CS 5710 Machine Learning

Assignment-2

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GitHub Link: *https://github.com/Keerthireddy860/Machine-Learning-Assignment-2*

Video Presentation link:
https://drive.google.com/file/d/18arYL21duSYaxyL9mCT8z1qL6Sas9xfU/view

Importing the required libraries.

```
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import numpy as np
import random as rnd

# loading the warnings module
import warnings
# setting a filter to ignore warnings that gets generated by the code
warnings.filterwarnings("ignore")

# Data Visualization Modules
import seaborn as sns
import matplotlib.pyplot as plt

# machine learning modules
from sklearn.svm import SVC, LinearSVC
from sklearn.naive_bayes import GaussianNB
from sklearn import preprocessing

# function is used to split the data into training and testing sets for machine learning modeling
from sklearn.model_selection import train_test_split

# importing functions used to evaluate the performance of machine learning models
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
```

1. Pandas:

Question 1:

Read the provided CSV file '***data. csv***'.

https://drive.google.com/drive/folders/1h8C3mLsso-R-sIOLsvoYwPLzy2fJ4IOF?usp=sharing

Source code:

```
# Reading the CSV file using read_csv( ) function
df = pd.read_csv('data.csv')

# Printing the first 5 rows of the DataFrame
df.head()
```

Output:

	Duration	Pulse	Maxpulse	Calories
0	60	110	130	409.1
1	60	117	145	479.0
2	60	103	135	340.0
3	45	109	175	282.4
4	45	117	148	406.0

Explanation:

Here in the code, I have used $\boldsymbol{read\_csv}()$ and $\boldsymbol{head}()$ functions to read CSV file and to display the first 5 rows of the $DataFrame$ respectively.

Question 2:

Show the basic statistical description about the data.

Source code:

```
# Getting the basic statistical description about the data
description = df.describe()

# Printing the description
description
```

Output:

	Duration	Pulse	Maxpulse	Calories
count	169.000000	169.000000	169.000000	164.000000
mean	63.846154	107.461538	134.047337	375.790244
std	42.299949	14.510259	16.450434	266.379919
min	15.000000	80.000000	100.000000	50.300000
25%	45.000000	100.000000	124.000000	250.925000
50%	60.000000	105.000000	131.000000	318.600000
75%	60.000000	111.000000	141.000000	387.600000
max	300.000000	159.000000	184.000000	1860.400000

Explanation:

Here in the code, I have used the $\boldsymbol{describe}()$ function to generate descriptive statistics of a $DataFrame$. Then the description is printed.

Question 3:

Check if the data has null values.

Source code:

```
print('Are there any null values: ', df.isnull().values.any())

# Checking for null values in the DataFrame
null_values = df.isnull().sum()

# Printing the number of null values for each column
null_values
```

Output:

```
Are there any null values:  True

Duration    0
Pulse       0
Maxpulse    0
Calories    5
dtype: int64
```

Explanation:

Here in the code, I have used the ***isnull( )*** function to identify null values in the *DataFrame*, and the ***values. any( )*** function to check if any of the values are null.

Then ***sum( )*** function is called on this Boolean DataFrame and displayed a new DataFrame containing the sum of ***True*** values for each column in ***df***.

Question 3 (a):

Replace the null values with the mean.

Source code:

```
# Replacing null values with the mean of the respective column
mean_values = df.mean()
df.fillna(mean_values, inplace=True)

print('Are there any null values after replacing: ', df.isnull().values.any())

# Checking for null values in the DataFrame (should return all 0s)
null_values = df.isnull().sum()

# Printing the number of null values for each column
null_values
```

Output:

```
Are there any null values after replacing:  False

Duration    0
Pulse       0
Maxpulse    0
Calories    0
dtype: int64
```

Explanation:

Here in the code, I have used ***mean*( )** function to calculate the mean of each column in the DataFrame and ***fillna*()** function is used with calculated mean to replace all null values in *df*. Then used the ***isnull*( )** function to identify null values in the *DataFrame*, and the ***values***. ***any*( )** function to check if any of the values are null.

sum*( )** function is called on this Boolean DataFrame and displayed a new DataFrame containing the sum of ***True values for each column in ***df***.

Question 4:

Select at least two columns and aggregate the data using: min, max, count, mean.

Source code:

```
# Selecting two columns maxpulse, calories and aggregating using min, max, count, and mean
agg_df = df.agg({'Maxpulse': ['min', 'max', 'count', 'mean'],
                 'Calories': ['min', 'max', 'count', 'mean']})

# Printing the aggregated data
agg_df
```

Output:

	Maxpulse	Calories
min	100.000000	50.300000
max	184.000000	1860.400000
count	169.000000	169.000000
mean	134.047337	375.790244

Explanation:

Here in the code, I have used ***agg*( )** function to perform the aggregation operations on the selected columns, with a dictionary as an argument, where the keys are the column names to be aggregated and the values are lists of aggregation functions to be applied to each column.

Finally, the aggregated DataFrame is printed.

Question 5:

Filter the DataFrame to select the rows with calories values between 500 and 1000.

Source code:

```
# Filtering the DataFrame to select rows with calorie values between 500 and 1000
filtered_df = df.loc[(df['Calories'] >= 500) & (df['Calories'] <= 1000)]

# Printing the filtered DataFrame
filtered_df
```

Output:

	Duration	Pulse	Maxpulse	Calories
51	80	123	146	643.1
62	160	109	135	853.0
65	180	90	130	800.4
66	150	105	135	873.4
67	150	107	130	816.0
72	90	100	127	700.0
73	150	97	127	953.2
75	90	98	125	563.2
78	120	100	130	500.4
83	120	100	130	500.0
90	180	101	127	600.1
99	90	93	124	604.1
101	90	90	110	500.0
102	90	90	100	500.0
103	90	90	100	500.4
106	180	90	120	800.3
108	90	90	120	500.3

Explanation:

Here in the code, the ***loc*[ ]** function is used to select rows based on a boolean condition. The condition is specified inside the square brackets of the ***loc*[ ]** function using the '*Calories*' column of *df*. Specifically, ***df*[*Calories*] >= 500** and ***df*[*Calories*] <= 1000** are two separate boolean conditions, which are combined using the & operator to specify the filter condition.

Finally, the filtered DataFrame is printed.

Question 6:

Filter the DataFrame to select the rows with calories values > 500 and pulse < 100.

Source code:

```
# Filtering the DataFrame to select rows with calorie values > 500 and pulse values < 100
filtered_df = df.loc[(df['Calories'] > 500) & (df['Pulse'] < 100)]

# Printing the filtered DataFrame
filtered_df
```

Output:

	Duration	Pulse	Maxpulse	Calories
65	180	90	130	800.4
70	150	97	129	1115.0
73	150	97	127	953.2
75	90	98	125	563.2
99	90	93	124	604.1
103	90	90	100	500.4
106	180	90	120	800.3
108	90	90	120	500.3

Explanation:

Here in the code, the ***loc*[ ]** function is used to select rows based on a boolean condition. The condition is specified inside the square brackets of the ***loc*[ ]** function using the '*Calories*' and '*Pulse*' columns of df. Specifically, $df[Calories] > 500$ and $df[Pulse] < 100$ are two separate boolean conditions, which are combined using the & operator to specify the filter condition.

Finally, the filtered DataFrame is printed.

Question 7:

Create a new "$df\_modified$" dataframe that contains all the columns from df except for "$Maxpulse$".

Source code:

```
# Droping the 'Maxpulse' column and creating a new DataFrame
df_modified = df.drop(columns=['Maxpulse'])

# Printing the first 5 rows of new DataFrame
df_modified.head()
```

Output:

	Duration	Pulse	Calories
0	60	110	409.1
1	60	117	479.0
2	60	103	340.0
3	45	109	282.4
4	45	117	406.0

Explanation:

Here in the code, I have used ***drop*( )** function is used to remove the specified column from the DataFrame, and the *columns* parameter is used to specify the name of the column to drop.

The resulting DataFrame is stored in ***df_modifed*** and is displayed.

Question 8:

Delete the "*Maxpulse*" column from the main *df* dataframe.

Source code:

```
# Droping the 'Maxpulse' column from the original DataFrame
df.drop(columns=['Maxpulse'], inplace=True)

#printing the modified dataframe
df.head()
```

Output:

	Duration	Pulse	Calories
0	60	110	409.1
1	60	117	479.0
2	60	103	340.0
3	45	109	282.4
4	45	117	406.0

Explanation:

Hereinthecode, Ihaveused***drop***() functionisusedwith ***inplace*** parametertoremove the specified column from the DataFrame and save it to the original DataFrame, and the *columns* parameter is usedtospecify thename ofthecolumn todrop.

The resulting DataFrame is printed.

Question 9:

Convert the datatype of *Calories* column to *int* datatype.

Source code:

```
# astype() function is used to convert the data type
df['Calories'] = df['Calories'].astype('int64')
df.dtypes
```

Output:

```
Duration    int64
Pulse       int64
Calories    int64
dtype: object
```

Explanation:

Hereinthecode, Ihaveused ***astype***() functionontheCalories columnof ***df*** DataFrame to convert the data type to integer. ***dtypes*** attribute is used to display the data types.

Question 10:

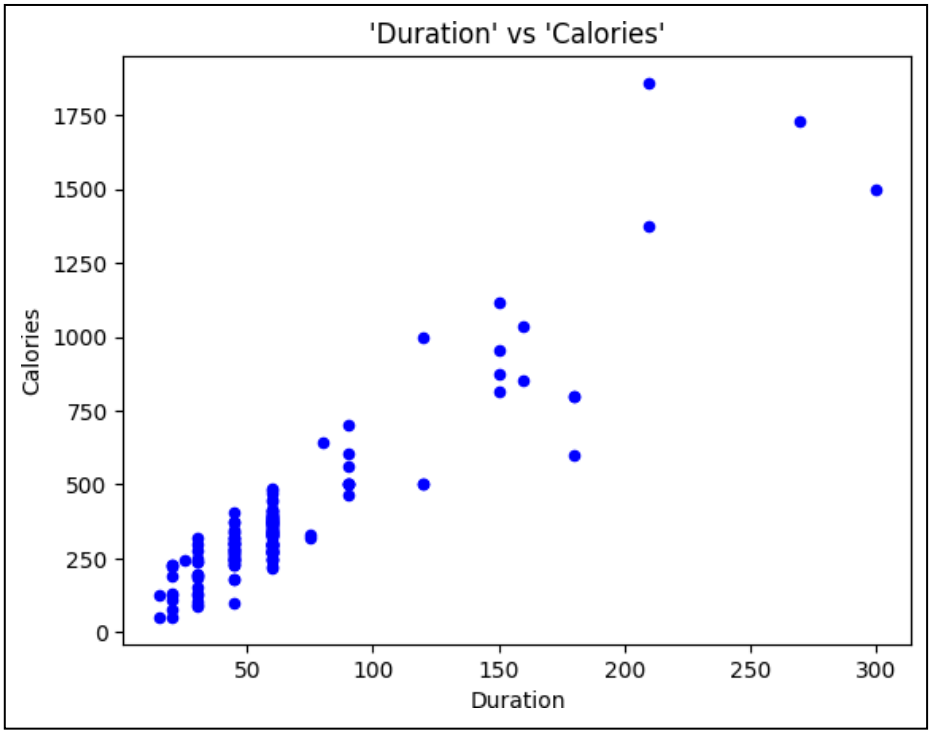
Using pandas create a scatter plot for the two columns (Duration and Calories).

Source code:

```
# Creating a scatter plot for 'Duration' vs 'Calories'
df.plot(x = 'Duration',
        y = 'Calories',
        kind = 'scatter',
        title = "'Duration' vs 'Calories'",
        c = 'blue')

# displaying the plot
plt.show()
```

Output:



Explanation:

Here in the code, I have used the ***plot*( )** function is used to create a scatter plot, with the '*Duration*' column plotted along the x-axis and the '*Calories*' column plotted along the y-axis. The ***kind*** parameter is set to '***scatter***', to create a scatter plot, and the ***title*** parameter is used to set the title of the plot to *'Duration' vs 'Calories'*. Additionally, the ***c*** parameter is set to '***blue***' to specify that the data points should be plotted in blue.

***plt*. *show*( )** function is used to display the plot.

1. (Glass Dataset):

Question 1:

Implement ***Naïve Bayes method*** using scikit-learn library.

a. Use the glass dataset available in Link also provided in your assignment.

Source code:

```
# Loading the dataset
glass_df = pd.read_csv("glass.csv")
glass_df.head()
```

Output:

	RI	Na	Mg	Al	Si	K	Ca	Ba	Fe	Type
0	1.52101	13.64	4.49	1.10	71.78	0.06	8.75	0.0	0.0	1
1	1.51761	13.89	3.60	1.36	72.73	0.48	7.83	0.0	0.0	1
2	1.51618	13.53	3.55	1.54	72.99	0.39	7.78	0.0	0.0	1
3	1.51766	13.21	3.69	1.29	72.61	0.57	8.22	0.0	0.0	1
4	1.51742	13.27	3.62	1.24	73.08	0.55	8.07	0.0	0.0	1

Explanation:

Here in the code, I have used $\boldsymbol{read\_csv}()$ and $\boldsymbol{head}()$ functions to read CSV file and to display the first 5 rows of the $DataFrame$ respectively.

Question 1 (b):

Use *train_test_split* to create training and testing part.

Source code:

```
x1 = glass_df.iloc[:,:-1].values
y1 = glass_df['Type'].values

# Splitting the dataset into training and testing sets
x_train, x_test, y_train, y_test=train_test_split(x1, y1, test_size = 0.30, random_state = 0)
```

Explanation:

Here in the code, I have used *train_test_split( )* is used to split the dataset in to training and testing sets. The ***test_size*** parameter specifies the percentage of the dataset to be used for testing, and the ***random_state*** parameter is used to ensure reproducibility of the split.

Question 2:

Evaluate the model on testing part using score and

classification_report(*y_true*, *y_pred*)

Source code:

```
# GaussianNB()- function creates an instance of the Gaussian Naive Bayes classifier
classifier1 = GaussianNB()

# Training the classifier using the training data
classifier1.fit(x_train, y_train)

# Making predictions on the testing data and storing in y_pred
y_pred = classifier1.predict(x_test)

# generates a confusion matrix that summarizes the number of TP, FP, TN, FN for each class
print('Confusion Matrix:\n', confusion_matrix(y_test, y_pred))

# accuracy of the classifier by comparing features (x_test) with true labels (y_test)
print("\n\t Accuracy by score:", classifier1.score(x_test, y_test))

# accuracy of the classifier by comparing the predicted values (y_pred) with true values (y_test)
print('\nAccuracy by accuracy_score:', accuracy_score(y_pred, y_test))

'''generating a summary of the predictions made by the classifier, including precision,
recall, and F1-score for each class, as well as an overall accuracy score. '''
print('\n',classification_report(y_test, y_pred))
```

Output:

```
Confusion Matrix:
 [[18  1  0  0  1  1]
 [21  3  1  1  0  0]
 [ 7  0  0  0  0  0]
 [ 0  2  0  0  0  0]
 [ 0  0  0  0  2  0]
 [ 0  0  0  0  0  7]]

         Accuracy by score: 0.46153846153846156

Accuracy by accuracy_score: 0.46153846153846156

               precision    recall  f1-score   support

           1       0.39      0.86      0.54        21
           2       0.50      0.12      0.19        26
           3       0.00      0.00      0.00         7
           5       0.00      0.00      0.00         2
           6       0.67      1.00      0.80         2
           7       0.88      1.00      0.93         7

    accuracy                           0.46        65
   macro avg       0.41      0.50      0.41        65
weighted avg       0.44      0.46      0.37        65
```

Explanation:

Here in the code, I have used ***GaussianNB( )*** function to create Gaussian Naive Bayes classifier. The classifier is then trained on the training data using the ***fit( )*** function. Predictions are made on the testing data using the ***predict( )*** function, and the predicted labels are stored in ***y_pred***. The results are then printed, including the confusion matrix using ***confusion_matrix( )*** function, accuracy scores using ***score( )*** and ***accuracy_score( )*** functions, and classification report using ***classification_report( )*** functions.

Question 1:

Implement ***linear SVM method*** using scikit library.

a. Use the glass dataset available in Link also provided in your assignment.

Source code:

```
# Loading the dataset
glass_df = pd.read_csv("glass.csv")
glass_df.head()
```

Output:

	RI	Na	Mg	Al	Si	K	Ca	Ba	Fe	Type
0	1.52101	13.64	4.49	1.10	71.78	0.06	8.75	0.0	0.0	1
1	1.51761	13.89	3.60	1.36	72.73	0.48	7.83	0.0	0.0	1
2	1.51618	13.53	3.55	1.54	72.99	0.39	7.78	0.0	0.0	1
3	1.51766	13.21	3.69	1.29	72.61	0.57	8.22	0.0	0.0	1
4	1.51742	13.27	3.62	1.24	73.08	0.55	8.07	0.0	0.0	1

Explanation:

Here in the code, I have used ***read_csv( )*** and ***head( )*** functions to read CSV file and to display the first 5 rows of the *DataFrame* respectively.

Question 1 (b):

Use $train\_test\_split$ to create training and testing part.

Source code:

```
x1 = glass_df.iloc[:,:-1].values
y1 = glass_df['Type'].values

# Splitting the dataset into training and testing sets
x_train, x_test, y_train, y_test=train_test_split(x1, y1, test_size = 0.30, random_state = 0)
```

Explanation:

Here in the code, I have used ***train_test_split( )*** is used to split the dataset in to training and testing sets. The $\boldsymbol{test\_size}$ parameter specifies the percentage of the dataset to be used for testing, and the $\boldsymbol{random\_state}$ parameter is used to ensure reproducibility of the split.

Question 2:

Evaluate the model on testing part using score and

$classification\_report(y\_true, y\_pred)$

Source code:

```
# LinearSVC( ) - function creates an instance of the Linear support vector classifier
classifier2 = LinearSVC(random_state = 1)

# Training the classifier using the training data
classifier2.fit(x_train, y_train)

# Making predictions on the testing data and storing in y_pred
y_pred2 = classifier2.predict(x_test)

# generates a confusion matrix that summarizes the number of TP, FP, TN, FN for each class
print('Confusion Matrix:\n',confusion_matrix(y_test, y_pred2))

# accuracy of the classifier by comparing features (x_test) with true labels (y_test)
print("\n\t Accuracy by score:", classifier2.score(x_test, y_test))

# accuracy of the classifier by comparing the predicted values (y_pred) with true values (y_test)
print('\nAccuracy by accuracy_score:', accuracy_score(y_pred2, y_test))

'''generating a summary of the predictions made by the classifier, including precision,
recall, and F1-score for each class, as well as an overall accuracy score. '''
print('\n',classification_report(y_test, y_pred))
```

Output:

```
Confusion Matrix:
 [[10 11  0  0  0  0]
 [ 8 18  0  0  0  0]
 [ 2  5  0  0  0  0]
 [ 0  2  0  0  0  0]
 [ 0  2  0  0  0  0]
 [ 0  6  0  0  0  1]]

        Accuracy by score: 0.4461538461538462

Accuracy by accuracy_score: 0.4461538461538462

              precision    recall  f1-score   support

           1       0.39      0.86      0.54        21
           2       0.50      0.12      0.19        26
           3       0.00      0.00      0.00         7
           5       0.00      0.00      0.00         2
           6       0.67      1.00      0.80         2
           7       0.88      1.00      0.93         7

    accuracy                           0.46        65
   macro avg       0.41      0.50      0.41        65
weighted avg       0.44      0.46      0.37        65
```

Explanation:

Here in the code, I have used ***LinearSVC( )*** function to create Linear Support Vector Classifier. The classifier is then trained on the training data using the ***fit( )*** function. Predictions are made on the testing data using the ***predict( )*** function, and the predicted labels are stored in ***y_pred2***. The results are then printed, including the confusion matrix using ***confusion_matrix( )*** function, accuracy scores using ***score( )*** and ***accuracy_score( )*** functions, and classification report using ***classification_report( )*** functions.

Question:

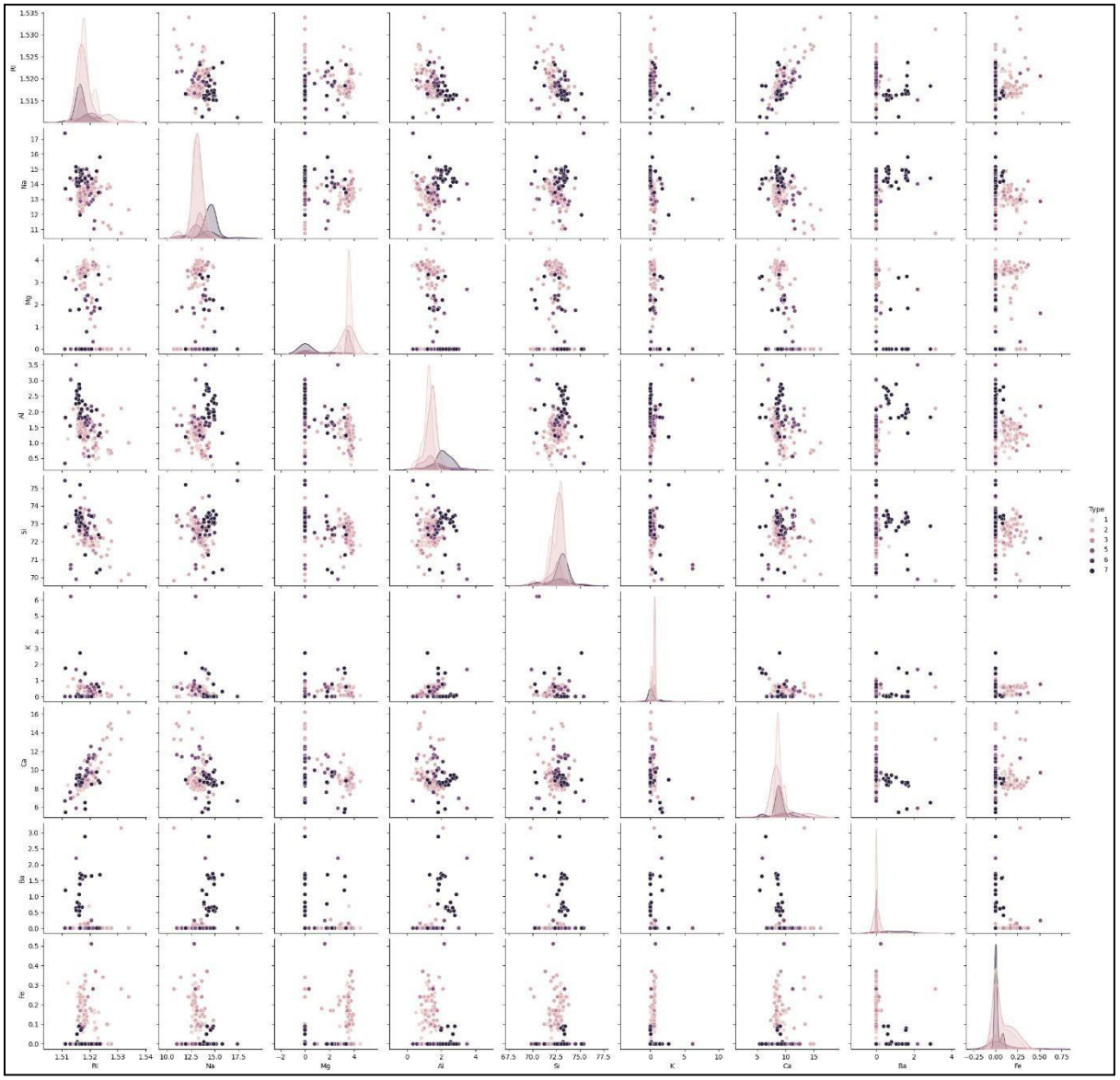
Do at least two visualizations to describe or show correlations in the Glass Dataset.

Visualization 1: Scatter Plot Matrix

Source code:

```
# scatter plot matrix - shows the pairwise scatter plots of multiple variables in a dataset
# as the hue parameter is set to 'Type', it colors the scatter plot points based on the 'Type' column
sns.pairplot(glass_df, hue='Type')
```

Output:



Explanation:

Here in the code, I have used ***pairplot()*** function to generate scatterplots of all pairs. The ***hue*** parameter is set to '***Type***', it colors the scatter plot points based on the 'Type' column.

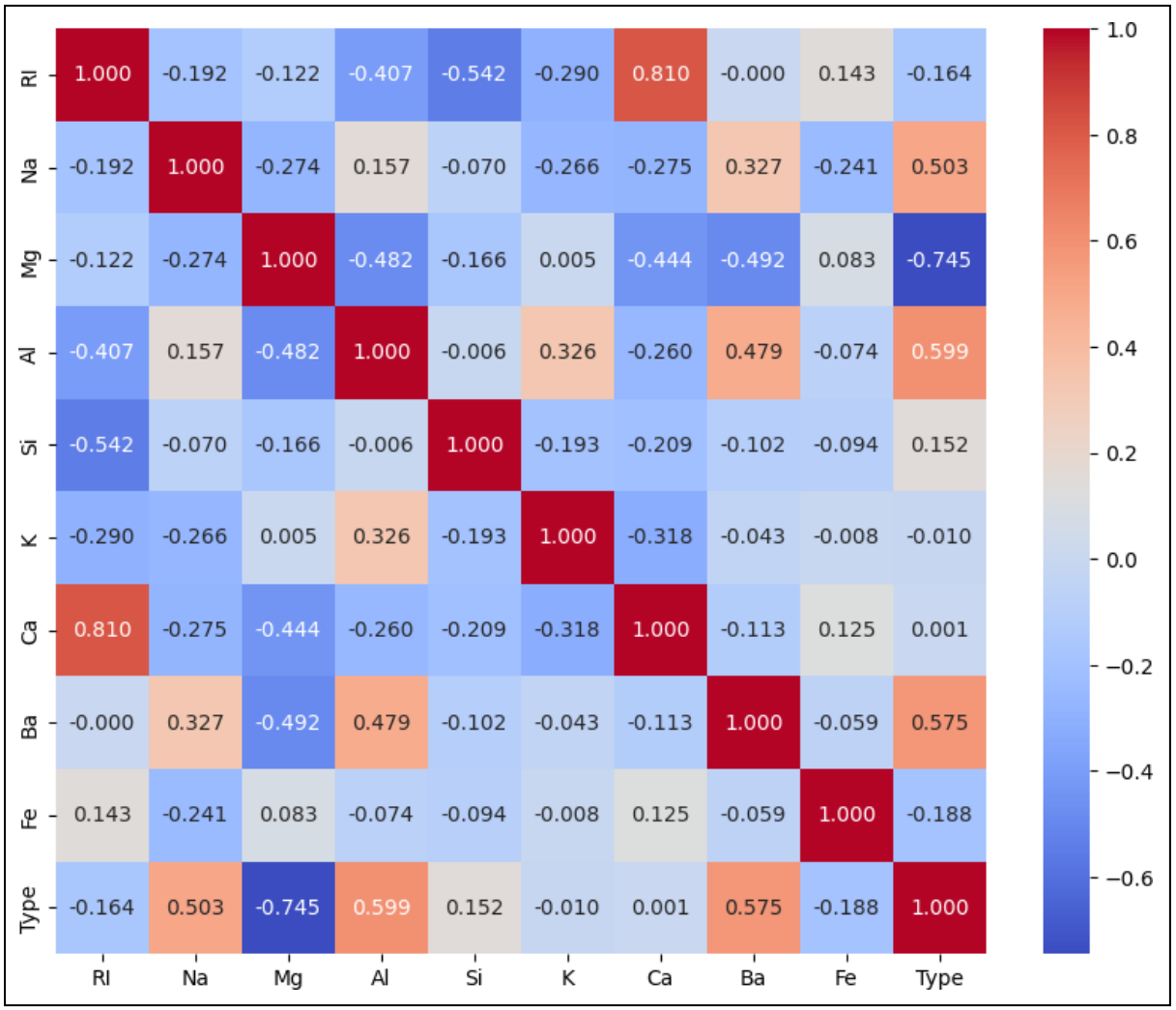
Visualization 2: Heatmap

Source code:

```
plt.figure(figsize=(10, 8))
corr = glass_df.corr()

#Heatmap: shows the correlation between pairs of variables, with a color scale indicating the strength of the relationship
sns.heatmap(corr, annot=True, cmap='coolwarm', fmt='.3f')
plt.show()
```

Output:



Explanation:

Here in the code, I have used ***corr*( )** function to compute the pairwise correlations between all columns and ***heatmap*( )** function from the ***seaborn*** library to plot the correlations with a color scale.

The ***figsize*** parameter of the ***figure*( )** function sets the size of the figure in inches. The ***annot*** parameterofthe***heatmap*( )** functionspecifiesthatthenumerical correlationvalues

should be annotated on the plot. The ***cmap*** parameter sets the color map to use for the heatmap, and the ***fmt*** parameter sets the format string for the annotation values to three decimal places.

plt. ***show***( ) function is used to display the plot.

Question:

Which algorithm you got better accuracy? Can you justify why?

Answer:

The accuracy scores for both classifiers are very low. Considering the accuracy scores, Naïve Bayes classifier performed slightly better than the Linear SVC classifier.

Justification:

Naive Bayes analysis works well with probabilistic concepts whereas Linear SVM works better with linear regression logics. But to perform more accurately, SVM requires large amounts of data to train and test the data.

So, based on the amount of data given, Naive Bayes algorithm gives better accuracy compared to Linear SVM.