

```
In [152]: #ROC curve
from sklearn.metrics import roc_curve,auc
fpr, tpr, threshold = roc_curve(y_test, grid_predictions)
roc_auc = auc(fpr, tpr)

plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()

print("auc = ",roc_auc)
```



```
auc =  0.5
```

## K Folds Cross Validation

```
In [136]: from sklearn.model_selection import KFold
```

```
In [137]: kf=KFold(n_splits=2)
kf.get_n_splits(X)
print(kf)

KFold(n_splits=2, random_state=None, shuffle=False)
```

```
In [138]: for train_index,test_index in kf.split(X):
    print('TRAIN :',train_index,'TEST :',test_index)
    X_train,X_test=X.iloc[train_index],X.iloc[test_index]
    y_train,y_test=y[train_index],y[test_index]
```

```
TRAIN : [50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
98 99] TEST : [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
48 49]
TRAIN : [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
48 49] TEST : [50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73
74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
98 99]
```

```
In [139]: #necessary imports:
from sklearn.cross_validation import cross_val_score, cross_val_predict
from sklearn import metrics
from sklearn import linear_model
```

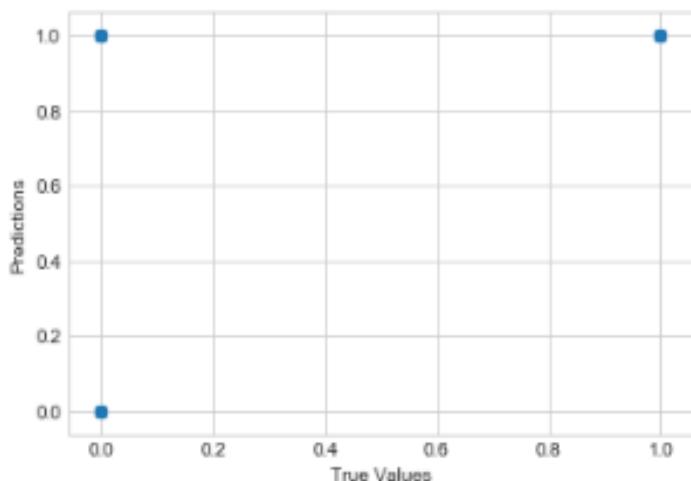
```
f:\ProgramData\Anaconda3\lib\site-packages\sklearn\cross_validation.py:41: DeprecationWarning: This module was deprecated in version 0.18 in favor of the model_selection module into which all the refactored classes and functions are moved. Also note that the interface of the new CV iterators are different from that of this module. This module will be removed in 0.20.
"This module will be removed in 0.20.", DeprecationWarning)
```

```
In [140]: #fit a model  
logmodel=linear_model.LogisticRegression()  
model=logmodel.fit(x_train,y_train)  
predictions=logmodel.predict(x_test)  
predictions[:5]
```

```
Out[140]: array([1, 1, 1, 1, 1], dtype=int64)
```

```
In [141]: plt.scatter(y_test,predictions)  
plt.xlabel('True Values')  
plt.ylabel('Predictions')
```

```
Out[141]: Text(0,0.5,'Predictions')
```



```
In [142]: print('Score:',model.score(x_test,y_test))
```

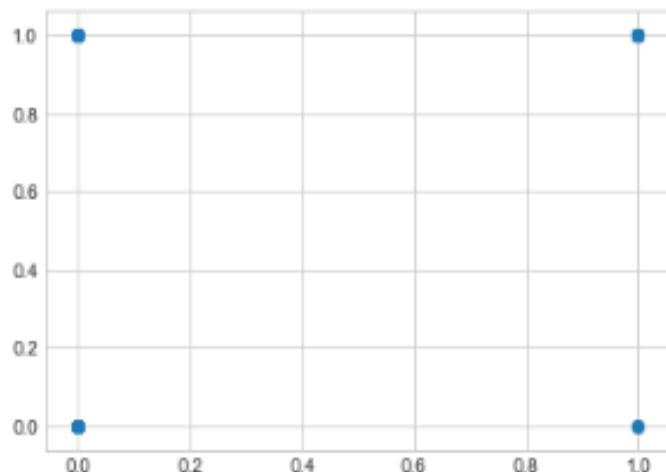
```
Score: 0.8
```

```
In [143]: #seeing score after cross validation  
#Performing 6-fold cross validation  
scores=cross_val_score(model,X,y,cv=6)  
print('Cross-validated scores:',scores)
```

```
Cross-validated scores: [0.76470588 0.82352941 0.82352941 0.82352941 0.8125 0.6875 ]
```

```
In [144]: #make cross validated predictions  
predictions=cross_val_predict(model,X,y,cv=6)  
plt.scatter(y,predictions)
```

```
out[144]: <matplotlib.collections.PathCollection at 0x564e4e8198>
```



```
In [145]: accuracy=metrics.r2_score(y,predictions)  
print('Cross-Predicted Accuracy:',accuracy)
```

```
Cross-Predicted Accuracy: 0.08854166666666663
```

# PCA

```
In [151]: from sklearn.model_selection import KFold
         from sklearn.model_selection import cross_val_score
         from sklearn.preprocessing import StandardScaler
         from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
```

```
In [152]: #Create Pipeline
estimators=[]
estimators.append(('standardize',StandardScaler()))
estimators.append(('lda',LinearDiscriminantAnalysis()))
print(estimators)
model=Pipeline(estimators)
seed=7
kfold=KFold(n_splits=10,random_state=seed)
results=cross_val_score(model,X,y,cv=kfold)
print(results.mean())

[('standardize', StandardScaler(copy=True, with_mean=True, with_std=True)), ('lda', LinearDiscriminantAnalysis(n_components=None, priors=None, shrinkage=None,
           solver='svd', store_covariance=False, tol=0.0001))]
0.8099999999999999
```

```
In [154]: from sklearn.pipeline import FeatureUnion
         from sklearn.linear_model import LogisticRegression
         from sklearn.preprocessing import StandardScaler
         from sklearn.decomposition import PCA
         from sklearn.pipeline import Pipeline
         from sklearn.feature_selection import SelectKBest
```

```
In [155]: features=[]
         features.append(('pca',PCA(n_components=3)))
         features.append(('select_best',SelectKBest(k=6)))
         feature_union=FeatureUnion(features)
         #Create Pipeline
         estimators=[]
         estimators.append(('logistic',LogisticRegression()))
         print(estimators)
         model=Pipeline(estimators)

         #Evaluate pipeline
         seed=7
         kfold=KFold(n_splits=10,random_state=seed)
         results=cross_val_score(model,X,y,cv=kfold)
         print(results.mean())

[('logistic', LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
        intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
        penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
        verbose=0, warm_start=False))]
```

0.8

## **Future Scope of Improvements**

In the near future the so –called software could be made more secure, reliable and dynamic .In near future this module of prediction can be integrated with the module of automated processing system. The system is trained on old training dataset. In future software can be made such that new testing date should also take part in training data after some fixed time.

# Certificate

This is to certify that **Mr. SAYAN DEY** of **GOVT. COLLEGE OF ENGG & CERAMIC TECHNOLOGY**, registration number: **151130110024** of **2015-16**, has successfully completed a project on **PREDICT LOAN APPLICATION STATUS** using **MACHINE LEARNING WITH PYTHON** under the guidance of **Mr. ANUBHAV CHATURVEDI**.

---

**Mr. ANUBHAV CHATURVEDI**  
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