VEHICLE LOAN PREDICTION

REPORT BY,

Mrunalini Devineni
Aihan Liu
Sara Sanchez

DATS6103
Professor Amir Jafari
December 6, 2021

TABLE OF CONTENTS

Introduction	***3***
Data Description	***4***
EDA	***5***
Data Preprocessing	***8***
Data Modelling	***10***
Conclusion	***11***
Reference	***12***
Appendix	***13***

INTRODUCTION

Financial institutions incur significant losses due to the default of Vehicle Loans. This situation has led to the constricting of vehicle loan underwriting and increased vehicle loan rejection rates. These institutions also raise the need for a better credit risk scoring model. By doing this, the institutions are trying to accurately predict the Probability of loanee defaulting on a vehicle loan on the due date. In this sense, the credit scores are significant as a tool that can decide which clients can take or not a credit, considering their unique characteristics. The scoring is also a helpful tool for the clients because this can avoid accepting a loan that will not be able to be paid in the future and, consequently, prevent having problems with financial institutions.

Furthermore, the scoring tool is helpful not only for cash loans but also for mortgages and car loans, so this is the main reason that motivated us to choose this topic because it is helpful for many kinds of businesses.

To develop this scoring project, we will analyze an L&T car loan company database from Kaggle. Then we are doing some preprocessing and cleaning of the data to apply the classification models like Decision tree, Random Forest, logistic, and Gradient Boosting. Finally, we will show the results by using the Pyqt5.

The following report will be organized: first, we will describe the data set, then the methodology to be used, and finally, the results and main conclusions.

DATA DESCRIPTION

For this study, we have chosen to analyze an L&T company dataset, in charge of cars' sale from kaggle.com. This dataset is like the one that financial institution must build the scoring models that allow them to forecast the approval or rejection of customers. This dataset does not require any cleaning and is equipped to fuel the analysis of this project. The base consists of 40 variables and 233 154 observations assessing a person's attributes ranging from demographic data (date of birth, etc.) and bureau data, like the amount of loan disbursed and the asset's cost.

The following Information regarding the loan and loanee are provided in the datasets:

- **Loanee Information** (Demographic data like age, Identity proof etc.)
- **Loan Information** (Disbursal details, loan to value ratio etc.)
- **Bureau data & history** (Bureau score, number of active accounts, the status of other loans, credit history etc.)

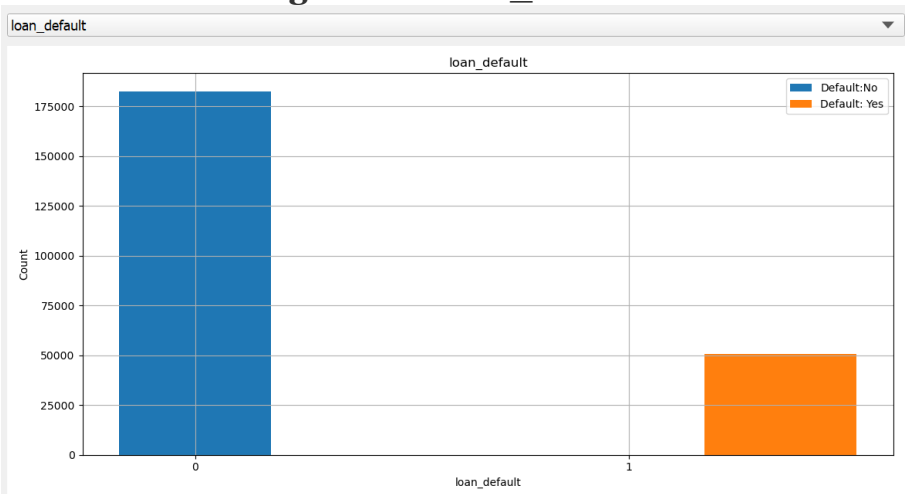
The dataset available on Kaggle contains:

- Train.csv: a base that contains the training data with details on loan as described in the last section.
- data_dictionary.csv: a base containing a brief description of each variable provided in the training and test set.

EXPLORATORY DATA ANALYSIS (EDA)

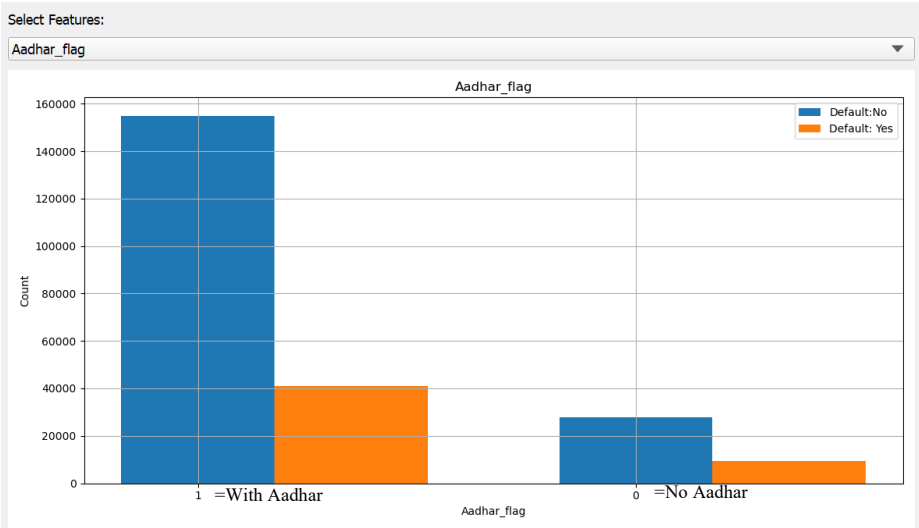
From the car loan database, we will develop the Exploratory data analysis (EDA). This kind of analysis permits a better understanding of the data and builds a better model. The target variable is the "loan default," this gives us information related to the number of persons that defaulted, and for this database, the default ratio is around 27.7%.

Figure 1 – Loan_deafult



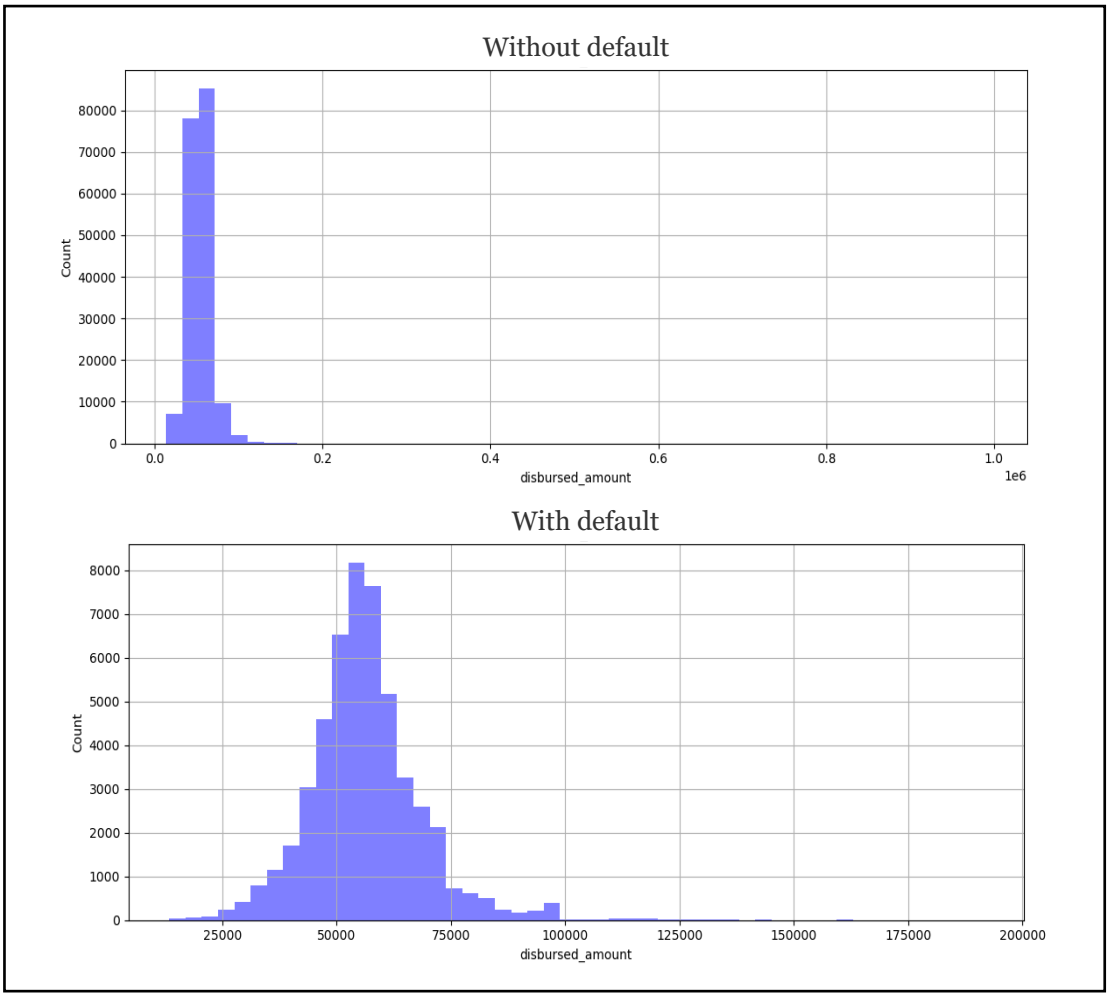
Another essential variable is the Aadhar flag. As this is a database from India, it is crucial to highlight that Aadhar is given to all the citizens from this country. A person who doesn't have a citizen status will not have an Aadhar. The graph shows that people who have an Aadhar are more likely to be on default than others.

Figure 2 – Aadhar flag



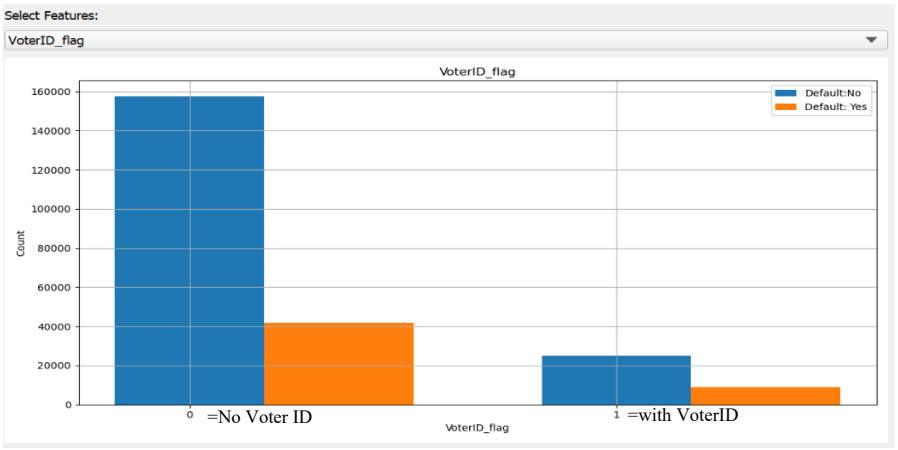
The disbursed amount is the financial institution's quantity to the borrower. Figure number three shows a significant difference in the amount between those without and those with default. Again, there is a concentration around shorter amounts. This is different from the former who have a normal distribution for the latter.

Figure 3 – The disbursed amount



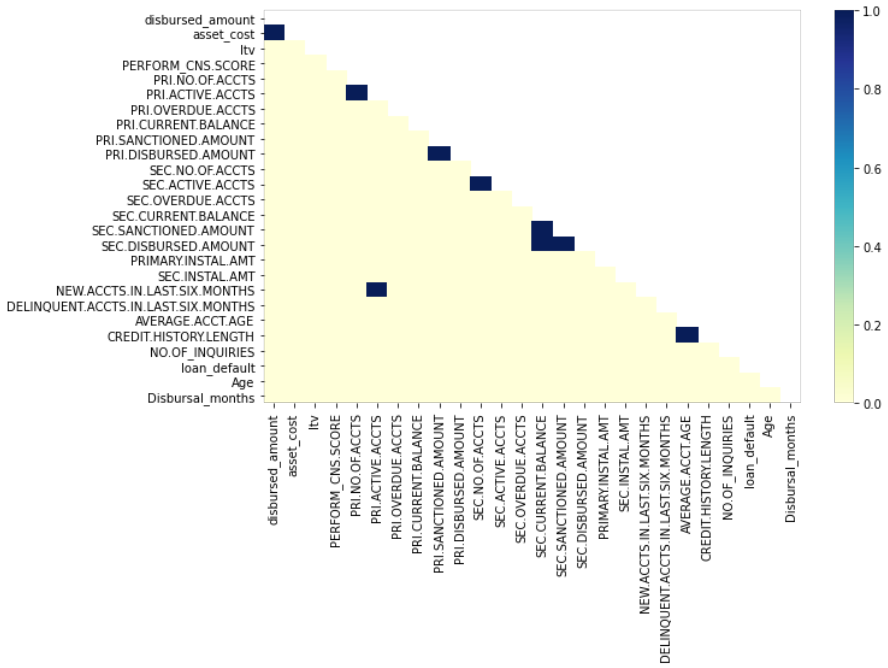
From figure number four, we can analyze the voter ID flag. This variable is essential because this makes differences between profiles with and without default. As is possible to observe, most people from the database do not have a Voter ID, and this is the group with the biggest default. Therefore, it is possible that people who cannot have the biggest default could be an indicator or informality.

Figure 4 – Voter ID



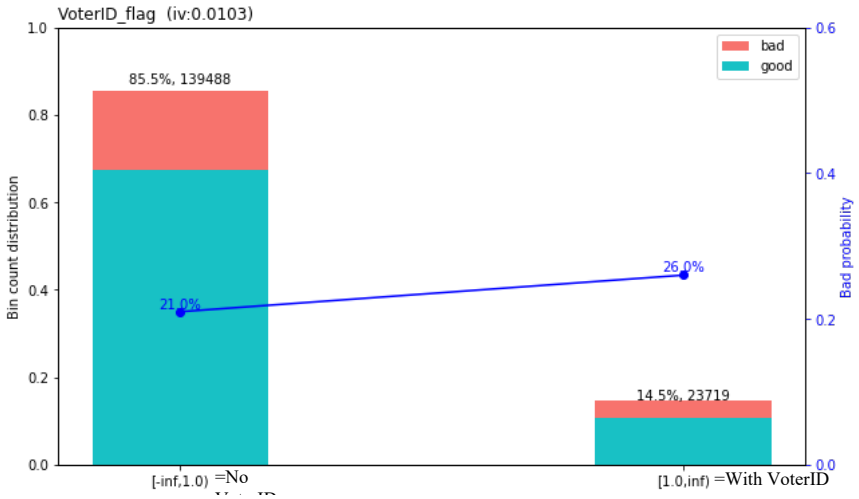
From this plot, we can observe a positive and strong correlation. Therefore, we choose to select those points with a correlation more significant than 70%. The variables that fulfill this requirement are asset cost, disbursed amount, sanctioned amount, credit history length, and average account age.

Figure 5 – Correlation Plot



The weight of the evidence plot is well known among the risk areas from financial institutions. Therefore, we can interpret this plot as 21 over 100 will default from those with a Voter ID. On the other hand, from those who do not have a Voter ID, 26 over 100 will have a default. This is a crucial plot given that confirms the importance of the variable as a predictor because those who contribute more to the model are the ones that can differentiate the profiles better.

Figure 6 – Weight of evidence from Voter ID



DATA PREPROCESSING

Data preprocessing is a technique that works for the dirty data that cannot mine directly and transform into the one that is efficiently used. Data preprocessing has several methods: data cleansing, data integration, data transformation, etc. These data processing techniques are used before data mining, significantly improving the quality of the data mining model and reducing the time required to excavate.
The following are the various preprocessing techniques that we applied to our dataset.

Moving null values:
There are over 5000 null values in our dataset. To prevent them from affecting the accuracy of the prediction, we remove them from the dataset.

Format converting:
Variables' CREDIT.HISTORY. LENGTH' and 'AVERAGE.ACCT.AGE' (credit history length and average account age) have informed date format (such as '2yrs 4mon'), we formatted and calculated them into a month.

Date of Birth to Age:
Converted date of birth to age.

Categorized ID data:
Made buckets for supplier id, branch id, manufacturer id, and State ID to reduce the levels of these features.

One hot encoding:
One hot encoded categorical feature such as employment type and the categorical features we generated earlier.

Scaling:
Scaled the features when required. We applied Standard Scaler for the dataset when we used specific algorithms related to the distance calculation, including logistic Regression.

Balanced Data:
We found that this data was imbalanced since the target feature-loan default was imbalanced. There were fewer defaulters than non-defaulters. To overcome this issue and improve the precision, we applied Synesthetic Minority Oversampling Technique (SMOTE) method to fix the imbalanced data. SMOTE is implemented by finding the k-nearest neighbors for minority class observations and randomly choosing one of the k-nearest neighbors. The new observations it created will be added to the group defaulter.

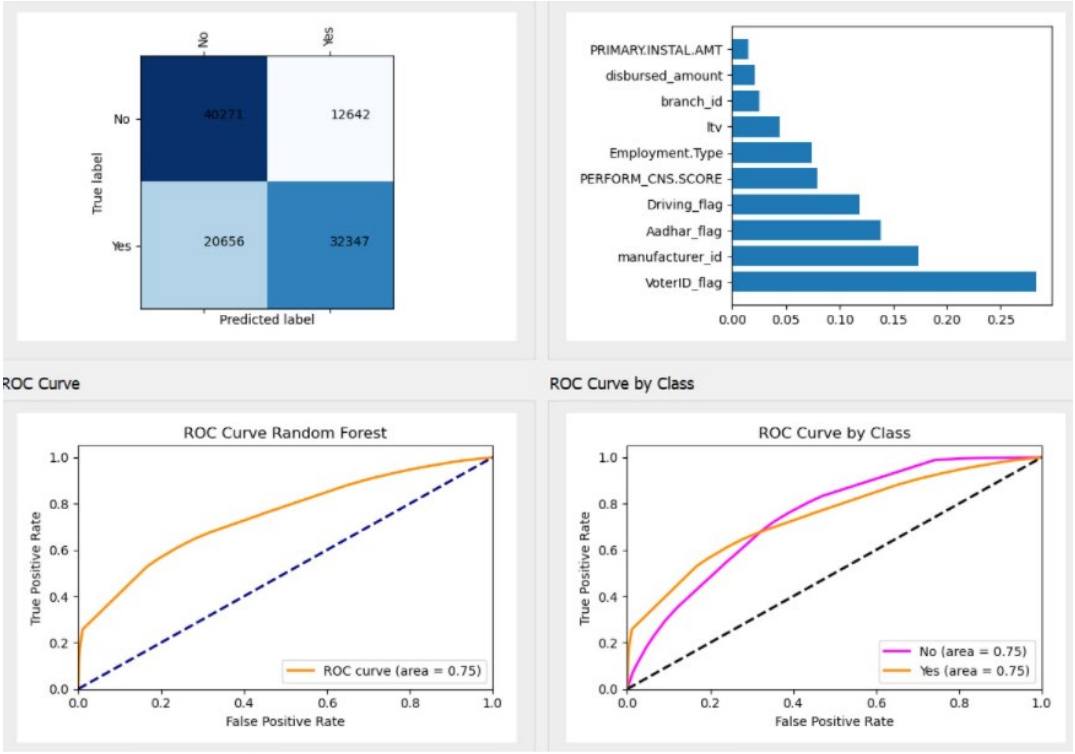
Feature Selection
Since we have over 40 features, we used Random Forest Classifier to find the essential features with a higher step score on the selection iteration. Finally, we have 25 features left in our dataset, which will be applied to the following model generation.

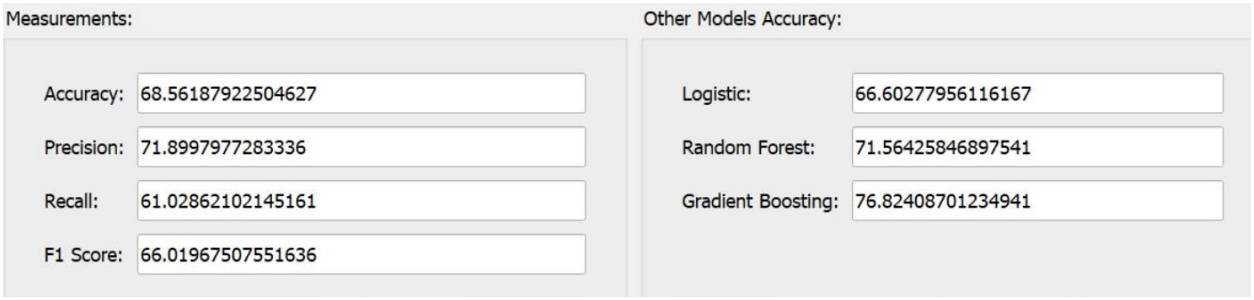
DATA MODELING

Classification is the process of assigning data points to predefined classes or categories. In this project, we have implemented four classification Algorithms.

Decision tree:

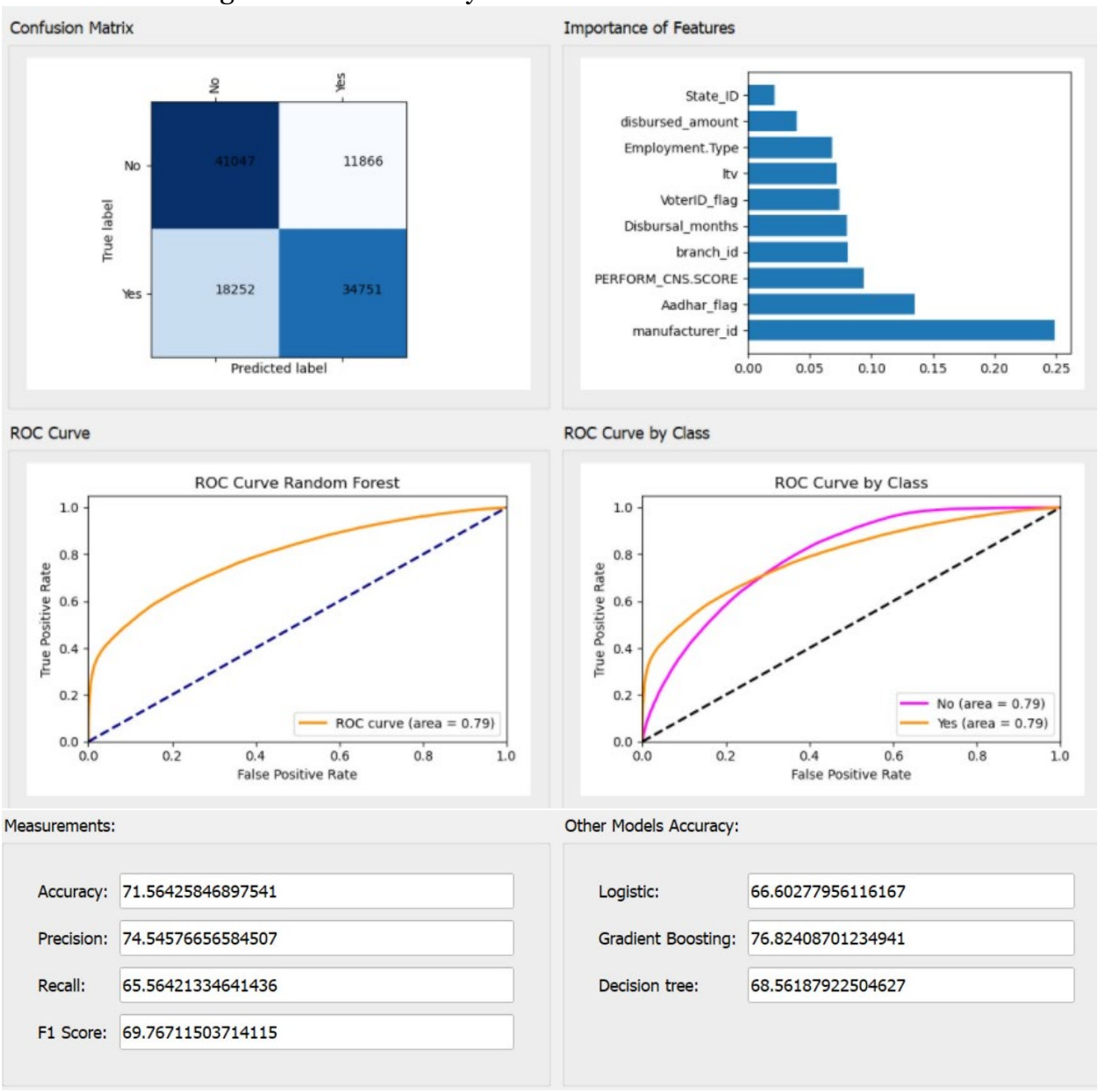
Decision Tree is a tree flowchart-like structure that divides the data into different subgroups based on conditions to classify the data. A condition is selected such that the classification is as pure as possible. At each node of the tree, a decision is made about splitting the data and getting the purest nodes. We can use different measures like Gini, entropy or misclassification error to calculate what attribute to split on. When you travel down the tree, finally, at leaf nodes, we find the labels of the data of a particular sample.





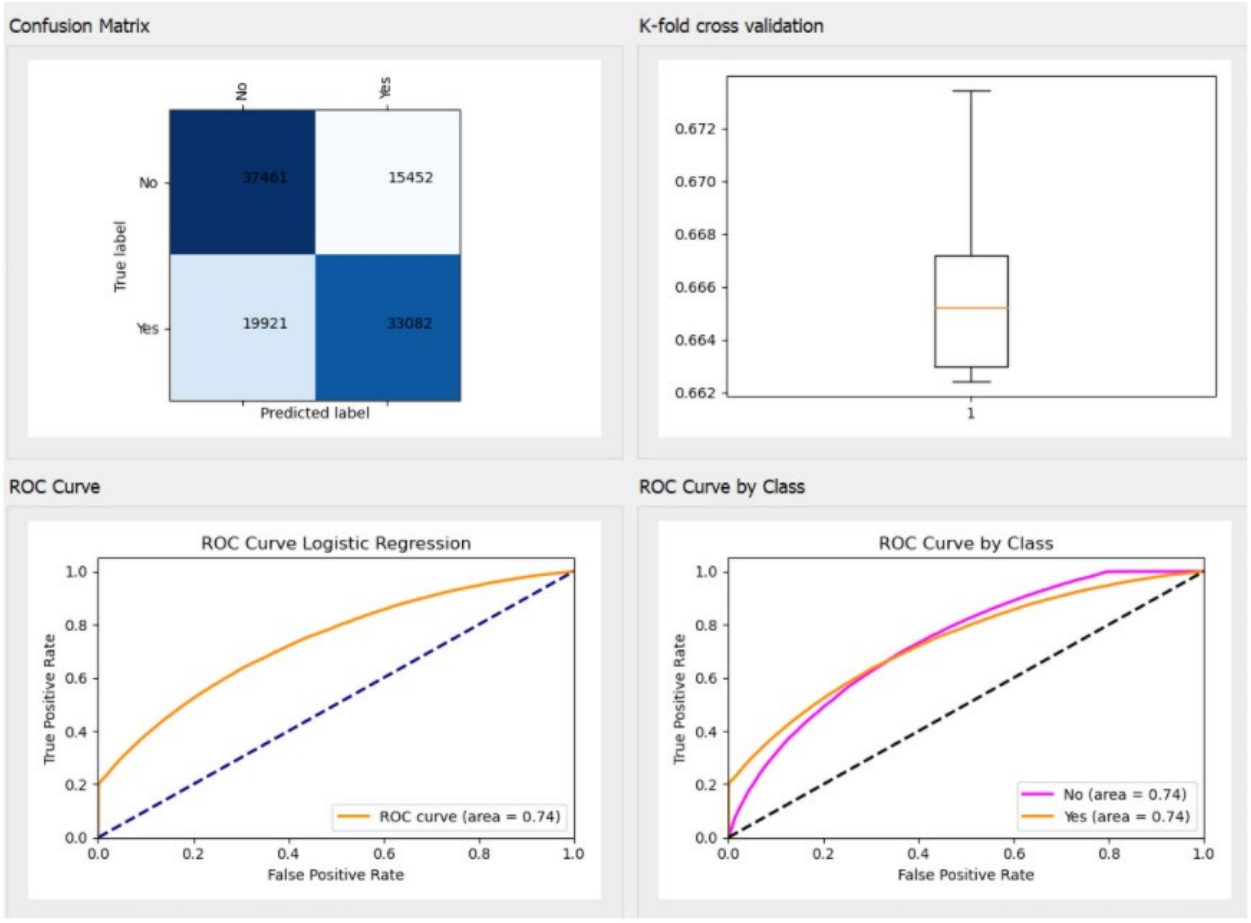
Random Forest:

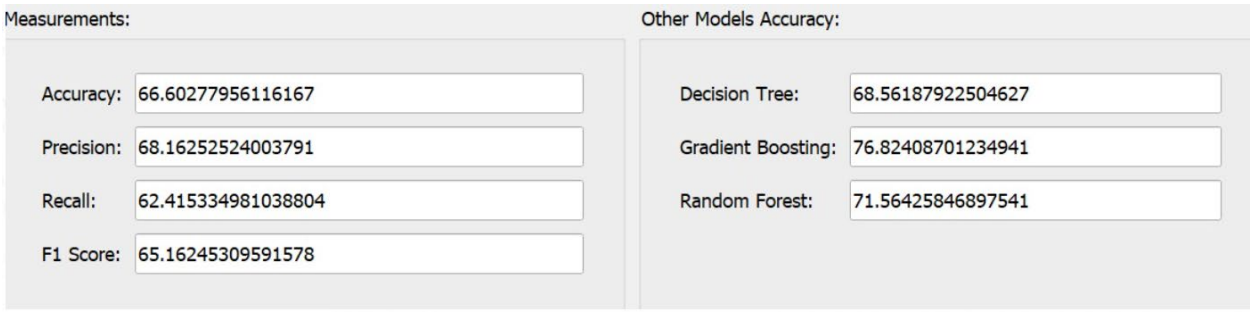
For random forest, we select random features to check for the best split attribute. And we use the max voting classifier to classify the data.



Logistic Regression:

Logistic Regression is a Statistical Learning technique. It is one of the Supervised Machine Learning methods used in Classification tasks. We used K-fold Cross-validation as one metric for this classification.

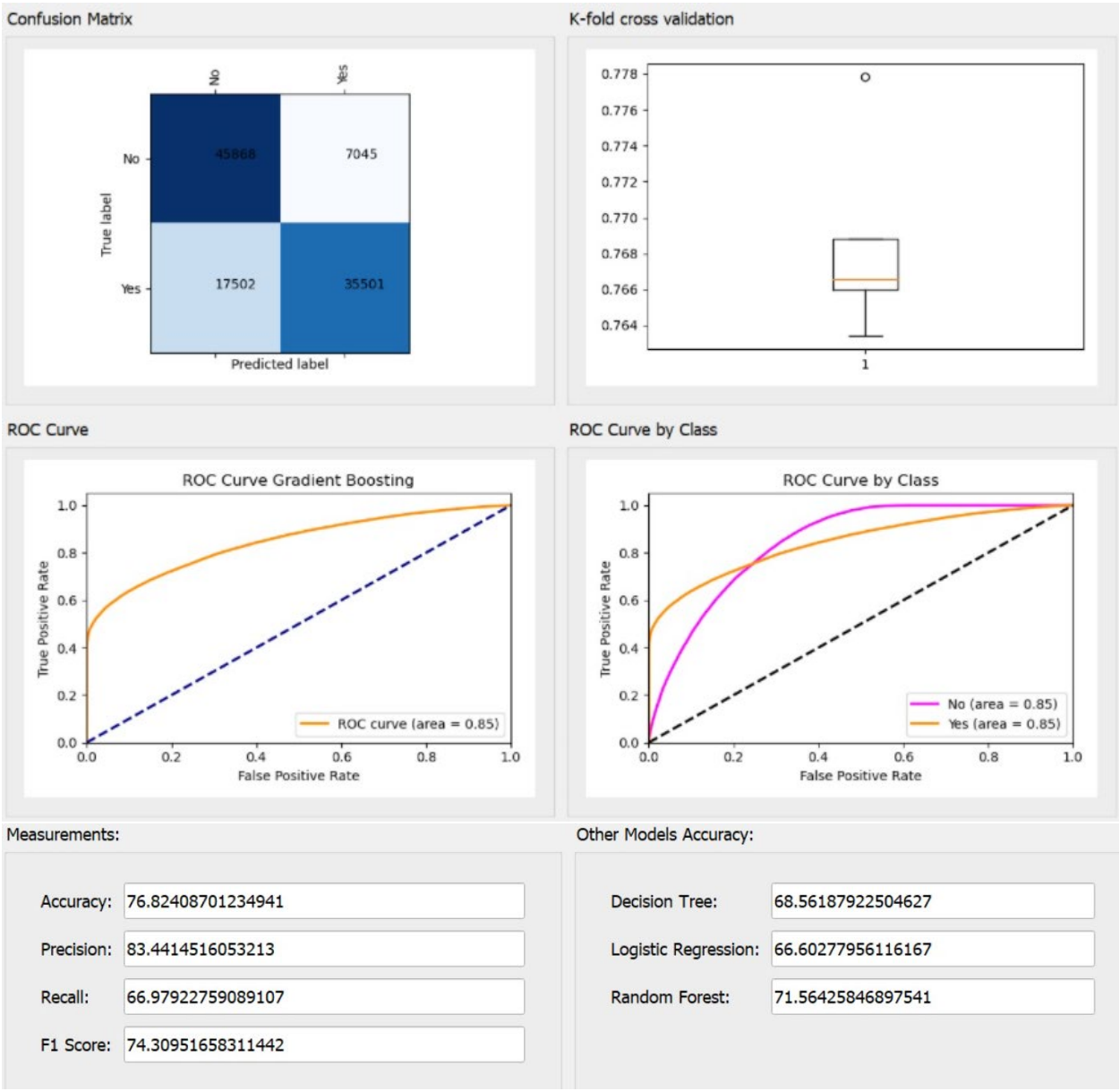




Gradient Boosting:

Gradient boosting is a machine learning technique used in classification and Regression. It relies on the intuition that the best possible next model minimizes the overall prediction error when compared with previous models. This extraordinary ensemble learning technique combines several weak learners into strong learners. This works by each model paying attention to its predecessor's mistakes.

The following shows the results of all the Algorithms run so far. We can see that Gradient boosting gives the best prediction with a high precision of 83.4% and an accuracy of 76.8%.



METRICS	RANDOM FOREST	LOGISTIC REGRESSION	GRADIENT BOOSTING	DECISION TREE
Accuracy	71.6%	66.6%	76.8%	68.6%
F1_score	69.8%	65.2%	74.3%	66.0%
Precision score	74.5%	68.2%	83.4%	71.9%

Recall	65.6%	62.4%	67.0%	61.0%

CONCLUSION

We have significantly improved the accuracy and precision of predicting a loan defaulter. We also found that Gradient Boosting gives the best prediction with high accuracy of 78.43. Further, we can improve the accuracy of this data by applying PCA or other feature selection techniques. We can also use other ensemble methods to get a better result.

REFERENCES

[1] 2019. LT Vehicle Loan Default Prediction. (2019). https://www.kaggle.com/mamtadhaker/lt-vehicle-loan-defaultpredictiondata_dictionary.csv

[2] T. Cover &P. Hart Mickey Haggblade.Nearest neighbor pattern classification, IEEE Transactions on Information Theory 2013.

[3] C.J.C. Burges, "A Tutorial on Support Vector Machines for Pattern Recognition," submitted to Data Mining and Knowledge Discovery, 1998.

[4] Lloyd, Stuart P. "Least squares quantization in PCM." Information Theory, IEEE Transactions on 28.2 (1982): 129-137.

[5] Nitesh V. Chawla, Kevin W. Bowyer. SMOTE: synthetic minority oversampling technique, Journal of Artificial Intelligence Research Archive Volume 16 Issue 1, January 2002

[6] Herve Abdi, Lynne J. Williams. Principal component analysis, WIREs Computational Statistics, 2010

[7] Aadhar, https://uidai.gov.in/

APPENDIX

1. Data Download

```
'''
Please install opendatasets package first
Please
'''

import opendatasets as od
od.download(r'https://www.kaggle.com/mamtadhaker/lt-vehicle-loan-default-prediction')
```

2. PREPROCESSING

```
import
pandas
as pd
        import numpy as np
        import seaborn as sns
        from scipy import stats
        import matplotlib.pyplot as plt
```

```
import os
import re
from sklearn.model_selection import train_test_split
import random

import scorecardpy as sc

# split train into train data and test data
# os.chdir(r'D:\GWU\Aihan\DATS 6103 Data Mining\Final Project\Code')


def split_data(inpath, target_name, test_size):
    df = pd.read_csv(inpath)
    y = df[target_name]
    #x = df1.loc[:,df1.columns!='loan_default']
    x=df.drop(target_name,axis=1)
    # set a random seed for the data, so that we could get the same train and test set
    random.seed(12345)
    X_train, X_test, y_train, y_test = train_test_split(x, y, test_size=test_size, random_state=1, stratify=y)

    training = pd.concat([X_train, y_train], axis=1)
    testing = pd.concat([X_test, y_test], axis=1)
    return training, testing


class PreProcessing():
    def __init__(self, df):
        self.Title = "Preprocessing Start"
        self.df = df
# checking the null value and drop the null value
    def Null_value(self):
        self.df.isnull().sum()
        self.df_new = self.df.dropna()
        return self.df_new

    # convert the format of 'AVERAGE.ACCT.AGE' and 'CREDIT.HISTORY.LENGTH' from 'xyrs xmon'
to numbers that represent month.
    def find_number(self, text):
        num = re.findall(r'[0-9]+',text)
        return int(num[0])*12 + int(num[1])

    def comvert_format(self, colname):
        colname_new = self.df[colname].apply(lambda x: self.find_number(x))
```

```
        self.df[colname] = colname_new


    # convert categorical string to numbers
    def convert_cate_to_num(self, colname_list):
        for colname in colname_list:
            self.df[colname] = self.df[colname].astype('category')
        cat_columns = self.df.select_dtypes(['category']).columns
        self.df[cat_columns] = self.df[cat_columns].apply(lambda x: x.cat.codes)

    def format_date(self, colname_list):
        for colname in colname_list:
            self.df[colname] = pd.to_datetime(self.df[colname], format = "%d-%m-
%y",infer_datetime_format=True)

    def format_age_disbursal(self):
        self.df['Date.of.Birth'] = self.df['Date.of.Birth'].where(self.df['Date.of.Birth'] < pd.Timestamp('now'),
                                            self.df['Date.of.Birth'] - np.timedelta64(100, 'Y'))
        self.df['Age'] = (pd.Timestamp('now') - self.df['Date.of.Birth']).astype('<m8[Y]').astype(int)
        self.df['Disbursal_months'] = ((pd.Timestamp('now') - self.df['DisbursalDate']) / np.timedelta64(1,
'M')).astype(int)


    def bin_cutpoint(self, target_name, colname_list):
        for colname in colname_list:
            bins_disbursed_amount = sc.woebin(self.df, y=target_name, x=[colname])
            sc.woebin_plot(bins_disbursed_amount)

            pd.concat(bins_disbursed_amount)
            list_break = pd.concat(bins_disbursed_amount).breaks.astype('float').to_list()
            list_break.insert(0, float('-inf'))
            # list_break

            self.df[colname] = pd.cut(self.df[colname], list_break)

    def delet_columns(self, delete_list):
        df_new = self.df.drop(delete_list, axis=1)
        return df_new

    def save_csv(self, outpath):
        self.df.to_csv(outpath)
```

```
'''
# format the date variable
training['Date.of.Birth'] = pd.to_datetime(training['Date.of.Birth']).dt.strftime('%d/%m/%Y')
training['DisbursalDate'] = pd.to_datetime(training['DisbursalDate'], format = "%d-%m-
%y",infer_datetime_format=True)
# covert Date of birth to age
def age(born):
    born_date = datetime.strptime(born, "%d/%m/%Y").date()
    today = datetime.now()
    return relativedelta(today, born_date).years
training['Age'] = training['Date.of.Birth'].apply(age)
training['Disbursal_months'] = ((pd.Timestamp('now') -
training['DisbursalDate'])/np.timedelta64(1,'M')).astype(int)
'''


if __name__ == "__main__":
    inpath = r'lt-vehicle-loan-default-prediction/train.csv'
    target_name = 'loan_default'
    outpath_train = r'lt-vehicle-loan-default-prediction/final_train.csv'
    outpath_test = r'lt-vehicle-loan-default-prediction/final_test.csv'
    training, testing = split_data(inpath, target_name, test_size=0.3)
    # checking the format of each variable
    print(training.dtypes)

    print(PreProcessing(training).Title)
    df_new = PreProcessing(training).Null_value()

    # There are 5375 missing value

    PreProcessing(df_new).comvert_format('AVERAGE.ACCT.AGE')
    PreProcessing(df_new).comvert_format('CREDIT.HISTORY.LENGTH')
    # comvert_format(training, 'AVERAGE.ACCT.AGE')
    # comvert_format(training, 'CREDIT.HISTORY.LENGTH')

    PreProcessing(df_new).convert_cate_to_num(['Employment.Type',
'PERFORM_CNS.SCORE.DESCRIPTION'])

    # Create Age and Disbursal_months
    PreProcessing(df_new).format_date(['Date.of.Birth', 'DisbursalDate'])
    PreProcessing(df_new).format_age_disbursal()
```

```
    df_all = PreProcessing(df_new).delet_columns(['UniqueID', 'Date.of.Birth', 'DisbursalDate',
'PERFORM_CNS.SCORE.DESCRIPTION', 'Employee_code_ID', 'Current_pincode_ID'])


    PreProcessing(df_all).save_csv(outpath_train)



'''
# FINISH FOR NOW
'''
```

3. MODELLING

```
import pandas as pd
import xlwt
from sklearn.preprocessing import LabelEncoder, OneHotEncoder, StandardScaler
from sklearn.pipeline import make_pipeline
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn.compose import make_column_transformer
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from imblearn.over_sampling import SMOTE
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve, auc, log_loss, brier_score_loss
from sklearn.calibration import calibration_curve
from sklearn.linear_model import LogisticRegression
from sklearn import feature_selection
from sklearn import metrics
from sklearn.preprocessing import label_binarize
from sklearn.model_selection import cross_val_predict
import matplotlib.pyplot as plt
import numpy as np
```

```
from sklearn.decomposition import PCA
import random
from sklearn.model_selection import train_test_split


'''
############################### Final Result ##############################
################################ loading data ################################
'''
import os
# os.chdir(r'D:\GWU\Aihan\DATS 6103 Data Mining\Final Project\Code\lt-vehicle-loan-default-prediction')
# read csv
df_original = pd.read_csv(r"lt-vehicle-loan-default-prediction\final_train.csv")
df_original.shape
df_original.info()

'''
################################ data cleaning ################################
'''
# # ## null value check
# df_original.isnull().sum()
# ds = df_original.dropna()
# # print("The total number of data-points after removing the rows with missing values are:", len(df))
# #
# # ## Checking for the duplicates
# ds.duplicated().sum()

df = df_original.drop(['loan_default'], axis=1)
y = df_original['loan_default']

sm = SMOTE(random_state=0)
df, y = sm.fit_resample(df, y)

'''
################################ Classification ################################
'''
F1 = []
model_names =[]
scalar = StandardScaler()

X_train_std = scalar.fit_transform(df) # normalizing the features
df_temp = pd.DataFrame(X_train_std)
df_temp.columns = df.columns
```

```
y = pd.DataFrame({'loan_default': y})
X_train, X_test, y_train, y_test = train_test_split(df_temp, y, test_size=0.3, random_state=1)

testing = pd.concat([X_test, y_test], axis=1)
testing.to_csv(r"final_test2.csv", index=False)

'''
################### Modelling, please comment this part if necessary ######################
'''
'''
######## Logistic - scale##############
'''
lr = LogisticRegression(solver='liblinear')

lr.fit(X_train, y_train)
y_pred_lr = lr.predict(X_test)

accuracy_testing=accuracy_score(y_test,y_pred_lr)
f1_score_testing = f1_score(y_test,y_pred_lr)
precision_score_testing = precision_score(y_test,y_pred_lr)
recall_score_testing = recall_score(y_test,y_pred_lr)

print('################Logistic Regression')
print("Accuracy")
print("Testing")
print(accuracy_testing)

print("F1_score")
print("Testing")
print(f1_score_testing)

print("Precision_score")
print("Testing")
print(precision_score_testing)

print("Recall")
print("Testing")
print(recall_score_testing)

import pickle
filename = 'lr_finalized_model2.sav'
pickle.dump(lr, open(filename, 'wb'))
```

```
# filename2 = 'lr_finalized_model2.sav'
# clf_entropy = pickle.load(open(filename2, 'rb'))
# y_pred_entropy = clf_entropy.predict(X_test)
# accuracy_score = accuracy_score(y_test, y_pred_entropy)
# f1_score= f1_score(y_test,y_pred_entropy)
# precision = precision_score(y_test,y_pred_entropy)
# recall = recall_score(y_test,y_pred_entropy)
#
# print("Accuracy")
# print(accuracy_score)
# print("F1_score")
# print(f1_score)
# print("Precision_score")
# print(precision)
# print("Recall")
# print(recall)



dt =
DecisionTreeClassifier(max_depth=5,min_samples_leaf=0.01,criterion='gini',class_weight='balanced',random_state=1
23)

dt.fit(X_train, y_train)
y_pred_lr = dt.predict(X_test)

accuracy_testing=accuracy_score(y_test,y_pred_lr)
f1_score_testing = f1_score(y_test,y_pred_lr)
precision_score_testing = precision_score(y_test,y_pred_lr)
recall_score_testing = recall_score(y_test,y_pred_lr)

print('##################Decision Tree')
print("Accuracy")
print(accuracy_testing)

print("F1_score")
print(f1_score_testing)

print("Precision_score")
print(precision_score_testing)

print("Recall")
print(recall_score_testing)
```

```
import pickle
# filename = 'dt_finalized_model2.sav'
# pickle.dump(dt, open(filename, 'wb'))
# to graph the tree
from pydotplus import graph_from_dot_data
from sklearn.tree import export_graphviz
dot_data = export_graphviz(dt, filled=True, rounded=True, class_names=["No","Yes"],
feature_names=X_test.columns, out_file=None)
graph = graph_from_dot_data(dot_data)
graph.write_pdf("decision_tree_entropy.pdf")
```

4.GUI

```
import sys,os
#os.chdir("/Users/utkarshvirendranigam/Desktop/Homework/Project")
# required_packages=["PyQt5","re",
"scipy","itertools","random","matplotlib","pandas","numpy","sklearn","pydotplus","collections","warnings","seaborn"]

#print(os.getcwd())
# for my_package in required_packages:
#     try:
#         command_string="conda install "+ my_package+ " --yes"
#         os.system(command_string)
#     except:
#         count=1


from PyQt5.QtWidgets import (QMainWindow, QApplication, QWidget, QPushButton, QAction, QComboBox, QLabel,
                             QGridLayout, QCheckBox, QGroupBox, QVBoxLayout, QHBoxLayout, QLineEdit, QPlainTextEdit)

from PyQt5.QtGui import QIcon
from PyQt5.QtCore import pyqtSlot, QRect
from PyQt5.QtCore import pyqtSignal
from PyQt5.QtCore import Qt

# from scipy import interp
from itertools import cycle, combinations
import random
from PyQt5.QtWidgets import QDialog, QVBoxLayout, QSizePolicy, QFormLayout, QRadioButton, QScrollArea,
QMessageBox
```

```
from PyQt5.QtGui import QPixmap

from matplotlib.backends.backend_qt5agg import FigureCanvasQTAgg as FigureCanvas
from matplotlib.backends.backend_qt5agg import NavigationToolbar2QT as NavigationToolbar
from matplotlib.figure import Figure
import pandas as pd
import numpy as np
import pickle
from numpy.polynomial.polynomial import polyfit

from sklearn.preprocessing import LabelEncoder, OneHotEncoder, StandardScaler
from sklearn.pipeline import make_pipeline
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn.compose import make_column_transformer
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve, auc, log_loss, brier_score_loss
from sklearn.calibration import calibration_curve
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import GradientBoostingClassifier
from sklearn import feature_selection
from sklearn import metrics
from sklearn.preprocessing import label_binarize
from sklearn.model_selection import cross_val_predict

# Libraries to display decision tree
from pydotplus import graph_from_dot_data
import collections
from sklearn.tree import export_graphviz
import webbrowser

import warnings
warnings.filterwarnings("ignore")
import matplotlib.pyplot as plt
from Preprocessing import PreProcessing
import random
import seaborn as sns
```

```
#%%-------------------------------------------------------------------------
import os
os.environ["PATH"] += os.pathsep + 'C:\\Program Files (x86)\\graphviz-2.38\\release\\bin'
#%%-------------------------------------------------------------------------

#::--------------------------------
# Deafault font size for all the windows
#::--------------------------------
font_size_window = 'font-size:18px'


class DecisionTree(QMainWindow):
    #::-----------------------------------------------------------------------------
    # Implementation of Random Forest Classifier using the happiness dataset
    # the methods in this class are
    #       _init_ : initialize the class
    #       initUi : creates the canvas and all the elements in the canvas
    #       update : populates the elements of the canvas base on the parametes
    #                chosen by the user
    #::-----------------------------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        super(DecisionTree, self).__init__()
        self.Title = "Decision Tree Classifier"
        self.initUi()

    def initUi(self):
    #::--------------------------------------------------------------------
    #  Create the canvas and all the element to create a dashboard with
    #  all the necessary elements to present the results from the algorithm
    #  The canvas is divided using a  grid loyout to facilitate the drawing
    #  of the elements
    #::--------------------------------------------------------------------

        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)

        self.main_widget = QWidget(self)

        self.layout = QGridLayout(self.main_widget)
```

```
self.groupBox1 = QGroupBox('Decision Tree Features')
self.groupBox1Layout= QGridLayout()
self.groupBox1.setLayout(self.groupBox1Layout)

self.feature0 = QCheckBox(features_list[0],self)
self.feature1 = QCheckBox(features_list[1],self)
self.feature2 = QCheckBox(features_list[2], self)
self.feature3 = QCheckBox(features_list[3], self)
self.feature4 = QCheckBox(features_list[4],self)
self.feature5 = QCheckBox(features_list[5],self)
self.feature6 = QCheckBox(features_list[6], self)
self.feature7 = QCheckBox(features_list[7], self)
self.feature8 = QCheckBox(features_list[8], self)
self.feature9 = QCheckBox(features_list[9], self)
self.feature10 = QCheckBox(features_list[10], self)
self.feature11 = QCheckBox(features_list[11], self)
self.feature12 = QCheckBox(features_list[12], self)
self.feature13 = QCheckBox(features_list[13], self)
self.feature14 = QCheckBox(features_list[14], self)
self.feature15 = QCheckBox(features_list[15], self)
self.feature16 = QCheckBox(features_list[16], self)
self.feature17 = QCheckBox(features_list[17], self)
self.feature18 = QCheckBox(features_list[18], self)
self.feature19 = QCheckBox(features_list[19], self)
self.feature20 = QCheckBox(features_list[20], self)
self.feature21 = QCheckBox(features_list[21], self)
self.feature22 = QCheckBox(features_list[22], self)
self.feature23 = QCheckBox(features_list[23], self)
self.feature24 = QCheckBox(features_list[24], self)
self.feature25 = QCheckBox(features_list[25], self)
self.feature26 = QCheckBox(features_list[26], self)
self.feature27 = QCheckBox(features_list[27], self)
self.feature28 = QCheckBox(features_list[28], self)
self.feature29 = QCheckBox(features_list[29], self)
self.feature30 = QCheckBox(features_list[30], self)
self.feature31 = QCheckBox(features_list[31], self)
self.feature32 = QCheckBox(features_list[32], self)
self.feature33 = QCheckBox(features_list[33], self)
self.feature34 = QCheckBox(features_list[34], self)
self.feature35 = QCheckBox(features_list[35], self)

self.feature0.setChecked(True)
self.feature1.setChecked(True)
```

```
self.feature2.setChecked(True)
self.feature3.setChecked(True)
self.feature4.setChecked(True)
self.feature5.setChecked(True)
self.feature6.setChecked(True)
self.feature7.setChecked(True)
self.feature8.setChecked(True)
self.feature9.setChecked(True)
self.feature10.setChecked(True)
self.feature11.setChecked(True)
self.feature12.setChecked(True)
self.feature13.setChecked(True)
self.feature14.setChecked(True)
self.feature15.setChecked(True)
self.feature16.setChecked(True)
self.feature17.setChecked(True)
self.feature18.setChecked(True)
self.feature19.setChecked(True)
self.feature20.setChecked(True)
self.feature21.setChecked(True)
self.feature22.setChecked(True)
self.feature23.setChecked(True)
self.feature24.setChecked(True)
self.feature25.setChecked(True)
self.feature26.setChecked(True)
self.feature27.setChecked(True)
self.feature28.setChecked(True)
self.feature29.setChecked(True)
self.feature30.setChecked(True)
self.feature31.setChecked(True)
self.feature32.setChecked(True)
self.feature33.setChecked(True)
self.feature34.setChecked(True)
self.feature35.setChecked(True)


self.lblPercentTest = QLabel('Percentage for Test :')
self.lblPercentTest.adjustSize()

self.txtPercentTest = QLineEdit(self)
self.txtPercentTest.setText("30")

self.lblMaxDepth = QLabel('Maximun Depth :')
```

```
self.txtMaxDepth = QLineEdit(self)
self.txtMaxDepth.setText("3")

self.btnExecute = QPushButton("Run Model")
self.btnExecute.setGeometry(QRect(60, 500, 75, 23))
self.btnExecute.clicked.connect(self.update)

self.btnDTFigure = QPushButton("View Tree")
self.btnDTFigure.setGeometry(QRect(60, 500, 75, 23))
self.btnDTFigure.clicked.connect(self.view_tree)

# We create a checkbox for each feature

self.groupBox1Layout.addWidget(self.feature0, 0, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature1, 0, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature2, 1, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature3, 1, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature4, 2, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature5, 2, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature6, 3, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature7, 3, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature8, 4, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature9, 4, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature10, 5, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature11, 5, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature12, 6, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature13, 6, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature14, 7, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature15, 7, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature16, 8, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature17, 8, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature18, 9, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature19, 9, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature20, 10, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature21, 10, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature22, 11, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature23, 11, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature24, 12, 0, 1, 1)

self.groupBox1Layout.addWidget(self.lblPercentTest, 19, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtPercentTest, 19, 1, 1, 1)
self.groupBox1Layout.addWidget(self.lblMaxDepth, 20, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtMaxDepth, 20, 1, 1, 1)
```

```
self.groupBox1Layout.addWidget(self.btnExecute, 21, 0, 1, 1)
self.groupBox1Layout.addWidget(self.btnDTFigure, 21, 1, 1, 1)


self.groupBox2 = QGroupBox('Measurements:')

self.groupBox2Layout = QVBoxLayout()
self.groupBox2.setLayout(self.groupBox2Layout)
# self.groupBox2.setMinimumSize(400, 100)

self.current_model_summary = QWidget(self)
self.current_model_summary.layout = QFormLayout(self.current_model_summary)
self.txtCurrentAccuracy = QLineEdit()
self.txtCurrentPrecision = QLineEdit()
self.txtCurrentRecall = QLineEdit()
self.txtCurrentF1score = QLineEdit()

self.current_model_summary.layout.addRow('Accuracy:', self.txtCurrentAccuracy)
self.current_model_summary.layout.addRow('Precision:', self.txtCurrentPrecision)
self.current_model_summary.layout.addRow('Recall:', self.txtCurrentRecall)
self.current_model_summary.layout.addRow('F1 Score:', self.txtCurrentF1score)

self.groupBox2Layout.addWidget(self.current_model_summary)

self.groupBox3 = QGroupBox('Other Models Accuracy:')
self.groupBox3Layout = QVBoxLayout()
self.groupBox3.setLayout(self.groupBox3Layout)
self.other_models = QWidget(self)
self.other_models.layout = QFormLayout(self.other_models)
self.txtAccuracy_lr = QLineEdit()
self.txtAccuracy_gb = QLineEdit()
self.txtAccuracy_rf = QLineEdit()
self.other_models.layout.addRow('Logistic:', self.txtAccuracy_lr)
self.other_models.layout.addRow('Random Forest:', self.txtAccuracy_rf)
self.other_models.layout.addRow('Gradient Boosting:', self.txtAccuracy_gb)

self.groupBox3Layout.addWidget(self.other_models)

#::-------------------------------------
# Graphic 1 : Confusion Matrix
#::-------------------------------------

self.fig = Figure()
```

```
self.ax1 = self.fig.add_subplot(111)
self.axes=[self.ax1]
self.canvas = FigureCanvas(self.fig)

self.canvas.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas.updateGeometry()

self.groupBoxG1 = QGroupBox('Confusion Matrix')
self.groupBoxG1Layout= QVBoxLayout()
self.groupBoxG1.setLayout(self.groupBoxG1Layout)

self.groupBoxG1Layout.addWidget(self.canvas)

#::------------------------------------------------
# Graphic 2 : ROC Curve
#::------------------------------------------------

self.fig2 = Figure()
self.ax2 = self.fig2.add_subplot(111)
self.axes2 = [self.ax2]
self.canvas2 = FigureCanvas(self.fig2)

self.canvas2.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas2.updateGeometry()

self.groupBoxG2 = QGroupBox('ROC Curve')
self.groupBoxG2Layout = QVBoxLayout()
self.groupBoxG2.setLayout(self.groupBoxG2Layout)

self.groupBoxG2Layout.addWidget(self.canvas2)

#::------------------------------------------------
# Graphic 3 : Importance of Features
#::------------------------------------------------

self.fig3 = Figure()
self.ax3 = self.fig3.add_subplot(111)
self.axes3 = [self.ax3]
self.canvas3 = FigureCanvas(self.fig3)

self.canvas3.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)
```

```
        self.canvas3.updateGeometry()

        self.groupBoxG3 = QGroupBox('Importance of Features')
        self.groupBoxG3Layout = QVBoxLayout()
        self.groupBoxG3.setLayout(self.groupBoxG3Layout)
        self.groupBoxG3Layout.addWidget(self.canvas3)

        #::------------------------------------------------
        # Graphic 4 : ROC Curve by class
        #::------------------------------------------------

        self.fig4 = Figure()
        self.ax4 = self.fig4.add_subplot(111)
        self.axes4 = [self.ax4]
        self.canvas4 = FigureCanvas(self.fig4)

        self.canvas4.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

        self.canvas4.updateGeometry()

        self.groupBoxG4 = QGroupBox('ROC Curve by Class')
        self.groupBoxG4Layout = QVBoxLayout()
        self.groupBoxG4.setLayout(self.groupBoxG4Layout)
        self.groupBoxG4Layout.addWidget(self.canvas4)

        #::------------------------------------------------
        # End of graphs
        #::------------------------------------------------

        self.layout.addWidget(self.groupBox1, 0, 0, 3, 2)
        self.layout.addWidget(self.groupBoxG1, 0, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG3, 0, 3, 1, 1)
        self.layout.addWidget(self.groupBoxG2, 1, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG4, 1, 3, 1, 1)
        self.layout.addWidget(self.groupBox2, 2, 2, 1, 1)
        self.layout.addWidget(self.groupBox3, 2, 3, 1, 1)

        self.setCentralWidget(self.main_widget)
        self.resize(1800, 1200)
        self.show()

    def update(self):
```

```
'''
Random Forest Classifier
We pupulate the dashboard using the parametres chosen by the user
The parameters are processed to execute in the skit-learn Random Forest algorithm
  then the results are presented in graphics and reports in the canvas
:return:None
'''

# processing the parameters

self.list_corr_features = pd.DataFrame([])
if self.feature0.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[0]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[0]]],axis=1)

if self.feature1.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[1]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[1]]],axis=1)

if self.feature2.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[2]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[2]]],axis=1)

if self.feature3.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[3]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[3]]],axis=1)

if self.feature4.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[4]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[4]]],axis=1)

if self.feature5.isChecked():
    if len(self.list_corr_features) == 0:
```

```
            self.list_corr_features = df[features_list[5]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[5]]],axis=1)

    if self.feature6.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[6]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[6]]],axis=1)

    if self.feature7.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[7]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[7]]],axis=1)

    if self.feature8.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[8]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[8]]],axis=1)

    if self.feature9.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[9]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[9]]],axis=1)

    if self.feature10.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[10]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[10]]], axis=1)

    if self.feature11.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[11]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[11]]], axis=1)

    if self.feature12.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[12]]
```

```
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[12]]], axis=1)

if self.feature13.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[13]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[13]]], axis=1)

if self.feature14.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[14]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[14]]], axis=1)

if self.feature15.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[15]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[15]]], axis=1)

if self.feature16.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[16]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[16]]], axis=1)

if self.feature17.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[17]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[17]]], axis=1)

if self.feature18.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[18]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[18]]], axis=1)

if self.feature19.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[19]]
    else:
```

```
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[19]]], axis=1)

if self.feature20.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[20]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[20]]],axis=1)

if self.feature21.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[21]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[21]]],axis=1)

if self.feature22.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[22]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[22]]],axis=1)

if self.feature23.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[23]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[23]]],axis=1)

if self.feature24.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[24]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[24]]],axis=1)

if self.feature25.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[25]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[25]]],axis=1)

if self.feature26.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[26]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[26]]],axis=1)
```

```
if self.feature27.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[27]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[27]]],axis=1)

if self.feature28.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[28]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[28]]],axis=1)

if self.feature29.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[29]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[29]]],axis=1)

if self.feature30.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[30]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[30]]], axis=1)

if self.feature31.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[31]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[31]]], axis=1)

if self.feature32.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[32]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[32]]], axis=1)

if self.feature33.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[33]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[33]]], axis=1)
```

```
if self.feature34.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[34]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[34]]], axis=1)

if self.feature35.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[35]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[35]]], axis=1)


vtest_per = float(self.txtPercentTest.text())
vmax_depth = float(self.txtMaxDepth.text())
# Clear the graphs to populate them with the new information

self.ax1.clear()
self.ax2.clear()
self.ax3.clear()
self.ax4.clear()
# self.txtResults.clear()
# self.txtResults.setUndoRedoEnabled(False)

vtest_per = vtest_per / 100

# ------------------------------------------------------------------------
filename = 'dt_finalized_model2.sav'
self.clf_entropy = pickle.load(open(filename, 'rb'))
y_test = y
X_test= X
#
# scalar = StandardScaler()
# X_test = scalar.fit_transform(X)

# predicton on test using entropy
y_pred_entropy = self.clf_entropy.predict(X_test)
# confusion matrix for RandomForest
conf_matrix = confusion_matrix(y_test, y_pred_entropy)


# accuracy score
```

```
self.ff_accuracy_score = accuracy_score(y_test, y_pred_entropy) * 100
self.txtCurrentAccuracy.setText(str(self.ff_accuracy_score))

# precision score

self.ff_precision_score = precision_score(y_test, y_pred_entropy) * 100
self.txtCurrentPrecision.setText(str(self.ff_precision_score))

# recall score

self.ff_recall_score = recall_score(y_test, y_pred_entropy) * 100
self.txtCurrentRecall.setText(str(self.ff_recall_score))

# f1_score

self.ff_f1_score = f1_score(y_test, y_pred_entropy) * 100
self.txtCurrentF1score.setText(str(self.ff_f1_score))

#::------------------------------------
##  Ghaph1 :
##  Confusion Matrix
#::------------------------------------
class_names1 = ['', 'No', 'Yes']

self.ax1.matshow(conf_matrix, cmap=plt.cm.get_cmap('Blues', 14))
self.ax1.set_yticklabels(class_names1)
self.ax1.set_xticklabels(class_names1, rotation=90)
self.ax1.set_xlabel('Predicted label')
self.ax1.set_ylabel('True label')

for i in range(len(class_names)):
    for j in range(len(class_names)):
        y_pred_score = self.clf_entropy.predict_proba(X_test)
        self.ax1.text(j, i, str(conf_matrix[i][j]))

self.fig.tight_layout()
self.fig.canvas.draw_idle()

#::----------------------------------------
## Graph 2 - ROC Curve
#::----------------------------------------
y_test_bin = pd.get_dummies(y_test).to_numpy()
n_classes = y_test_bin.shape[1]
```

```
# From the sckict learn site
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
fpr = dict()
tpr = dict()
roc_auc = dict()
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test_bin[:, i], y_pred_score[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])

# Compute micro-average ROC curve and ROC area
fpr["micro"], tpr["micro"], _ = roc_curve(y_test_bin.ravel(), y_pred_score.ravel())

roc_auc["micro"] = auc(fpr["micro"], tpr["micro"])

lw = 2
self.ax2.plot(fpr[1], tpr[1], color='darkorange',
             lw=lw, label='ROC curve (area = %0.2f)' % roc_auc[1])
self.ax2.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
self.ax2.set_xlim([0.0, 1.0])
self.ax2.set_ylim([0.0, 1.05])
self.ax2.set_xlabel('False Positive Rate')
self.ax2.set_ylabel('True Positive Rate')
self.ax2.set_title('ROC Curve Random Forest')
self.ax2.legend(loc="lower right")

self.fig2.tight_layout()
self.fig2.canvas.draw_idle()

########################################
# Graph - 3 Feature Importances
########################################
# get feature importances
importances = self.clf_entropy.feature_importances_

# convert the importances into one-dimensional 1darray with corresponding df column names as axis labels
f_importances = pd.Series(importances, self.list_corr_features.columns)

# sort the array in descending order of the importances, only show the first 10
f_importances.sort_values(ascending=False, inplace=True)
f_importances = f_importances[0:10]
X_Features = f_importances.index
y_Importance = list(f_importances)
```

```
self.ax3.barh(X_Features, y_Importance)
self.ax3.set_aspect('auto')

# show the plot
self.fig3.tight_layout()
self.fig3.canvas.draw_idle()

#::--------------------------------------------------------
# Graph 4 - ROC Curve by Class
#::--------------------------------------------------------
str_classes = ['No','Yes']
colors = cycle(['magenta', 'darkorange'])
for i, color in zip(range(n_classes), colors):
    self.ax4.plot(fpr[i], tpr[i], color=color, lw=lw,
                  label='{0} (area = {1:0.2f})'
                        ''.format(str_classes[i], roc_auc[i]))

self.ax4.plot([0, 1], [0, 1], 'k--', lw=lw)
self.ax4.set_xlim([0.0, 1.0])
self.ax4.set_ylim([0.0, 1.05])
self.ax4.set_xlabel('False Positive Rate')
self.ax4.set_ylabel('True Positive Rate')
self.ax4.set_title('ROC Curve by Class')
self.ax4.legend(loc="lower right")

# show the plot
self.fig4.tight_layout()
self.fig4.canvas.draw_idle()

#::--------------------------------------------------------
# Other Models Comparison
#::--------------------------------------------------------

filename2 = 'lr_finalized_model2.sav'
self.other_clf_lr = pickle.load(open(filename2, 'rb'))
y_pred_lr = self.other_clf_lr.predict(X_test)
self.accuracy_lr = accuracy_score(y_test, y_pred_lr) * 100
self.txtAccuracy_lr.setText(str(self.accuracy_lr))

filename3 = 'rf_finalized_model2.sav'
self.other_clf_rf = pickle.load(open(filename3, 'rb'))
y_pred_rf = self.other_clf_rf.predict(X_test)
```

```
        self.accuracy_rf = accuracy_score(y_test, y_pred_rf) * 100
        self.txtAccuracy_rf.setText(str(self.accuracy_rf))

        filename4 = 'gb_finalized_model2.sav'
        self.other_clf_gb = pickle.load(open(filename4, 'rb'))
        y_pred_gb = self.other_clf_gb.predict(X_test)
        self.accuracy_gb = accuracy_score(y_test, y_pred_gb) * 100
        self.txtAccuracy_gb.setText(str(self.accuracy_gb))


    def view_tree(self):
        '''
        Executes the graphviz to create a tree view of the information
         then it presents the graphic in a pdf formt using webbrowser
        :return:None
        '''

        webbrowser.open_new(r'decision_tree_entropy.pdf')

class RandomForest(QMainWindow):
    #::----------------------------------------------------------------------------
    # Implementation of Random Forest Classifier using the happiness dataset
    # the methods in this class are
    #       _init_ : initialize the class
    #       initUi : creates the canvas and all the elements in the canvas
    #       update : populates the elements of the canvas base on the parametes
    #               chosen by the user
    #::----------------------------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        super(RandomForest, self).__init__()
        self.Title = "Random Forest Classifier"
        self.initUi()

    def initUi(self):
    #::--------------------------------------------------------------------
    #  Create the canvas and all the element to create a dashboard with
    #  all the necessary elements to present the results from the algorithm
    #  The canvas is divided using a  grid loyout to facilitate the drawing
    #  of the elements
    #::--------------------------------------------------------------------
```

```
self.setWindowTitle(self.Title)
self.setStyleSheet(font_size_window)

self.main_widget = QWidget(self)

self.layout = QGridLayout(self.main_widget)

self.groupBox1 = QGroupBox('Random Forest Features')
self.groupBox1Layout= QGridLayout()
self.groupBox1.setLayout(self.groupBox1Layout)

self.feature0 = QCheckBox(features_list[0], self)
self.feature1 = QCheckBox(features_list[1], self)
self.feature2 = QCheckBox(features_list[2], self)
self.feature3 = QCheckBox(features_list[3], self)
self.feature4 = QCheckBox(features_list[4], self)
self.feature5 = QCheckBox(features_list[5], self)
self.feature6 = QCheckBox(features_list[6], self)
self.feature7 = QCheckBox(features_list[7], self)
self.feature8 = QCheckBox(features_list[8], self)
self.feature9 = QCheckBox(features_list[9], self)
self.feature10 = QCheckBox(features_list[10], self)
self.feature11 = QCheckBox(features_list[11], self)
self.feature12 = QCheckBox(features_list[12], self)
self.feature13 = QCheckBox(features_list[13], self)
self.feature14 = QCheckBox(features_list[14], self)
self.feature15 = QCheckBox(features_list[15], self)
self.feature16 = QCheckBox(features_list[16], self)
self.feature17 = QCheckBox(features_list[17], self)
self.feature18 = QCheckBox(features_list[18], self)
self.feature19 = QCheckBox(features_list[19], self)
self.feature20 = QCheckBox(features_list[20], self)
self.feature21 = QCheckBox(features_list[21], self)
self.feature22 = QCheckBox(features_list[22], self)
self.feature23 = QCheckBox(features_list[23], self)
self.feature24 = QCheckBox(features_list[24], self)
self.feature25 = QCheckBox(features_list[25], self)
self.feature26 = QCheckBox(features_list[26], self)
self.feature27 = QCheckBox(features_list[27], self)
self.feature28 = QCheckBox(features_list[28], self)
self.feature29 = QCheckBox(features_list[29], self)
self.feature30 = QCheckBox(features_list[30], self)
self.feature31 = QCheckBox(features_list[31], self)
```

```
self.feature32 = QCheckBox(features_list[32], self)
self.feature33 = QCheckBox(features_list[33], self)
self.feature34 = QCheckBox(features_list[34], self)
self.feature35 = QCheckBox(features_list[35], self)

self.feature0.setChecked(True)
self.feature1.setChecked(True)
self.feature2.setChecked(True)
self.feature3.setChecked(True)
self.feature4.setChecked(True)
self.feature5.setChecked(True)
self.feature6.setChecked(True)
self.feature7.setChecked(True)
self.feature8.setChecked(True)
self.feature9.setChecked(True)
self.feature10.setChecked(True)
self.feature11.setChecked(True)
self.feature12.setChecked(True)
self.feature13.setChecked(True)
self.feature14.setChecked(True)
self.feature15.setChecked(True)
self.feature16.setChecked(True)
self.feature17.setChecked(True)
self.feature18.setChecked(True)
self.feature19.setChecked(True)
self.feature20.setChecked(True)
self.feature21.setChecked(True)
self.feature22.setChecked(True)
self.feature23.setChecked(True)
self.feature24.setChecked(True)
self.feature25.setChecked(True)
self.feature26.setChecked(True)
self.feature27.setChecked(True)
self.feature28.setChecked(True)
self.feature29.setChecked(True)
self.feature30.setChecked(True)
self.feature31.setChecked(True)
self.feature32.setChecked(True)
self.feature33.setChecked(True)
self.feature34.setChecked(True)
self.feature35.setChecked(True)

self.lblPercentTest = QLabel('Percentage for Test :')
```

```
self.lblPercentTest.adjustSize()

self.txtPercentTest = QLineEdit(self)
self.txtPercentTest.setText("30")

self.lblMaxDepth = QLabel('Maximun Depth :')
self.txtMaxDepth = QLineEdit(self)
self.txtMaxDepth.setText("3")

self.btnExecute = QPushButton("Run Model")
self.btnExecute.setGeometry(QRect(60, 500, 75, 23))
self.btnExecute.clicked.connect(self.update)



# We create a checkbox for each feature

self.groupBox1Layout.addWidget(self.feature0, 0, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature1, 0, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature2, 1, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature3, 1, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature4, 2, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature5, 2, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature6, 3, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature7, 3, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature8, 4, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature9, 4, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature10, 5, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature11, 5, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature12, 6, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature13, 6, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature14, 7, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature15, 7, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature16, 8, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature17, 8, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature18, 9, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature19, 9, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature20, 10, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature21, 10, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature22, 11, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature23, 11, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature24, 12, 0, 1, 1)
```

```
self.groupBox1Layout.addWidget(self.lblPercentTest, 19, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtPercentTest, 19, 1, 1, 1)
self.groupBox1Layout.addWidget(self.lblMaxDepth, 20, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtMaxDepth, 20, 1, 1, 1)
self.groupBox1Layout.addWidget(self.btnExecute, 21, 0, 1, 1)



self.groupBox2 = QGroupBox('Measurements:')

self.groupBox2Layout = QVBoxLayout()
self.groupBox2.setLayout(self.groupBox2Layout)
# self.groupBox2.setMinimumSize(400, 100)

self.current_model_summary = QWidget(self)
self.current_model_summary.layout = QFormLayout(self.current_model_summary)
self.txtCurrentAccuracy = QLineEdit()
self.txtCurrentPrecision = QLineEdit()
self.txtCurrentRecall = QLineEdit()
self.txtCurrentF1score = QLineEdit()

self.current_model_summary.layout.addRow('Accuracy:', self.txtCurrentAccuracy)
self.current_model_summary.layout.addRow('Precision:', self.txtCurrentPrecision)
self.current_model_summary.layout.addRow('Recall:', self.txtCurrentRecall)
self.current_model_summary.layout.addRow('F1 Score:', self.txtCurrentF1score)

self.groupBox2Layout.addWidget(self.current_model_summary)

self.groupBox3 = QGroupBox('Other Models Accuracy:')
self.groupBox3Layout = QVBoxLayout()
self.groupBox3.setLayout(self.groupBox3Layout)
self.other_models = QWidget(self)
self.other_models.layout = QFormLayout(self.other_models)
self.txtAccuracy_lr = QLineEdit()
self.txtAccuracy_gb = QLineEdit()
self.txtAccuracy_dt = QLineEdit()

self.other_models.layout.addRow('Logistic:', self.txtAccuracy_lr)
self.other_models.layout.addRow('Gradient Boosting:', self.txtAccuracy_gb)
self.other_models.layout.addRow('Decision tree:', self.txtAccuracy_dt)



self.groupBox3Layout.addWidget(self.other_models)
```

```
#::-------------------------------------
# Graphic 1 : Confusion Matrix
#::-------------------------------------

self.fig = Figure()
self.ax1 = self.fig.add_subplot(111)
self.axes=[self.ax1]
self.canvas = FigureCanvas(self.fig)

self.canvas.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas.updateGeometry()

self.groupBoxG1 = QGroupBox('Confusion Matrix')
self.groupBoxG1Layout= QVBoxLayout()
self.groupBoxG1.setLayout(self.groupBoxG1Layout)

self.groupBoxG1Layout.addWidget(self.canvas)

#::-----------------------------------------------
# Graphic 2 : ROC Curve
#::-----------------------------------------------

self.fig2 = Figure()
self.ax2 = self.fig2.add_subplot(111)
self.axes2 = [self.ax2]
self.canvas2 = FigureCanvas(self.fig2)

self.canvas2.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas2.updateGeometry()

self.groupBoxG2 = QGroupBox('ROC Curve')
self.groupBoxG2Layout = QVBoxLayout()
self.groupBoxG2.setLayout(self.groupBoxG2Layout)

self.groupBoxG2Layout.addWidget(self.canvas2)

#::-----------------------------------------------
# Graphic 3 : Importance of Features
#::-----------------------------------------------
```

```
self.fig3 = Figure()
self.ax3 = self.fig3.add_subplot(111)
self.axes3 = [self.ax3]
self.canvas3 = FigureCanvas(self.fig3)

self.canvas3.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas3.updateGeometry()

self.groupBoxG3 = QGroupBox('Importance of Features')
self.groupBoxG3Layout = QVBoxLayout()
self.groupBoxG3.setLayout(self.groupBoxG3Layout)
self.groupBoxG3Layout.addWidget(self.canvas3)

#::------------------------------------------
# Graphic 4 : ROC Curve by class
#::------------------------------------------

self.fig4 = Figure()
self.ax4 = self.fig4.add_subplot(111)
self.axes4 = [self.ax4]
self.canvas4 = FigureCanvas(self.fig4)

self.canvas4.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas4.updateGeometry()

self.groupBoxG4 = QGroupBox('ROC Curve by Class')
self.groupBoxG4Layout = QVBoxLayout()
self.groupBoxG4.setLayout(self.groupBoxG4Layout)
self.groupBoxG4Layout.addWidget(self.canvas4)

#::------------------------------------------------
# End of graphs
#::------------------------------------------------

self.layout.addWidget(self.groupBox1, 0, 0, 3, 2)
self.layout.addWidget(self.groupBoxG1, 0, 2, 1, 1)
self.layout.addWidget(self.groupBoxG3, 0, 3, 1, 1)
self.layout.addWidget(self.groupBoxG2, 1, 2, 1, 1)
self.layout.addWidget(self.groupBoxG4, 1, 3, 1, 1)
self.layout.addWidget(self.groupBox2, 2, 2, 1, 1)
self.layout.addWidget(self.groupBox3, 2, 3, 1, 1)
```

```
    self.setCentralWidget(self.main_widget)
    self.resize(1800, 1200)
    self.show()

def update(self):
    '''
    Random Forest Classifier
    We pupulate the dashboard using the parametres chosen by the user
    The parameters are processed to execute in the skit-learn Random Forest algorithm
      then the results are presented in graphics and reports in the canvas
    :return:None
    '''

    # processing the parameters

    self.list_corr_features = pd.DataFrame([])
    if self.feature0.isChecked():
        if len(self.list_corr_features)==0:
            self.list_corr_features = df[features_list[0]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[0]]],axis=1)

    if self.feature1.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[1]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[1]]],axis=1)

    if self.feature2.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[2]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[2]]],axis=1)

    if self.feature3.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[3]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[3]]],axis=1)

    if self.feature4.isChecked():
        if len(self.list_corr_features) == 0:
```

```
            self.list_corr_features = df[features_list[4]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[4]]],axis=1)

    if self.feature5.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[5]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[5]]],axis=1)

    if self.feature6.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[6]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[6]]],axis=1)

    if self.feature7.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[7]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[7]]],axis=1)

    if self.feature8.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[8]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[8]]],axis=1)

    if self.feature9.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[9]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[9]]],axis=1)

    if self.feature10.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[10]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[10]]], axis=1)

    if self.feature11.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[11]]
```

```
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[11]]], axis=1)

if self.feature12.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[12]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[12]]], axis=1)

if self.feature13.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[13]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[13]]], axis=1)

if self.feature14.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[14]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[14]]], axis=1)

if self.feature15.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[15]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[15]]], axis=1)

if self.feature16.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[16]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[16]]], axis=1)

if self.feature17.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[17]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[17]]], axis=1)

if self.feature18.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[18]]
    else:
```

```
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[18]]], axis=1)

    if self.feature19.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[19]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[19]]], axis=1)

    if self.feature20.isChecked():
        if len(self.list_corr_features)==0:
            self.list_corr_features = df[features_list[20]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[20]]],axis=1)

    if self.feature21.isChecked():
        if len(self.list_corr_features) == 20:
            self.list_corr_features = df[features_list[1]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[21]]],axis=1)

    if self.feature22.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[22]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[22]]],axis=1)

    if self.feature23.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[23]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[23]]],axis=1)

    if self.feature24.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[24]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[24]]],axis=1)

    if self.feature25.isChecked():
        if len(self.list_corr_features)==0:
            self.list_corr_features = df[features_list[25]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[25]]],axis=1)
```

```
if self.feature26.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[26]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[26]]],axis=1)

if self.feature27.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[27]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[27]]],axis=1)

if self.feature28.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[28]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[28]]],axis=1)

if self.feature29.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[29]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[29]]],axis=1)

if self.feature30.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[30]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[30]]], axis=1)

if self.feature31.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[31]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[31]]], axis=1)

if self.feature32.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[32]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[32]]], axis=1)
```

```
if self.feature33.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[33]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[33]]], axis=1)

if self.feature34.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[34]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[34]]], axis=1)

if self.feature35.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[35]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[35]]], axis=1)




vtest_per = float(self.txtPercentTest.text())
vmax_depth = float(self.txtMaxDepth.text())
# Clear the graphs to populate them with the new information

self.ax1.clear()
self.ax2.clear()
self.ax3.clear()
self.ax4.clear()
# self.txtResults.clear()
# self.txtResults.setUndoRedoEnabled(False)

vtest_per = vtest_per / 100
filename = 'rf_finalized_model2.sav'
self.clf_entropy = pickle.load(open(filename, 'rb'))
y_test = y
X_test = X[features_list]


# ------------------------------------------------------------------------

# predicton on test using entropy
y_pred_entropy = self.clf_entropy.predict(X_test)
```

```
# confusion matrix for RandomForest
conf_matrix = confusion_matrix(y_test, y_pred_entropy)


# accuracy score

self.ff_accuracy_score = accuracy_score(y_test, y_pred_entropy) * 100
self.txtCurrentAccuracy.setText(str(self.ff_accuracy_score))

# precision score

self.ff_precision_score = precision_score(y_test, y_pred_entropy) * 100
self.txtCurrentPrecision.setText(str(self.ff_precision_score))

# recall score

self.ff_recall_score = recall_score(y_test, y_pred_entropy) * 100
self.txtCurrentRecall.setText(str(self.ff_recall_score))

# f1_score

self.ff_f1_score = f1_score(y_test, y_pred_entropy) * 100
self.txtCurrentF1score.setText(str(self.ff_f1_score))

#::------------------------------------
##  Ghaph1 :
##  Confusion Matrix
#::------------------------------------
class_names1 = ['', 'No', 'Yes']

self.ax1.matshow(conf_matrix, cmap=plt.cm.get_cmap('Blues', 14))
self.ax1.set_yticklabels(class_names1)
self.ax1.set_xticklabels(class_names1, rotation=90)
self.ax1.set_xlabel('Predicted label')
self.ax1.set_ylabel('True label')

for i in range(len(class_names)):
    for j in range(len(class_names)):
        y_pred_score = self.clf_entropy.predict_proba(X_test)
        self.ax1.text(j, i, str(conf_matrix[i][j]))

self.fig.tight_layout()
```

```
self.fig.canvas.draw_idle()

#::-------------------------------------
## Graph 2 - ROC Curve
#::-------------------------------------
y_test_bin = pd.get_dummies(y_test).to_numpy()
n_classes = y_test_bin.shape[1]

# From the sckict learn site
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
fpr = dict()
tpr = dict()
roc_auc = dict()
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test_bin[:, i], y_pred_score[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])

# Compute micro-average ROC curve and ROC area
fpr["micro"], tpr["micro"], _ = roc_curve(y_test_bin.ravel(), y_pred_score.ravel())

roc_auc["micro"] = auc(fpr["micro"], tpr["micro"])

lw = 2
self.ax2.plot(fpr[1], tpr[1], color='darkorange',
             lw=lw, label='ROC curve (area = %0.2f)' % roc_auc[1])
self.ax2.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
self.ax2.set_xlim([0.0, 1.0])
self.ax2.set_ylim([0.0, 1.05])
self.ax2.set_xlabel('False Positive Rate')
self.ax2.set_ylabel('True Positive Rate')
self.ax2.set_title('ROC Curve Random Forest')
self.ax2.legend(loc="lower right")

self.fig2.tight_layout()
self.fig2.canvas.draw_idle()

########################################
# Graph - 3 Feature Importances
########################################
# get feature importances
importances = self.clf_entropy.feature_importances_

# convert the importances into one-dimensional 1darray with corresponding df column names as axis labels
```

```
f_importances = pd.Series(importances, self.list_corr_features.columns)

# sort the array in descending order of the importances, only show the first 10
f_importances.sort_values(ascending=False, inplace=True)
f_importances = f_importances[0:10]
X_Features = f_importances.index
y_Importance = list(f_importances)

self.ax3.barh(X_Features, y_Importance)
self.ax3.set_aspect('auto')

# show the plot
self.fig3.tight_layout()
self.fig3.canvas.draw_idle()

#::--------------------------------------------------------
# Graph 4 - ROC Curve by Class
#::--------------------------------------------------------
str_classes = ['No','Yes']
colors = cycle(['magenta', 'darkorange'])
for i, color in zip(range(n_classes), colors):
    self.ax4.plot(fpr[i], tpr[i], color=color, lw=lw,
                  label='{0} (area = {1:0.2f})'
                        ''.format(str_classes[i], roc_auc[i]))

self.ax4.plot([0, 1], [0, 1], 'k--', lw=lw)
self.ax4.set_xlim([0.0, 1.0])
self.ax4.set_ylim([0.0, 1.05])
self.ax4.set_xlabel('False Positive Rate')
self.ax4.set_ylabel('True Positive Rate')
self.ax4.set_title('ROC Curve by Class')
self.ax4.legend(loc="lower right")

# show the plot
self.fig4.tight_layout()
self.fig4.canvas.draw_idle()

#::--------------------------------------------------------
# Other Models Comparison
#::--------------------------------------------------------
filename2 = 'lr_finalized_model2.sav'
self.other_clf_lr = pickle.load(open(filename2, 'rb'))
y_pred_lr = self.other_clf_lr.predict(X_test)
```

```
        self.accuracy_lr = accuracy_score(y_test, y_pred_lr) * 100
        self.txtAccuracy_lr.setText(str(self.accuracy_lr))

        filename3 = 'dt_finalized_model2.sav'
        self.other_clf_dt = pickle.load(open(filename3, 'rb'))
        y_pred_dt = self.other_clf_dt.predict(X_test)
        self.accuracy_dt = accuracy_score(y_test, y_pred_dt) * 100
        self.txtAccuracy_dt.setText(str(self.accuracy_dt))

        filename4 = 'gb_finalized_model2.sav'
        self.other_clf_gb = pickle.load(open(filename4, 'rb'))
        y_pred_gb = self.other_clf_gb.predict(X_test)
        self.accuracy_gb = accuracy_score(y_test, y_pred_gb) * 100
        self.txtAccuracy_gb.setText(str(self.accuracy_gb))



class LogisticReg(QMainWindow):
    #::--------------------------------------------------------------------------------
    # Implementation of Random Forest Classifier using the happiness dataset
    # the methods in this class are
    #       _init_ : initialize the class
    #       initUi : creates the canvas and all the elements in the canvas
    #       update : populates the elements of the canvas base on the parametes
    #               chosen by the user
    #::--------------------------------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        super(LogisticReg, self).__init__()
        self.Title = "Logistic Regression Classifier"
        self.initUi()

    def initUi(self):
    #::--------------------------------------------------------------------
    #  Create the canvas and all the element to create a dashboard with
    #  all the necessary elements to present the results from the algorithm
    #  The canvas is divided using a  grid loyout to facilitate the drawing
    #  of the elements
    #::--------------------------------------------------------------------

        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)
```

```
self.main_widget = QWidget(self)

self.layout = QGridLayout(self.main_widget)

self.groupBox1 = QGroupBox('Logistic Regression Features')
self.groupBox1Layout= QGridLayout()
self.groupBox1.setLayout(self.groupBox1Layout)

self.feature0 = QCheckBox(features_list[0], self)
self.feature1 = QCheckBox(features_list[1], self)
self.feature2 = QCheckBox(features_list[2], self)
self.feature3 = QCheckBox(features_list[3], self)
self.feature4 = QCheckBox(features_list[4], self)
self.feature5 = QCheckBox(features_list[5], self)
self.feature6 = QCheckBox(features_list[6], self)
self.feature7 = QCheckBox(features_list[7], self)
self.feature8 = QCheckBox(features_list[8], self)
self.feature9 = QCheckBox(features_list[9], self)
self.feature10 = QCheckBox(features_list[10], self)
self.feature11 = QCheckBox(features_list[11], self)
self.feature12 = QCheckBox(features_list[12], self)
self.feature13 = QCheckBox(features_list[13], self)
self.feature14 = QCheckBox(features_list[14], self)
self.feature15 = QCheckBox(features_list[15], self)
self.feature16 = QCheckBox(features_list[16], self)
self.feature17 = QCheckBox(features_list[17], self)
self.feature18 = QCheckBox(features_list[18], self)
self.feature19 = QCheckBox(features_list[19], self)
self.feature20 = QCheckBox(features_list[20], self)
self.feature21 = QCheckBox(features_list[21], self)
self.feature22 = QCheckBox(features_list[22], self)
self.feature23 = QCheckBox(features_list[23], self)
self.feature24 = QCheckBox(features_list[24], self)
self.feature25 = QCheckBox(features_list[25], self)
self.feature26 = QCheckBox(features_list[26], self)
self.feature27 = QCheckBox(features_list[27], self)
self.feature28 = QCheckBox(features_list[28], self)
self.feature29 = QCheckBox(features_list[29], self)
self.feature30 = QCheckBox(features_list[30], self)
self.feature31 = QCheckBox(features_list[31], self)
self.feature32 = QCheckBox(features_list[32], self)
self.feature33 = QCheckBox(features_list[33], self)
```

```
self.feature34 = QCheckBox(features_list[34], self)
self.feature35 = QCheckBox(features_list[35], self)

self.feature0.setChecked(True)
self.feature1.setChecked(True)
self.feature2.setChecked(True)
self.feature3.setChecked(True)
self.feature4.setChecked(True)
self.feature5.setChecked(True)
self.feature6.setChecked(True)
self.feature7.setChecked(True)
self.feature8.setChecked(True)
self.feature9.setChecked(True)
self.feature10.setChecked(True)
self.feature11.setChecked(True)
self.feature12.setChecked(True)
self.feature13.setChecked(True)
self.feature14.setChecked(True)
self.feature15.setChecked(True)
self.feature16.setChecked(True)
self.feature17.setChecked(True)
self.feature18.setChecked(True)
self.feature19.setChecked(True)
self.feature20.setChecked(True)
self.feature21.setChecked(True)
self.feature22.setChecked(True)
self.feature23.setChecked(True)
self.feature24.setChecked(True)
self.feature25.setChecked(True)
self.feature26.setChecked(True)
self.feature27.setChecked(True)
self.feature28.setChecked(True)
self.feature29.setChecked(True)
self.feature30.setChecked(True)
self.feature31.setChecked(True)
self.feature32.setChecked(True)
self.feature33.setChecked(True)
self.feature34.setChecked(True)
self.feature35.setChecked(True)

self.lblPercentTest = QLabel('Percentage for Test :')
self.lblPercentTest.adjustSize()
```

```
self.txtPercentTest = QLineEdit(self)
self.txtPercentTest.setText("30")

self.btnExecute = QPushButton("Run Model")
self.btnExecute.setGeometry(QRect(60, 500, 75, 23))
self.btnExecute.clicked.connect(self.update)



# We create a checkbox for each feature

self.groupBox1Layout.addWidget(self.feature0, 0, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature1, 0, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature2, 1, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature3, 1, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature4, 2, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature5, 2, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature6, 3, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature7, 3, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature8, 4, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature9, 4, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature10, 5, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature11, 5, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature12, 6, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature13, 6, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature14, 7, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature15, 7, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature16, 8, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature17, 8, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature18, 9, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature19, 9, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature20, 10, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature21, 10, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature22, 11, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature23, 11, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature24, 12, 0, 1, 1)

self.groupBox1Layout.addWidget(self.lblPercentTest, 19, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtPercentTest, 19, 1, 1, 1)
self.groupBox1Layout.addWidget(self.btnExecute, 21, 0, 1, 1)
```

```
self.groupBox2 = QGroupBox('Measurements:')

self.groupBox2Layout = QVBoxLayout()
self.groupBox2.setLayout(self.groupBox2Layout)
# self.groupBox2.setMinimumSize(400, 100)

self.current_model_summary = QWidget(self)
self.current_model_summary.layout = QFormLayout(self.current_model_summary)
self.txtCurrentAccuracy = QLineEdit()
self.txtCurrentPrecision = QLineEdit()
self.txtCurrentRecall = QLineEdit()
self.txtCurrentF1score = QLineEdit()

self.current_model_summary.layout.addRow('Accuracy:', self.txtCurrentAccuracy)
self.current_model_summary.layout.addRow('Precision:', self.txtCurrentPrecision)
self.current_model_summary.layout.addRow('Recall:', self.txtCurrentRecall)
self.current_model_summary.layout.addRow('F1 Score:', self.txtCurrentF1score)

self.groupBox2Layout.addWidget(self.current_model_summary)

self.groupBox3 = QGroupBox('Other Models Accuracy:')
self.groupBox3Layout = QVBoxLayout()
self.groupBox3.setLayout(self.groupBox3Layout)
self.other_models = QWidget(self)
self.other_models.layout = QFormLayout(self.other_models)
self.txtAccuracy_dt = QLineEdit()
self.txtAccuracy_gb = QLineEdit()
self.txtAccuracy_rf = QLineEdit()

self.other_models.layout.addRow('Decision Tree:', self.txtAccuracy_dt)
self.other_models.layout.addRow('Gradient Boosting:', self.txtAccuracy_gb)
self.other_models.layout.addRow('Random Forest:', self.txtAccuracy_rf)


self.groupBox3Layout.addWidget(self.other_models)

#::------------------------------------
# Graphic 1 : Confusion Matrix
#::------------------------------------

self.fig = Figure()
self.ax1 = self.fig.add_subplot(111)
self.axes=[self.ax1]
```

```
self.canvas = FigureCanvas(self.fig)

self.canvas.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas.updateGeometry()

self.groupBoxG1 = QGroupBox('Confusion Matrix')
self.groupBoxG1Layout= QVBoxLayout()
self.groupBoxG1.setLayout(self.groupBoxG1Layout)

self.groupBoxG1Layout.addWidget(self.canvas)

#::-----------------------------------------------
# Graphic 2 : ROC Curve
#::-----------------------------------------------

self.fig2 = Figure()
self.ax2 = self.fig2.add_subplot(111)
self.axes2 = [self.ax2]
self.canvas2 = FigureCanvas(self.fig2)

self.canvas2.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas2.updateGeometry()

self.groupBoxG2 = QGroupBox('ROC Curve')
self.groupBoxG2Layout = QVBoxLayout()
self.groupBoxG2.setLayout(self.groupBoxG2Layout)

self.groupBoxG2Layout.addWidget(self.canvas2)

#::-----------------------------------------------
# Graphic 3 : k-fold Cross validation
#::-----------------------------------------------

self.fig3 = Figure()
self.ax3 = self.fig3.add_subplot(111)
self.axes3 = [self.ax3]
self.canvas3 = FigureCanvas(self.fig3)

self.canvas3.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas3.updateGeometry()
```

```
        self.groupBoxG3 = QGroupBox('K-fold cross validation')
        self.groupBoxG3Layout = QVBoxLayout()
        self.groupBoxG3.setLayout(self.groupBoxG3Layout)
        self.groupBoxG3Layout.addWidget(self.canvas3)

        #::--------------------------------------------
        # Graphic 4 : ROC Curve by class
        #::--------------------------------------------

        self.fig4 = Figure()
        self.ax4 = self.fig4.add_subplot(111)
        self.axes4 = [self.ax4]
        self.canvas4 = FigureCanvas(self.fig4)

        self.canvas4.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

        self.canvas4.updateGeometry()

        self.groupBoxG4 = QGroupBox('ROC Curve by Class')
        self.groupBoxG4Layout = QVBoxLayout()
        self.groupBoxG4.setLayout(self.groupBoxG4Layout)
        self.groupBoxG4Layout.addWidget(self.canvas4)

        #::--------------------------------------------------
        # End of graphs
        #::--------------------------------------------------

        self.layout.addWidget(self.groupBox1, 0, 0, 3, 2)
        self.layout.addWidget(self.groupBoxG1, 0, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG3, 0, 3, 1, 1)
        self.layout.addWidget(self.groupBoxG2, 1, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG4, 1, 3, 1, 1)
        self.layout.addWidget(self.groupBox2, 2, 2, 1, 1)
        self.layout.addWidget(self.groupBox3, 2, 3, 1, 1)

        self.setCentralWidget(self.main_widget)
        self.resize(1800, 1200)
        self.show()

    def update(self):
        '''
        Random Forest Classifier
```

```
We pupulate the dashboard using the parametres chosen by the user
The parameters are processed to execute in the skit-learn Random Forest algorithm
  then the results are presented in graphics and reports in the canvas
:return:None
'''

# processing the parameters

self.list_corr_features = pd.DataFrame([])
if self.feature0.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[0]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[0]]],axis=1)

if self.feature1.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[1]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[1]]],axis=1)

if self.feature2.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[2]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[2]]],axis=1)

if self.feature3.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[3]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[3]]],axis=1)

if self.feature4.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[4]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[4]]],axis=1)

if self.feature5.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[5]]
    else:
```

```
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[5]]],axis=1)

    if self.feature6.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[6]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[6]]],axis=1)

    if self.feature7.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[7]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[7]]],axis=1)

    if self.feature8.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[8]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[8]]],axis=1)

    if self.feature9.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[9]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[9]]],axis=1)

    if self.feature10.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[10]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[10]]], axis=1)

    if self.feature11.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[11]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[11]]], axis=1)

    if self.feature12.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[12]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[12]]], axis=1)
```

```
if self.feature13.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[13]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[13]]], axis=1)

if self.feature14.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[14]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[14]]], axis=1)

if self.feature15.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[15]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[15]]], axis=1)

if self.feature16.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[16]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[16]]], axis=1)

if self.feature17.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[17]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[17]]], axis=1)

if self.feature18.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[18]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[18]]], axis=1)

if self.feature19.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[19]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[19]]], axis=1)
```

```
if self.feature20.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[20]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[20]]],axis=1)

if self.feature21.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[1]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[21]]],axis=1)

if self.feature22.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[22]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[22]]],axis=1)

if self.feature23.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[23]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[23]]],axis=1)

if self.feature24.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[24]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[24]]],axis=1)

if self.feature25.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[25]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[25]]],axis=1)

if self.feature26.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[26]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[26]]],axis=1)

if self.feature27.isChecked():
```

```
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[27]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[27]]],axis=1)

if self.feature28.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[28]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[28]]],axis=1)

if self.feature29.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[29]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[29]]],axis=1)

if self.feature30.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[30]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[30]]], axis=1)

if self.feature31.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[31]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[31]]], axis=1)

if self.feature32.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[32]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[32]]], axis=1)

if self.feature33.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[33]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[33]]], axis=1)

if self.feature34.isChecked():
    if len(self.list_corr_features) == 0:
```

```
        self.list_corr_features = df[features_list[34]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[34]]], axis=1)

if self.feature35.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[35]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[35]]], axis=1)




vtest_per = float(self.txtPercentTest.text())

# Clear the graphs to populate them with the new information

self.ax1.clear()
self.ax2.clear()
self.ax3.clear()
self.ax4.clear()
# self.txtResults.clear()
# self.txtResults.setUndoRedoEnabled(False)

vtest_per = vtest_per / 100
filename = 'lr_finalized_model2.sav'
self.clf_entropy = pickle.load(open(filename, 'rb'))
y_test = y
X_test = X[features_list]




# ------------------------------------------------------------------------

# predicton on test using entropy
y_pred_entropy = self.clf_entropy.predict(X_test)

# confusion matrix for RandomForest
conf_matrix = confusion_matrix(y_test, y_pred_entropy)


# accuracy score
```

```
self.ff_accuracy_score = accuracy_score(y_test, y_pred_entropy) * 100
self.txtCurrentAccuracy.setText(str(self.ff_accuracy_score))

# precision score

self.ff_precision_score = precision_score(y_test, y_pred_entropy) * 100
self.txtCurrentPrecision.setText(str(self.ff_precision_score))

# recall score

self.ff_recall_score = recall_score(y_test, y_pred_entropy) * 100
self.txtCurrentRecall.setText(str(self.ff_recall_score))

# f1_score

self.ff_f1_score = f1_score(y_test, y_pred_entropy) * 100
self.txtCurrentF1score.setText(str(self.ff_f1_score))

#::------------------------------------
##  Ghaph1 :
##  Confusion Matrix
#::------------------------------------
class_names1 = ['', 'No', 'Yes']

self.ax1.matshow(conf_matrix, cmap=plt.cm.get_cmap('Blues', 14))
self.ax1.set_yticklabels(class_names1)
self.ax1.set_xticklabels(class_names1, rotation=90)
self.ax1.set_xlabel('Predicted label')
self.ax1.set_ylabel('True label')

for i in range(len(class_names)):
    for j in range(len(class_names)):
        y_pred_score = self.clf_entropy.predict_proba(X_test)
        self.ax1.text(j, i, str(conf_matrix[i][j]))

self.fig.tight_layout()
self.fig.canvas.draw_idle()

#::----------------------------------------
## Graph 2 - ROC Curve
#::----------------------------------------
y_test_bin = pd.get_dummies(y_test).to_numpy()
```

```
n_classes = y_test_bin.shape[1]

# From the sckict learn site
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
fpr = dict()
tpr = dict()
roc_auc = dict()
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test_bin[:, i], y_pred_score[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])

# Compute micro-average ROC curve and ROC area
fpr["micro"], tpr["micro"], _ = roc_curve(y_test_bin.ravel(), y_pred_score.ravel())

roc_auc["micro"] = auc(fpr["micro"], tpr["micro"])

lw = 2
self.ax2.plot(fpr[1], tpr[1], color='darkorange',
            lw=lw, label='ROC curve (area = %0.2f)' % roc_auc[1])
self.ax2.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
self.ax2.set_xlim([0.0, 1.0])
self.ax2.set_ylim([0.0, 1.05])
self.ax2.set_xlabel('False Positive Rate')
self.ax2.set_ylabel('True Positive Rate')
self.ax2.set_title('ROC Curve Logistic Regression')
self.ax2.legend(loc="lower right")

self.fig2.tight_layout()
self.fig2.canvas.draw_idle()

########################################
# Graph - cross validation
########################################
# get cross validation

score2=cross_val_score(self.clf_entropy,X_test,cv=5,y=y_test,scoring='accuracy',n_jobs=-1)
# repeats=range(1,15)
# results=list()
# for r in repeats:
self.ax3.boxplot(score2)
self.ax3.set_aspect('auto')

# show the plot
```

```
self.fig3.tight_layout()
self.fig3.canvas.draw_idle()


#::-----------------------------------------------------
# Graph 4 - ROC Curve by Class
#::-----------------------------------------------------
str_classes = ['No','Yes']
colors = cycle(['magenta', 'darkorange'])
for i, color in zip(range(n_classes), colors):
    self.ax4.plot(fpr[i], tpr[i], color=color, lw=lw,
                  label='{0} (area = {1:0.2f})'
                        ''.format(str_classes[i], roc_auc[i]))

self.ax4.plot([0, 1], [0, 1], 'k--', lw=lw)
self.ax4.set_xlim([0.0, 1.0])
self.ax4.set_ylim([0.0, 1.05])
self.ax4.set_xlabel('False Positive Rate')
self.ax4.set_ylabel('True Positive Rate')
self.ax4.set_title('ROC Curve by Class')
self.ax4.legend(loc="lower right")

# show the plot
self.fig4.tight_layout()
self.fig4.canvas.draw_idle()

#::-----------------------------------------------------
# Other Models Comparison
#::-----------------------------------------------------

filename2 = 'dt_finalized_model2.sav'
self.other_clf_dt = pickle.load(open(filename2, 'rb'))
y_pred_dt = self.other_clf_dt.predict(X_test)
self.accuracy_dt = accuracy_score(y_test, y_pred_dt) * 100
self.txtAccuracy_dt.setText(str(self.accuracy_dt))

filename3 = 'rf_finalized_model2.sav'
self.other_clf_rf = pickle.load(open(filename3, 'rb'))
y_pred_rf = self.other_clf_rf.predict(X_test)
self.accuracy_rf = accuracy_score(y_test, y_pred_rf) * 100
self.txtAccuracy_rf.setText(str(self.accuracy_rf))

filename4 = 'gb_finalized_model2.sav'
```

```
        self.other_clf_gb = pickle.load(open(filename4, 'rb'))
        y_pred_gb = self.other_clf_gb.predict(X_test)
        self.accuracy_gb = accuracy_score(y_test, y_pred_gb) * 100
        self.txtAccuracy_gb.setText(str(self.accuracy_gb))

class GradientBoosting(QMainWindow):
    #::-----------------------------------------------------------------------------
    # Implementation of Random Forest Classifier using the happiness dataset
    # the methods in this class are
    #       _init_ : initialize the class
    #       initUi : creates the canvas and all the elements in the canvas
    #       update : populates the elements of the canvas base on the parametes
    #               chosen by the user
    #::-----------------------------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        super(GradientBoosting, self).__init__()
        self.Title = "Gradient Boosting Classifier"
        self.initUi()

    def initUi(self):
    #::-----------------------------------------------------------------
    #  Create the canvas and all the element to create a dashboard with
    #  all the necessary elements to present the results from the algorithm
    #  The canvas is divided using a  grid loyout to facilitate the drawing
    #  of the elements
    #::-----------------------------------------------------------------

        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)

        self.main_widget = QWidget(self)

        self.layout = QGridLayout(self.main_widget)

        self.groupBox1 = QGroupBox('Gradient Boosting Features')
        self.groupBox1Layout= QGridLayout()
        self.groupBox1.setLayout(self.groupBox1Layout)

        self.feature0 = QCheckBox(features_list[0], self)
        self.feature1 = QCheckBox(features_list[1], self)
        self.feature2 = QCheckBox(features_list[2], self)
```

```
self.feature3 = QCheckBox(features_list[3], self)
self.feature4 = QCheckBox(features_list[4], self)
self.feature5 = QCheckBox(features_list[5], self)
self.feature6 = QCheckBox(features_list[6], self)
self.feature7 = QCheckBox(features_list[7], self)
self.feature8 = QCheckBox(features_list[8], self)
self.feature9 = QCheckBox(features_list[9], self)
self.feature10 = QCheckBox(features_list[10], self)
self.feature11 = QCheckBox(features_list[11], self)
self.feature12 = QCheckBox(features_list[12], self)
self.feature13 = QCheckBox(features_list[13], self)
self.feature14 = QCheckBox(features_list[14], self)
self.feature15 = QCheckBox(features_list[15], self)
self.feature16 = QCheckBox(features_list[16], self)
self.feature17 = QCheckBox(features_list[17], self)
self.feature18 = QCheckBox(features_list[18], self)
self.feature19 = QCheckBox(features_list[19], self)
self.feature20 = QCheckBox(features_list[20], self)
self.feature21 = QCheckBox(features_list[21], self)
self.feature22 = QCheckBox(features_list[22], self)
self.feature23 = QCheckBox(features_list[23], self)
self.feature24 = QCheckBox(features_list[24], self)
self.feature25 = QCheckBox(features_list[25], self)
self.feature26 = QCheckBox(features_list[26], self)
self.feature27 = QCheckBox(features_list[27], self)
self.feature28 = QCheckBox(features_list[28], self)
self.feature29 = QCheckBox(features_list[29], self)
self.feature30 = QCheckBox(features_list[30], self)
self.feature31 = QCheckBox(features_list[31], self)
self.feature32 = QCheckBox(features_list[32], self)
self.feature33 = QCheckBox(features_list[33], self)
self.feature34 = QCheckBox(features_list[34], self)
self.feature35 = QCheckBox(features_list[35], self)

self.feature0.setChecked(True)
self.feature1.setChecked(True)
self.feature2.setChecked(True)
self.feature3.setChecked(True)
self.feature4.setChecked(True)
self.feature5.setChecked(True)
self.feature6.setChecked(True)
self.feature7.setChecked(True)
self.feature8.setChecked(True)
```

```
self.feature9.setChecked(True)
self.feature10.setChecked(True)
self.feature11.setChecked(True)
self.feature12.setChecked(True)
self.feature13.setChecked(True)
self.feature14.setChecked(True)
self.feature15.setChecked(True)
self.feature16.setChecked(True)
self.feature17.setChecked(True)
self.feature18.setChecked(True)
self.feature19.setChecked(True)
self.feature20.setChecked(True)
self.feature21.setChecked(True)
self.feature22.setChecked(True)
self.feature23.setChecked(True)
self.feature24.setChecked(True)
self.feature25.setChecked(True)
self.feature26.setChecked(True)
self.feature27.setChecked(True)
self.feature28.setChecked(True)
self.feature29.setChecked(True)
self.feature30.setChecked(True)
self.feature31.setChecked(True)
self.feature32.setChecked(True)
self.feature33.setChecked(True)
self.feature34.setChecked(True)
self.feature35.setChecked(True)

self.lblPercentTest = QLabel('Percentage for Test :')
self.lblPercentTest.adjustSize()

self.txtPercentTest = QLineEdit(self)
self.txtPercentTest.setText("30")

self.btnExecute = QPushButton("Run Model")
self.btnExecute.setGeometry(QRect(60, 500, 75, 23))
self.btnExecute.clicked.connect(self.update)



# We create a checkbox for each feature

self.groupBox1Layout.addWidget(self.feature0, 0, 0, 1, 1)
```

```
self.groupBox1Layout.addWidget(self.feature1, 0, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature2, 1, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature3, 1, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature4, 2, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature5, 2, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature6, 3, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature7, 3, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature8, 4, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature9, 4, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature10, 5, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature11, 5, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature12, 6, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature13, 6, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature14, 7, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature15, 7, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature16, 8, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature17, 8, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature18, 9, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature19, 9, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature20, 10, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature21, 10, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature22, 11, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature23, 11, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature24, 12, 0, 1, 1)
self.groupBox1Layout.addWidget(self.lblPercentTest, 19, 0, 1, 1)
self.groupBox1Layout.addWidget(self.txtPercentTest, 19, 1, 1, 1)
self.groupBox1Layout.addWidget(self.btnExecute, 21, 0, 1, 1)



self.groupBox2 = QGroupBox('Measurements:')

self.groupBox2Layout = QVBoxLayout()
self.groupBox2.setLayout(self.groupBox2Layout)
# self.groupBox2.setMinimumSize(400, 100)

self.current_model_summary = QWidget(self)
self.current_model_summary.layout = QFormLayout(self.current_model_summary)
self.txtCurrentAccuracy = QLineEdit()
self.txtCurrentPrecision = QLineEdit()
self.txtCurrentRecall = QLineEdit()
self.txtCurrentF1score = QLineEdit()
```

```
self.current_model_summary.layout.addRow('Accuracy:', self.txtCurrentAccuracy)
self.current_model_summary.layout.addRow('Precision:', self.txtCurrentPrecision)
self.current_model_summary.layout.addRow('Recall:', self.txtCurrentRecall)
self.current_model_summary.layout.addRow('F1 Score:', self.txtCurrentF1score)

self.groupBox2Layout.addWidget(self.current_model_summary)

self.groupBox3 = QGroupBox('Other Models Accuracy:')
self.groupBox3Layout = QVBoxLayout()
self.groupBox3.setLayout(self.groupBox3Layout)
self.other_models = QWidget(self)
self.other_models.layout = QFormLayout(self.other_models)
self.txtAccuracy_lr = QLineEdit()
self.txtAccuracy_dt = QLineEdit()
self.txtAccuracy_rf = QLineEdit()

self.other_models.layout.addRow('Decision Tree:', self.txtAccuracy_dt)
self.other_models.layout.addRow('Logistic Regression:', self.txtAccuracy_lr)
self.other_models.layout.addRow('Random Forest:', self.txtAccuracy_rf)


self.groupBox3Layout.addWidget(self.other_models)

#::-------------------------------------
# Graphic 1 : Confusion Matrix
#::-------------------------------------

self.fig = Figure()
self.ax1 = self.fig.add_subplot(111)
self.axes=[self.ax1]
self.canvas = FigureCanvas(self.fig)

self.canvas.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas.updateGeometry()

self.groupBoxG1 = QGroupBox('Confusion Matrix')
self.groupBoxG1Layout= QVBoxLayout()
self.groupBoxG1.setLayout(self.groupBoxG1Layout)

self.groupBoxG1Layout.addWidget(self.canvas)

#::-----------------------------------------------
```

```
# Graphic 2 : ROC Curve
#::-----------------------------------------

self.fig2 = Figure()
self.ax2 = self.fig2.add_subplot(111)
self.axes2 = [self.ax2]
self.canvas2 = FigureCanvas(self.fig2)

self.canvas2.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas2.updateGeometry()

self.groupBoxG2 = QGroupBox('ROC Curve')
self.groupBoxG2Layout = QVBoxLayout()
self.groupBoxG2.setLayout(self.groupBoxG2Layout)

self.groupBoxG2Layout.addWidget(self.canvas2)

#::-----------------------------------------
# Graphic 3 : k-fold Cross validation
#::-----------------------------------------

self.fig3 = Figure()
self.ax3 = self.fig3.add_subplot(111)
self.axes3 = [self.ax3]
self.canvas3 = FigureCanvas(self.fig3)

self.canvas3.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

self.canvas3.updateGeometry()

self.groupBoxG3 = QGroupBox('K-fold cross validation')
self.groupBoxG3Layout = QVBoxLayout()
self.groupBoxG3.setLayout(self.groupBoxG3Layout)
self.groupBoxG3Layout.addWidget(self.canvas3)

#::-----------------------------------------
# Graphic 4 : ROC Curve by class
#::-----------------------------------------

self.fig4 = Figure()
self.ax4 = self.fig4.add_subplot(111)
self.axes4 = [self.ax4]
```

```
        self.canvas4 = FigureCanvas(self.fig4)

        self.canvas4.setSizePolicy(QSizePolicy.Expanding, QSizePolicy.Expanding)

        self.canvas4.updateGeometry()

        self.groupBoxG4 = QGroupBox('ROC Curve by Class')
        self.groupBoxG4Layout = QVBoxLayout()
        self.groupBoxG4.setLayout(self.groupBoxG4Layout)
        self.groupBoxG4Layout.addWidget(self.canvas4)

        #::-----------------------------------------------
        # End of graphs
        #::-----------------------------------------------

        self.layout.addWidget(self.groupBox1, 0, 0, 3, 2)
        self.layout.addWidget(self.groupBoxG1, 0, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG3, 0, 3, 1, 1)
        self.layout.addWidget(self.groupBoxG2, 1, 2, 1, 1)
        self.layout.addWidget(self.groupBoxG4, 1, 3, 1, 1)
        self.layout.addWidget(self.groupBox2, 2, 2, 1, 1)
        self.layout.addWidget(self.groupBox3, 2, 3, 1, 1)

        self.setCentralWidget(self.main_widget)
        self.resize(1800, 1200)
        self.show()

    def update(self):
        '''
        Random Forest Classifier
        We pupulate the dashboard using the parametres chosen by the user
        The parameters are processed to execute in the skit-learn Random Forest algorithm
          then the results are presented in graphics and reports in the canvas
        :return:None
        '''

        # processing the parameters

        self.list_corr_features = pd.DataFrame([])
        if self.feature0.isChecked():
            if len(self.list_corr_features)==0:
                self.list_corr_features = df[features_list[0]]
            else:
```

```
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[0]]],axis=1)

    if self.feature1.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[1]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[1]]],axis=1)

    if self.feature2.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[2]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[2]]],axis=1)

    if self.feature3.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[3]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[3]]],axis=1)

    if self.feature4.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[4]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[4]]],axis=1)

    if self.feature5.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[5]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[5]]],axis=1)

    if self.feature6.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[6]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[6]]],axis=1)

    if self.feature7.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[7]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[7]]],axis=1)
```

```
if self.feature8.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[8]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[8]]],axis=1)

if self.feature9.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[9]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[9]]],axis=1)

if self.feature10.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[10]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[10]]], axis=1)

if self.feature11.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[11]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[11]]], axis=1)

if self.feature12.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[12]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[12]]], axis=1)

if self.feature13.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[13]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[13]]], axis=1)

if self.feature14.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[14]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[14]]], axis=1)
```

```
if self.feature15.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[15]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[15]]], axis=1)

if self.feature16.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[16]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[16]]], axis=1)

if self.feature17.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[17]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[17]]], axis=1)

if self.feature18.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[18]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[18]]], axis=1)

if self.feature19.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[19]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[19]]], axis=1)

if self.feature20.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[20]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[20]]],axis=1)

if self.feature21.isChecked():
    if len(self.list_corr_features) == 20:
        self.list_corr_features = df[features_list[1]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[21]]],axis=1)

if self.feature22.isChecked():
```

```
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[22]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[22]]],axis=1)

if self.feature23.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[23]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[23]]],axis=1)

if self.feature24.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[24]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[24]]],axis=1)

if self.feature25.isChecked():
    if len(self.list_corr_features)==0:
        self.list_corr_features = df[features_list[25]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[25]]],axis=1)

if self.feature26.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[26]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[26]]],axis=1)

if self.feature27.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[27]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[27]]],axis=1)

if self.feature28.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[28]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[28]]],axis=1)

if self.feature29.isChecked():
    if len(self.list_corr_features) == 0:
```

```
            self.list_corr_features = df[features_list[29]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[29]]],axis=1)

    if self.feature30.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[30]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[30]]], axis=1)

    if self.feature31.isChecked():
        if len(self.list_corr_features) == 20:
            self.list_corr_features = df[features_list[31]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[31]]], axis=1)

    if self.feature32.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[32]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[32]]], axis=1)

    if self.feature33.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[33]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[33]]], axis=1)

    if self.feature34.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[34]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[34]]], axis=1)

    if self.feature35.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[35]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[35]]], axis=1)
```

```
vtest_per = float(self.txtPercentTest.text())

# Clear the graphs to populate them with the new information

self.ax1.clear()
self.ax2.clear()
self.ax3.clear()
self.ax4.clear()
# self.txtResults.clear()
# self.txtResults.setUndoRedoEnabled(False)

vtest_per = vtest_per / 100
filename = 'gb_finalized_model2.sav'
self.clf_entropy = pickle.load(open(filename, 'rb'))
y_test = y
X_test = X[features_list]



# ------------------------------------------------------------------------

# predicton on test using entropy
y_pred_entropy = self.clf_entropy.predict(X_test)

# confusion matrix for RandomForest
conf_matrix = confusion_matrix(y_test, y_pred_entropy)


# accuracy score

self.ff_accuracy_score = accuracy_score(y_test, y_pred_entropy) * 100
self.txtCurrentAccuracy.setText(str(self.ff_accuracy_score))

# precision score

self.ff_precision_score = precision_score(y_test, y_pred_entropy) * 100
self.txtCurrentPrecision.setText(str(self.ff_precision_score))

# recall score

self.ff_recall_score = recall_score(y_test, y_pred_entropy) * 100
self.txtCurrentRecall.setText(str(self.ff_recall_score))
```

```
# f1_score

self.ff_f1_score = f1_score(y_test, y_pred_entropy) * 100
self.txtCurrentF1score.setText(str(self.ff_f1_score))

#::------------------------------------
##  Ghaph1 :
##  Confusion Matrix
#::------------------------------------
class_names1 = ['', 'No', 'Yes']

self.ax1.matshow(conf_matrix, cmap=plt.cm.get_cmap('Blues', 14))
self.ax1.set_yticklabels(class_names1)
self.ax1.set_xticklabels(class_names1, rotation=90)
self.ax1.set_xlabel('Predicted label')
self.ax1.set_ylabel('True label')

for i in range(len(class_names)):
    for j in range(len(class_names)):
        y_pred_score = self.clf_entropy.predict_proba(X_test)
        self.ax1.text(j, i, str(conf_matrix[i][j]))

self.fig.tight_layout()
self.fig.canvas.draw_idle()

#::----------------------------------------
## Graph 2 - ROC Curve
#::----------------------------------------
y_test_bin = pd.get_dummies(y_test).to_numpy()
n_classes = y_test_bin.shape[1]

# From the sckict learn site
# https://scikit-learn.org/stable/auto_examples/model_selection/plot_roc.html
fpr = dict()
tpr = dict()
roc_auc = dict()
for i in range(n_classes):
    fpr[i], tpr[i], _ = roc_curve(y_test_bin[:, i], y_pred_score[:, i])
    roc_auc[i] = auc(fpr[i], tpr[i])

# Compute micro-average ROC curve and ROC area
fpr["micro"], tpr["micro"], _ = roc_curve(y_test_bin.ravel(), y_pred_score.ravel())
```

```
roc_auc["micro"] = auc(fpr["micro"], tpr["micro"])

lw = 2
self.ax2.plot(fpr[1], tpr[1], color='darkorange',
         lw=lw, label='ROC curve (area = %0.2f)' % roc_auc[1])
self.ax2.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
self.ax2.set_xlim([0.0, 1.0])
self.ax2.set_ylim([0.0, 1.05])
self.ax2.set_xlabel('False Positive Rate')
self.ax2.set_ylabel('True Positive Rate')
self.ax2.set_title('ROC Curve Gradient Boosting')
self.ax2.legend(loc="lower right")

self.fig2.tight_layout()
self.fig2.canvas.draw_idle()

########################################
# Graph - cross validation
########################################
# get cross validation

score2=cross_val_score(self.clf_entropy,X_test,cv=5,y=y_test,scoring='accuracy',n_jobs=-1)
# repeats=range(1,15)
# results=list()
# for r in repeats:
self.ax3.boxplot(score2)
self.ax3.set_aspect('auto')

# show the plot
self.fig3.tight_layout()
self.fig3.canvas.draw_idle()


#::------------------------------------------------------
# Graph 4 - ROC Curve by Class
#::------------------------------------------------------
str_classes = ['No','Yes']
colors = cycle(['magenta', 'darkorange'])
for i, color in zip(range(n_classes), colors):
    self.ax4.plot(fpr[i], tpr[i], color=color, lw=lw,
              label='{0} (area = {1:0.2f})'
                   ''.format(str_classes[i], roc_auc[i]))
```

```
        self.ax4.plot([0, 1], [0, 1], 'k--', lw=lw)
        self.ax4.set_xlim([0.0, 1.0])
        self.ax4.set_ylim([0.0, 1.05])
        self.ax4.set_xlabel('False Positive Rate')
        self.ax4.set_ylabel('True Positive Rate')
        self.ax4.set_title('ROC Curve by Class')
        self.ax4.legend(loc="lower right")

        # show the plot
        self.fig4.tight_layout()
        self.fig4.canvas.draw_idle()

        #::-----------------------------------------------------
        # Other Models Comparison
        #::-----------------------------------------------------

        filename2 = 'lr_finalized_model2.sav'
        self.other_clf_lr = pickle.load(open(filename2, 'rb'))
        y_pred_lr = self.other_clf_lr.predict(X_test)
        self.accuracy_lr = accuracy_score(y_test, y_pred_lr) * 100
        self.txtAccuracy_lr.setText(str(self.accuracy_lr))

        filename3 = 'rf_finalized_model2.sav'
        self.other_clf_rf = pickle.load(open(filename3, 'rb'))
        y_pred_rf = self.other_clf_rf.predict(X_test)
        self.accuracy_rf = accuracy_score(y_test, y_pred_rf) * 100
        self.txtAccuracy_rf.setText(str(self.accuracy_rf))

        filename4 = 'dt_finalized_model2.sav'
        self.other_clf_dt = pickle.load(open(filename4, 'rb'))
        y_pred_dt = self.other_clf_dt.predict(X_test)
        self.accuracy_dt = accuracy_score(y_test, y_pred_dt) * 100
        self.txtAccuracy_dt.setText(str(self.accuracy_dt))

class TargetDistribution(QMainWindow):
    #::-----------------------------------------------------------
    # This class crates a canvas with a plot to show the distribution
    # from each feature in the dataset with the target variables
    # methods
    #    _init_
    #   update
    #::-----------------------------------------------------------
    send_fig = pyqtSignal(str)
```

```
def __init__(self):
    #::--------------------------------------------------------
    # Crate a canvas with the layout to draw a dotplot
    # The layout sets all the elements and manage the changes
    # made on the canvas
    #::--------------------------------------------------------
    super(TargetDistribution, self).__init__()
    self.Title = "EDA: Variable Distribution"
    self.main_widget = QWidget(self)

    self.setWindowTitle(self.Title)
    self.setStyleSheet(font_size_window)

    self.fig = Figure()
    self.ax = self.fig.add_subplot(111)
    self.axes = [self.ax]
    self.canvas = FigureCanvas(self.fig)

    self.canvas.setSizePolicy(QSizePolicy.Expanding,
                              QSizePolicy.Expanding)

    self.canvas.updateGeometry()

    self.dropdown1 = QComboBox()
    self.featuresList = numerical.copy()
    self.dropdown1.addItems(self.featuresList)

    self.dropdown1.currentIndexChanged.connect(self.update)
    self.label = QLabel("A plot:")

    self.layout = QGridLayout(self.main_widget)
    self.layout.addWidget(QLabel("Select Features:"), 0, 0, 1, 1)
    self.layout.addWidget(self.dropdown1, 0, 1, 1, 1)


    self.filter_data = QWidget(self)
    self.filter_data.layout = QGridLayout(self.filter_data)
    self.filter_data.layout.addWidget(QLabel("Choose Data Filter:"), 0, 0, 1, 1)

    self.filter_radio_button = QRadioButton("All Data")
    self.filter_radio_button.setChecked(True)
    self.filter_radio_button.filter = "All_Data"
```

```
    self.set_Filter = "All_Data"
    self.filter_radio_button.toggled.connect(self.onFilterClicked)
    self.filter_data.layout.addWidget(self.filter_radio_button, 0, 1, 1, 1)

    self.filter_radio_button = QRadioButton("Loan Default: Yes")
    self.filter_radio_button.filter = 1
    self.filter_radio_button.toggled.connect(self.onFilterClicked)
    self.filter_data.layout.addWidget(self.filter_radio_button, 0, 2, 1, 1)

    self.filter_radio_button = QRadioButton("Loan Default: No")
    self.filter_radio_button.filter = 0
    self.filter_radio_button.toggled.connect(self.onFilterClicked)
    self.filter_data.layout.addWidget(self.filter_radio_button, 0, 3, 1, 1)

    self.btnCreateGraph = QPushButton("Show Distribution")
    self.btnCreateGraph.clicked.connect(self.update)

    self.groupBox1 = QGroupBox('Distribution')
    self.groupBox1Layout = QVBoxLayout()
    self.groupBox1.setLayout(self.groupBox1Layout)
    self.groupBox1Layout.addWidget(self.canvas)

    self.layout.addWidget(self.filter_data, 1, 0, 2, 2)
    self.layout.addWidget(self.btnCreateGraph, 0, 3, 2, 2)
    self.layout.addWidget(self.groupBox1, 3, 0, 5, 5)

    self.setCentralWidget(self.main_widget)
    self.resize(1200, 700)
    self.show()


def onFilterClicked(self):
    self.filter_radio_button = self.sender()
    if self.filter_radio_button.isChecked():
        self.set_Filter = self.filter_radio_button.filter
        self.update()

def update(self):
    #::--------------------------------------------------------
    # This method executes each time a change is made on the canvas
    # containing the elements of the graph
    # The purpose of the method es to draw a dot graph using the
    # score of happiness and the feature chosen the canvas
```

```
        #::---------------------------------------------------------
        colors = ["b", "r", "g", "y", "k", "c"]
        self.ax.clear()
        cat1 = self.dropdown1.currentText()
        if (self.set_Filter == 1 or self.set_Filter == 0):
            self.filtered_data = df_orig.copy()
            self.filtered_data = self.filtered_data[self.filtered_data["loan_default"] == self.set_Filter]
        else:
            self.filtered_data = df_orig.copy()

        self.ax.hist(self.filtered_data[cat1], bins=50, facecolor='blue', alpha=0.5)
        self.ax.set_title(cat1)
        self.ax.set_xlabel(cat1)
        self.ax.set_ylabel("Count")
        self.ax.grid(True)
        self.fig.tight_layout()
        self.fig.canvas.draw_idle()
        del cat1
        del self.filtered_data


class TargetCount(QMainWindow):
    #::---------------------------------------------------------
    # This class crates a canvas with a plot to show the distribution
    # from each feature in the dataset with the target variables
    # methods
    #    _init_
    #   update
    #::---------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        #::---------------------------------------------------------
        # Crate a canvas with the layout to draw a dotplot
        # The layout sets all the elements and manage the changes
        # made on the canvas
        #::---------------------------------------------------------
        super(TargetCount, self).__init__()
        self.Title = "EDA: Variable Distribution"
        self.main_widget = QWidget(self)

        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)
```

```
    self.fig = Figure()
    self.ax = self.fig.add_subplot(111)
    self.axes = [self.ax]
    self.canvas = FigureCanvas(self.fig)

    self.canvas.setSizePolicy(QSizePolicy.Expanding,
                              QSizePolicy.Expanding)

    self.canvas.updateGeometry()

    self.dropdown1 = QComboBox()
    self.featuresList = categorical.copy()
    self.dropdown1.addItems(self.featuresList)

    self.dropdown1.currentIndexChanged.connect(self.update)
    self.label = QLabel("A plot:")

    self.layout = QGridLayout(self.main_widget)
    self.layout.addWidget(QLabel("Select Features:"))
    self.layout.addWidget(self.dropdown1)

    self.layout.addWidget(self.canvas)

    self.setCentralWidget(self.main_widget)
    self.resize(1200, 700)
    self.show()

# def get_bar_dict(self, cat1, level_list):
#     count_yes = []
#     count_no = []
#     for level in level_list:
#         count_no.append(len(df_orig[(df_orig[cat1] == level) & (df_orig[target] == 0)]))
#         count_yes.append(len(df_orig[(df_orig[cat1] == level) & (df_orig[target] == 1)]))
#     return count_no, count_yes

def update(self):
    #::--------------------------------------------------------
    # This method executes each time a change is made on the canvas
    # containing the elements of the graph
    # The purpose of the method es to draw a dot graph using the
    # score of happiness and the feature chosen the canvas
    #::--------------------------------------------------------
```

```
        colors = ["b", "r", "g", "y", "k", "c"]
        self.ax.clear()
        cat1 = self.dropdown1.currentText()
        df_pick = df_orig[cat1]
        level_list = list(df_pick.unique())
        count_yes = []
        count_no = []
        for level in level_list:
            count_no.append(len(df_orig[(df_orig[cat1] == level) & (df_orig[target] == 0)]))
            count_yes.append(len(df_orig[(df_orig[cat1] == level) & (df_orig[target] == 1)]))
        all_width = 0.7
        width = all_width / 2
        onset = width / 2
        x1, x2 = [x - onset for x in range(len(level_list))], [x + onset for x in range(len(level_list))]
        self.ax.bar(x1, count_no, align='edge', width=width, label='Default:No')
        self.ax.bar(x2, count_yes, align='edge', width=width, label='Default: Yes')
        self.ax.set_xticks(range(len(level_list)))
        self.ax.set_xticklabels(level_list)
        self.ax.legend()
        self.ax.set_title(cat1)
        self.ax.set_xlabel(cat1)
        self.ax.set_ylabel("Count")
        self.ax.grid(True)
        self.fig.tight_layout()
        self.fig.canvas.draw_idle()
        del cat1

class CorrelationPlot(QMainWindow):
    #;:-----------------------------------------------------------------------
    # This class creates a canvas to draw a correlation plot
    # It presents all the features plus the happiness score
    # the methods for this class are:
    #   _init_
    #   initUi
    #   update
    #::-----------------------------------------------------------------------
    send_fig = pyqtSignal(str)

    def __init__(self):
        #::-------------------------------------------------------
        # Initialize the values of the class
        #::-------------------------------------------------------
        super(CorrelationPlot, self).__init__()
```

```
        self.Title = 'Correlation Plot'
        self.initUi()

    def initUi(self):
        #::----------------------------------------------------------------
        #  Creates the canvas and elements of the canvas
        #::----------------------------------------------------------------
        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)

        self.main_widget = QWidget(self)

        self.layout = QVBoxLayout(self.main_widget)

        self.groupBox1 = QGroupBox('Correlation Plot Features')
        self.groupBox1Layout= QGridLayout()
        self.groupBox1.setLayout(self.groupBox1Layout)

        self.feature0 = QCheckBox(features_list[0], self)
        self.feature1 = QCheckBox(features_list[1], self)
        self.feature2 = QCheckBox(features_list[2], self)
        self.feature3 = QCheckBox(features_list[3], self)
        self.feature4 = QCheckBox(features_list[4], self)
        self.feature5 = QCheckBox(features_list[5], self)
        self.feature6 = QCheckBox(features_list[6], self)
        self.feature7 = QCheckBox(features_list[7], self)
        self.feature8 = QCheckBox(features_list[8], self)
        self.feature9 = QCheckBox(features_list[9], self)
        self.feature10 = QCheckBox(features_list[10], self)
        self.feature11 = QCheckBox(features_list[11], self)
        self.feature12 = QCheckBox(features_list[12], self)
        self.feature13 = QCheckBox(features_list[13], self)
        self.feature14 = QCheckBox(features_list[14], self)
        self.feature15 = QCheckBox(features_list[15], self)
        self.feature16 = QCheckBox(features_list[16], self)
        self.feature17 = QCheckBox(features_list[17], self)
        self.feature18 = QCheckBox(features_list[18], self)
        self.feature19 = QCheckBox(features_list[19], self)
        self.feature20 = QCheckBox(features_list[20], self)
        self.feature21 = QCheckBox(features_list[21], self)
        self.feature22 = QCheckBox(features_list[22], self)
        self.feature23 = QCheckBox(features_list[23], self)
```

```
self.feature0.setChecked(True)
self.feature1.setChecked(True)
self.feature2.setChecked(True)
self.feature3.setChecked(True)
self.feature4.setChecked(True)
self.feature5.setChecked(True)
self.feature6.setChecked(True)
self.feature7.setChecked(True)
self.feature8.setChecked(True)
self.feature9.setChecked(True)
self.feature10.setChecked(True)
self.feature11.setChecked(True)
self.feature12.setChecked(True)
self.feature13.setChecked(True)
self.feature14.setChecked(True)
self.feature15.setChecked(True)
self.feature16.setChecked(True)
self.feature17.setChecked(True)
self.feature18.setChecked(True)
self.feature19.setChecked(True)
self.feature20.setChecked(True)
self.feature21.setChecked(True)
self.feature22.setChecked(True)
self.feature23.setChecked(True)

self.btnExecute = QPushButton("Create Plot")
self.btnExecute.clicked.connect(self.update)

self.groupBox1Layout.addWidget(self.feature0, 0, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature1, 0, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature2, 0, 2, 1, 1)
self.groupBox1Layout.addWidget(self.feature3, 0, 3, 1, 1)
self.groupBox1Layout.addWidget(self.feature4, 0, 4, 1, 1)
self.groupBox1Layout.addWidget(self.feature5, 0, 5, 1, 1)
self.groupBox1Layout.addWidget(self.feature6, 0, 6, 1, 1)
self.groupBox1Layout.addWidget(self.feature7, 0, 7, 1, 1)
self.groupBox1Layout.addWidget(self.feature8, 1, 0, 1, 1)
self.groupBox1Layout.addWidget(self.feature9, 1, 1, 1, 1)
self.groupBox1Layout.addWidget(self.feature10, 1, 2, 1, 1)
self.groupBox1Layout.addWidget(self.feature11, 1, 3, 1, 1)
self.groupBox1Layout.addWidget(self.feature12, 1, 4, 1, 1)
self.groupBox1Layout.addWidget(self.feature13, 1, 5, 1, 1)
```

```
        self.groupBox1Layout.addWidget(self.feature14, 1, 6, 1, 1)
        self.groupBox1Layout.addWidget(self.feature15, 1, 7, 1, 1)
        self.groupBox1Layout.addWidget(self.feature16, 2, 0, 1, 1)
        self.groupBox1Layout.addWidget(self.feature17, 2, 1, 1, 1)
        self.groupBox1Layout.addWidget(self.feature18, 2, 2, 1, 1)
        self.groupBox1Layout.addWidget(self.feature19, 2, 3, 1, 1)
        self.groupBox1Layout.addWidget(self.feature20, 2, 4, 1, 1)
        self.groupBox1Layout.addWidget(self.feature21, 2, 5, 1, 1)
        self.groupBox1Layout.addWidget(self.feature22, 2, 6, 1, 1)
        self.groupBox1Layout.addWidget(self.feature23, 2, 7, 1, 1)

        self.groupBox1Layout.addWidget(self.btnExecute,5,3,1,1)


        self.fig = Figure()
        self.ax1 = self.fig.add_subplot(111)
        self.axes=[self.ax1]
        self.canvas = FigureCanvas(self.fig)

        self.canvas.setSizePolicy(QSizePolicy.Expanding,
                                  QSizePolicy.Expanding)

        self.canvas.updateGeometry()


        self.groupBox2 = QGroupBox('Correlation Plot')
        self.groupBox2Layout= QVBoxLayout()
        self.groupBox2.setLayout(self.groupBox2Layout)

        self.groupBox2Layout.addWidget(self.canvas)


        self.layout.addWidget(self.groupBox1)
        self.layout.addWidget(self.groupBox2)

        self.setCentralWidget(self.main_widget)
        self.resize(1500, 1400)
        self.show()
        self.update()

    def update(self):

        #::----------------------------------------------------------------
```

```
# Populates the elements in the canvas using the values
# chosen as parameters for the correlation plot
#::---------------------------------------------------------------
self.ax1.clear()

self.list_corr_features = pd.DataFrame([])
if self.feature0.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[0]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[0]]], axis=1)

if self.feature1.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[1]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[1]]], axis=1)

if self.feature2.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[2]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[2]]], axis=1)

if self.feature3.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[3]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[3]]], axis=1)

if self.feature4.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[4]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[4]]], axis=1)

if self.feature5.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[5]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[5]]], axis=1)

if self.feature6.isChecked():
```

```
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[6]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[6]]], axis=1)

if self.feature7.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[7]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[7]]], axis=1)

if self.feature8.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[8]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[8]]], axis=1)

if self.feature9.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[9]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[9]]], axis=1)

if self.feature10.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[10]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[10]]], axis=1)

if self.feature11.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[11]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[11]]], axis=1)

if self.feature12.isChecked():
    if len(self.list_corr_features) == 0:
        self.list_corr_features = df[features_list[12]]
    else:
        self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[12]]], axis=1)

if self.feature13.isChecked():
    if len(self.list_corr_features) == 0:
```

```
            self.list_corr_features = df[features_list[13]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[13]]], axis=1)

    if self.feature14.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[14]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[14]]], axis=1)

    if self.feature15.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[15]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[15]]], axis=1)

    if self.feature16.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[16]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[16]]], axis=1)

    if self.feature17.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[17]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[17]]], axis=1)

    if self.feature18.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[18]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[18]]], axis=1)

    if self.feature19.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[19]]
        else:
            self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[19]]], axis=1)

    if self.feature20.isChecked():
        if len(self.list_corr_features) == 0:
            self.list_corr_features = df[features_list[20]]
```

```
            else:
                self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[20]]], axis=1)

        if self.feature21.isChecked():
            if len(self.list_corr_features) == 20:
                self.list_corr_features = df[features_list[1]]
            else:
                self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[21]]], axis=1)

        if self.feature22.isChecked():
            if len(self.list_corr_features) == 0:
                self.list_corr_features = df[features_list[22]]
            else:
                self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[22]]], axis=1)

        if self.feature23.isChecked():
            if len(self.list_corr_features) == 0:
                self.list_corr_features = df[features_list[23]]
            else:
                self.list_corr_features = pd.concat([self.list_corr_features, df[features_list[23]]], axis=1)


        vsticks = ["dummy"]
        vsticks1 = list(self.list_corr_features.columns)
        vsticks1 = vsticks + vsticks1
        res_corr = self.list_corr_features.corr()
        self.ax1.matshow(res_corr, cmap= plt.cm.get_cmap('Blues', 14))
        self.ax1.set_yticklabels(vsticks1)
        self.ax1.set_xticklabels(vsticks1,rotation = 90)

        self.fig.tight_layout()
        self.fig.canvas.draw_idle()

class TargetRelationship(QMainWindow):
    #::--------------------------------------------------------
    # This class crates a canvas with a plot to show the relation
    # from each feature in the dataset with the target variables
    # methods
    #    _init_
    #   update
    #::--------------------------------------------------------
    send_fig = pyqtSignal(str)
```

```
def __init__(self):
    super(TargetRelationship, self).__init__()
    self.Title = "Boxplot of Categorical vs Numerical Variables"
    self.main_widget = QWidget(self)

    self.setWindowTitle(self.Title)
    self.setStyleSheet(font_size_window)

    self.fig = Figure()
    self.ax1 = self.fig.add_subplot(111)
    self.axes = [self.ax1]
    self.canvas = FigureCanvas(self.fig)

    self.canvas.setSizePolicy(QSizePolicy.Expanding,
                              QSizePolicy.Expanding)

    self.canvas.updateGeometry()

    self.dropdown1 = QComboBox()
    self.featuresList = numerical.copy()
    self.dropdown1.addItems(self.featuresList)

    self.dropdown1.currentIndexChanged.connect(self.update)
    self.label = QLabel("A plot:")

    self.dropdown2 = QComboBox()
    self.featuresList = categorical.copy()
    self.dropdown2.addItems(self.featuresList)

    self.dropdown2.currentIndexChanged.connect(self.update)
    self.label = QLabel("A plot:")

    self.layout = QGridLayout(self.main_widget)
    self.layout.addWidget(QLabel("Select a Numerical Features:"), 0, 0, 1, 1)
    self.layout.addWidget(self.dropdown1, 1, 0, 1, 1)

    self.layout.addWidget(QLabel("Select a Categorical Features:"), 0, 1, 1, 1)
    self.layout.addWidget(self.dropdown2, 1, 1, 1, 1)

    self.groupBox1 = QGroupBox('Distribution')
    self.groupBox1Layout = QVBoxLayout()
    self.groupBox1.setLayout(self.groupBox1Layout)
    self.groupBox1Layout.addWidget(self.canvas)
```

```
        self.layout.addWidget(self.groupBox1, 3, 0, 5, 5)

        self.setCentralWidget(self.main_widget)
        self.resize(1500, 1200)
        self.show()
        self.update()

    def update(self):
        self.ax1.clear()
        cat1 = self.dropdown1.currentText()
        cat2 = self.dropdown2.currentText()

        df2 = df_orig[[cat1, cat2]]
        my_pt = pd.pivot_table(df2, index=df2.index, columns=cat2, values=cat1, aggfunc=np.sum)
        my_pt = pd.DataFrame(my_pt.to_records())
        my_pt = my_pt.drop(columns=['index'])
        my_np = my_pt.values
        mask = ~np.isnan(my_np)
        box_result = [d[m] for d, m in zip(my_np.T, mask.T)]
        class_names_x = my_pt.columns.values.tolist()
        self.ax1.boxplot(box_result)
        # X_1 = df_orig[cat2]
        # y_1 = df_orig[cat1]
        # for j, value2 in enumerate(X_1.unique()):
        #     df_orig.loc[df_orig[cat2] == value2].plot(kind="box", x=cat2, y=cat1, ax=self.ax1,label=value2)
        vtitle = cat2 + "vrs "+ cat1
        self.ax1.set_title(vtitle)
        self.ax1.set_xlabel(cat2)
        self.ax1.set_ylabel(cat1)
        self.ax1.set_xticklabels(class_names_x)
        self.ax1.grid(True)

        self.fig.tight_layout()
        self.fig.canvas.draw_idle()
        del cat1


class PlotCanvas(FigureCanvas):
    #::--------------------------------------------------------------
    # creates a figure on the canvas
    # later on this element will be used to draw a histogram graph
    #::--------------------------------------------------------------
    def __init__(self, parent=None, width=5, height=4, dpi=100):
```

```
        fig = Figure(figsize=(width, height), dpi=dpi)

        FigureCanvas.__init__(self, fig)
        self.setParent(parent)

        FigureCanvas.setSizePolicy(self,
                                   QSizePolicy.Expanding,
                                   QSizePolicy.Expanding)
        FigureCanvas.updateGeometry(self)

    def plot(self):
        self.ax = self.figure.add_subplot(111)

class CanvasWindow(QMainWindow):
    #::---------------------------------
    # Creates a canvaas containing the plot for the initial analysis
    #;;---------------------------------
    def __init__(self, parent=None):
        super(CanvasWindow, self).__init__(parent)

        self.left = 200
        self.top = 200
        self.Title = 'Distribution'
        self.width = 500
        self.height = 500
        self.initUI()

    def initUI(self):

        self.setWindowTitle(self.Title)
        self.setStyleSheet(font_size_window)

        self.setGeometry(self.left, self.top, self.width, self.height)

        self.m = PlotCanvas(self, width=5, height=4)
        self.m.move(0, 30)

class App(QMainWindow):
    #::---------------------------------------------------------
    # This class creates all the elements of the application
    #::---------------------------------------------------------

    def __init__(self):
```

```
        super().__init__()
        self.left = 100
        self.top = 100
        self.Title = 'Vehicle Loan Prediction'
        self.setWindowIcon(QIcon("logo.png"))

        self.width = 1000
        self.height = 500
        self.initUI()

    def initUI(self):
        #::-----------------------------------------------
        # Creates the manu and the items
        #::-----------------------------------------------
        self.setWindowTitle(self.Title)
        self.setGeometry(self.left, self.top, self.width, self.height)

        #::------------------------------
        # Create the menu bar
        # and three items for the menu, File, EDA Analysis and ML Models
        #::------------------------------
        mainMenu = self.menuBar()
        mainMenu.setStyleSheet('background-color: lightblue')

        fileMenu = mainMenu.addMenu('File')
        EDAMenu = mainMenu.addMenu('EDA Analysis')
        MLModelMenu = mainMenu.addMenu('ML Models')

        #::--------------------------------------
        # Exit application
        # Creates the actions for the fileMenu item
        #::--------------------------------------

        exitButton = QAction(QIcon('enter.png'), 'Exit', self)
        exitButton.setShortcut('Ctrl+Q')
        exitButton.setStatusTip('Exit application')
        exitButton.triggered.connect(self.close)

        fileMenu.addAction(exitButton)

        #::--------------------------------------
        # EDA analysis
        # Creates the actions for the EDA Analysis item
```

```
# Initial Assesment : Histogram about the level of happiness in 2017
# Happiness Final : Presents the correlation between the index of happiness and a feature from the datasets.
# Correlation Plot : Correlation plot using all the dims in the datasets
#::--------------------------------------



EDA1Button = QAction(QIcon('analysis.png'),'Variable Distribution', self)
EDA1Button.setStatusTip('Variable distribution against Loan Default')
EDA1Button.triggered.connect(self.EDA1)
EDAMenu.addAction(EDA1Button)


EDA3Button = QAction(QIcon('analysis.png'), 'Variable Counts', self)
EDA3Button.setStatusTip('Categorical Variable Counts')
EDA3Button.triggered.connect(self.EDA3)
EDAMenu.addAction(EDA3Button)


EDA4Button = QAction(QIcon('analysis.png'), 'Correlation Plot', self)
EDA4Button.setStatusTip('Features Correlation Plot')
EDA4Button.triggered.connect(self.EDA4)
EDAMenu.addAction(EDA4Button)

EDA5Button = QAction(QIcon('analysis.png'), 'Variable Relationship', self)
EDA5Button.setStatusTip('Boxplot of Loan Default')
EDA5Button.triggered.connect(self.EDA5)
EDAMenu.addAction(EDA5Button)

#::-----------------------------------------------------
# ML Models for prediction
# There are two models
#       Decision Tree
#       Random Forest
#::-----------------------------------------------------
# Decision Tree Model
#::-----------------------------------------------------
MLModel1Button =  QAction(QIcon(), 'Decision Tree Entropy', self)
MLModel1Button.setStatusTip('ML algorithm with Entropy ')
MLModel1Button.triggered.connect(self.MLDT)

#::-----------------------------------------------------
# Random Forest Classifier
```

```
    #::--------------------------------------------------------
    MLModel2Button = QAction(QIcon(), 'Random Forest Classifier', self)
    MLModel2Button.setStatusTip('Random Forest Classifier ')
    MLModel2Button.triggered.connect(self.MLRF)

    MLModel3Button = QAction(QIcon(), 'Logistic Regression Classifier', self)
    MLModel3Button.setStatusTip('Logistic Regression Classifier ')
    MLModel3Button.triggered.connect(self.MLLR)

    MLModel4Button = QAction(QIcon(), 'Gradient Boosting Classifier', self)
    MLModel4Button.setStatusTip('Gradient Boosting Classifier ')
    MLModel4Button.triggered.connect(self.MLGB)

    MLModelMenu.addAction(MLModel1Button)
    MLModelMenu.addAction(MLModel2Button)
    MLModelMenu.addAction(MLModel3Button)
    MLModelMenu.addAction(MLModel4Button)


    self.dialogs = list()


def EDA1(self):
    #::--------------------------------------------------------
    # Creates the histogram
    # The X variable contains the happiness.score
    # X was populated in the method data_happiness()
    # at the start of the application
    #::--------------------------------------------------------
    dialog = TargetDistribution()
    self.dialogs.append(dialog)
    dialog.show()

def EDA3(self):
    #::--------------------------------------------------------
    # Creates the histogram
    # The X variable contains the happiness.score
    # X was populated in the method data_happiness()
    # at the start of the application
    #::--------------------------------------------------------
    dialog = TargetCount()
    self.dialogs.append(dialog)
    dialog.show()
```

```
def EDA4(self):
    #::-------------------------------------------------------------
    # This function creates an instance of the CorrelationPlot class
    #::-------------------------------------------------------------
    dialog = CorrelationPlot()
    self.dialogs.append(dialog)
    dialog.show()

def EDA5(self):
    #::-------------------------------------------------------------
    # This function creates an instance of the CorrelationPlot class
    #::-------------------------------------------------------------
    dialog = TargetRelationship()
    self.dialogs.append(dialog)
    dialog.show()


def MLDT(self):
    #::-------------------------------------------------------------
    # This function creates an instance of the DecisionTree class
    # This class presents a dashboard for a Decision Tree Algorithm
    # using the happiness dataset
    #::-------------------------------------------------------------
    dialog = DecisionTree()
    self.dialogs.append(dialog)
    dialog.show()

def MLRF(self):
#     #::-------------------------------------------------------------
#     # This function creates an instance of the Random Forest Classifier Algorithm
#     # using the happiness dataset
#     #::-------------------------------------------------------------
      dialog = RandomForest()
      self.dialogs.append(dialog)
      dialog.show()

def MLLR(self):
#     #::-------------------------------------------------------------
#     # This function creates an instance of the Random Forest Classifier Algorithm
#     # using the happiness dataset
#     #::-------------------------------------------------------------
      dialog = LogisticReg()
```

```
        self.dialogs.append(dialog)
        dialog.show()

    def MLGB(self):
    #     #::---------------------------------------------------------------
    #     # This function creates an instance of the Random Forest Classifier Algorithm
    #     # using the happiness dataset
    #     #::---------------------------------------------------------------
        dialog = GradientBoosting()
        self.dialogs.append(dialog)
        dialog.show()



def main():
    #::-------------------------------------------------
    # Initiates the application
    #::-------------------------------------------------
    app = QApplication(sys.argv)
    app.setStyle('Fusion')
    ex = App()
    ex.show()
    ex.showMaximized()
    sys.exit(app.exec_())

def data_loan():
    #::-------------------------------------------------
    # Loads the dataset 2017.csv ( Index of happiness and esplanatory variables original dataset)
    # Loads the dataset final_happiness_dataset (index of happiness
    # and explanatory variables which are already preprocessed)
    # Populates X,y that are used in the classes above
    #::-------------------------------------------------
    global loan

    global X
    global y
    global X_test
    global y_test
    global features_list
    global class_names
    global target
    global categorical
    global numerical
```

```
    global df_orig
    global df
    df_orig = pd.read_csv(r'lt-vehicle-loan-default-prediction/train.csv')
    # df = pd.read_csv(r'lt-vehicle-loan-default-prediction/Ultry.csv')
    df=pd.read_csv(r'lt-vehicle-loan-default-prediction/final_test2.csv')

    target = 'loan_default'
    X = df.drop([target], axis=1)
    y= df[target].fillna(0)

    columns = X.columns.tolist()


    # indexes = [0,1,2,3,4,5,6,8,9,10,13,14,15,16,17,18,19,26,28,30,31,32,33,34,35]
    # features_list=['index', 'disbursed_amount', 'asset_cost', 'ltv', 'branch_id', 'manufacturer_id', 'Employment.Type',
'MobileNo_Avl_Flag', 'Aadhar_flag', 'PAN_flag', 'Passport_flag', 'PERFORM_CNS.SCORE', 'PRI.NO.OF.ACCTS',
'PRI.ACTIVE.ACCTS', 'PRI.OVERDUE.ACCTS', 'PRI.CURRENT.BALANCE', 'PRI.SANCTIONED.AMOUNT',
'SEC.DISBURSED.AMOUNT', 'SEC.INSTAL.AMT', 'DELINQUENT.ACCTS.IN.LAST.SIX.MONTHS',
'AVERAGE.ACCT.AGE', 'CREDIT.HISTORY.LENGTH', 'NO.OF_INQUIRIES', 'Age', 'Disbursal_months']
    # features_list = [columns[i+1] for i in indexes]
    features_list = columns
    class_names = ['No', 'Yes']

    categorical = ['Employment.Type', 'PERFORM_CNS.SCORE.DESCRIPTION', 'AVERAGE.ACCT.AGE' \
                   'Aadhar_flag', 'PAN_flag', 'VoterID_flag', 'Driving_flag', 'Passport_flag','loan_default']
    numerical = ['disbursed_amount', 'asset_cost','PERFORM_CNS.SCORE', 'PRI.NO.OF.ACCTS',
'PRI.ACTIVE.ACCTS', 'PRI.OVERDUE.ACCTS', \
                 'PRI.CURRENT.BALANCE', 'PRI.SANCTIONED.AMOUNT', 'PRI.DISBURSED.AMOUNT',
'SEC.NO.OF.ACCTS', 'SEC.ACTIVE.ACCTS', \
                 'SEC.OVERDUE.ACCTS', 'SEC.CURRENT.BALANCE','SEC.SANCTIONED.AMOUNT',
'SEC.DISBURSED.AMOUNT', 'PRIMARY.INSTAL.AMT', \
                 'SEC.INSTAL.AMT', 'NEW.ACCTS.IN.LAST.SIX.MONTHS',
'DELINQUENT.ACCTS.IN.LAST.SIX.MONTHS','NO.OF_INQUIRIES'\
                 ]


if __name__ == '__main__':
    #::------------------------------------
    # First reads the data then calls for the application
    #::------------------------------------
    data_loan()
    main()
```