```
# Importing essential libraries
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import pandas as pd

# Loading the dataset
df = pd.read_csv('heart.csv')
```

Exploring the dataset

```
# Returns number of rows and columns of the dataset
df.shape
```

```
(1328, 14)
```

```
# Returns an object with all of the column headers
df.columns
```

```
Index(['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg',
'thalach',
       'exang', 'oldpeak', 'slope', 'ca', 'thal', 'target'],
      dtype='object')
```

```
# Returns different datatypes for each columns (float, int, string,
bool, etc.)
df.dtypes
```

```
age           int64
sex           int64
cp            int64
trestbps      int64
chol          int64
fbs           int64
restecg       int64
thalach       int64
exang         int64
oldpeak     float64
slope         int64
ca            int64
thal          int64
target        int64
dtype: object
```

```
# Returns the first x number of rows when head(x). Without a number it
returns 5
df.head()
```

```
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak
slope  \
0   63    1   3       145   233    1        0      150      0      2.3
0
1   37    1   2       130   250    0        1      187      0      3.5
0
2   41    0   1       130   204    0        0      172      0      1.4
2
3   56    1   1       120   236    0        1      178      0      0.8
2
4   57    0   0       120   354    0        1      163      1      0.6
2

   ca  thal  target
0   0     1       1
1   0     2       1
2   0     2       1
3   0     2       1
4   0     2       1
```

```
# Returns the last x number of rows when tail(x). Without a number it
returns 5
df.tail()
```

```
      age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang
oldpeak  \
1323   59    1   1       140   221    0        1      164      1
0.0
1324   60    1   0       125   258    0        0      141      1
2.8
1325   47    1   0       110   275    0        0      118      1
1.0
1326   50    0   0       110   254    0        0      159      0
0.0
1327   54    1   0       120   188    0        1      113      0
1.4

      slope  ca  thal  target
1323      2   0     2       1
1324      1   1     3       0
1325      1   1     2       0
1326      2   0     2       1
1327      1   1     3       0
```

```
# Returns true for a column having null values, else false
df.isnull().any()
```

```
age         False
sex         False
cp          False
```

```
trestbps    False
chol        False
fbs         False
restecg     False
thalach     False
exang       False
oldpeak     False
slope       False
ca          False
thal        False
target      False
dtype: bool
```

```
# Returns basic information on all columns
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1328 entries, 0 to 1327
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1328 non-null   int64  
 1   sex       1328 non-null   int64  
 2   cp        1328 non-null   int64  
 3   trestbps  1328 non-null   int64  
 4   chol      1328 non-null   int64  
 5   fbs       1328 non-null   int64  
 6   restecg   1328 non-null   int64  
 7   thalach   1328 non-null   int64  
 8   exang     1328 non-null   int64  
 9   oldpeak   1328 non-null   float64
 10  slope     1328 non-null   int64  
 11  ca        1328 non-null   int64  
 12  thal      1328 non-null   int64  
 13  target    1328 non-null   int64  
dtypes: float64(1), int64(13)
memory usage: 145.4 KB
```

```
# Returns basic statistics on numeric columns
df.describe().T
```

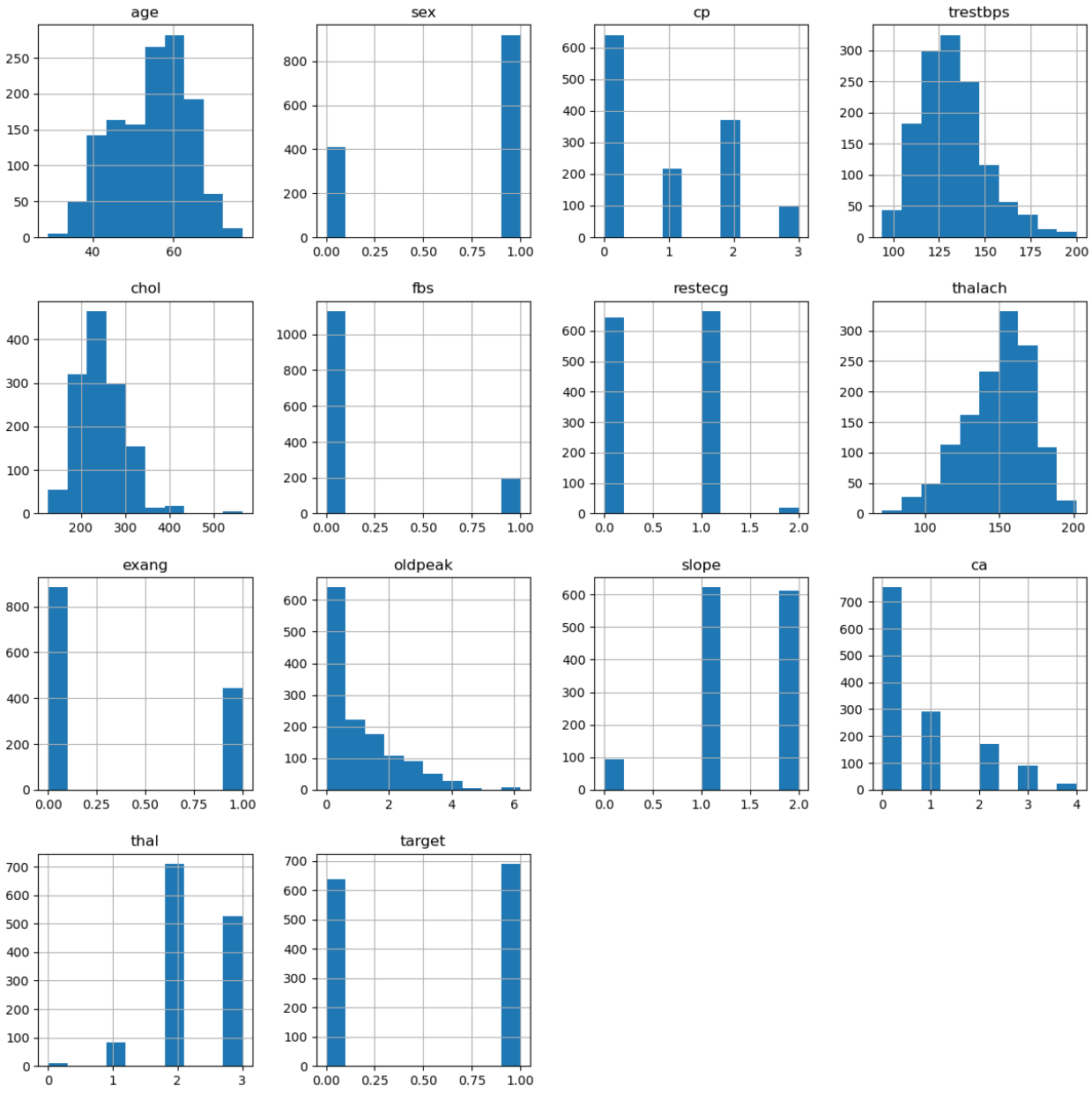
```
           count        mean        std    min    25%    50%    75%
max
age       1328.0   54.418675   9.071150   29.0   48.0   56.0   61.0
77.0
sex       1328.0    0.692771   0.461519    0.0    0.0    1.0    1.0
1.0
cp        1328.0    0.948042   1.029854    0.0    0.0    1.0    2.0
3.0
trestbps  1328.0  131.614458  17.514997   94.0  120.0  130.0  140.0
```

```
200.0
chol      1328.0  246.060241  51.627522  126.0  211.0  240.0  275.0
564.0
fbs       1328.0    0.149096   0.356318    0.0    0.0    0.0    0.0
1.0
restecg   1328.0    0.529367   0.527220    0.0    0.0    1.0    1.0
2.0
thalach   1328.0  149.235693  22.975286   71.0  132.0  152.0  166.0
202.0
exang     1328.0    0.334337   0.471936    0.0    0.0    0.0    1.0
1.0
oldpeak   1328.0    1.064232   1.171519    0.0    0.0    0.8    1.8
6.2
slope     1328.0    1.388554   0.617203    0.0    1.0    1.0    2.0
2.0
ca        1328.0    0.748494   1.028603    0.0    0.0    0.0    1.0
4.0
thal      1328.0    2.321536   0.618543    0.0    2.0    2.0    3.0
3.0
target    1328.0    0.520331   0.499775    0.0    0.0    1.0    1.0
1.0
```

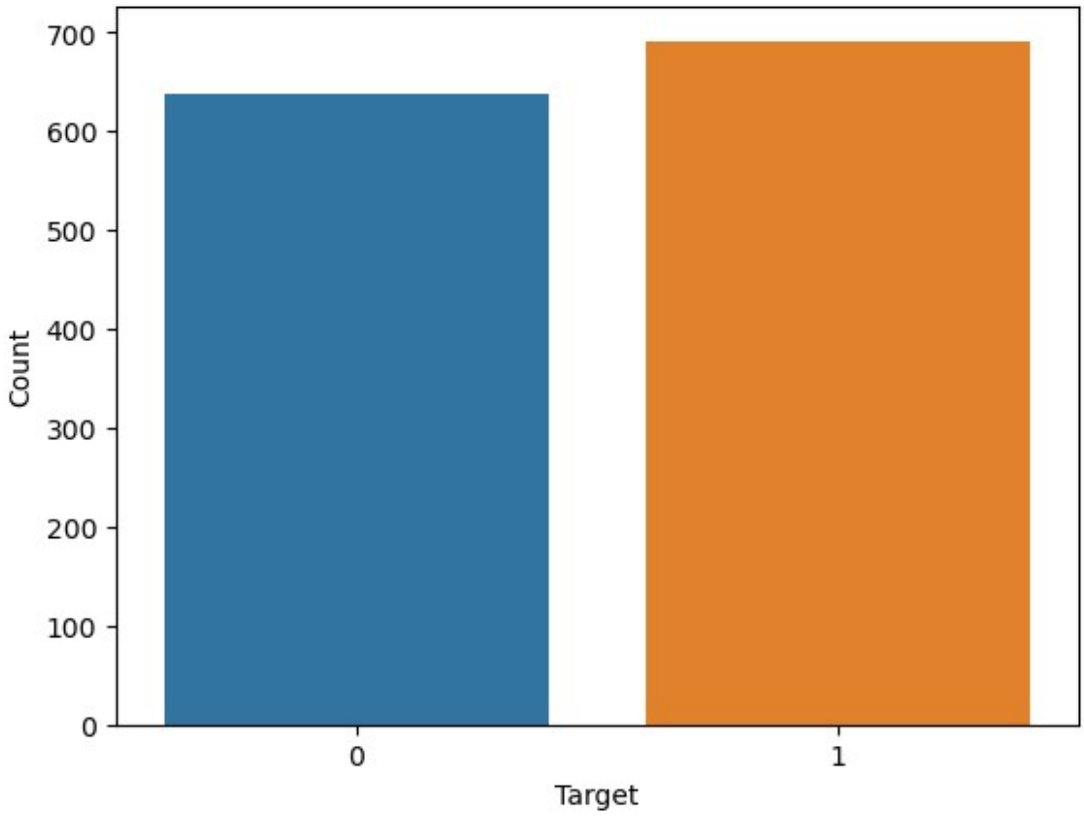
Data Visualization

```
# Importing essential libraries
%matplotlib inline

# Plotting histogram for the entire dataset
fig = plt.figure(figsize = (15,15))
ax = fig.gca()
g = df.hist(ax=ax)
```

```
C:\Users\Miet_\AppData\Local\Temp\ipykernel_17060\1840251571.py:4:
UserWarning: To output multiple subplots, the figure containing the
passed axes is being cleared.
  g = df.hist(ax=ax)
```




```
# Visualization to check if the dataset is balanced or not
g = sns.countplot(x='target', data=df)
plt.xlabel('Target')
plt.ylabel('Count')

Text(0, 0.5, 'Count')
```

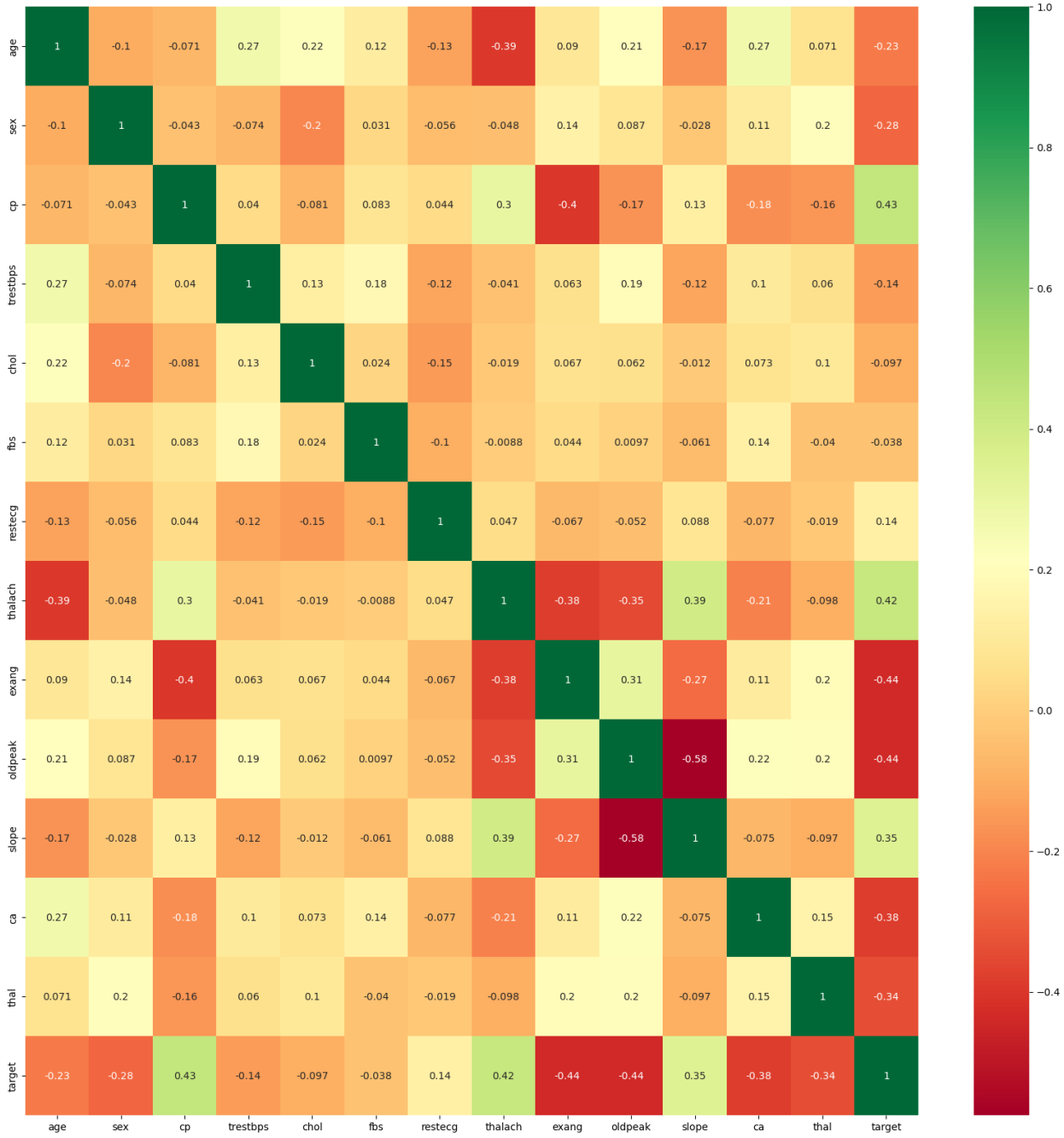


Feature Engineering

Feature Selection

```
# Selecting correlated features using Heatmap

# Get correlation of all the features of the dataset
corr_matrix = df.corr()
top_corr_features = corr_matrix.index

# Plotting the heatmap
plt.figure(figsize=(20,20))
sns.heatmap(data=df[top_corr_features].corr(), annot=True,
cmap='RdYlGn')
```

```
<AxesSubplot:>
```



Data Preprocessing

Handling categorical features

After exploring the dataset, I observed that converting the categorical variables into dummy variables using 'get_dummies()'. Though we don't have any strings in our dataset it is necessary to convert ('sex', 'cp', 'fbs', 'restecg', 'exang', 'slope', 'ca', 'thal') these features.

Example: Consider the 'sex' column, it is a binary feature which has 0's and 1's as its values. Keeping it as it is would lead the algorithm to think 0 is lower value and 1 is a higher value, which should not be the case since the gender cannot be ordinal feature.

```
dataset = pd.get_dummies(df, columns=['sex', 'cp', 'fbs', 'restecg',
'exang', 'slope', 'ca', 'thal'])
```

Feature Scaling

```
dataset.columns
```

```
Index(['age', 'trestbps', 'chol', 'thalach', 'oldpeak', 'target',
'sex_0',
       'sex_1', 'cp_0', 'cp_1', 'cp_2', 'cp_3', 'fbs_0', 'fbs_1',
'restecg_0',
       'restecg_1', 'restecg_2', 'exang_0', 'exang_1', 'slope_0',
'slope_1',
       'slope_2', 'ca_0', 'ca_1', 'ca_2', 'ca_3', 'ca_4', 'thal_0',
'thal_1',
       'thal_2', 'thal_3'],
      dtype='object')
```

```
from sklearn.preprocessing import StandardScaler
standScaler = StandardScaler()
columns_to_scale = ['age', 'trestbps', 'chol', 'thalach', 'oldpeak']
dataset[columns_to_scale] =
standScaler.fit_transform(dataset[columns_to_scale])
```

```
dataset.head()
```

```
        age  trestbps      chol   thalach   oldpeak  target  sex_0
sex_1  \
0  0.946358  0.764521 -0.253066  0.033279  1.055240       1      0
1
1 -1.920951 -0.092210  0.076340  1.644312  2.079936       1      0
1
2 -1.479827 -0.092210 -0.814993  0.991190  0.286717       1      1
0
3  0.174390 -0.663365 -0.194935  1.252439 -0.225631       1      0
1
4  0.284671 -0.663365  2.091528  0.599318 -0.396414       1      1
0

   cp_0  cp_1  ...  slope_2  ca_0  ca_1  ca_2  ca_3  ca_4  thal_0
thal_1  \
0     0     0  ...        0     1     0     0     0     0       0
1
1     0     0  ...        0     1     0     0     0     0       0
0
2     0     1  ...        1     1     0     0     0     0       0
```

```
0
3     0     1  ...         1     1     0     0     0     0        0
0
4     1     0  ...         1     1     0     0     0     0        0
0

   thal_2  thal_3
0       0       0
1       1       0
2       1       0
3       1       0
4       1       0

[5 rows x 31 columns]
```

```
# Splitting the dataset into dependent and independent features
X = dataset.drop('target', axis=1)
y = dataset['target']
```

Model Building

I will be experimenting with 3 algorithms:

1. KNeighbors Classifier
2. Decision Tree Classifier
3. Random Forest Classifier

KNeighbors Classifier Model

```
# Importing essential libraries
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import cross_val_score

# Finding the best accuracy for knn algorithm using cross_val_score
knn_scores = []
for i in range(1, 21):
  knn_classifier = KNeighborsClassifier(n_neighbors=i)
  cvs_scores = cross_val_score(knn_classifier, X, y, cv=10)
  knn_scores.append(round(cvs_scores.mean(),3))
```

```
C:\Users\Miet_\anaconda3\lib\site-packages\sklearn\neighbors\
_classification.py:228: FutureWarning: Unlike other reduction
functions (e.g. `skew`, `kurtosis`), the default behavior of `mode`
typically preserves the axis it acts along. In SciPy 1.11.0, this
behavior will change: the default value of `keepdims` will become
False, the `axis` over which the statistic is taken will be
eliminated, and the value None will no longer be accepted. Set
`keepdims` to True or False to avoid this warning.
```

```
  mode, _ = stats.mode(_y[neigh_ind, k], axis=1)
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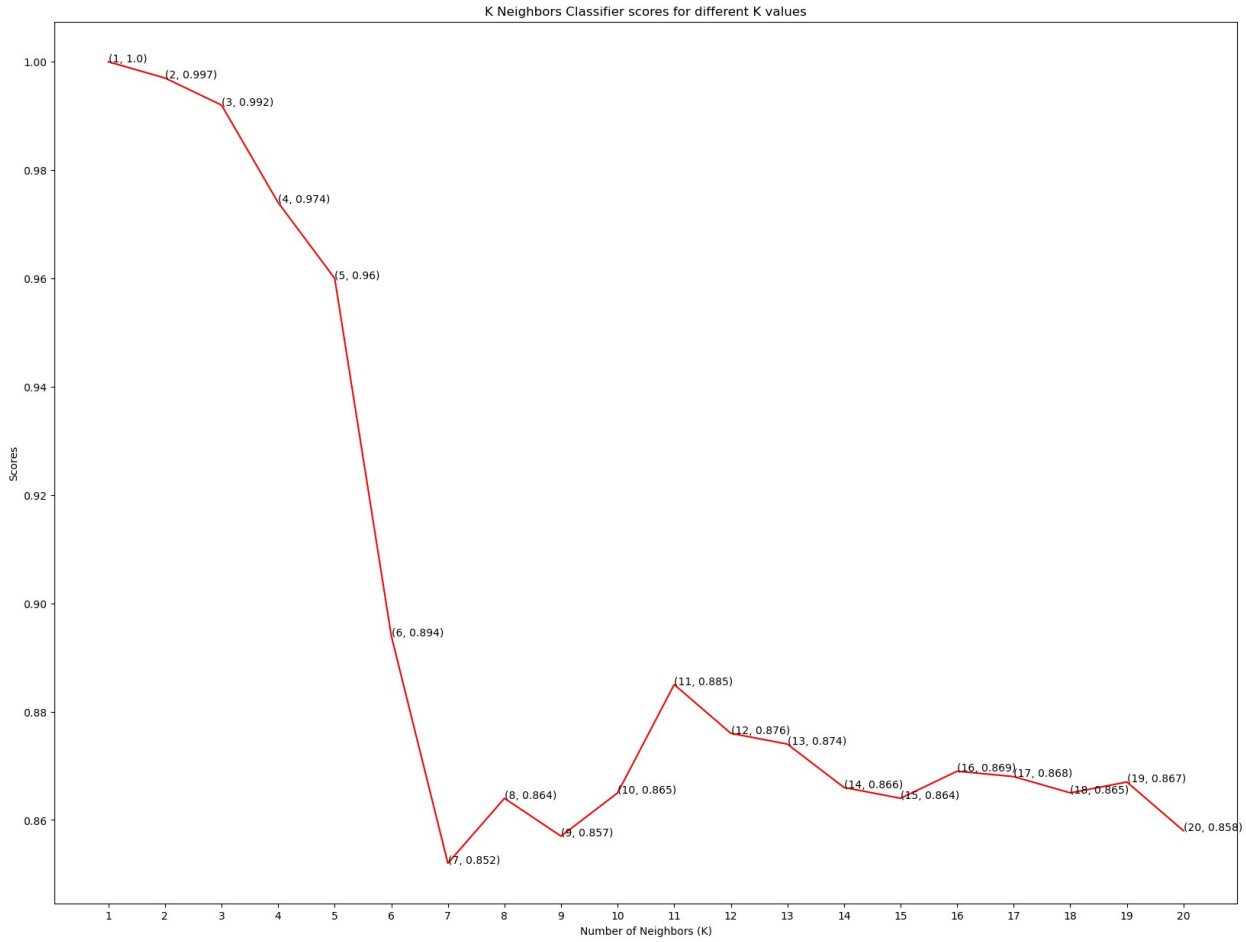
```
# Plotting the results of knn_scores
plt.figure(figsize=(20,15))
plt.plot([k for k in range(1, 21)], knn_scores, color = 'red')
for i in range(1,21):
    plt.text(i, knn_scores[i-1], (i, knn_scores[i-1]))
plt.xticks([i for i in range(1, 21)])
plt.xlabel('Number of Neighbors (K)')
plt.ylabel('Scores')
plt.title('K Neighbors Classifier scores for different K values')
```

```
Text(0.5, 1.0, 'K Neighbors Classifier scores for different K values')
```




```
# Training the knn classifier model with k value as 12
knn_classifier = KNeighborsClassifier(n_neighbors=12)
cvs_scores = cross_val_score(knn_classifier, X, y, cv=10)
print("KNeighbours Classifier Accuracy with K=12 is: {}
%".format(round(cvs_scores.mean(), 4)*100))
```

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functions (e.g. `skew`, `kurtosis`), the default behavior of `mode`
typically preserves the axis it acts along. In SciPy 1.11.0, this
behavior will change: the default value of `keepdims` will become
False, the `axis` over which the statistic is taken will be
eliminated, and the value None will no longer be accepted. Set
`keepdims` to True or False to avoid this warning.
  mode, _ = stats.mode(_y[neigh_ind, k], axis=1)
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KNeighbours Classifier Accuracy with K=12 is: 87.58%
```

```
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eliminated, and the value None will no longer be accepted. Set
`keepdims` to True or False to avoid this warning.
  mode, _ = stats.mode(_y[neigh_ind, k], axis=1)
```

Decision Tree Classifier

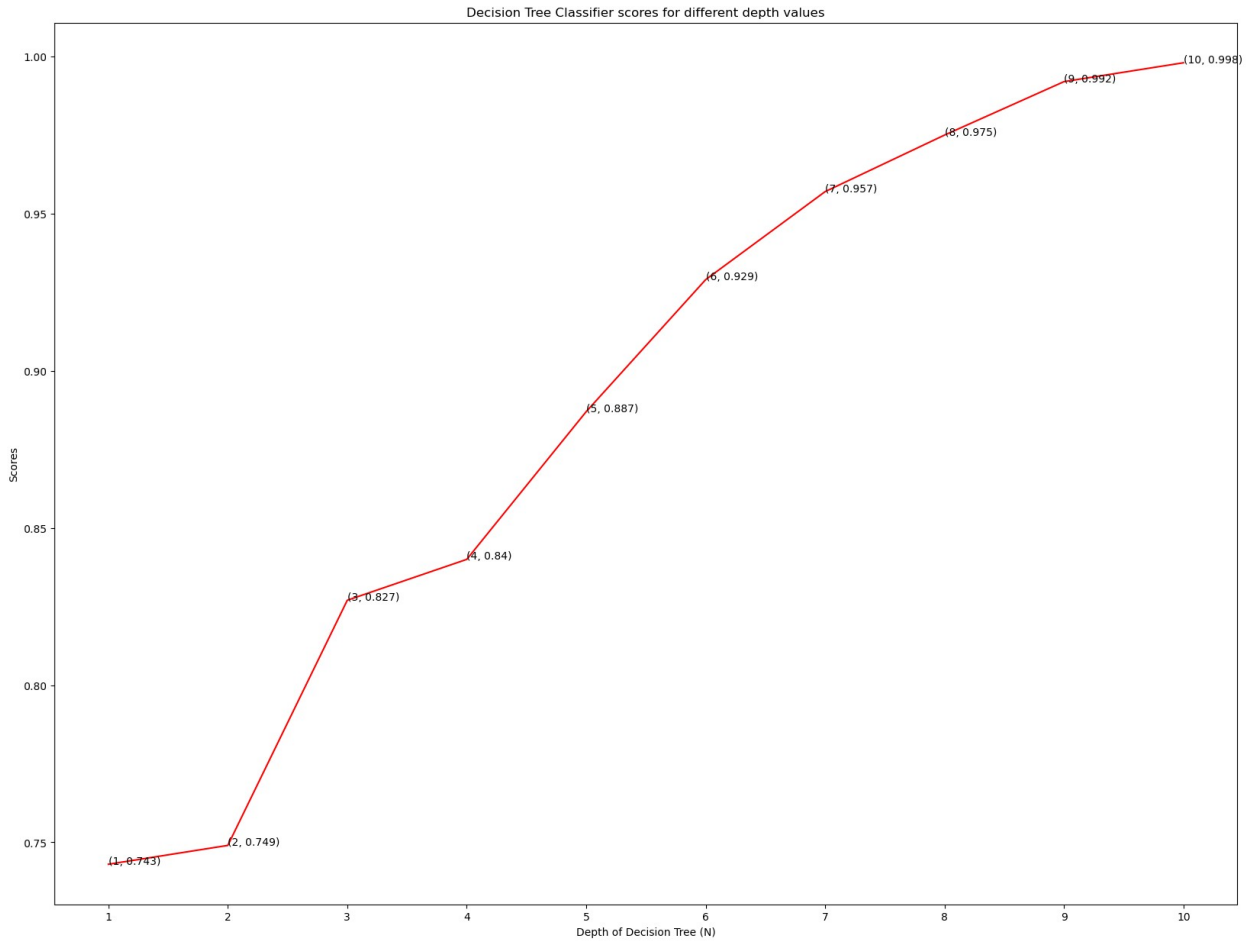
```python
# Importing essential libraries
from sklearn.tree import DecisionTreeClassifier

# Finding the best accuracy for decision tree algorithm using
cross_val_score
decision_scores = []
for i in range(1, 11):
  decision_classifier = DecisionTreeClassifier(max_depth=i)
  cvs_scores = cross_val_score(decision_classifier, X, y, cv=10)
  decision_scores.append(round(cvs_scores.mean(),3))

# Plotting the results of decision_scores
plt.figure(figsize=(20,15))
plt.plot([i for i in range(1, 11)], decision_scores, color = 'red')
for i in range(1,11):
    plt.text(i, decision_scores[i-1], (i, decision_scores[i-1]))
plt.xticks([i for i in range(1, 11)])
plt.xlabel('Depth of Decision Tree (N)')
plt.ylabel('Scores')
```

```
plt.title('Decision Tree Classifier scores for different depth values')
```

```
Text(0.5, 1.0, 'Decision Tree Classifier scores for different depth values')
```




```
# Training the decision tree classifier model with max_depth value as 3
decision_classifier = DecisionTreeClassifier(max_depth=3)
cvs_scores = cross_val_score(decision_classifier, X, y, cv=10)
print("Decision Tree Classifier Accuracy with max_depth=3 is: {}%".format(round(cvs_scores.mean(), 4)*100))
```

```
Decision Tree Classifier Accuracy with max_depth=3 is: 82.67999999999999%
```

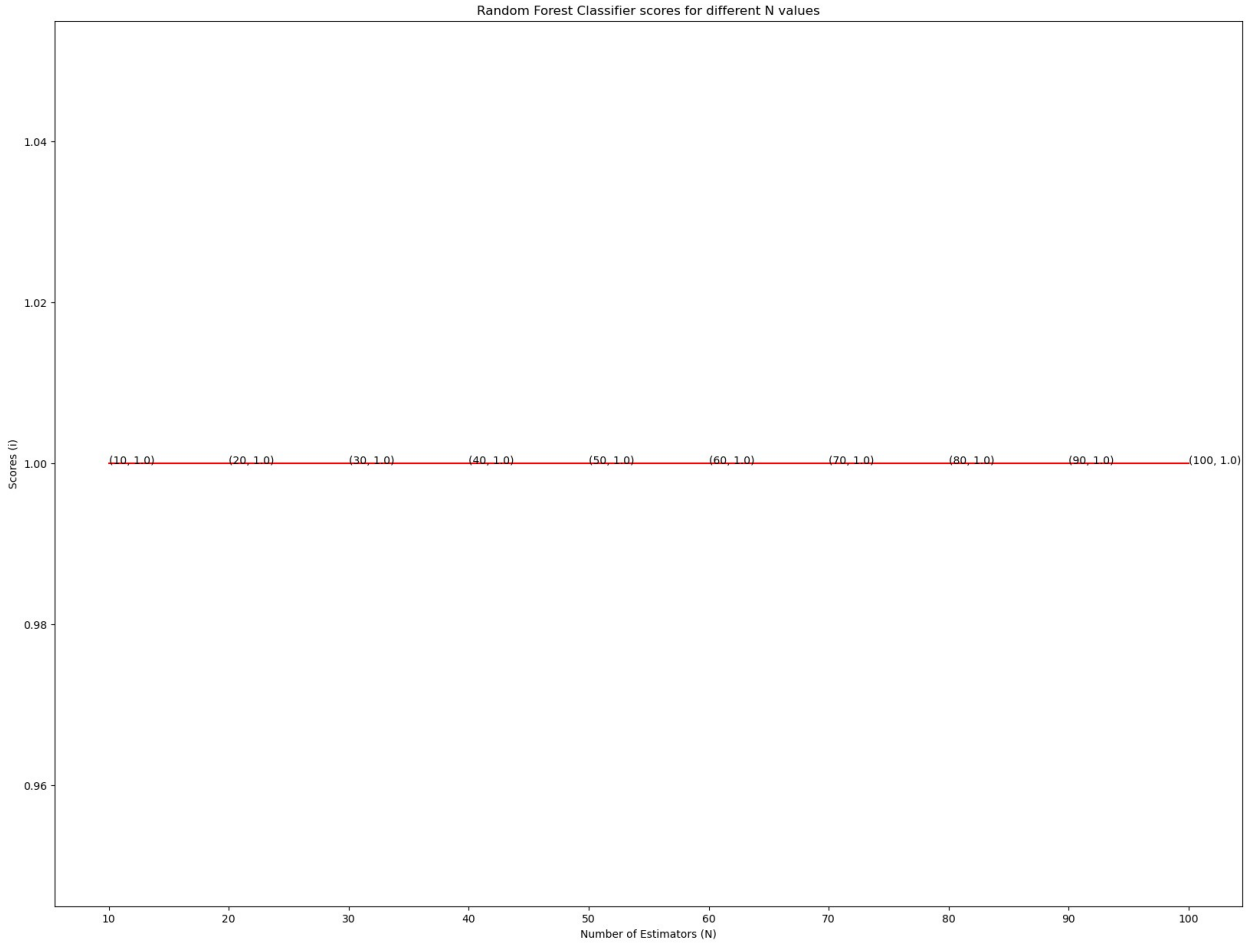
Random Forest Classifier

```
# Importing essential libraries
from sklearn.ensemble import RandomForestClassifier
```

```
# Finding the best accuracy for random forest algorithm using
cross_val_score
forest_scores = []
for i in range(10, 101, 10):
  forest_classifier = RandomForestClassifier(n_estimators=i)
  cvs_scores = cross_val_score(forest_classifier, X, y, cv=5)
  forest_scores.append(round(cvs_scores.mean(),3))

# Plotting the results of forest_scores
plt.figure(figsize=(20,15))
plt.plot([n for n in range(10, 101, 10)], forest_scores, color =
'red')
for i in range(1,11):
    plt.text(i*10, forest_scores[i-1], (i*10, forest_scores[i-1]))
plt.xticks([i for i in range(10, 101, 10)])
plt.xlabel('Number of Estimators (N)')
plt.ylabel('Scores (i)')
plt.title('Random Forest Classifier scores for different N values')

Text(0.5, 1.0, 'Random Forest Classifier scores for different N
values')
```



```
# Training the random forest classifier model with n value as 90
forest_classifier = RandomForestClassifier(n_estimators=90)
cvs_scores = cross_val_score(forest_classifier, X, y, cv=5)
print("Random Forest Classifier Accuracy with n_estimators=90 is: {}
%".format(round(cvs_scores.mean(), 4)*100))
```

```
Random Forest Classifier Accuracy with n_estimators=90 is: 100.0%
```