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

# Ignoring warnings
warnings.filterwarnings('ignore')

# Ensuring plots are displayed inline
%matplotlib inline
```

```
df = pd.read_csv("bank.csv",delimiter=';')
df.rename(columns={'y':'deposit'}, inplace=True)
df.head()
```

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	p
0	30	blue-collar	married	basic.9y	no	yes	no	cellular	may	fri	...	2	999	0	no
1	39	services	single	high.school	no	no	no	telephone	may	fri	...	4	999	0	no
2	25	services	married	high.school	no	yes	no	telephone	jun	wed	...	1	999	0	no
3	38	services	married	basic.9y	no	unknown	unknown	telephone	jun	fri	...	3	999	0	no
4	47	admin.	married	university.degree	no	yes	no	cellular	nov	mon	...	1	999	0	no

5 rows × 21 columns

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4119 entries, 0 to 4118
Data columns (total 21 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   age             4119 non-null   int64
 1   job             4119 non-null   object
 2   marital         4119 non-null   object
 3   education       4119 non-null   object
 4   default         4119 non-null   object
 5   housing         4119 non-null   object
 6   loan            4119 non-null   object
 7   contact         4119 non-null   object
 8   month           4119 non-null   object
 9   day_of_week     4119 non-null   object
 10  duration        4119 non-null   int64
 11  campaign        4119 non-null   int64
 12  pdays           4119 non-null   int64
 13  previous        4119 non-null   int64
 14  poutcome        4119 non-null   object
 15  emp.var.rate    4119 non-null   float64
 16  cons.price.idx  4119 non-null   float64
 17  cons.conf.idx   4119 non-null   float64
 18  euribor3m       4119 non-null   float64
 19  nr.employed     4119 non-null   float64
 20  deposit         4119 non-null   object
dtypes: float64(5), int64(5), object(11)
memory usage: 675.9+ KB
```

```
df.tail()
```

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	po
4114	30	admin.	married	basic.6y	no	yes	yes	cellular	jul	thu	...	1	999	0	none
4115	39	admin.	married	high.school	no	yes	no	telephone	jul	fri	...	1	999	0	none
4116	27	student	single	high.school	no	no	no	cellular	may	mon	...	2	999	1	
4117	58	admin.	married	high.school	no	no	no	cellular	aug	fri	...	1	999	0	none
4118	34	management	single	high.school	no	yes	no	cellular	nov	wed	...	1	999	0	none

5 rows × 21 columns

```
df.tail()
```

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	po
4114	30	admin.	married	basic.6y	no	yes	yes	cellular	jul	thu	...	1	999	0	none
4115	39	admin.	married	high.school	no	yes	no	telephone	jul	fri	...	1	999	0	none
4116	27	student	single	high.school	no	no	no	cellular	may	mon	...	2	999	1	
4117	58	admin.	married	high.school	no	no	no	cellular	aug	fri	...	1	999	0	none
4118	34	management	single	high.school	no	yes	no	cellular	nov	wed	...	1	999	0	none

5 rows × 21 columns

```
df.tail()
```

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	po
4114	30	admin.	married	basic.6y	no	yes	yes	cellular	jul	thu	...	1	999	0	none
4115	39	admin.	married	high.school	no	yes	no	telephone	jul	fri	...	1	999	0	none
4116	27	student	single	high.school	no	no	no	cellular	may	mon	...	2	999	1	
4117	58	admin.	married	high.school	no	no	no	cellular	aug	fri	...	1	999	0	none
4118	34	management	single	high.school	no	yes	no	cellular	nov	wed	...	1	999	0	none

5 rows × 21 columns

```
df.dtypes
```

```
age                int64
job               object
marital           object
education         object
default           object
housing           object
loan              object
contact           object
month             object
day_of_week       object
duration           int64
campaign           int64
pdays              int64
previous           int64
poutcome          object
emp.var.rate     float64
cons.price.idx   float64
cons.conf.idx    float64
euribor3m        float64
nr.employed      float64
deposit           object
dtype: object
```

```
df.columns
```

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'emp.var.rate', 'cons.price.idx',
       'cons.conf.idx', 'euribor3m', 'nr.employed', 'deposit'],
      dtype='object')
```

```
df.dtypes
```

```
age                int64
job               object
marital           object
education         object
default           object
housing           object
loan              object
contact           object
month             object
day_of_week       object
duration           int64
campaign           int64
pdays              int64
previous           int64
poutcome          object
emp.var.rate     float64
cons.price.idx   float64
cons.conf.idx    float64
euribor3m        float64
```

```
nr.employed       float64
deposit            object
dtype: object
```

```
df.dtypes.value_counts()
```

```
object     11
int64       5
float64     5
Name: count, dtype: int64
```

```
df.duplicated().sum()
```

```
0
```

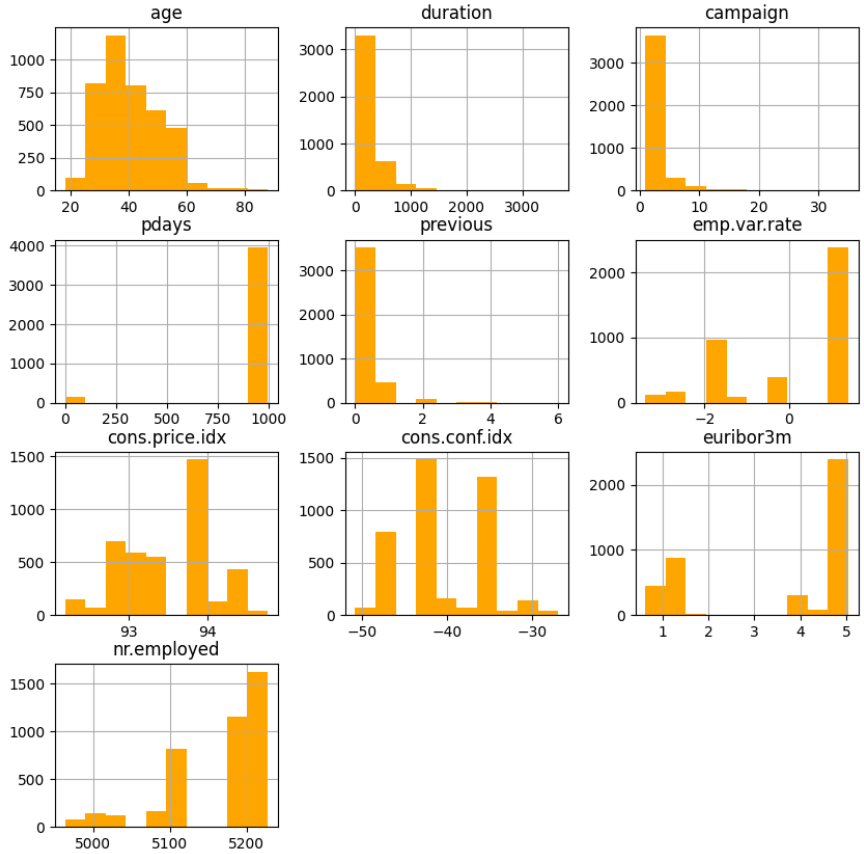
```
df.isna().sum()
```

```
age               0
job               0
marital           0
education         0
default           0
housing           0
loan              0
contact           0
month             0
day_of_week       0
duration          0
campaign          0
pdays             0
previous          0
poutcome          0
emp.var.rate      0
cons.price.idx    0
cons.conf.idx     0
euribor3m         0
nr.employed       0
deposit           0
dtype: int64
```

```
cat_cols = df.select_dtypes(include='object').columns
print(cat_cols)

num_cols = df.select_dtypes(exclude='object').columns
print(num_cols)
```

```
Index(['job', 'marital', 'education', 'default', 'housing', 'loan', 'contact',
       'month', 'day_of_week', 'poutcome', 'deposit'],
      dtype='object')
Index(['age', 'duration', 'campaign', 'pdays', 'previous', 'emp.var.rate',
       'cons.price.idx', 'cons.conf.idx', 'euribor3m', 'nr.employed'],
      dtype='object')
```

```
df.hist(figsize=(10,10), color='orange')
plt.show()
```



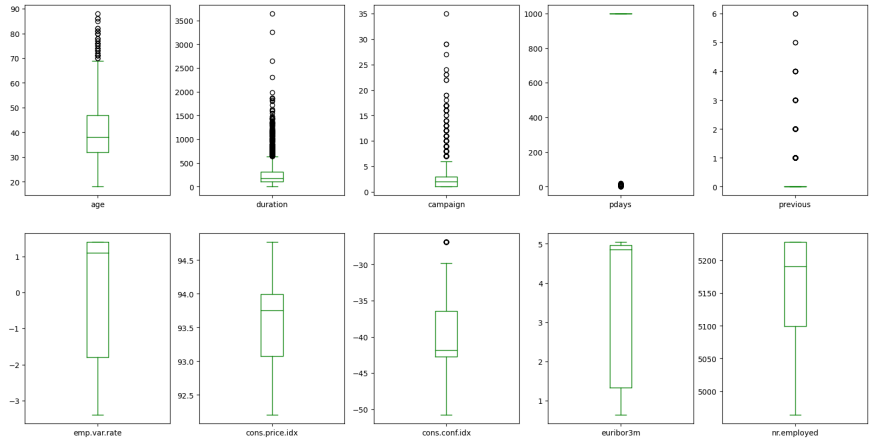

```
df.describe(include='object')
```

	job	marital	education	default	housing	loan	contact	month	day_o
count	4119	4119	4119	4119	4119	4119	4119	4119	
unique	12	4	8	3	3	3	2	10	
top	admin.	married	university.degree	no	yes	no	cellular	may	
freq	1012	2509	1264	3315	2175	3349	2652	1378	

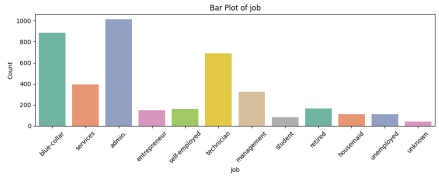
```
df.describe()
```

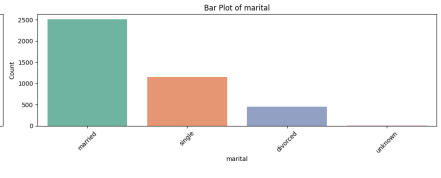
	age	duration	campaign	pdays	previous	emp.var.rate	cc
count	4119.000000	4119.000000	4119.000000	4119.000000	4119.000000	4119.000000	
mean	40.113620	256.788055	2.537266	960.422190	0.190337	0.084972	
std	10.313362	254.703736	2.568159	191.922786	0.541788	1.563114	
min	18.000000	0.000000	1.000000	0.000000	0.000000	-3.400000	
25%	32.000000	103.000000	1.000000	999.000000	0.000000	-1.800000	
50%	38.000000	181.000000	2.000000	999.000000	0.000000	1.100000	
75%	47.000000	317.000000	3.000000	999.000000	0.000000	1.400000	
max	88.000000	3643.000000	35.000000	999.000000	6.000000	1.400000	

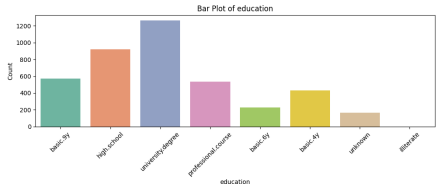
```
df.plot(kind='box', subplots=True, layout=(2,5), figsize=(20,10), color='green')
plt.show()
```

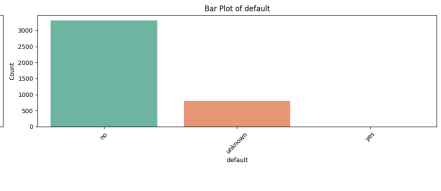


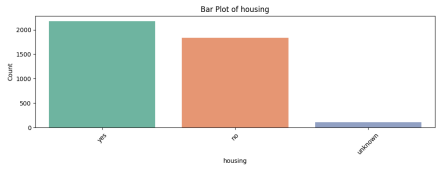

```
# Calculate the number of rows and columns for subplots
num_plots = len(cat_cols)
num_rows = (num_plots + 1) // 2  # Add 1 and divide by 2 to round up for odd numbers
num_cols = 2

# Create a new figure
plt.figure(figsize=(20, 25))  # Adjust the figure size as needed

# Loop through each feature and create a countplot
for i, feature in enumerate(cat_cols, 1):
    plt.subplot(num_rows, num_cols, i)
    sns.countplot(x=feature, data=df, palette='Set2')  # Changed palette to 'Set2'
    plt.title(f'Bar Plot of {feature}')
    plt.xlabel(feature)
    plt.ylabel('Count')
    plt.xticks(rotation=45)

# Adjust layout to prevent overlap of subplots
plt.tight_layout()
plt.show()
```

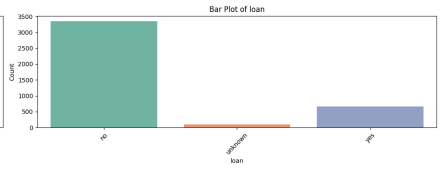

Bar Plot of job
Count
job
blue-collar
services
admin.
entrepreneur
self-employed
technician
management
student
retired
housemaid
unemployed
unknown

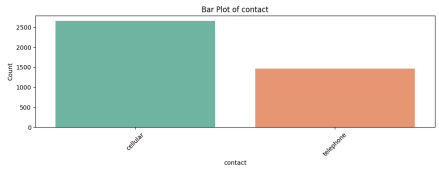

Bar Plot of marital
Count
marital
married
single
divorced
unknown

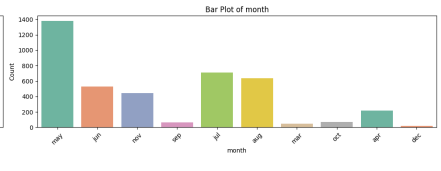

Bar Plot of education
Count
education
basic.9y
high.school
university.degree
professional.course
basic.6y
basic.4y
unknown
illiterate

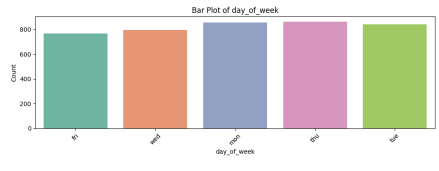

Bar Plot of default
Count
default
no
unknown
yes

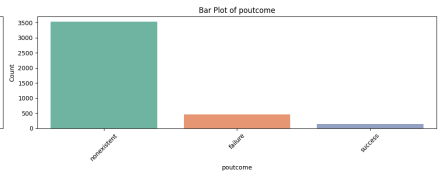

Bar Plot of housing
Count
housing
yes
no
unknown

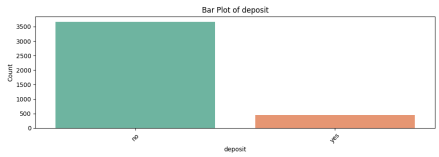

Bar Plot of loan
Count
loan
no
unknown
yes


Bar Plot of contact
Count
contact
cellular
telephone


Bar Plot of month
Count
month
may
jun
nov
sep
jul
aug
mar
oct
apr
dec

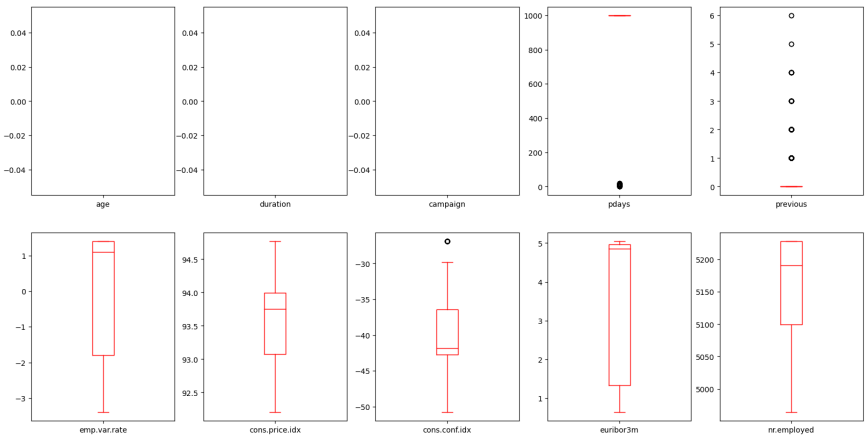

Bar Plot of day_of_week
Count
day_of_week
fri
wed
mon
thu
tue


Bar Plot of poutcome
Count
poutcome
nonexistent
failure
success

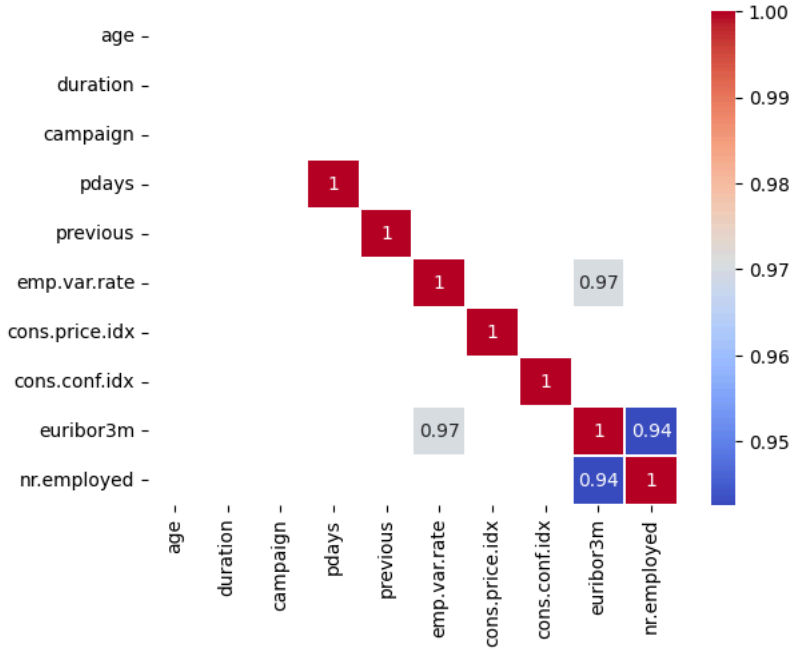

Bar Plot of deposit
Count
deposit
no
yes

```
# Assigning selected columns to a new variable
columns_to_check = df[['age', 'campaign', 'duration']]

# Calculating quartiles and IQR
q1 = np.percentile(columns_to_check, 25)
q3 = np.percentile(columns_to_check, 75)
iqr = q3 - q1

# Calculating lower and upper bounds
lower_bound = q1 - 1.5 * iqr
upper_bound = q3 + 1.5 * iqr

# Filtering out values beyond the bounds
df[['age', 'campaign', 'duration']] = columns_to_check[(columns_to_check > lower_bound) & (columns_to_check < upper_bound)]
```

```
# Plotting boxplot with a different color
df.plot(kind='box', subplots=True, layout=(2,5), figsize=(20,10), color='red')
plt.show()
```



```
# Exclude non-numeric columns
numeric_df = df.drop(columns=cat_cols)

# Compute the correlation matrix
corr = numeric_df.corr()

# Filter correlations with absolute value >= 0.90
corr = corr[abs(corr) >= 0.90]

# Plotting heatmap with a different color palette
# Plotting heatmap with a different color palette
sns.heatmap(corr, annot=True, cmap='coolwarm', linewidths=0.2)
plt.show()
```




```
high_corr_cols = ['emp.var.rate','euribor3m','nr.employed']
```

```
df1 = df.copy()
df1.columns
```

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'emp.var.rate', 'cons.price.idx',
       'cons.conf.idx', 'euribor3m', 'nr.employed', 'deposit'],
      dtype='object')
```

```
df1.drop(high_corr_cols,inplace=True,axis=1)  # axis=1 indicates columns
df1.columns
```

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'cons.price.idx', 'cons.conf.idx', 'deposit'],
      dtype='object')
```

```
df1.shape
```

```
(4119, 18)
```

```
from sklearn.preprocessing import LabelEncoder
lb = LabelEncoder()
df_encoded = df1.apply(lb.fit_transform)
df_encoded
```

	age	job	marital	education	default	housing	loan	contact	month	day_of_wee
0	0	1	1	2	0	2	0	0	6	
1	0	7	2	3	0	0	0	1	6	
2	0	7	1	3	0	2	0	1	4	
3	0	7	1	2	0	1	1	1	4	
4	0	0	1	6	0	2	0	0	7	
...	...	...	...	...	...	...	...	...	...	
4114	0	0	1	1	0	2	2	0	3	
4115	0	0	1	3	0	2	0	1	3	
4116	0	8	2	3	0	0	0	0	6	
4117	0	0	1	3	0	0	0	0	1	
4118	0	4	2	3	0	2	0	0	7	

4119 rows × 18 columns

```
df_encoded['deposit'].value_counts()
```

```
deposit
0    3668
1     451
Name: count, dtype: int64
```

```
x = df_encoded.drop('deposit',axis=1)  # independent variable
y = df_encoded['deposit']              # dependent variable
print(x.shape)
print(y.shape)
print(type(x))
print(type(y))
```

```
(4119, 17)
(4119,)
<class 'pandas.core.frame.DataFrame'>
<class 'pandas.core.series.Series'>
```

```
from sklearn.model_selection import train_test_split
```

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.25,random_state=1)
print(x_train.shape)
print(x_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(3089, 17)
(1030, 17)
(3089,)
(1030,)
```

```
from sklearn.metrics import confusion_matrix,classification_report,accuracy_score

def eval_model(y_test,y_pred):
    acc = accuracy_score(y_test,y_pred)
    print('Accuracy_Score',acc)
    cm = confusion_matrix(y_test,y_pred)
    print('Confusion Matrix\n',cm)
    print('Classification Report\n',classification_report(y_test,y_pred))

def mscore(model):
    train_score = model.score(x_train,y_train)
    test_score = model.score(x_test,y_test)
    print('Training Score',train_score)
    print('Testing Score',test_score)
```

```
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier(criterion='gini',max_depth=5,min_samples_split=10)
dt.fit(x_train,y_train)
```

```
▾ DecisionTreeClassifier
DecisionTreeClassifier(max_depth=5, min_samples_split=10)
```

```
mscore(dt)
```

```
Training Score 0.9080608611201036
Testing Score 0.9067961165048544
```

```
ypred_dt = dt.predict(x_test)
print(ypred_dt)
```

```
[0 0 1 ... 0 0 0]
```

```
eval_model(y_test,ypred_dt)
```

```
Accuracy_Score 0.9067961165048544
Confusion Matrix
 [[915  15]
 [ 81  19]]
Classification Report
              precision    recall  f1-score   support

           0       0.92      0.98      0.95       930
           1       0.56      0.19      0.28       100

    accuracy                           0.91      1030
   macro avg       0.74      0.59      0.62      1030
weighted avg       0.88      0.91      0.89      1030
```

```
from sklearn.tree import plot_tree
```

```
cn = ['no','yes']
fn = x_train.columns
print(fn)
print(cn)
```

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'cons.price.idx', 'cons.conf.idx'],
      dtype='object')
['no', 'yes']
```

```
def custom_plot_tree(tree_model, class_names=None, filled=True):
    # Generate plot data
    dot_data = export_graphviz(tree_model, out_file=None, class_names=class_names, filled=filled, rounded=True, special_characters=True)

    # Modify DOT data to change colors
    dot_data = dot_data.replace('fillcolor="#', 'fillcolor="#90EE90')
    dot_data = dot_data.replace('color="#', 'color="#90EE90')

    # Create graph from modified DOT data
    graph = graphviz.Source(dot_data)

    # Display the graph
    return graph

# Call the custom function to plot the tree with modified colors
plt.figure(figsize=(30,10))
custom_plot_tree(dt, class_names=cn, filled=True)
```