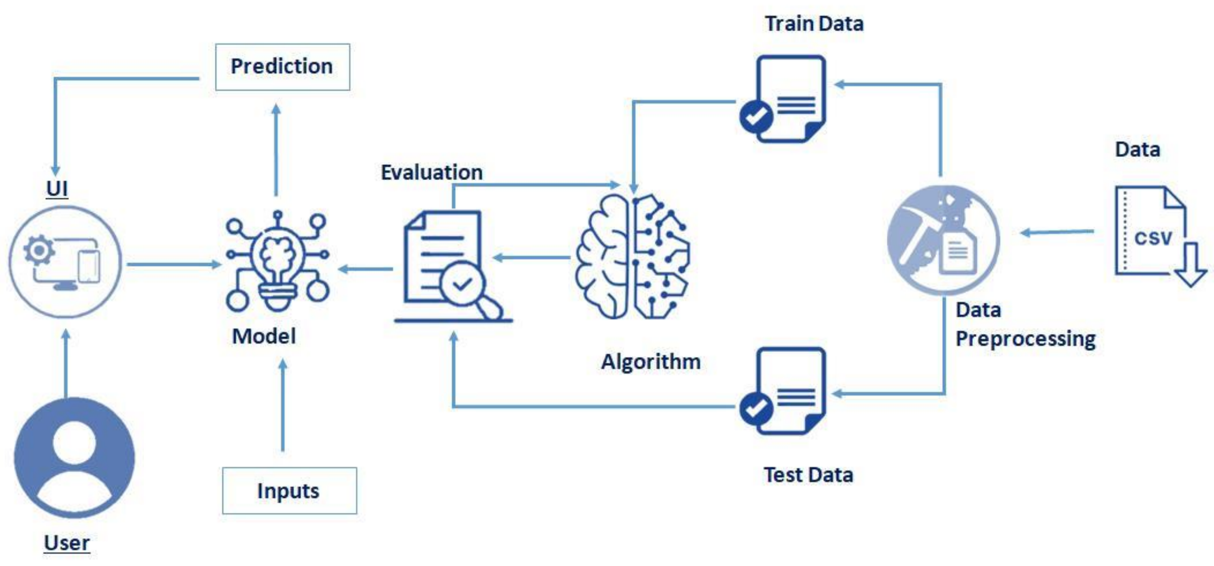
Wine Quality Prediction Using Machine Learning

Project Description:

Wine is the most commonly used beverage globally, and its values are considered important in society. Wine is an alcoholic drink that is made up of fermented grapes. Quality of wine is important for its consumers, mainly for producers in the present competitive market to raise the revenue. Wine quality refers to the factors that go into producing a wine, as well as the indicators or characteristics that tell you if the wine is of high quality. Historically, wine quality used to be determined by testing at the end of the production.

If you have come across wine then you will notice that wine has also their type, they are red and white wine. According to experts, wine is differentiated according to its smell, flavour, and colour, but we are not wine experts to say that wine is good or bad. Every person has their own opinion about the tastes, so identifying a quality based on a person's taste is challenging. Judging the quality of wine manually is a really tough task, even the professional wine tasters have the accuracy of 71%.

In this project, we present a wine quality prediction technique that utilizes historical data to train simple machine learning models which are more accurate and can help us know the quality of wine. The models can be run on much less resource intensive environments. From this the best model is selected and saved in pkl format. We will be doing flask integration and IBM deployment.
Technical Architecture:
Project Objectives



By the end of this project:

You'll be able to understand the problem to classify if it is a regression or a classification kind of problem.
You will be able to know how to pre-process/clean the data using different data pre-processing techniques.
You will be able to analyze or get insights into data through visualization.
Applying different algorithms according to the dataset and based on visualization.
You will be able to know how to find the accuracy of the model.
You will be able to know how to build a web application using the Flask framework.

Prerequisites
To complete this project, you must require following software's   concepts and packages

- Anaconda navigator:

Refer to the video below to know more about how download anaconda navigator

- Python packages:

Open anaconda prompt as administrator
- Type "pip install numpy" and click enter.
- Type "pip install pandas" and click enter.
- Type "pip install scikit-learn" and click enter.
- Type "pip install matplotlib" and click enter.
- Type "pip install pickle-mixin" and click enter.
- Type "pip install seaborn" and click enter.
- Type "pip install Flask" and click enter.

https://youtu.be/5mDYijMfSzs
Refer this link to know about the above libraries.

Prior Knowledge
You must have prior knowledge of following topics to complete this project.

- ML Concepts
    - Supervised learning
    - Unsupervised learning
    - Regression
    - Linear Regression
    - Randomforest
    - SVR
    - Stochastic Gradient Descent Classifier
    - Xgboost
    - Evaluation metrics

- Flask Basics: Refer the video given below

https://youtu.be/lj4I_CvBnt0

Project Flow

Project Flow:

- User interacts with the UI to enter the input.
- Entered input is analyzed by the model which is integrated.
- Once model analyses the input the prediction is showcased on the UI

To accomplish this, we have to complete all the activities and tasks listed below

- Data Collection.
  Collect the dataset or Create the dataset

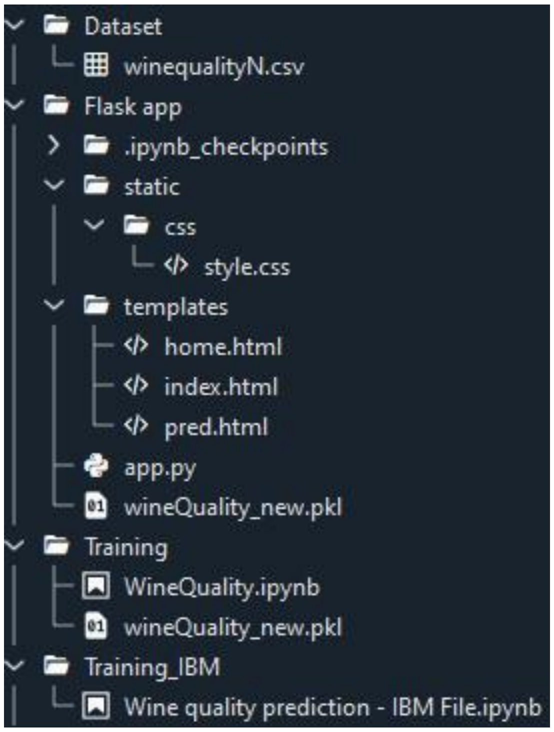
- Visualizing and analyzing data
  Univariate analysis
  Bivariate analysis
  Multivariate analysis
  Descriptive analysis
- Data Pre-processing
  Drop unwanted features
  Checking for null values
  Handling categorical data
  Splitting data into train and test
  Feature Scaling

- Model Building
  Import the model building Libraries
  Initializing the model
  Training and testing the model
  Evaluation of Model
  Save the Model

- Application Building
  Create an HTML file
  Build a Python Code

Project Structure:

Create a Project folder that contains files as shown below



```
Dataset
  winequalityN.csv
Flask app
  .ipynb_checkpoints
  static
    css
      style.css
  templates
    home.html
    index.html
    pred.html
  app.py
  wineQuality_new.pkl
Training
  WineQuality.ipynb
  wineQuality_new.pkl
Training_IBM
  Wine quality prediction - IBM File.ipynb
```

- Dataset folder contains the dataset file **winequalityN.csv**
- Flask folder contains
    - A python file called **app.py** for server-side scripting.
    - Static folder contains CSS folder that contains the cascading stylesheet for our web application named **style.css**
    - Templates folder which contains **index.html file, home.html file, pred.html** file.
    - Trained model file in .pkl format **wineQuality_new.pkl**
- Training folder that contains the model building file **WineQuality.ipynb** and saved model file **wineQuality_new.pkl**
- Traing_IBM folder that contains IBM model building file

Data Collection

ML depends heavily on data, it is the most crucial aspect that makes algorithm training possible. So this section allows you to download the required dataset.

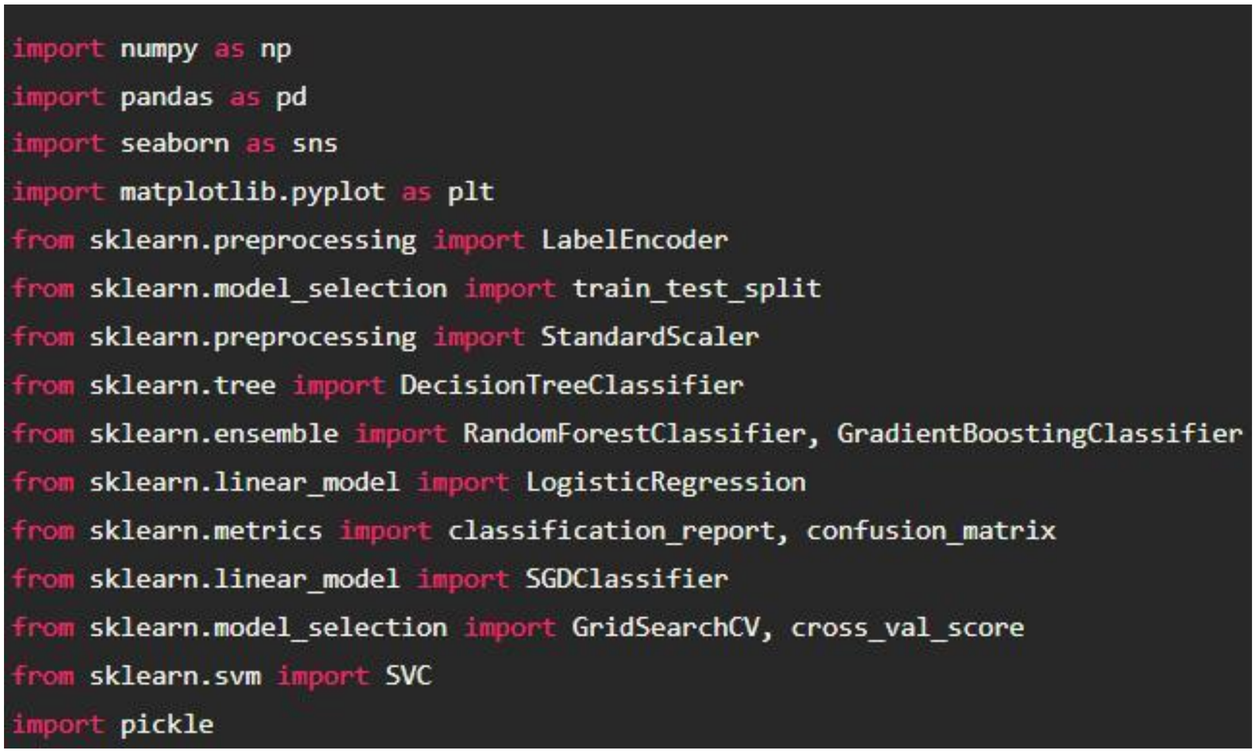
Download The Dataset:

You can collect datasets from different open sources like kaggle.com, data.gov, UCI machine learning repository, etc. Please refer to the link given below to download the data set and to know about the data

Visualizing And Analysing The Data:

As the dataset is downloaded. Let us read and understand the data properly with the help of some visualization techniques and some analysing techniques.
Note: There are n number of techniques for understanding the data. But here we have used some of it. In an additional way, you can use multiple techniques.

Importing The Libraries:
Import the necessary libraries as shown in the image.
To know about the packages refer the link given in pre requisites.

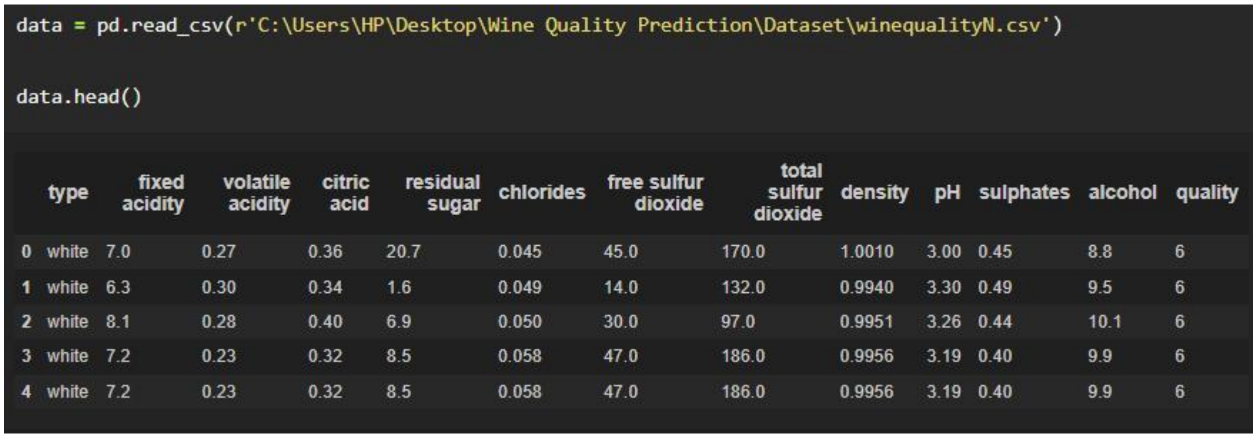

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import GridSearchCV, cross_val_score
from sklearn.svm import SVC
import pickle
```

Read The Dataset:
Our dataset format might be in .csv, excel files, txt, json, etc. We can with the help of pandas.

Read the dataset

In pandas we have a function called read_csv() to read the dataset. As a parameter we

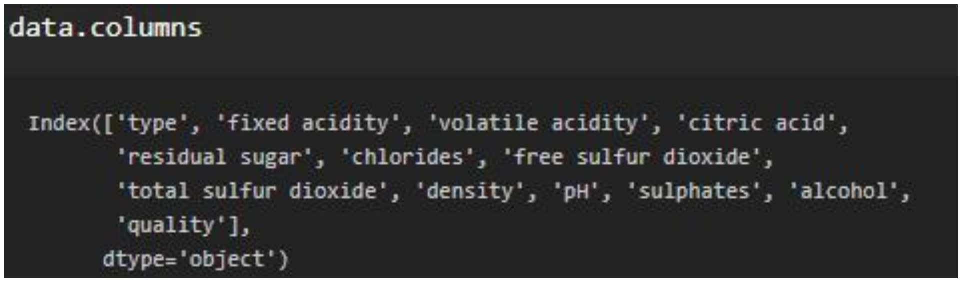
Have to give the directory of csv file.



```
data = pd.read_csv(r'C:\Users\HP\Desktop\Wine Quality Prediction\Dataset\winequalityN.csv')

data.head()
```

	type	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	white	7.0	0.27	0.36	20.7	0.045	45.0	170.0	1.0010	3.00	0.45	8.8	6
1	white	6.3	0.30	0.34	1.6	0.049	14.0	132.0	0.9940	3.30	0.49	9.5	6
2	white	8.1	0.28	0.40	6.9	0.050	30.0	97.0	0.9951	3.26	0.44	10.1	6
3	white	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.9956	3.19	0.40	9.9	6
4	white	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.9956	3.19	0.40	9.9	6

Let's know more about our data



```
data.columns

 Index(['type', 'fixed acidity', 'volatile acidity', 'citric acid',
        'residual sugar', 'chlorides', 'free sulfur dioxide',
        'total sulfur dioxide', 'density', 'pH', 'sulphates', 'alcohol',
        'quality'],
       dtype='object')
```

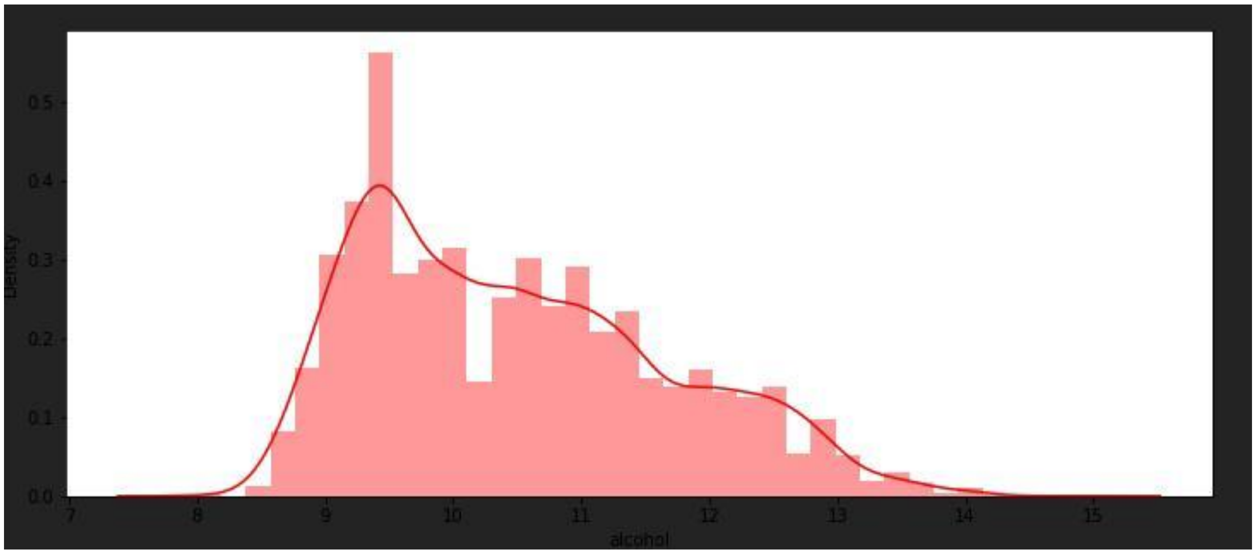
These are the different columns present in our dataset, let’s understand what these features indicates:

- **volatile acidity. Volatile acidity is the gaseous acids present in wine.**
- **Fixed acidity: Primary fixed acids found in wine are tartaric, succinic, citric, andMalic**
- **Residual sugar. Amount of sugar left after fermentation.**
- **Citric acid: It is weak organic acid, found in citrus fruits naturally.**
- **Chlorides: Amount of salt present in wine.**
- **free sulfur dioxide: So2 is used for prevention of wine by oxidation and microbial Spoilage.**
- **total sulfur dioxide: Total SO2 used**
- **pH: In wine pH is used for checking acidity**
- **density: Density of the wine**
- **sulphates Added sulphites preserve freshness and protect wine from oxidation, and bacteria.**
- **Alcohol: Percent of alcohol present in wine.**

Univariate Analysis:

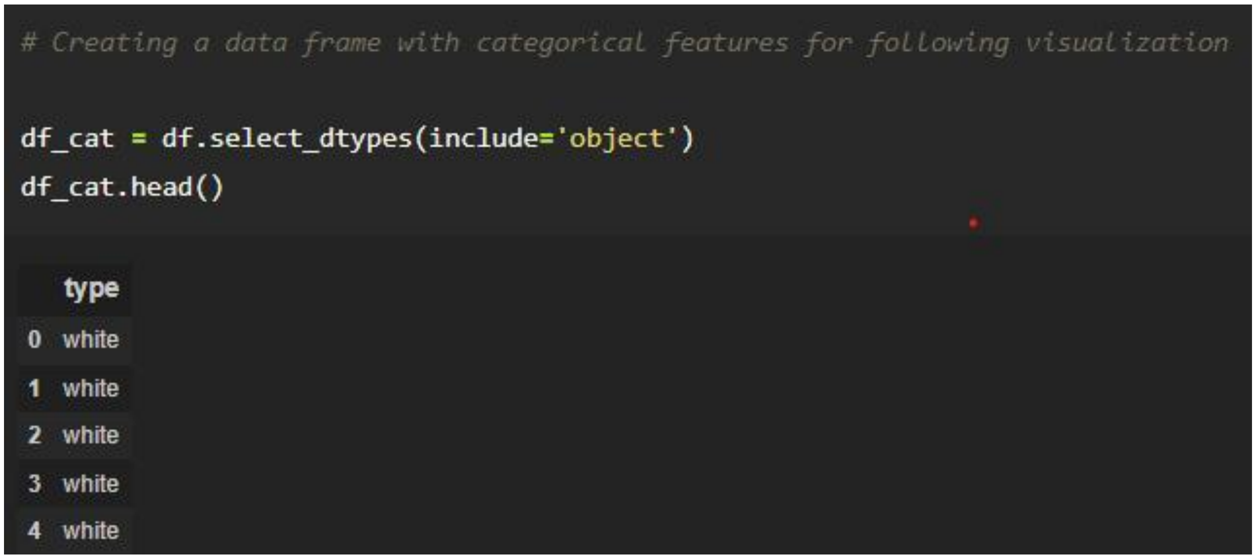
In simple words, univariate analysis is understanding the data with single feature Here we have displayed two different graphs such as pie plot, box plot and count plot.

• Seaborn package provides a wonderful function distplot. The distplot represents the univariate distribution of data i.e. data distribution of a variable against the density distribution. With the help of distplot, we can find the distribution of the feature. We have used distplot here to check whether alcohol is normally distributed or is skewed.



In our dataset we have a categorical features. With the countplot function, we are going to count the unique category in that feature. With for loop and subplot we have plotted this below graph.

• **From the plot we came to know, count of white wine observations is much more than the**

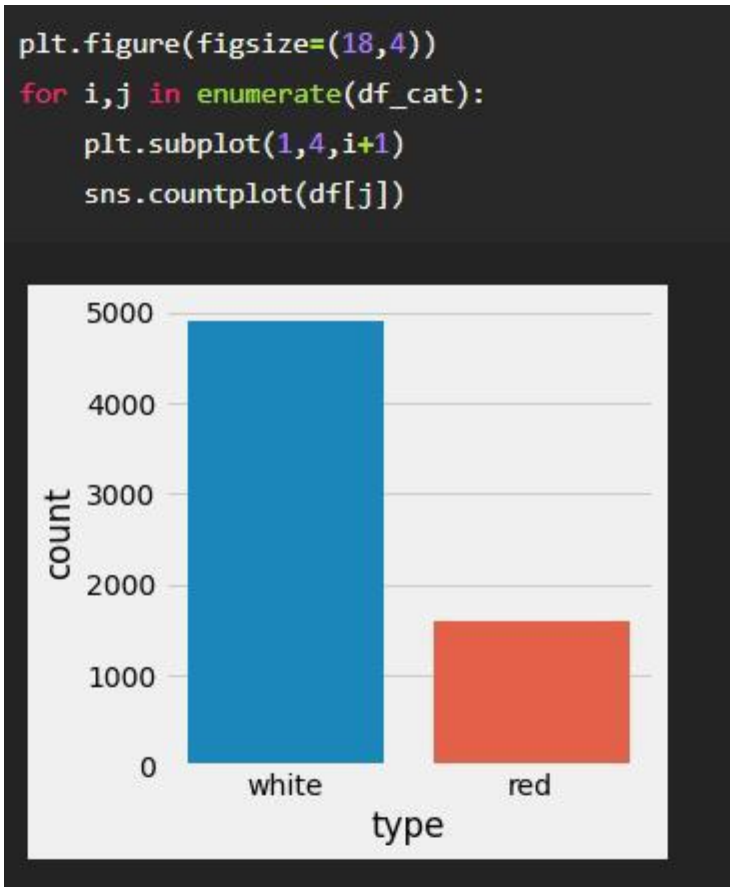


```
# Creating a data frame with categorical features for following visualization

df_cat = df.select_dtypes(include='object')
df_cat.head()
```

```
   type
0  white
1  white
2  white
3  white
4  white
```

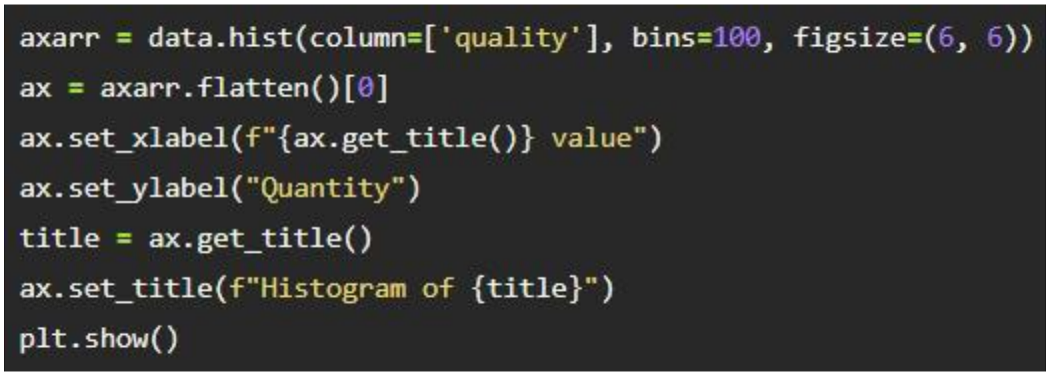
red wine.

- ○
- ○

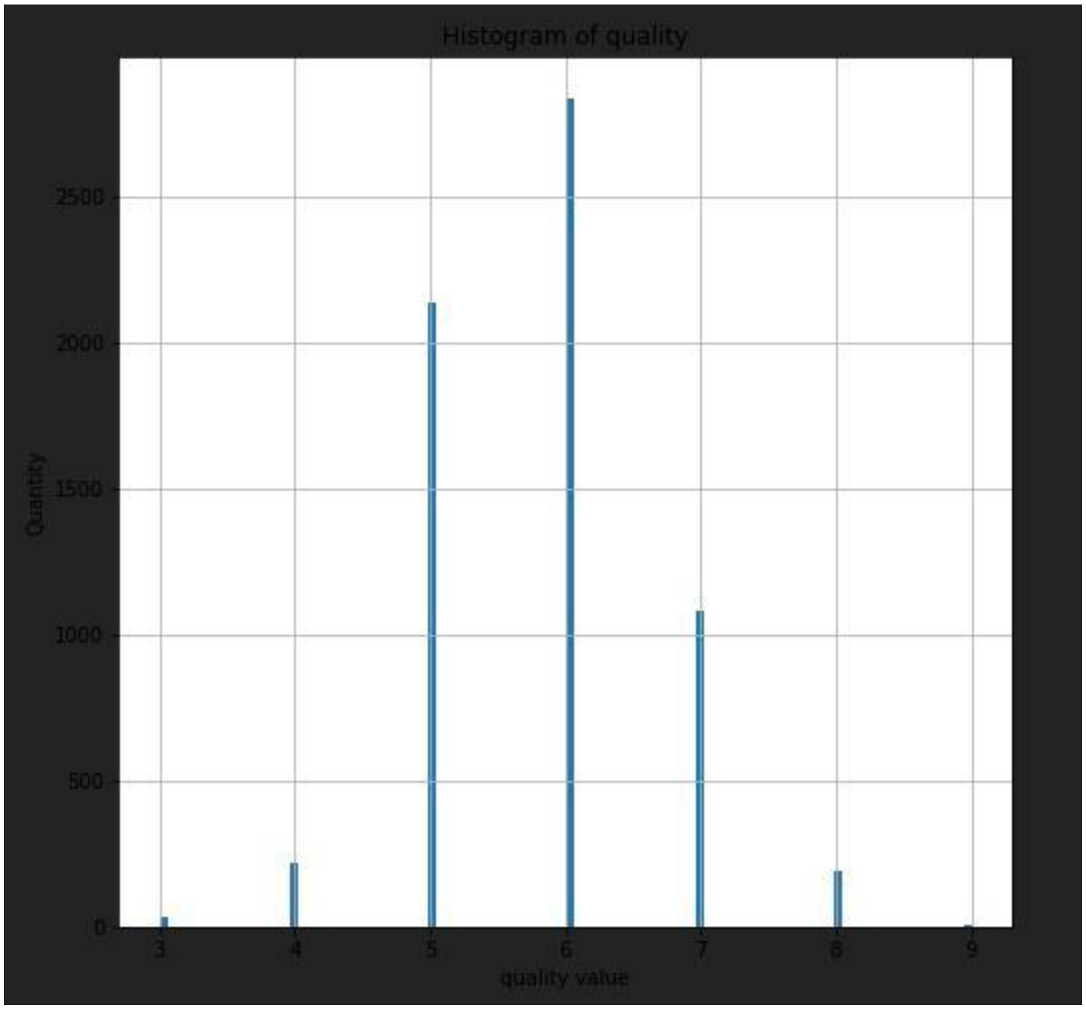


```
plt.figure(figsize=(18,4))
for i,j in enumerate(df_cat):
    plt.subplot(1,4,i+1)
    sns.countplot(df[j])
```

- **The hist() function in pyplot module of matplotlib library is used to plot a Histogram.**



```
axarr = data.hist(column=['quality'], bins=100, figsize=(6, 6))
ax = axarr.flatten()[0]
ax.set_xlabel(f"{ax.get_title()} value")
ax.set_ylabel("Quantity")
title = ax.get_title()
ax.set_title(f"Histogram of {title}")
plt.show()
```



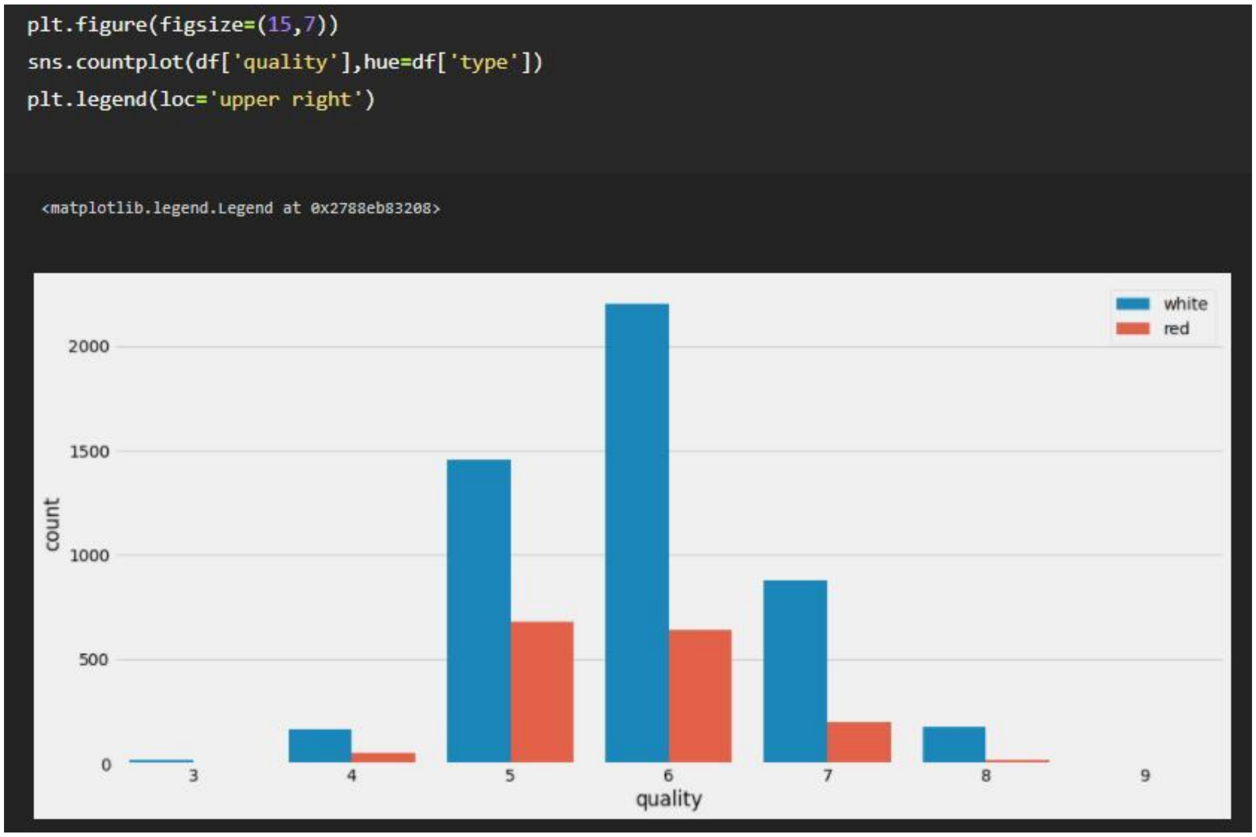
- As we can see, the most common vote is ‘6’, when the lowest vote is 3, and the highest vote is 6. In general, we may see that most of the parameters (except the “type” parameter, which is binary parameter) are normally distributed.

Bivariate Analysis

Activity 4 Bivariate analysis To find the relation between two features we use bivariate analysis.

Countplot is used here. As a 1st parameter we are passing x value and as a 2nd parameter we are passing hue value.

• From this plot we can see the relationship between type and the quality of the



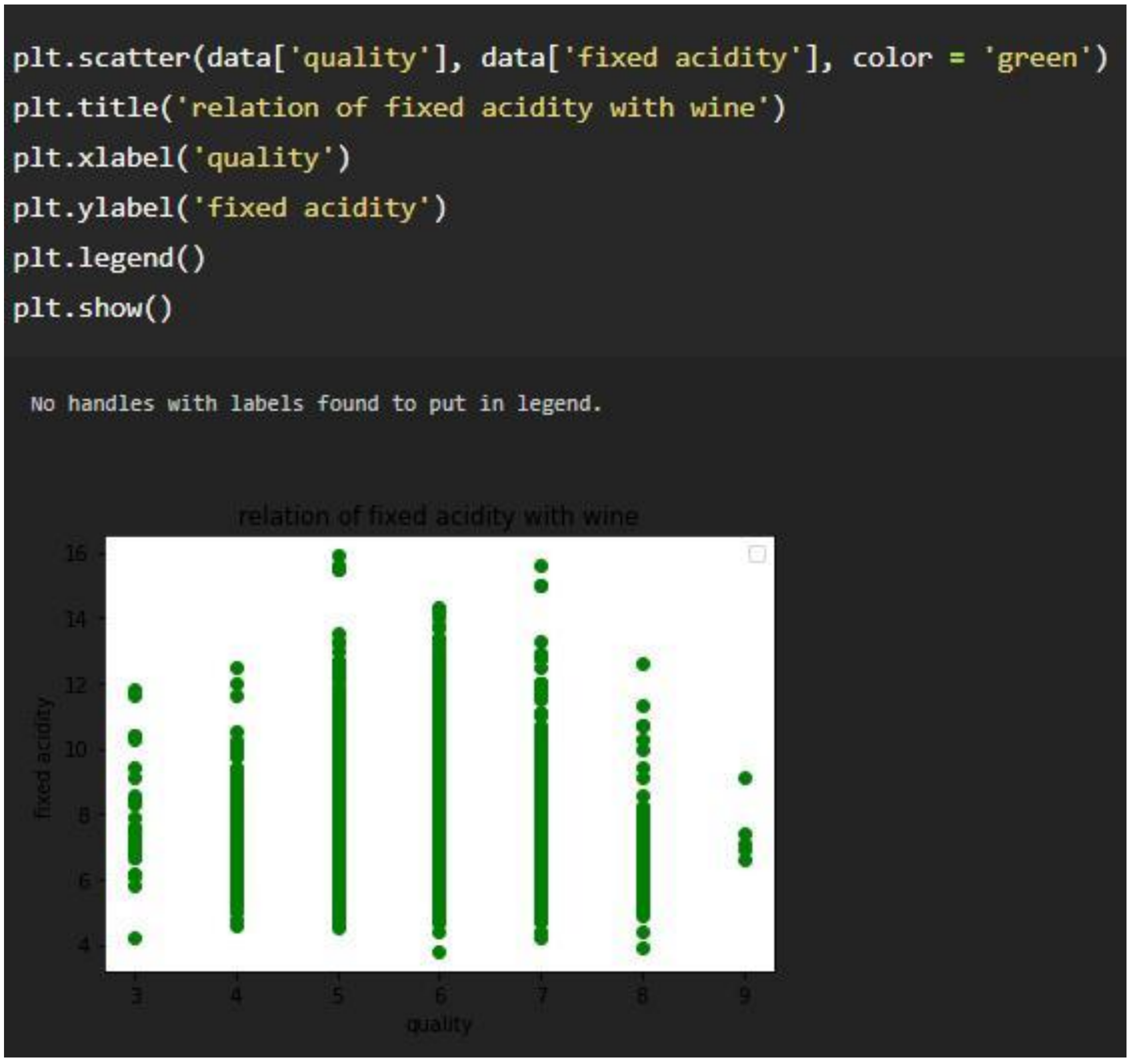
```
plt.figure(figsize=(15,7))
sns.countplot(df['quality'],hue=df['type'])
plt.legend(loc='upper right')
```

```
<matplotlib.legend.Legend at 0x2788eb83208>
```

Data
A scatter plot is a means to represent data in a graphical format. A simple scatter plot makes use of the Coordinate axes to plot the points, based on their values Scatter plots uses dots to represent individual pieces of data

• The following scatter plot represents the relationship between quality and fixed

Acidity as a scatter plot.

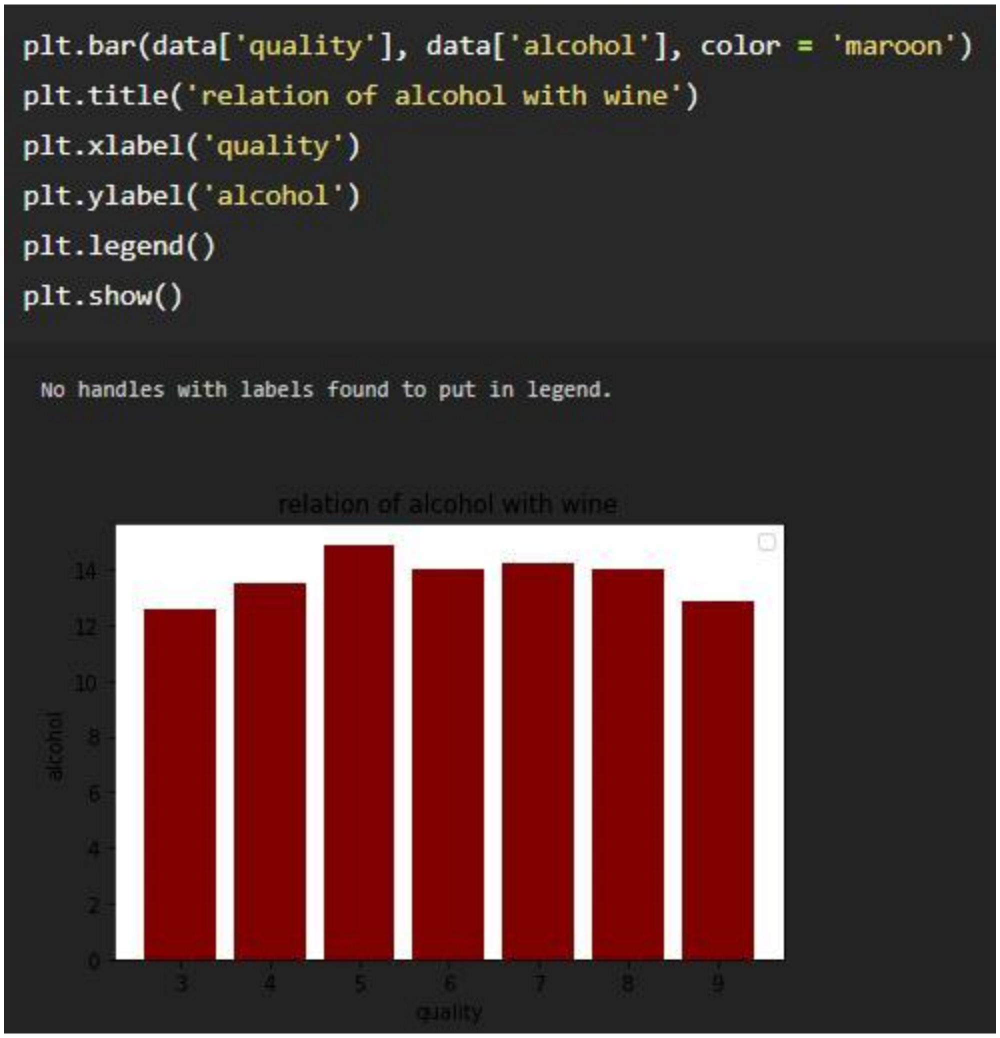


```
plt.scatter(data['quality'], data['fixed acidity'], color = 'green')
plt.title('relation of fixed acidity with wine')
plt.xlabel('quality')
plt.ylabel('fixed acidity')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```

• **A bar chart or bar graph is a chart or graph that presents categorical data with rectangular bars with heights or lengths proportional to the values that they represent**

• The following visualization represents the variation of fixed acidity in the different Qualities of wine.

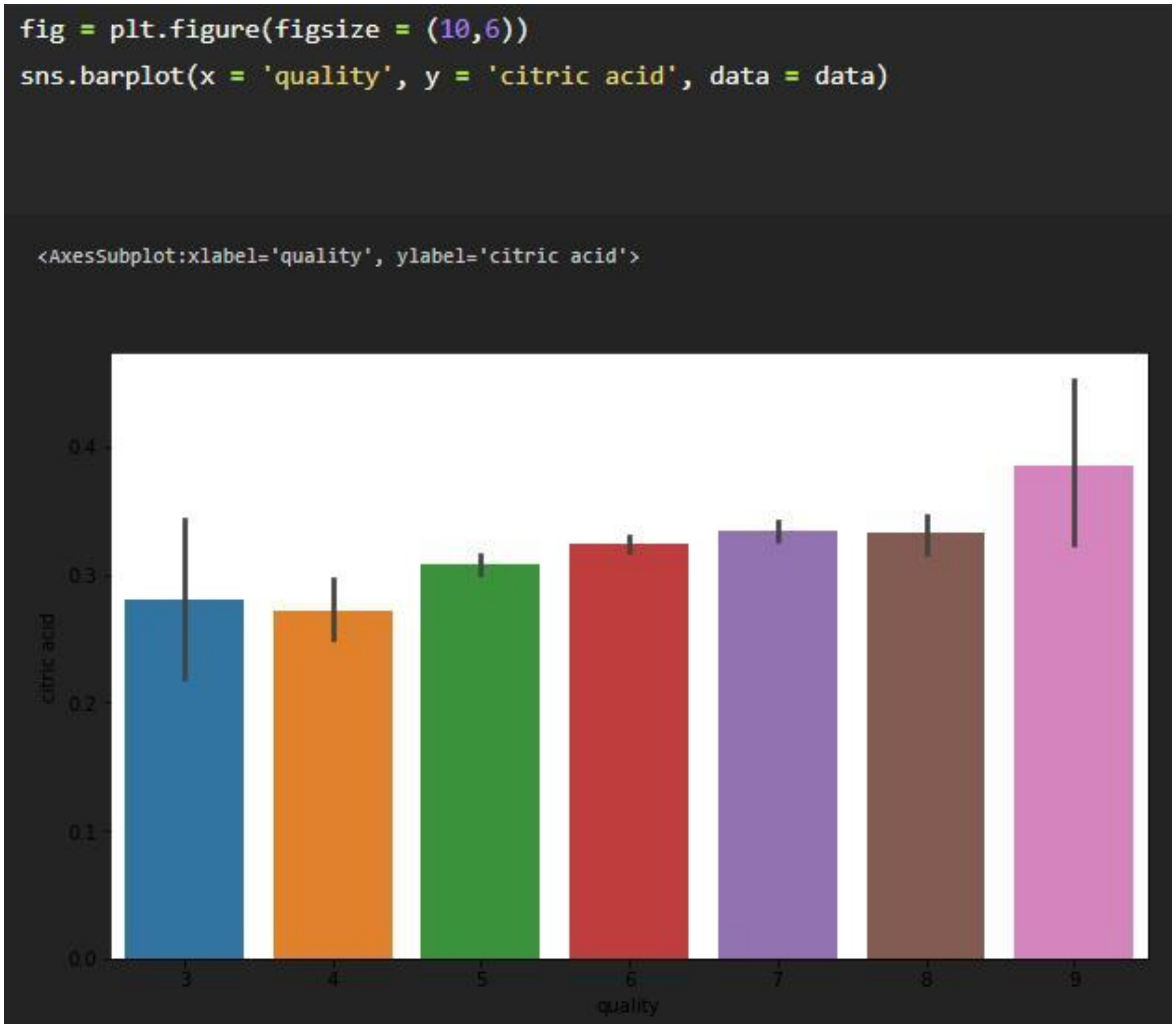


```
plt.bar(data['quality'], data['alcohol'], color = 'maroon')
plt.title('relation of alcohol with wine')
plt.xlabel('quality')
plt.ylabel('alcohol')
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```

• Let's see the relationship between the dependent and independent variables of Our dataset.

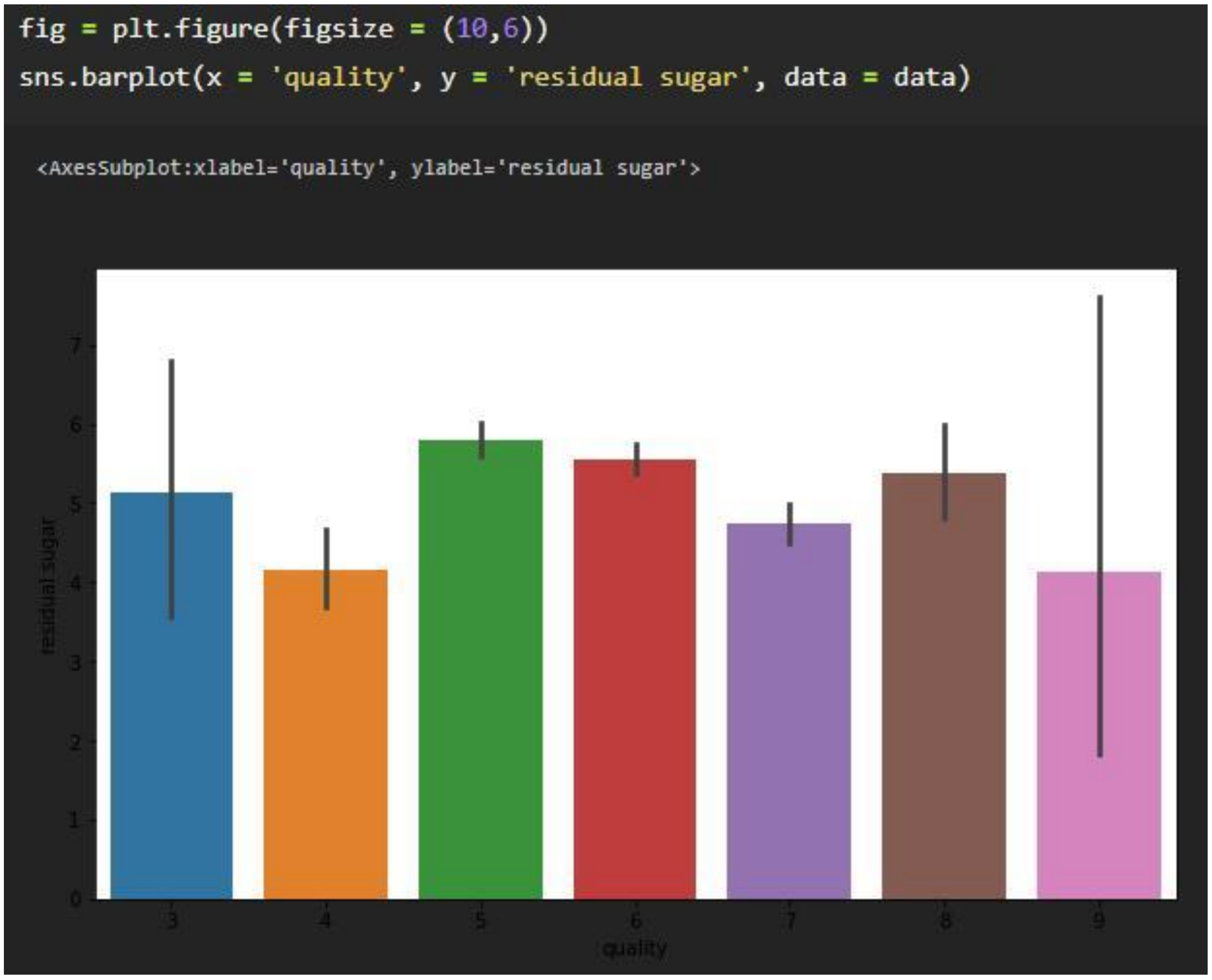
The following visualization represents the relationship between Citric Acid and our target variable, Quality. We can see there's not much variation in citric acid values over the quality.



```
fig = plt.figure(figsize = (10,6))
sns.barplot(x = 'quality', y = 'citric acid', data = data)
```

```
<AxesSubplot:xlabel='quality', ylabel='citric acid'>
```

- **The following visualization represents the relationship between Residual sugar and our target variable, Quality. We can see the variation in Residual sugar values over The quality.**

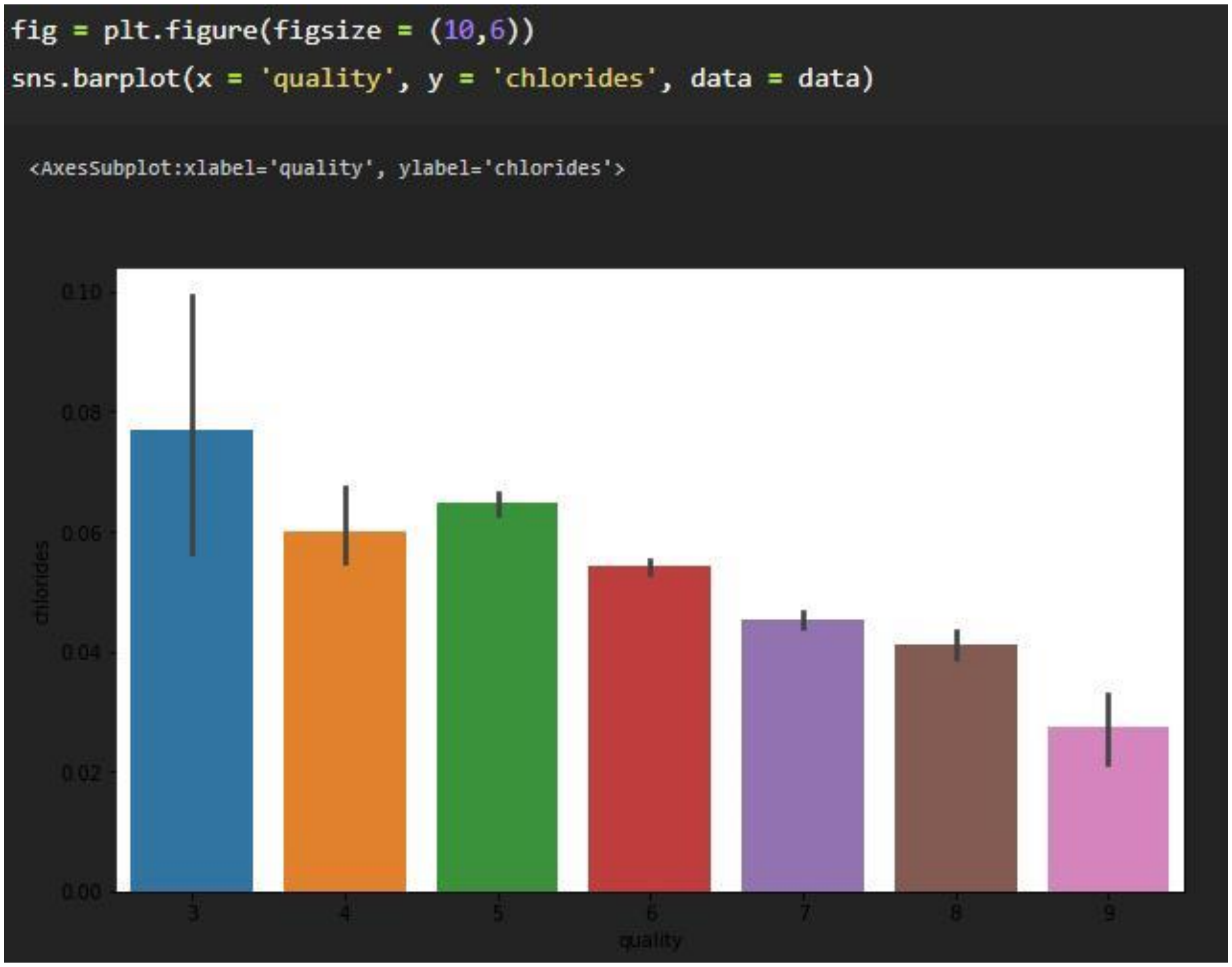


```
fig = plt.figure(figsize = (10,6))
sns.barplot(x = 'quality', y = 'residual sugar', data = data)
```

```
<AxesSubplot:xlabel='quality', ylabel='residual sugar'>
```

- The following visualization represents the relationship between Chlorides and our target variable, Quality We can see the variation in Chlorides values over the quality

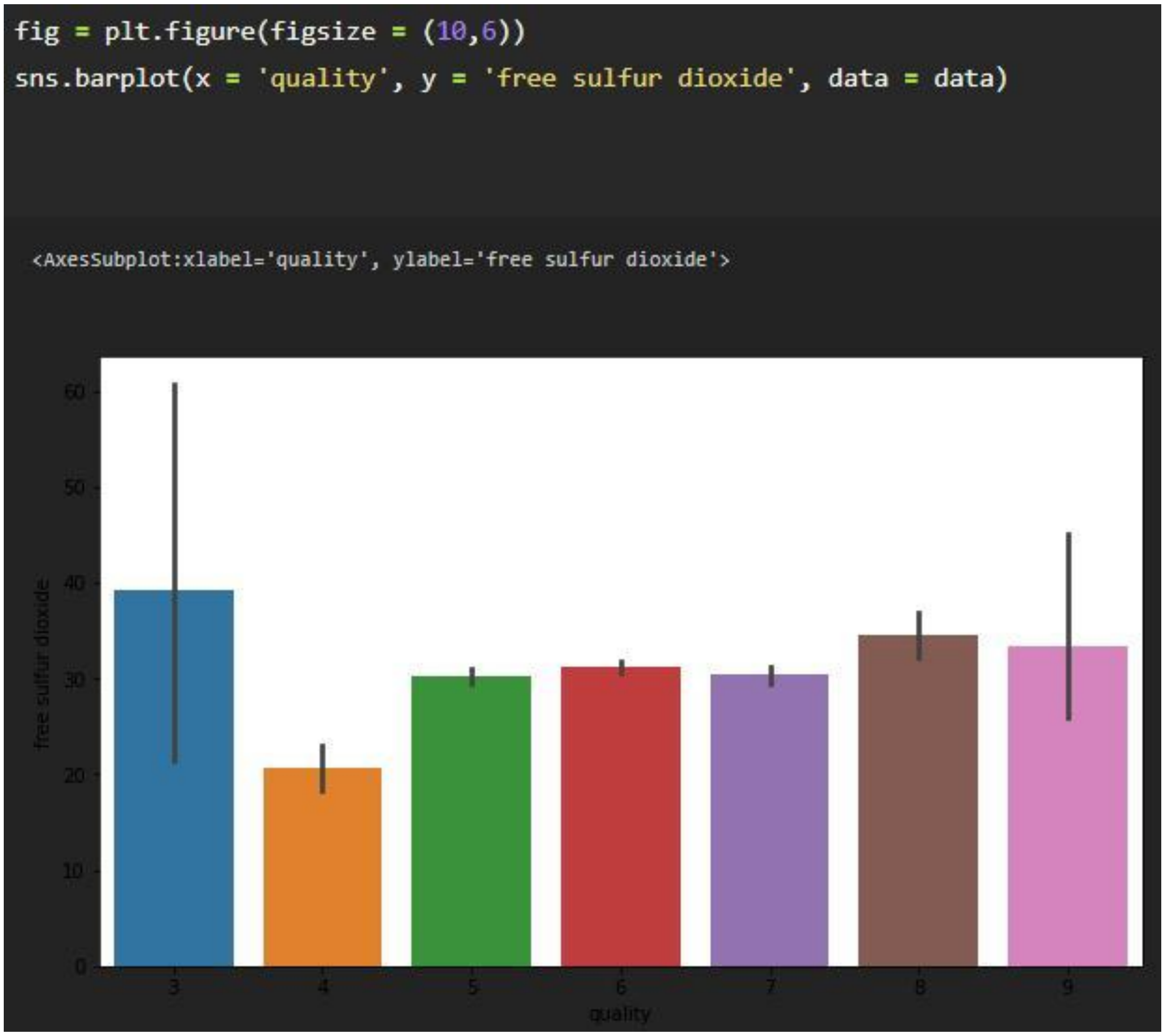
- We can see that the Composition of chloride also go down as we go higher in the quality of the wine so, we can say that Chlorides and Quality are inversely related



```
fig = plt.figure(figsize = (10,6))
sns.barplot(x = 'quality', y = 'chlorides', data = data)
```

```
<AxesSubplot:xlabel='quality', ylabel='chlorides'>
```

- **The following visualization represents the relationship between free sulfur dioxide and our target variable, Quality. We can see the variation in free sulfur dioxide values over the quality.**



```
fig = plt.figure(figsize = (10,6))
sns.barplot(x = 'quality', y = 'free sulfur dioxide', data = data)
```

```
<AxesSubplot:xlabel='quality', ylabel='free sulfur dioxide'>
```

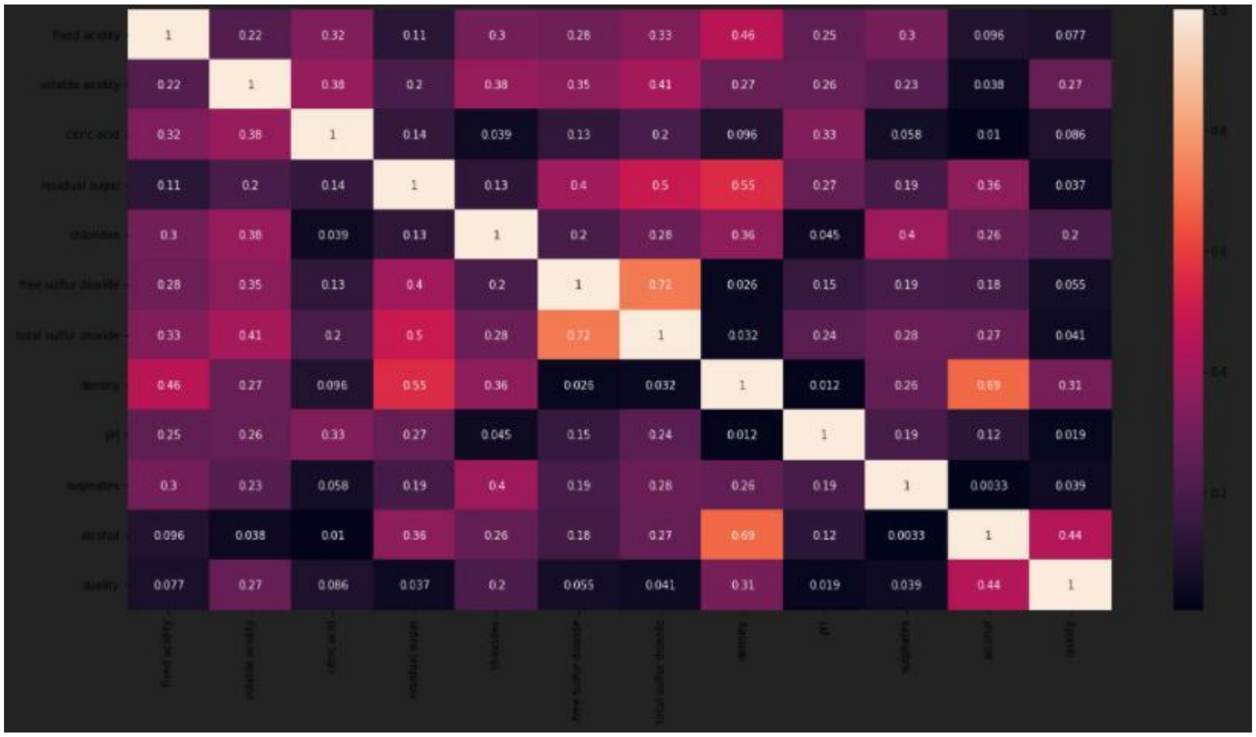
- **The following visualization represents the relationship between sulphates and our target variable, Quality. We can see that there’s not much variation in sulphates values over the quality.**

- **As we can see that like the above two items do not have very strong relation to the dependent variable, we have to showcase a correlation plot to check which of the items are more related to the dependent variable and which items are less related to the dependent variables.**

Multivariate Analysis:

In simple words, multivariate analysis is to find the relation between multiple features. Here we have used a heatmap from the seaborn package.

• Correlation is a statistical measure that expresses the extent to which two variables are linearly related. It's a common tool for describing simple relationships without making a statement about cause and effect. • To visualize the correlation heat map() function is used. From the below image we can easily find the highly correlated feature. Abs() method is used to convert theNegative correlation to positive correlation.



• From the above correlation plot for the given dataset for wine quality prediction, we can easily see which items are related strongly with each other and which items are related weekly with each other. For Example, The strongly correlated items are:

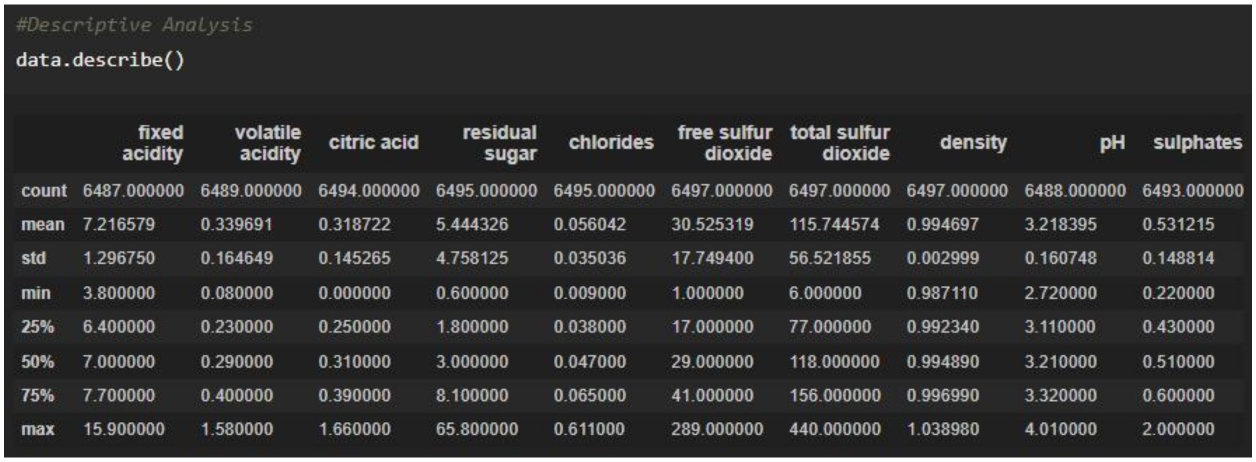
Lfixed acidity and citric acid. 2.free sulphur dioxide and total sulphor dioxide 3.fixed acidity and density. 4. Alcohol and quality.

So, from above points there is a clear inference that alcohol is the most important characteristic to determine the quality of wine.

The weakly correlated items are:
1citric acid and volatile acidity. 2.fixed acidity and ph. 3.density and alcohol.

These are some relations which do not depend on each other at all.

Descriptive Analysis:
Descriptive analysis is to study the basic features of data with the statistical process. Here pandas has a worthy function called describe. With this describe function we can understand the unique, top and frequent values of categorical features. And we can find mean, std, min, max and percentile values of continuous features.



```
#Descriptive Analysis
data.describe()
```

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates
count	6487.000000	6489.000000	6494.000000	6495.000000	6495.000000	6497.000000	6497.000000	6497.000000	6488.000000	6493.000000
mean	7.216579	0.339691	0.318722	5.444326	0.056042	30.525319	115.744574	0.994697	3.218395	0.531215
std	1.296750	0.164649	0.145265	4.758125	0.035036	17.749400	56.521855	0.002999	0.160748	0.148814
min	3.800000	0.080000	0.000000	0.600000	0.009000	1.000000	6.000000	0.987110	2.720000	0.220000
25%	6.400000	0.230000	0.250000	1.800000	0.038000	17.000000	77.000000	0.992340	3.110000	0.430000
50%	7.000000	0.290000	0.310000	3.000000	0.047000	29.000000	118.000000	0.994890	3.210000	0.510000
75%	7.700000	0.400000	0.390000	8.100000	0.065000	41.000000	156.000000	0.996990	3.320000	0.600000
max	15.900000	1.580000	1.660000	65.800000	0.611000	289.000000	440.000000	1.038980	4.010000	2.000000

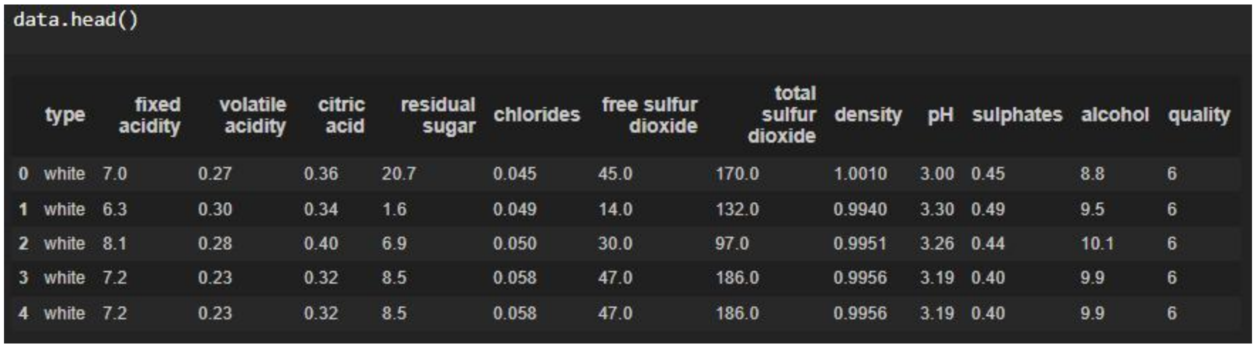
Data Pre-Processing:

- **As we have understood how the data is Lets pre-process the collected data The download data set is not suitable for training the machine learning model as it might have so much of randomness so we need to clean the dataset properly in order to fetch good results. This activity includes the following steps**

- **Removing unwanted columns • Handling missing values**
- **Converting the target variable into binary class variable**
- **Handling categorical data**
- **Splitting dataset into training and test set**
- **Scaling Techniques**

Note: These are the general steps of pre-processing the data before using it for machine learning Depending on the condition of your dataset, you may or may not have to go through all these steps

In the data frame, held) function is used to display the first 5 data. Our dataset has employee id (unique values), department (totally 9 dept.), region (location), education gender, recruitment channel, age, no of trainings previous year ratings, length of service KPIs, award won average training score and is promoted (target variable) columns



```
data.head()
```

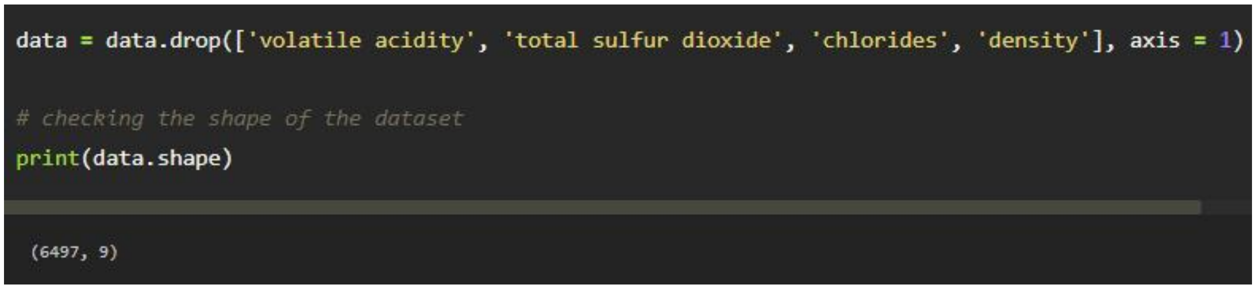
	type	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	white	7.0	0.27	0.36	20.7	0.045	45.0	170.0	1.0010	3.00	0.45	8.8	6
1	white	6.3	0.30	0.34	1.6	0.049	14.0	132.0	0.9940	3.30	0.49	9.5	6
2	white	8.1	0.28	0.40	6.9	0.050	30.0	97.0	0.9951	3.26	0.44	10.1	6
3	white	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.9956	3.19	0.40	9.9	6
4	white	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.9956	3.19	0.40	9.9	6

Drop Unwanted Features:

- **drop() is used to drop specified labels from rows or columns**

  Remove rows or columns by specifying label names and corresponding axis, or by Specifying directly index or column names

- **We are building the model to predict the Quality of wine. As we saw that volatile acidity, total sulfur dioxide, chlorides, density are very less related to the dependent variable quality so even if we remove these columns the accuracy won't be affected that much.**

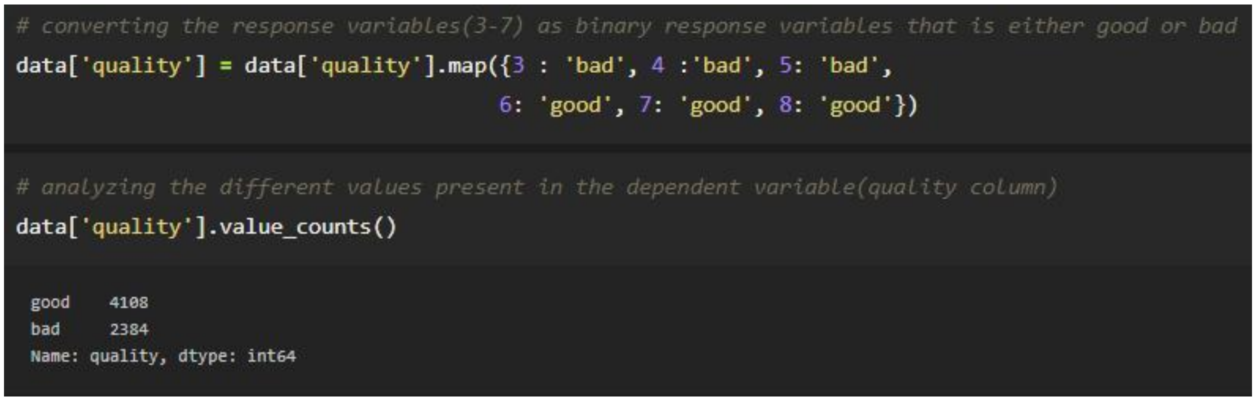


```
data = data.drop(['volatile acidity', 'total sulfur dioxide', 'chlorides', 'density'], axis = 1)

# checking the shape of the dataset
print(data.shape)
```

```
(6497, 9)
```

Converting The Target Variable Into Binary Class Variable :

We are predicting the quality of wine but our quality column has rating in the range 3-9,We need to change it into binary class ie good or bad as the quality can be either good orBad.



```
# converting the response variables(3-7) as binary response variables that is either good or bad
data['quality'] = data['quality'].map({3 : 'bad', 4 :'bad', 5: 'bad',
                                       6: 'good', 7: 'good', 8: 'good'})
```

```
# analyzing the different values present in the dependent variable(quality column)
data['quality'].value_counts()
```

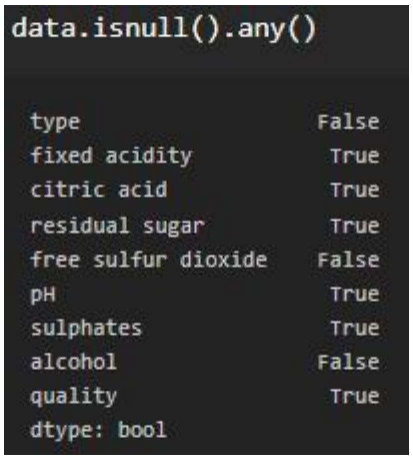
```
good    4108
bad     2384
Name: quality, dtype: int64
```

Value_counts() is used to count different values in the column.

Now, let's see if our dataset has null values or not and if there's any null value so we need to handle the null values as they can affect the accuracy.

Checking For Null Values:
For checking the null values, df.isnull() function is used.

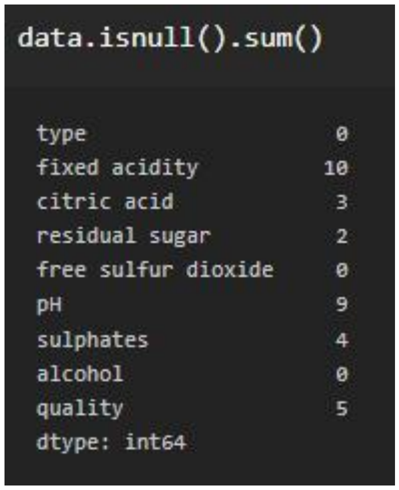
- **To check if there is any null value or not. True indicates the respective column hasNull values and False indicates that there's no null value in that column**



```
data.isnull().any()
```

```
type                    False
fixed acidity            True
citric acid              True
residual sugar           True
free sulfur dioxide     False
pH                       True
sulphates                True
alcohol                 False
quality                  True
dtype: bool
```

- **To sum those null values we use sum() function to it. From the below image we found that education column and previous year rating column has null values.**



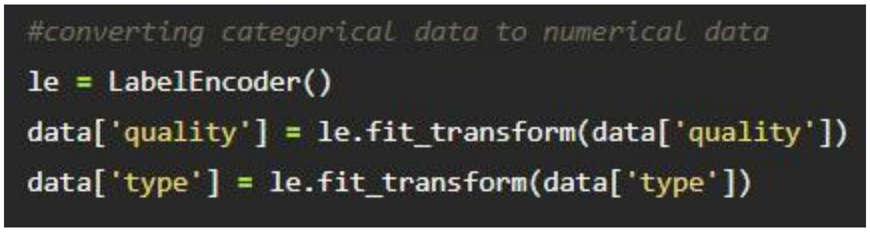
```
data.isnull().sum()

type                    0
fixed acidity          10
citric acid             3
residual sugar          2
free sulfur dioxide     0
pH                      9
sulphates               4
alcohol                 0
quality                 5
dtype: int64
```

- **Let's handle the null values.**
- **For features like fixed acidity, suphates, pH, residual sugar, Citric acid we canreplace the null values with their mean as these columns have numerical valuesWe can use mean() to calculate the mean**
- **For the Quality we can replace it with its respective mode[0] value**

Handling Categorical Values:

As we can see our dataset has categorical data we must convert the categorical data to Integer encoding or binary encoding To convert the categorical features into numerical features we use encoding techniques There are several techniques but in our project we are using feature mapping and label encoding

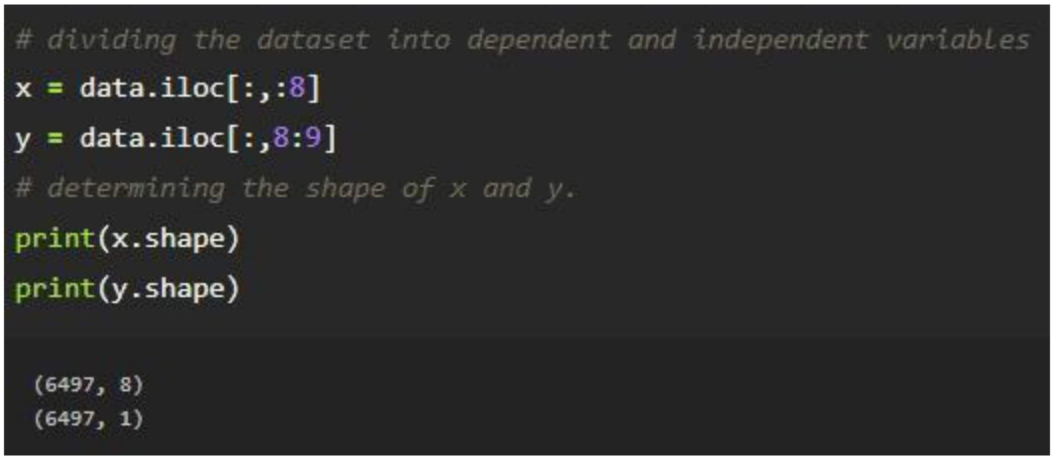
●in our project, categorical features are education and department feature FFeature Mapping on education is done by replace() function.
• Label encoder is initialized and department feature is passed as parameter for fit transform() function Label encoding uses alphabetical ordering in type feature we have 2 categories, white and red and in quality also we have 2 categories, good or bad. Those categories are labelled in alphabetical order.



```
#converting categorical data to numerical data
le = LabelEncoder()
data['quality'] = le.fit_transform(data['quality'])
data['type'] = le.fit_transform(data['type'])
```

Splitting Data Into Train And Test:

Now let's split the Dataset into train and test sets. First split the dataset into x and y and then split the data set



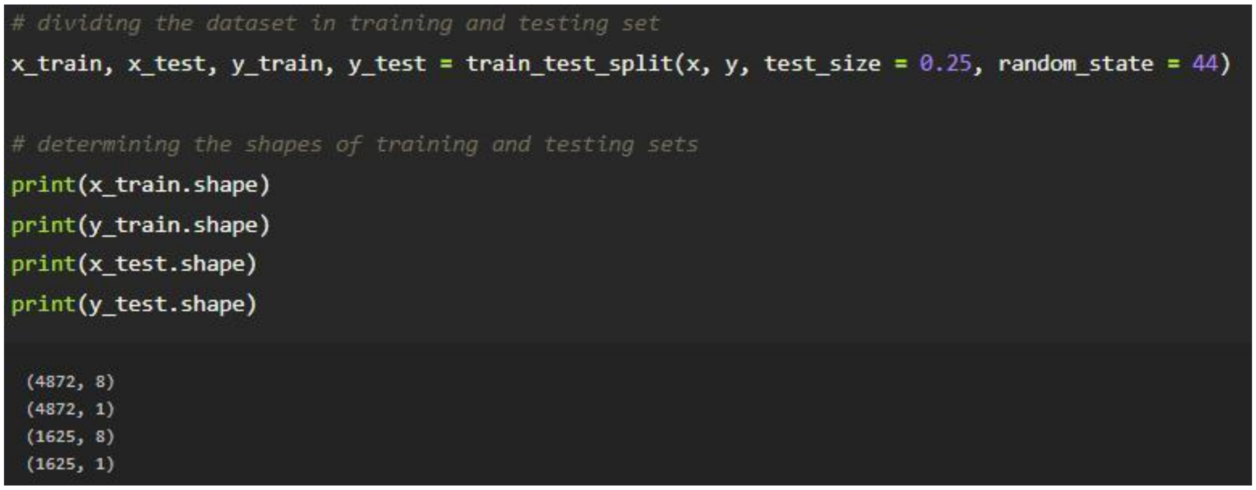
```
# dividing the dataset into dependent and independent variables
x = data.iloc[:,:8]
y = data.iloc[:,8:9]
# determining the shape of x and y.
print(x.shape)
print(y.shape)
```

```
(6497, 8)
(6497, 1)
```

Now let’s split the Dataset into train and test sets. For splitting training and testing data we are using train_test_split() function from sklearn. As parameters, we are passing x, y, test size, random_state

For deep understanding refer this link: https://www.geeksforgeeks.org/how-to-split-a

Dataset-into-train-and-test-sets-using-python/

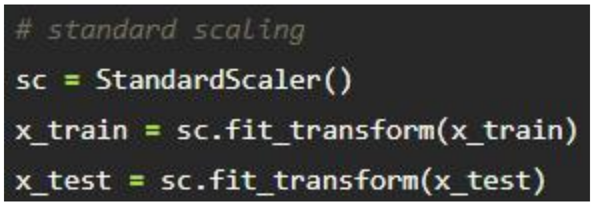


```
# dividing the dataset in training and testing set
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size = 0.25, random_state = 44)

# determining the shapes of training and testing sets
print(x_train.shape)
print(y_train.shape)
print(x_test.shape)
print(y_test.shape)
```

```
(4872, 8)
(4872, 1)
(1625, 8)
(1625, 1)
```

Feature Scaling:

Feature scaling is a method used to normalize the range of independent variables or features of data. Standard scaler) is initialized independent training data is passed in the fit transfering method and independent test data is passed in the transform function



```
# standard scaling
sc = StandardScaler()
x_train = sc.fit_transform(x_train)
x_test = sc.fit_transform(x_test)
```

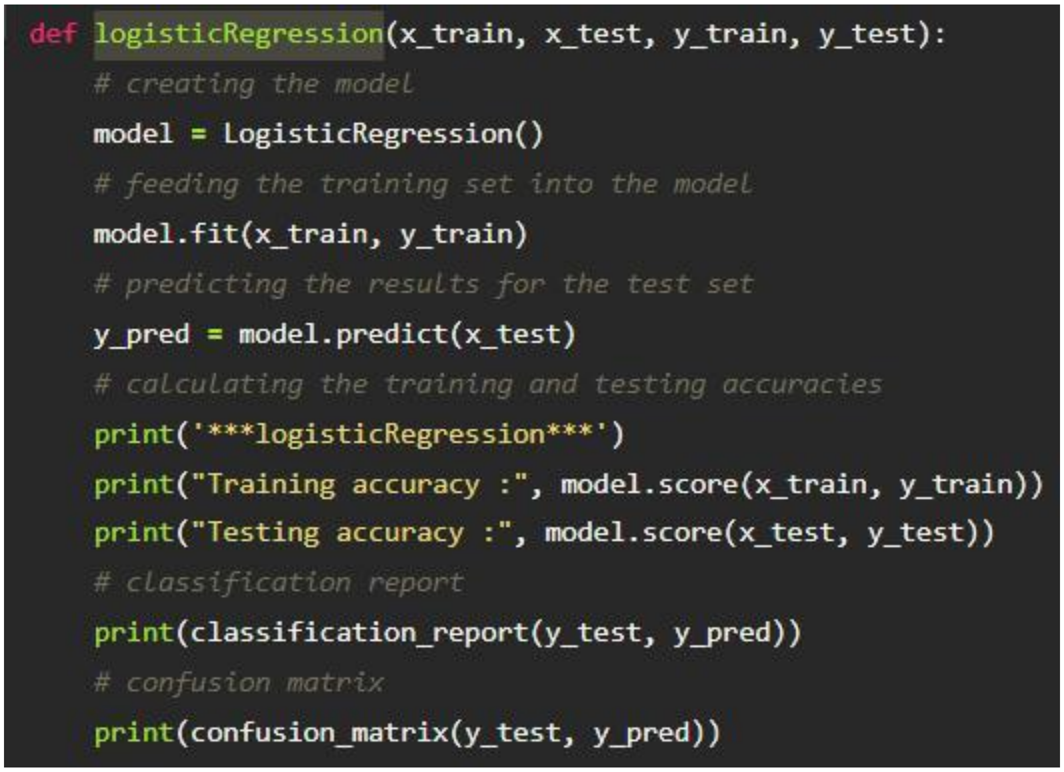
<u>Model</u> Building:

Now our data is cleaned and it's time to build the model. We can train our data on different algorithms. For this project we are applying two regression algorithms. The best model is saved based on its performance.

Logistic Regression:
Logistic Regression is a Machine Learning algorithm which is used for the classification

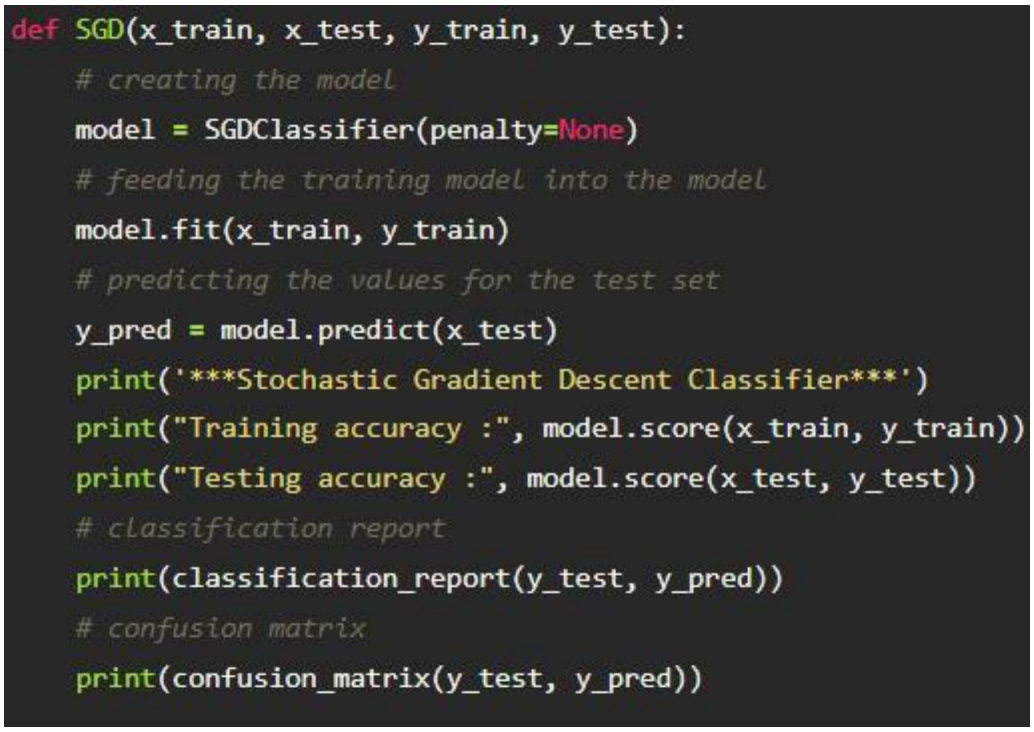
Problems, it is a predictive analysis algorithm and based on the concept of probability A function named logistic Regression is created and train and test data are passed as the parameters: Inside the function, Logistic Regression algorithm is initialized and training data is passed to the model with fit() function. Test data is predicted with predict function and saved in

new variable. For evaluating the model, confusion matrix and classification report is done.



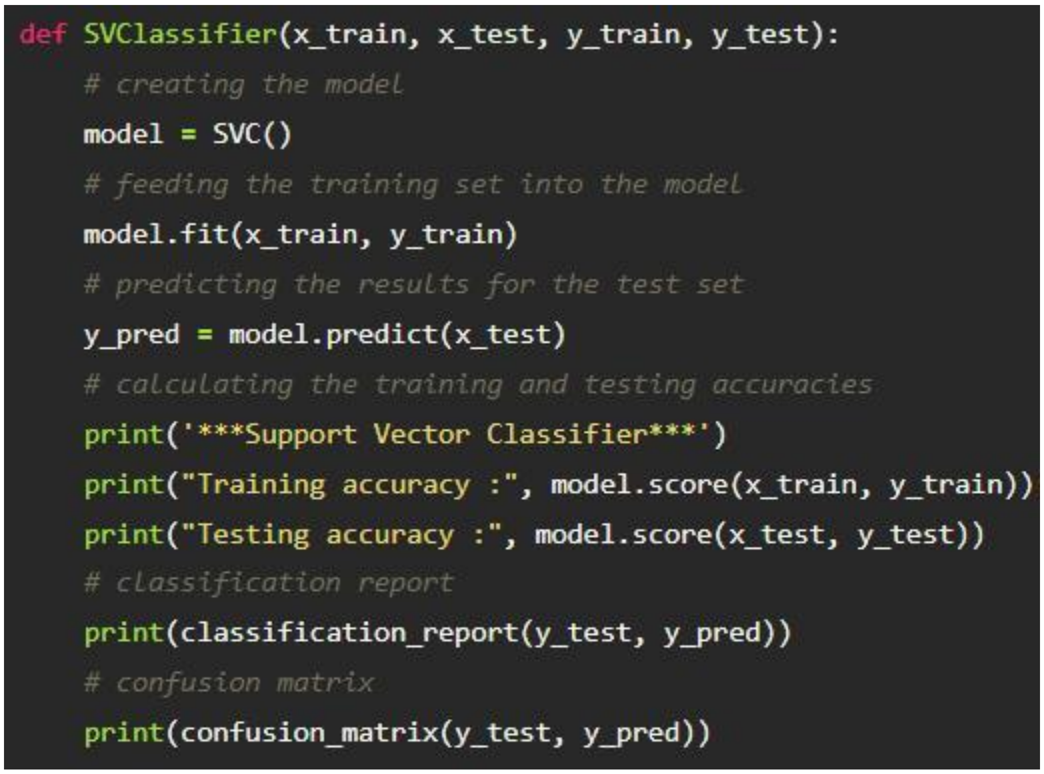
```python
def logisticRegression(x_train, x_test, y_train, y_test):
    # creating the model
    model = LogisticRegression()
    # feeding the training set into the model
    model.fit(x_train, y_train)
    # predicting the results for the test set
    y_pred = model.predict(x_test)
    # calculating the training and testing accuracies
    print('***logisticRegression***')
    print("Training accuracy :", model.score(x_train, y_train))
    print("Testing accuracy :", model.score(x_test, y_test))
    # classification report
    print(classification_report(y_test, y_pred))
    # confusion matrix
    print(confusion_matrix(y_test, y_pred))
```

Stochastic Gradient Descent Classifier Model:
A function named SGD is created and train and test data are passed as the parameters. Inside the function, SGD Classifier algorithm is initialized and training data is passed to the model with fit() function. Test data is predicted with predict() function and saved in new variable. For evaluating the model, confusion matrix and classification report is done.



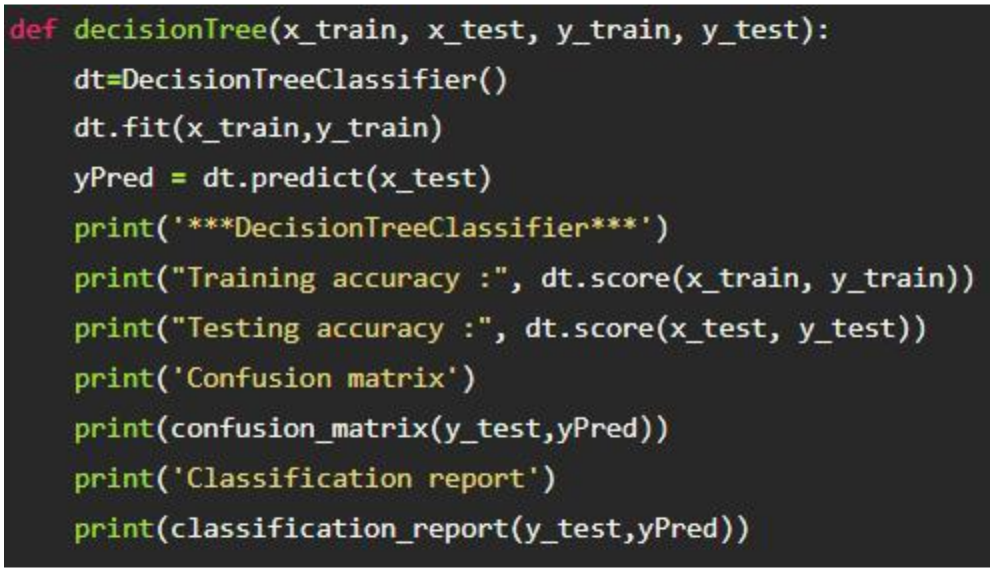
```
def SGD(x_train, x_test, y_train, y_test):
    # creating the model
    model = SGDClassifier(penalty=None)
    # feeding the training model into the model
    model.fit(x_train, y_train)
    # predicting the values for the test set
    y_pred = model.predict(x_test)
    print('***Stochastic Gradient Descent Classifier***')
    print("Training accuracy :", model.score(x_train, y_train))
    print("Testing accuracy :", model.score(x_test, y_test))
    # classification report
    print(classification_report(y_test, y_pred))
    # confusion matrix
    print(confusion_matrix(y_test, y_pred))
```

Support Vector Classifier Model:
A function named SVClassifier is created and train and test data are passed as the parameters inside the function, SVC algorithm is initialized and training data is passed to the model with fito function, Test data is predicted with predict function and saved in new variable. For evaluating the model, confusion matrix and classification report is done


```
def SVClassifier(x_train, x_test, y_train, y_test):
    # creating the model
    model = SVC()
    # feeding the training set into the model
    model.fit(x_train, y_train)
    # predicting the results for the test set
    y_pred = model.predict(x_test)
    # calculating the training and testing accuracies
    print('***Support Vector Classifier***')
    print("Training accuracy :", model.score(x_train, y_train))
    print("Testing accuracy :", model.score(x_test, y_test))
    # classification report
    print(classification_report(y_test, y_pred))
    # confusion matrix
    print(confusion_matrix(y_test, y_pred))
```

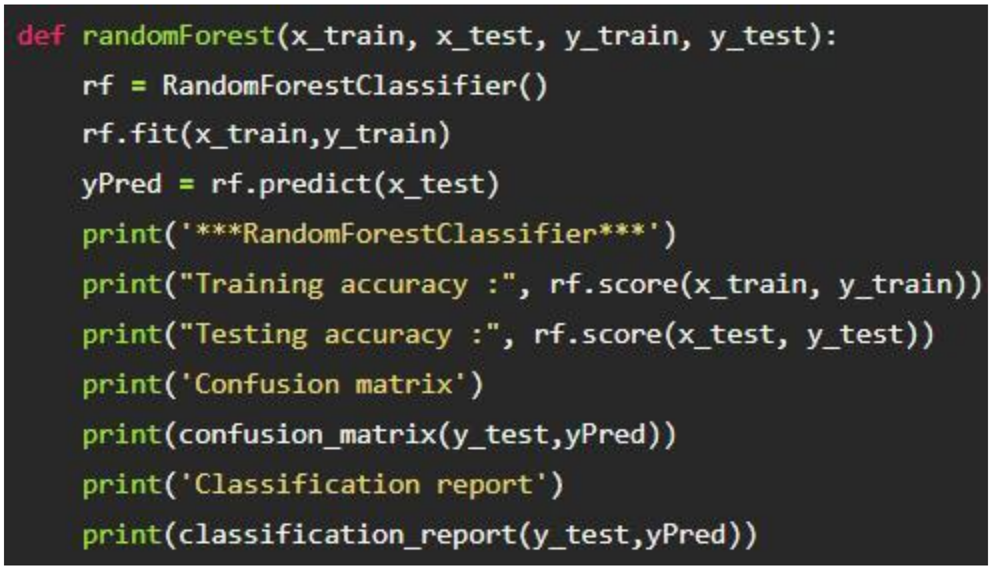
Decision Tree Model:

A function named decisionTree is created and train and test data are passed as the parameters. Inside the function, DecisionTreeClassifier algorithm is initialized and training data is passed to the model with fit() function. Test data is predicted with predict() function and saved in new variable. For evaluating the model, confusion matrix and classification report is done.



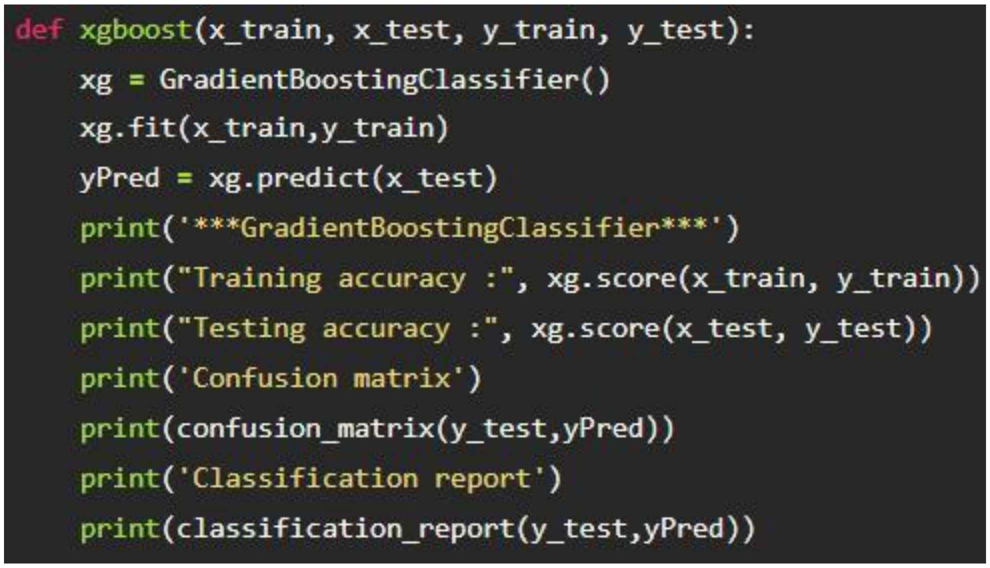
```python
def decisionTree(x_train, x_test, y_train, y_test):
    dt=DecisionTreeClassifier()
    dt.fit(x_train,y_train)
    yPred = dt.predict(x_test)
    print('***DecisionTreeClassifier***')
    print("Training accuracy :", dt.score(x_train, y_train))
    print("Testing accuracy :", dt.score(x_test, y_test))
    print('Confusion matrix')
    print(confusion_matrix(y_test,yPred))
    print('Classification report')
    print(classification_report(y_test,yPred))
```

Random Forest Regressor Model:
A function named randomForest is created and train and test data are passed as the parameters. Inside the function, Random Forest Classifier algorithm is initialized and training data is passed to the model with .fit() function. Test data is predicted with predict() function and saved in new variable. For evaluating the model, confusion matrix and classification report is done.



```python
def randomForest(x_train, x_test, y_train, y_test):
    rf = RandomForestClassifier()
    rf.fit(x_train,y_train)
    yPred = rf.predict(x_test)
    print('***RandomForestClassifier***')
    print("Training accuracy :", rf.score(x_train, y_train))
    print("Testing accuracy :", rf.score(x_test, y_test))
    print('Confusion matrix')
    print(confusion_matrix(y_test,yPred))
    print('Classification report')
    print(classification_report(y_test,yPred))
```

XGBoost Model:

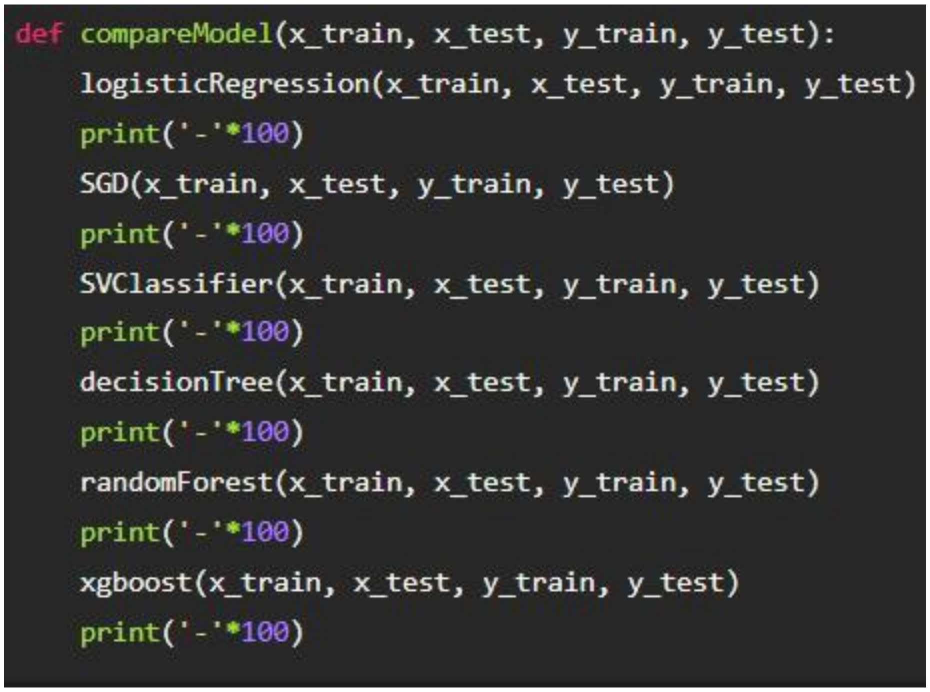


```python
def xgboost(x_train, x_test, y_train, y_test):
    xg = GradientBoostingClassifier()
    xg.fit(x_train,y_train)
    yPred = xg.predict(x_test)
    print('***GradientBoostingClassifier***')
    print("Training accuracy :", xg.score(x_train, y_train))
    print("Testing accuracy :", xg.score(x_test, y_test))
    print('Confusion matrix')
    print(confusion_matrix(y_test,yPred))
    print('Classification report')
    print(classification_report(y_test,yPred))
```

A function named xgboost is created and train and test data are passed as the parameters. Inside the function, Gradient Boosting Classifier algorithm is initialized and training data is passed to the model with fit() function. Test data is predicted with predict() function and saved in new variable. For evaluating the model, confusion matrix and classification reportis done.

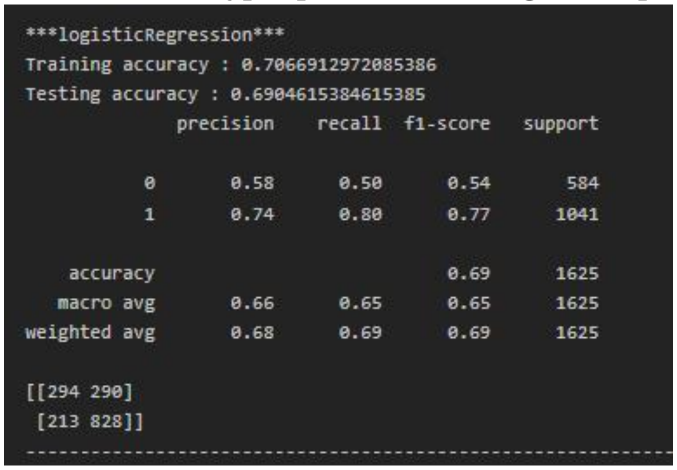
Now let's see the performance of all the models and save the best model

Compare The Models:
For comparing the above four models compareModel function is defined.

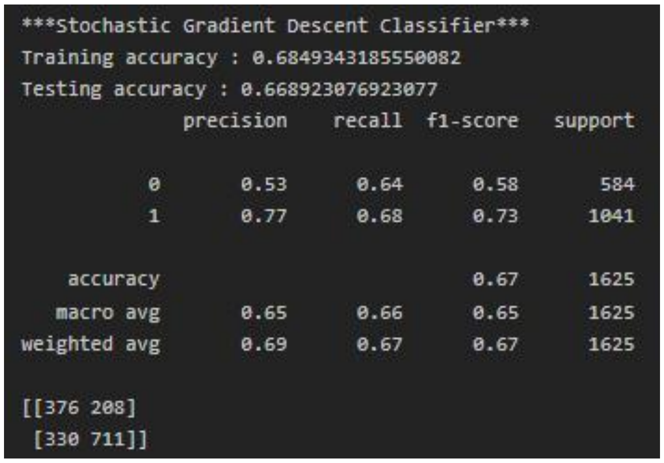


```python
def compareModel(x_train, x_test, y_train, y_test):
    logisticRegression(x_train, x_test, y_train, y_test)
    print('-'*100)
    SGD(x_train, x_test, y_train, y_test)
    print('-'*100)
    SVClassifier(x_train, x_test, y_train, y_test)
    print('-'*100)
    decisionTree(x_train, x_test, y_train, y_test)
    print('-'*100)
    randomForest(x_train, x_test, y_train, y_test)
    print('-'*100)
    xgboost(x_train, x_test, y_train, y_test)
    print('-'*100)
```

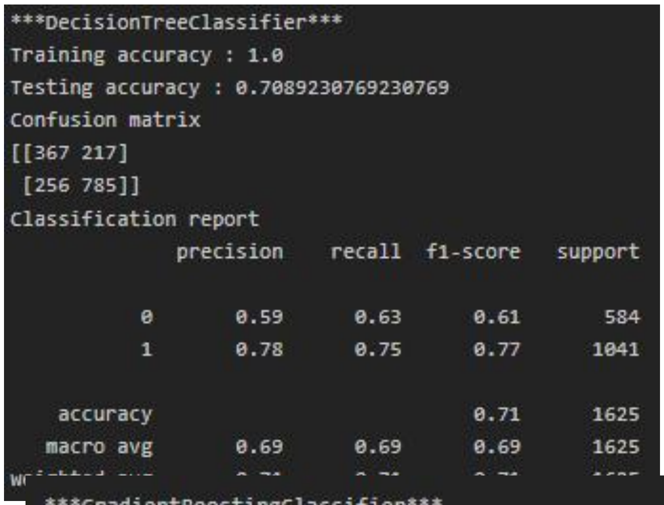
After calling the function, the results of models are displayed as output. From the six models, random forest is performing well. From the below image, we can see the train accuracy of the model is 81% accuracy. So, here random forest is selected as the best performing algorithm and evaluated with cross validation. Additionally, we can tune the model with hyper parameter tuning techniques



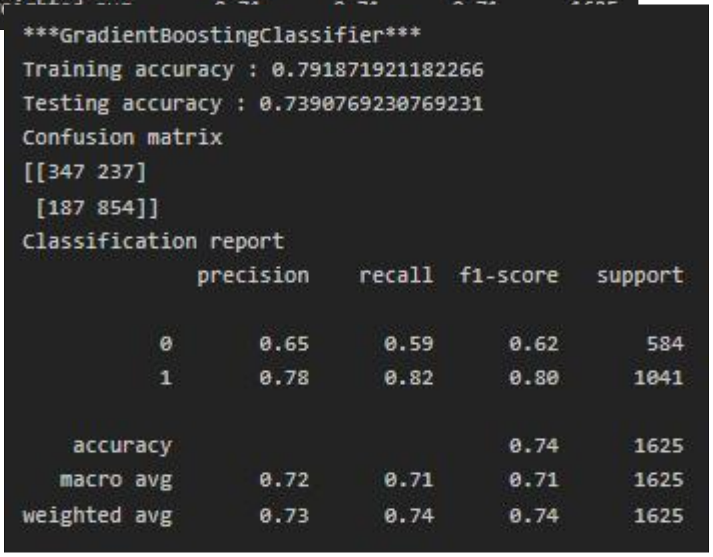
```
***logisticRegression***
Training accuracy : 0.7066912972085386
Testing accuracy : 0.6904615384615385
              precision    recall  f1-score   support

           0       0.58      0.50      0.54       584
           1       0.74      0.80      0.77      1041

    accuracy                           0.69      1625
   macro avg       0.66      0.65      0.65      1625
weighted avg       0.68      0.69      0.69      1625

[[294 290]
 [213 828]]
-----------------------------------------------------------
```



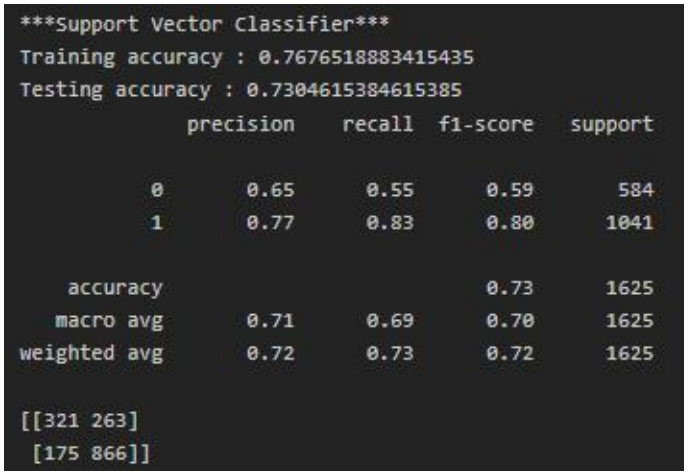
```
***Stochastic Gradient Descent Classifier***
Training accuracy : 0.6849343185550082
Testing accuracy : 0.668923076923077
              precision    recall  f1-score   support

           0       0.53      0.64      0.58       584
           1       0.77      0.68      0.73      1041

    accuracy                           0.67      1625
   macro avg       0.65      0.66      0.65      1625
weighted avg       0.69      0.67      0.67      1625

[[376 208]
 [330 711]]
```



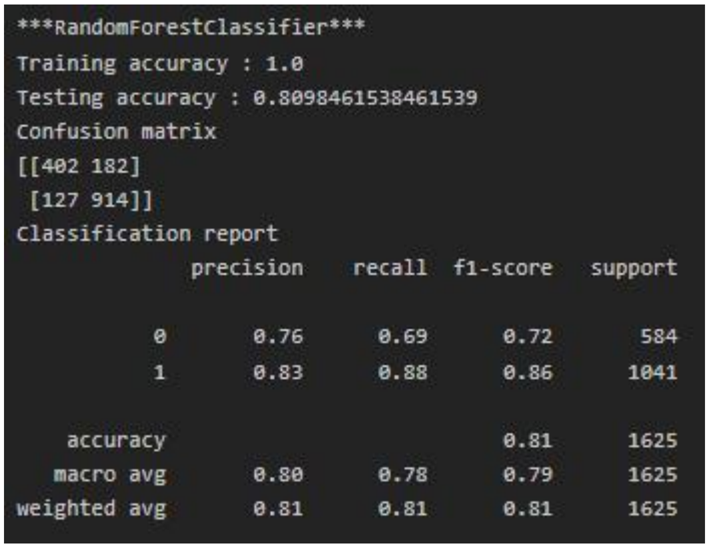
```
***DecisionTreeClassifier***
Training accuracy : 1.0
Testing accuracy : 0.7089230769230769
Confusion matrix
[[367 217]
 [256 785]]
Classification report
              precision    recall  f1-score   support

           0       0.59      0.63      0.61       584
           1       0.78      0.75      0.77      1041

    accuracy                           0.71      1625
   macro avg       0.69      0.69      0.69      1625
```



```
***GradientBoostingClassifier***
Training accuracy : 0.791871921182266
Testing accuracy : 0.7390769230769231
Confusion matrix
[[347 237]
 [187 854]]
Classification report
              precision    recall  f1-score   support

           0       0.65      0.59      0.62       584
           1       0.78      0.82      0.80      1041

    accuracy                           0.74      1625
   macro avg       0.72      0.71      0.71      1625
weighted avg       0.73      0.74      0.74      1625
```



```
***Support Vector Classifier***
Training accuracy : 0.7676518883415435
Testing accuracy : 0.7304615384615385
              precision    recall  f1-score   support

           0       0.65      0.55      0.59       584
           1       0.77      0.83      0.80      1041

    accuracy                           0.73      1625
   macro avg       0.71      0.69      0.70      1625
weighted avg       0.72      0.73      0.72      1625

[[321 263]
 [175 866]]
```



```
***RandomForestClassifier***
Training accuracy : 1.0
Testing accuracy : 0.8098461538461539
Confusion matrix
[[402 182]
 [127 914]]
Classification report
              precision    recall  f1-score   support

           0       0.76      0.69      0.72       584
           1       0.83      0.88      0.86      1041

    accuracy                           0.81      1625
   macro avg       0.80      0.78      0.79      1625
weighted avg       0.81      0.81      0.81      1625
```

Evaluating Performance Of The Model And Saving The Model:

- **From sklearn, cross val score is used to evaluate the score of the model. On the Parameters, we have given rf (model name), x, y, cv (as 5 folds). Our model is Performing well. So, we are saving the model by pickle.dump().**

- **Note: To understand cross validation, refer this link.https:/towardsdatascience.com/cross-validation-explained-evaluating-estimator performance-e51e5430ff85**
- **Confusion Matrix It is a matrix representation of the results of any binary testing**

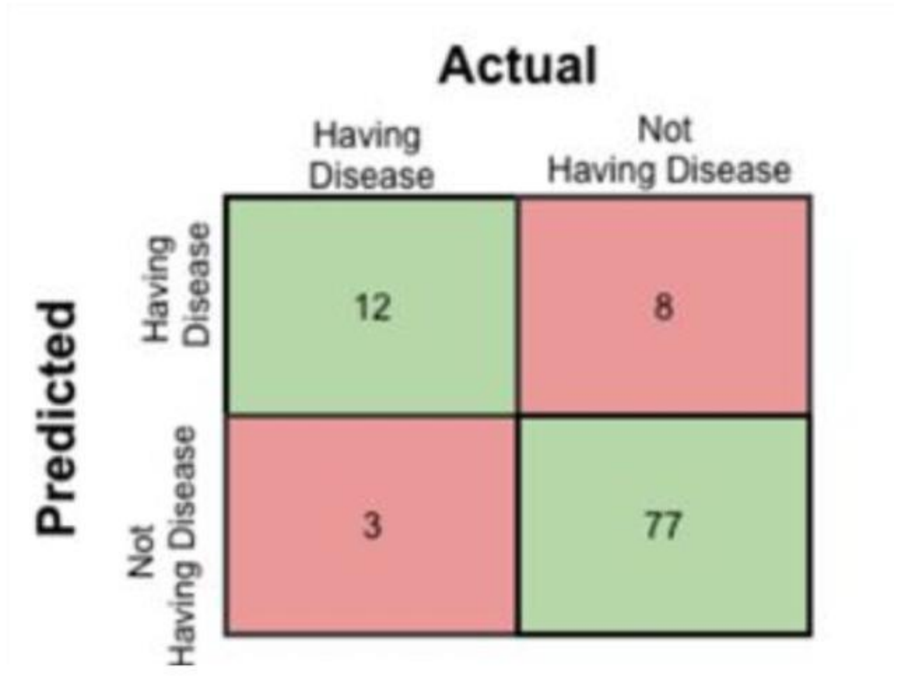
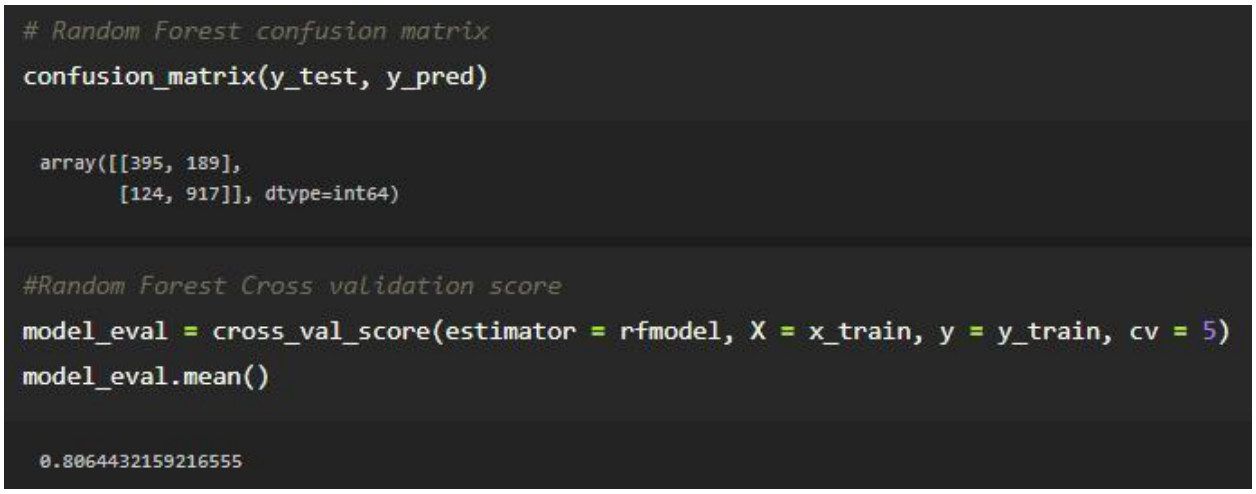


Fig: Confusion Matrix of prediction a disease:

1. **True Positive: 12 (You have predicted the positive case correctly!) 2 True Negative: 77 (You have predicted negative case correctly!)**

2. **False Positive: 8 (You have predicted these people as having disease, but inThey do not have.)**

3. **False Negative: 3 (Wrong predictions)**



```
# Random Forest confusion matrix
confusion_matrix(y_test, y_pred)
```

```
array([[395, 189],
       [124, 917]], dtype=int64)
```

```
#Random Forest Cross validation score
model_eval = cross_val_score(estimator = rfmodel, X = x_train, y = y_train, cv = 5)
model_eval.mean()
```

```
0.8064432159216555
```

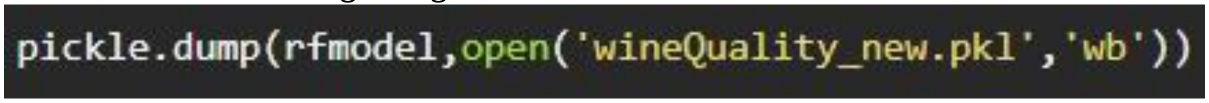
Let's now save the model
Application Building:

This section will build a web application integrated into the model we built. A UI is provided for the uses where he has to enter the values for predictions. The enter values are given to the saved model and prediction is showcased on the UL
This section has the following tasks
Building HTML Pages Building server-side script

Building HTML Pages:

• We will create the front-end part of the web page on this HTML page. On this page, we will accept input from the user and Predict the values.

For more information regarding HTML



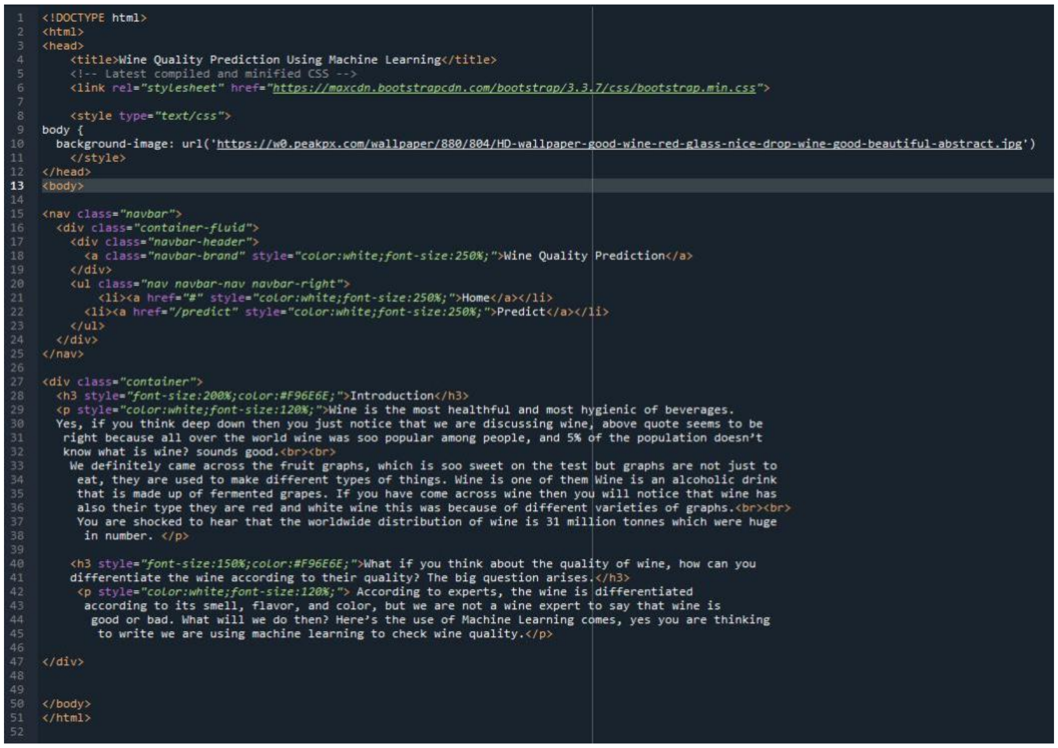
```
pickle.dump(rfmodel,open('wineQuality_new.pkl','wb'))
```

https://www.w3schools.com/html/

In our project we have HTML files, they are

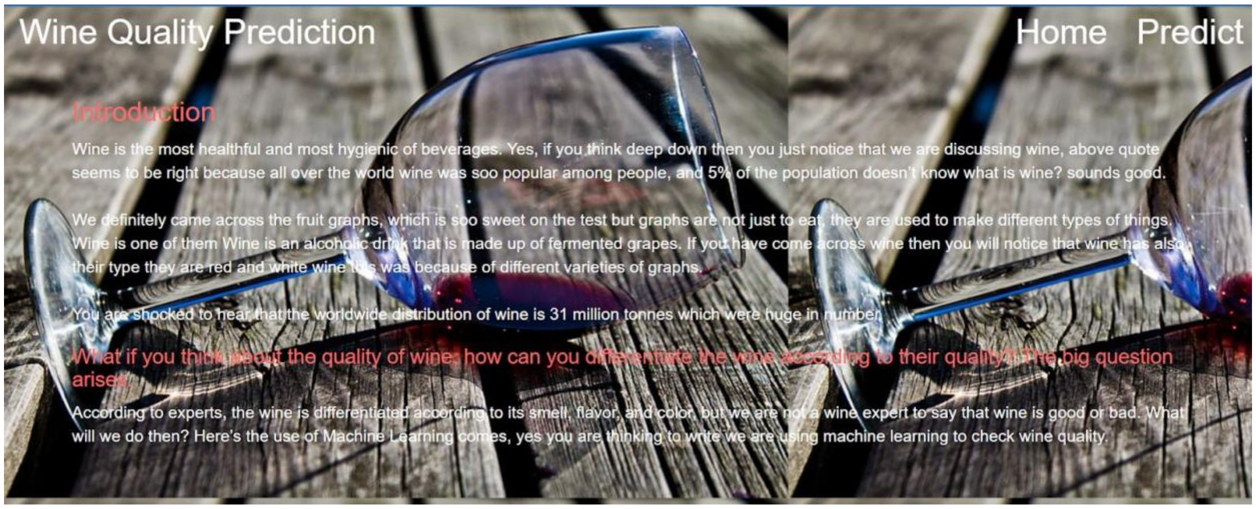
1. **Home.html 2. Index.html**
3.Pred.html

Home.html



```html
<!DOCTYPE html>
<html>
<head>
    <title>Wine Quality Prediction Using Machine Learning</title>
    <!-- Latest compiled and minified CSS -->
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css">

    <style type="text/css">
body {
  background-image: url('https://w0.peakpx.com/wallpaper/880/804/HD-wallpaper-good-wine-red-glass-nice-drop-wine-good-beautiful-abstract.jpg')
    </style>
</head>
<body>

<nav class="navbar">
  <div class="container-fluid">
    <div class="navbar-header">
      <a class="navbar-brand" style="color:white;font-size:250%;">Wine Quality Prediction</a>
    </div>
    <ul class="nav navbar-nav navbar-right">
        <li><a href="#" style="color:white;font-size:250%;">Home</a></li>
      <li><a href="/predict" style="color:white;font-size:250%;">Predict</a></li>
    </ul>
  </div>
</nav>

<div class="container">
  <h3 style="font-size:200%;color:#F96E6E;">Introduction</h3>
  <p style="color:white;font-size:120%;">Wine is the most healthful and most hygienic of beverages.
  Yes, if you think deep down then you just notice that we are discussing wine, above quote seems to be
   right because all over the world wine was soo popular among people, and 5% of the population doesn’t
   know what is wine? sounds good.<br><br>
    We definitely came across the fruit graphs, which is soo sweet on the test but graphs are not just to
     eat, they are used to make different types of things. Wine is one of them Wine is an alcoholic drink
     that is made up of fermented grapes. If you have come across wine then you will notice that wine has
     also their type they are red and white wine this was because of different varieties of graphs.<br><br>
     You are shocked to hear that the worldwide distribution of wine is 31 million tonnes which were huge
      in number. </p>

    <h3 style="font-size:150%;color:#F96E6E;">What if you think about the quality of wine, how can you
    differentiate the wine according to their quality? The big question arises.</h3>
     <p style="color:white;font-size:120%;"> According to experts, the wine is differentiated
      according to its smell, flavor, and color, but we are not a wine expert to say that wine is
       good or bad. What will we do then? Here’s the use of Machine Learning comes, yes you are thinking
        to write we are using machine learning to check wine quality.</p>

</div>


</body>
</html>
```

The HTML page looks like



Introduction

Wine is the most healthful and most hygienic of beverages. Yes, if you think deep down then you just notice that we are discussing wine, above quote seems to be right because all over the world wine was soo popular among people, and 5% of the population doesn't know what is wine? sounds good.

We definitely came across the fruit graphs, which is soo sweet on the test but graphs are not just to eat, they are used to make different types of things. Wine is one of them Wine is an alcoholic drink that is made up of fermented grapes. If you have come across wine then you will notice that wine has also their type they are red and white wine this was because of different varieties of graphs.

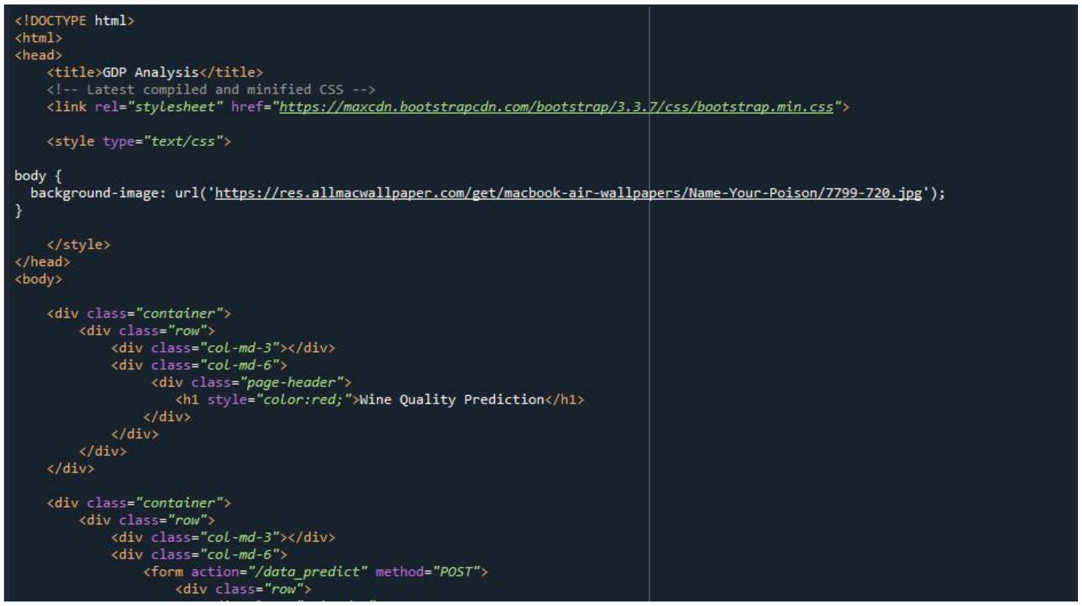
You are shocked to hear that the worldwide distribution of wine is 31 million tonnes which were huge in number.

What if you think about the quality of wine; how can you differentiate the wine according to their quality? The big question arises.

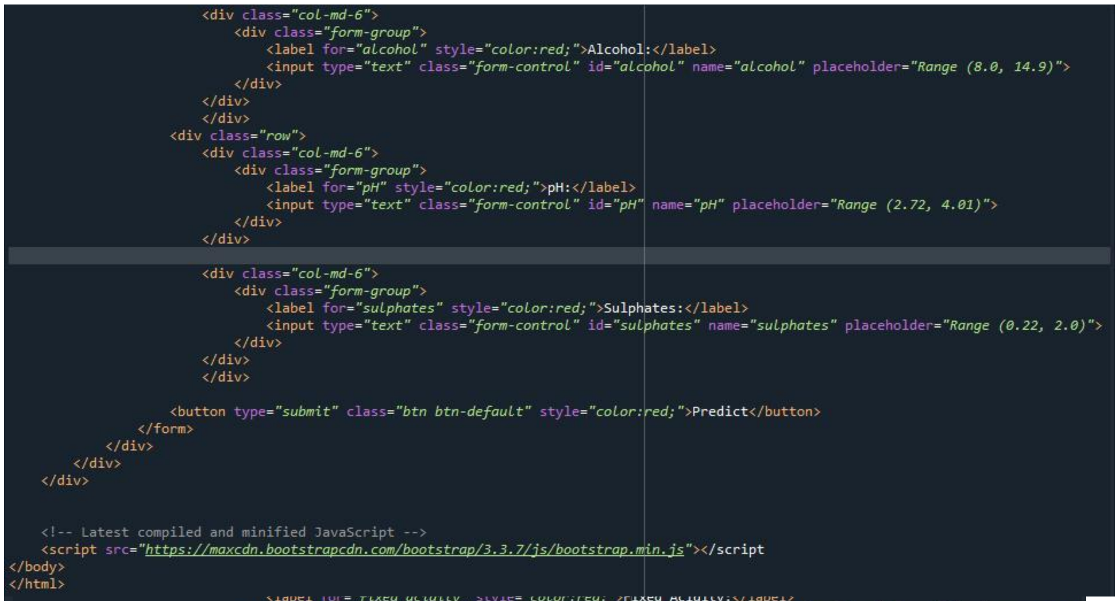
According to experts, the wine is differentiated according to its smell, flavor, and color, but we are not a wine expert to say that wine is good or bad. What will we do then? Here's the use of Machine Learning comes, yes you are thinking to write we are using machine learning to check wine quality.

It will display all the input parameters and the prediction text will display the output value of the data given by the user.

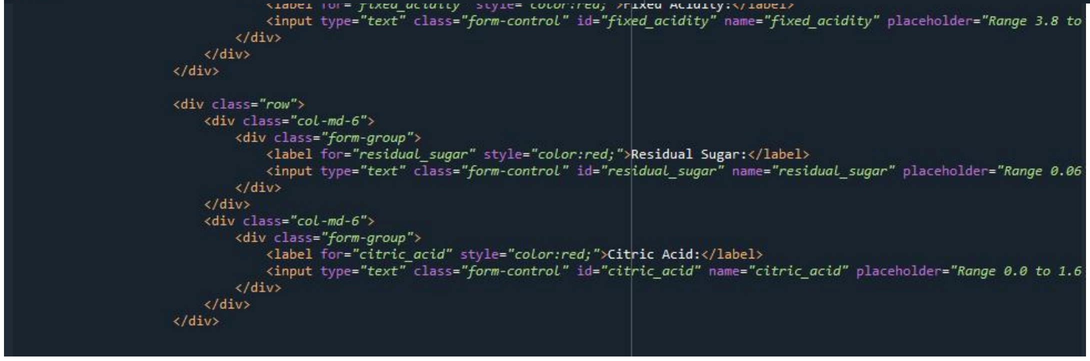
Index.html



```
<!DOCTYPE html>
<html>
<head>
    <title>GDP Analysis</title>
    <!-- Latest compiled and minified CSS -->
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css">

    <style type="text/css">

body {
  background-image: url('https://res.allmacwallpaper.com/get/macbook-air-wallpapers/Name-Your-Poison/7799-720.jpg');
}

    </style>
</head>
<body>

    <div class="container">
        <div class="row">
            <div class="col-md-3"></div>
            <div class="col-md-6">
                 <div class="page-header">
                    <h1 style="color:red;">Wine Quality Prediction</h1>
                </div>
            </div>
        </div>
    </div>

    <div class="container">
        <div class="row">
            <div class="col-md-3"></div>
            <div class="col-md-6">
                <form action="/data_predict" method="POST">
                    <div class="row">
```

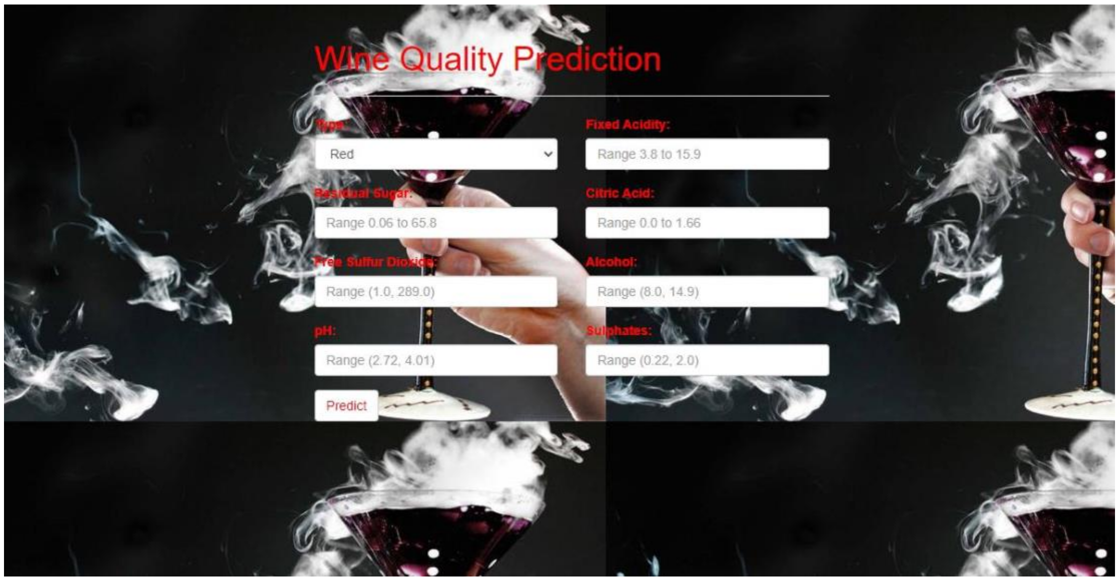


```
                        <div class="col-md-6">
                            <div class="form-group">
                                <label for="alcohol" style="color:red;">Alcohol:</label>
                                <input type="text" class="form-control" id="alcohol" name="alcohol" placeholder="Range (8.0, 14.9)">
                            </div>
                        </div>
                        </div>
                    <div class="row">
                        <div class="col-md-6">
                            <div class="form-group">
                                <label for="pH" style="color:red;">pH:</label>
                                <input type="text" class="form-control" id="pH" name="pH" placeholder="Range (2.72, 4.01)">
                            </div>
                        </div>

                        <div class="col-md-6">
                            <div class="form-group">
                                <label for="sulphates" style="color:red;">Sulphates:</label>
                                <input type="text" class="form-control" id="sulphates" name="sulphates" placeholder="Range (0.22, 2.0)">
                            </div>
                        </div>
                        </div>

                    <button type="submit" class="btn btn-default" style="color:red;">Predict</button>
                </form>
            </div>
        </div>
    </div>


    <!-- Latest compiled and minified JavaScript -->
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/js/bootstrap.min.js"></script
</body>
</html>
```



```
                                <label for="fixed_acidity" style="color:red;">Fixed Acidity:</label>
                                <input type="text" class="form-control" id="fixed_acidity" name="fixed_acidity" placeholder="Range 3.8 to
                            </div>
                        </div>
                    </div>

                    <div class="row">
                        <div class="col-md-6">
                            <div class="form-group">
                                <label for="residual_sugar" style="color:red;">Residual Sugar:</label>
                                <input type="text" class="form-control" id="residual_sugar" name="residual_sugar" placeholder="Range 0.06
                            </div>
                        </div>
                        <div class="col-md-6">
                            <div class="form-group">
                                <label for="citric_acid" style="color:red;">Citric Acid:</label>
                                <input type="text" class="form-control" id="citric_acid" name="citric_acid" placeholder="Range 0.0 to 1.6
                            </div>
                        </div>
                    </div>
```

The HTML page looks like



Wine Quality Prediction

Type: Red

Fixed Acidity: Range 3.8 to 15.9

Residual Sugar: Range 0.06 to 65.8

Citric Acid: Range 0.0 to 1.66

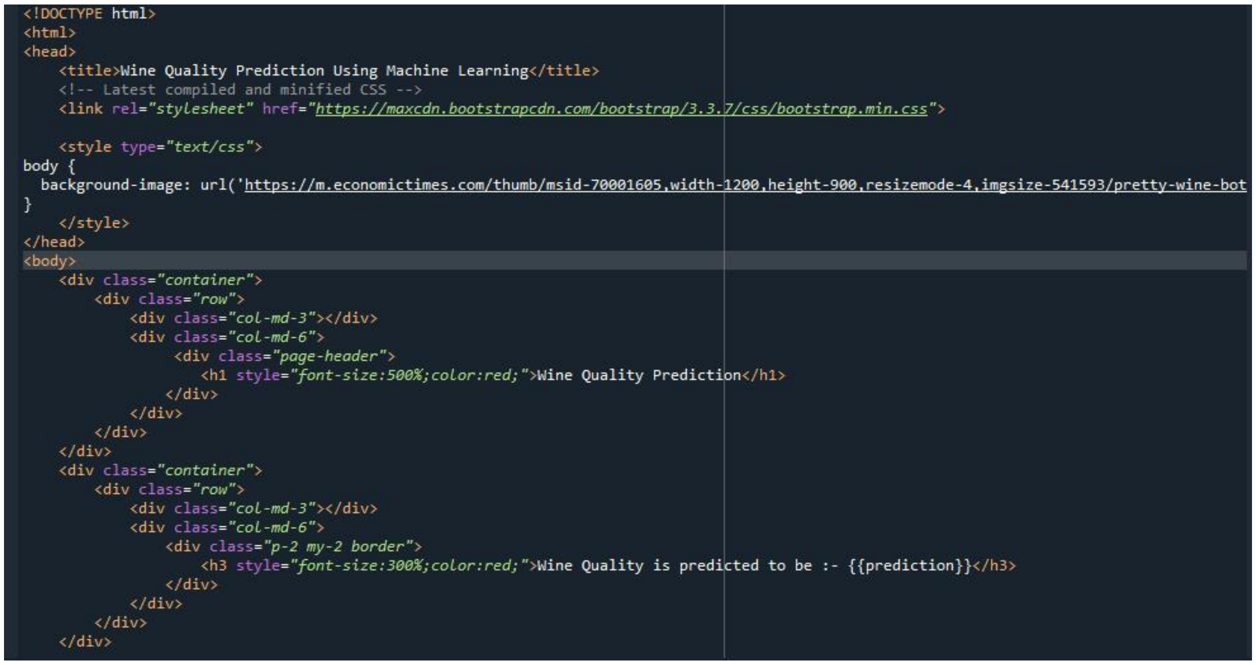
Free Sulfur Dioxide: Range (1.0, 289.0)

Alcohol: Range (8.0, 14.9)

pH: Range (2.72, 4.01)

Sulphates: Range (0.22, 2.0)

Pred.html



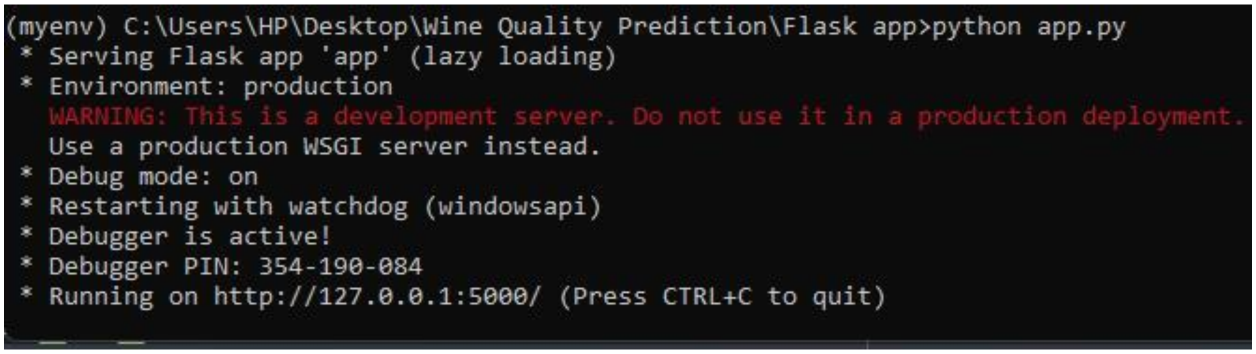
```
<!DOCTYPE html>
<html>
<head>
    <title>Wine Quality Prediction Using Machine Learning</title>
    <!-- Latest compiled and minified CSS -->
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css">

    <style type="text/css">
body {
  background-image: url('https://m.economictimes.com/thumb/msid-70001605,width-1200,height-900,resizemode-4,imgsize-541593/pretty-wine-bot
}
    </style>
</head>
<body>
    <div class="container">
        <div class="row">
            <div class="col-md-3"></div>
            <div class="col-md-6">
                 <div class="page-header">
                    <h1 style="font-size:500%;color:red;">Wine Quality Prediction</h1>
                </div>
            </div>
        </div>
    </div>
    <div class="container">
        <div class="row">
            <div class="col-md-3"></div>
            <div class="col-md-6">
                <div class="p-2 my-2 border">
                    <h3 style="font-size:300%;color:red;">Wine Quality is predicted to be :- {{prediction}}</h3>
                </div>
            </div>
        </div>
    </div>
```

Building Python Code:
Let us build an app.py flask file which is a web framework written in python for server-side scripting. Let's see the step by step procedure for building the backend application.

Run The App:

- **Open anaconda prompt from the start menu**
- **Navigate to the folder where your python script is.**
- **Now type the "python app.py" command**

Navigate to the localhost where you can view your web page, Then it will run on local host:5000



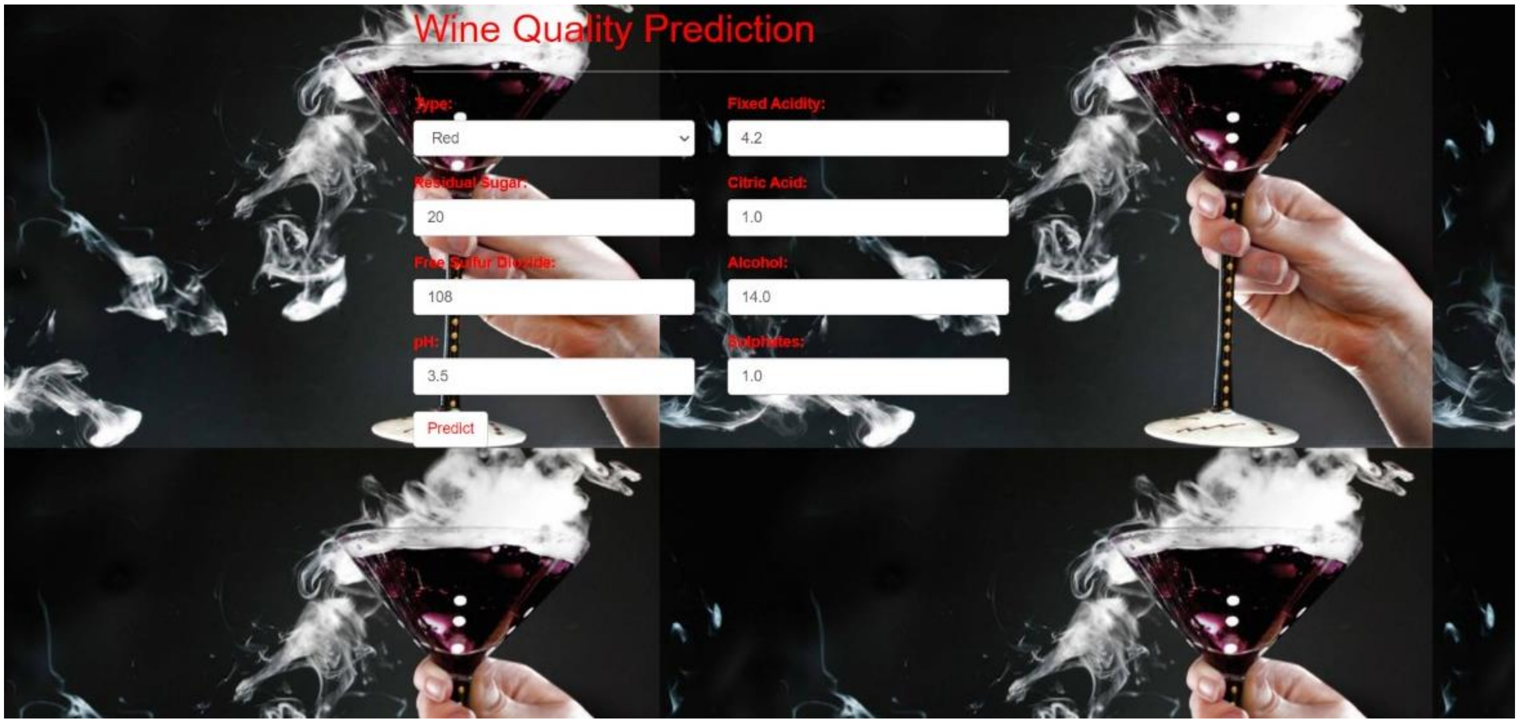
```
(myenv) C:\Users\HP\Desktop\Wine Quality Prediction\Flask app>python app.py
 * Serving Flask app 'app' (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with watchdog (windowsapi)
 * Debugger is active!
 * Debugger PIN: 354-190-084
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Output:
Copy the HTTP link and paste it in the google link tab, it will display the form page

Enter the values as per the form and click on predict button

It will redirect to the page based on prediction output

Input: -



Wine Quality Prediction

Type: Red

Fixed Acidity: 4.2

Residual Sugar: 20

Citric Acid: 1.0

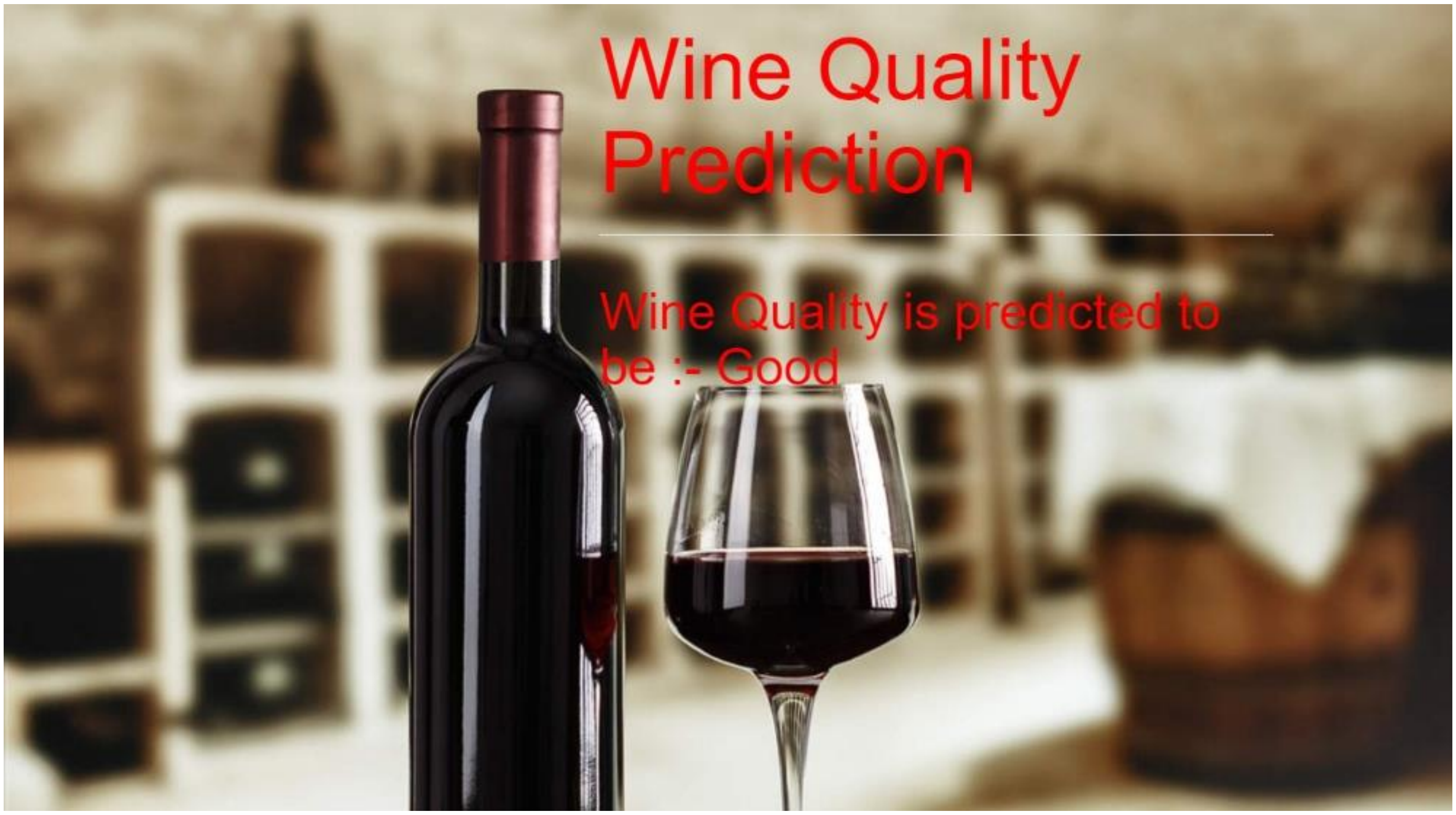
Free Sulfur Dioxide: 108

Alcohol: 14.0

pH: 3.5

Sulphates: 1.0

Final Output: -



Wine Quality Prediction

Wine Quality is predicted to be :- Good