Task 1: Retrieving and Preparing the Data

In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

df = pd.read_csv('file:///Users/amayiyer/Desktop/DatSci_Python/Ass2/Datasets/Online%20Shoppers%20Purchasing%20I
df.head(7)
```

Out[1]:

	Administrative	Administrative_Duration	Informational	Informational_Duration	ProductRelated	ProductRelated_Duration	BounceRates	ExitRates	PageValu
0	0	0.0	0	0.0	1	0.000000	0.200000	0.200000	
1	0	0.0	0	0.0	2	64.000000	0.000000	0.100000	
2	0	0.0	0	0.0	1	0.000000	0.200000	0.200000	
3	0	0.0	0	0.0	2	2.666667	0.050000	0.140000	
4	0	0.0	0	0.0	10	627.500000	0.020000	0.050000	
5	0	0.0	0	0.0	19	154.216667	0.015789	0.024561	
6	0	0.0	0	0.0	1	0.000000	0.200000	0.200000	

1.1: Checking for Missing Values (I have also conducted more data cleaning further in the notebook when the occasion arises)

In [2]:
```
# Checking the data types of all columns
print(df.dtypes)
print(df.isnull().sum())
```

```
Administrative             int64
Administrative_Duration    float64
Informational              int64
Informational_Duration     float64
ProductRelated             int64
ProductRelated_Duration    float64
BounceRates                float64
ExitRates                  float64
PageValues                 float64
SpecialDay                 float64
Month                      object
OperatingSystems           int64
Browser                    int64
Region                     int64
TrafficType                int64
VisitorType                object
Weekend                    bool
Revenue                    bool
dtype: object
Administrative             0
Administrative_Duration    0
Informational              0
Informational_Duration     0
ProductRelated             0
ProductRelated_Duration    0
BounceRates                0
ExitRates                  0
PageValues                 0
SpecialDay                 0
Month                      0
OperatingSystems           0
Browser                    0
Region                     0
TrafficType                0
VisitorType                0
Weekend                    0
Revenue                    0
dtype: int64
```

In [3]:
```
duplicate_rows = df.duplicated()
print("Number of duplicate rows: ", duplicate_rows.sum())
```

```
Number of duplicate rows:  125
```

Task 2.1 Description of the Statistics

In [4]:

```
#Descriptive and Summarizing Statistics will help me get a numerical understanding of the data
print(df.describe())

# This is for all of the categorical columns
for column in ['Month', 'OperatingSystems', 'Browser', 'Region', 'TrafficType', 'VisitorType', 'Weekend', 'Rever
    print(df[column].value_counts())
```

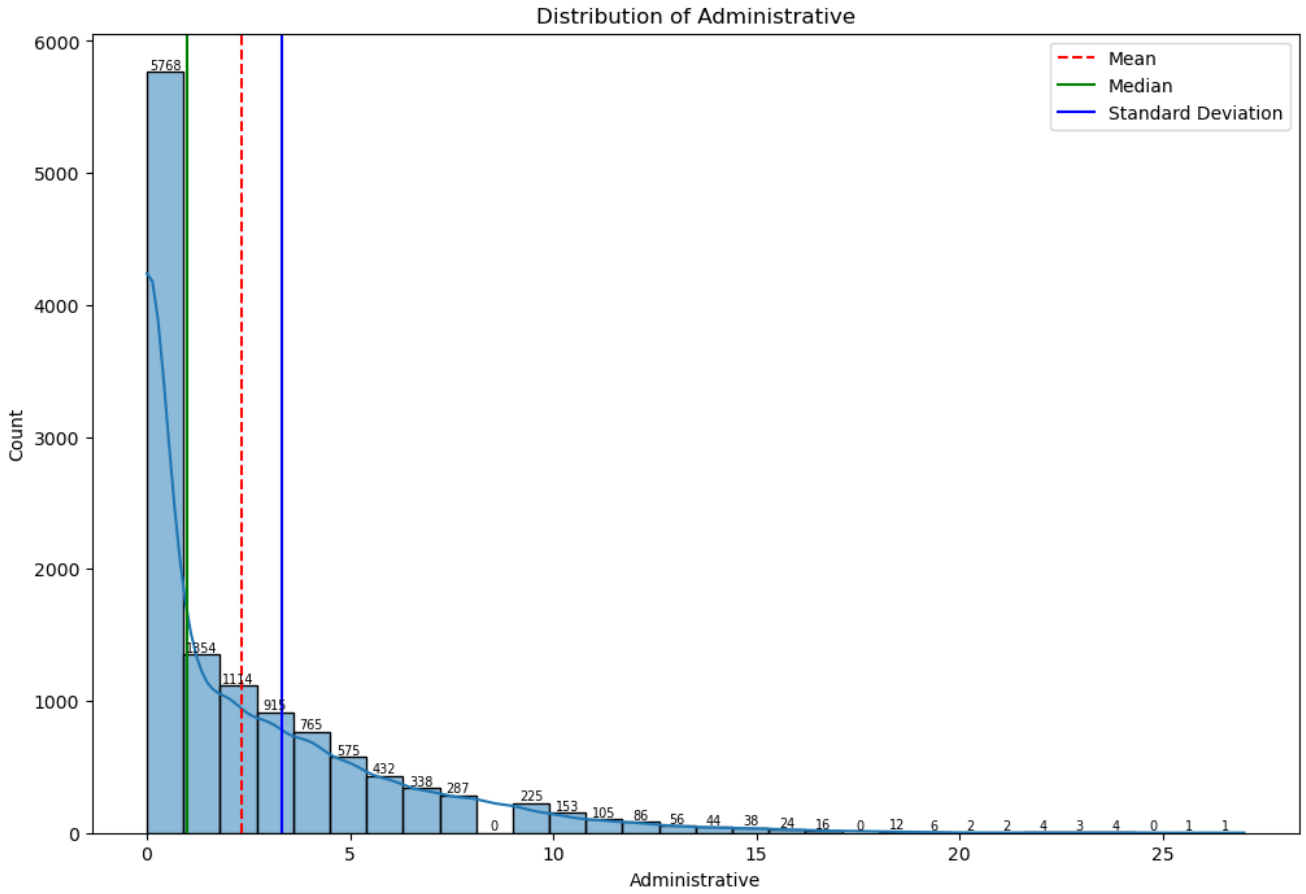
```
       Administrative  Administrative_Duration  Informational  \
count    12330.000000             12330.000000   12330.000000
mean         2.315166                80.818611       0.503569
std          3.321784               176.779107       1.270156
min          0.000000                 0.000000       0.000000
25%          0.000000                 0.000000       0.000000
50%          1.000000                 7.500000       0.000000
75%          4.000000                93.256250       0.000000
max         27.000000              3398.750000      24.000000

       Informational_Duration  ProductRelated  ProductRelated_Duration  \
count            12330.000000    12330.000000             12330.000000
mean                34.472398       31.731468              1194.746220
std                140.749294       44.475503              1913.669288
min                  0.000000        0.000000                 0.000000
25%                  0.000000        7.000000               184.137500
50%                  0.000000       18.000000               598.936905
75%                  0.000000       38.000000              1464.157214
max               2549.375000      705.000000             63973.522230

        BounceRates     ExitRates    PageValues    SpecialDay  \
count  12330.000000  12330.000000  12330.000000  12330.000000
mean       0.022191      0.043073      5.889258      0.061427
std        0.048488      0.048597     18.568437      0.198917
min        0.000000      0.000000      0.000000      0.000000
25%        0.000000      0.014286      0.000000      0.000000
50%        0.003112      0.025156      0.000000      0.000000
75%        0.016813      0.050000      0.000000      0.000000
max        0.200000      0.200000    361.763742      1.000000

       OperatingSystems       Browser        Region   TrafficType
count      12330.000000  12330.000000  12330.000000  12330.000000
mean           2.124006      2.357097      3.147364      4.069586
std            0.911325      1.717277      2.401591      4.025169
min            1.000000      1.000000      1.000000      1.000000
25%            2.000000      2.000000      1.000000      2.000000
50%            2.000000      2.000000      3.000000      2.000000
75%            3.000000      2.000000      4.000000      4.000000
max            8.000000     13.000000      9.000000     20.000000
May     3364
Nov     2998
Mar     1907
Dec     1727
Oct      549
Sep      448
Aug      433
Jul      432
June     288
Feb      184
Name: Month, dtype: int64
2    6601
1    2585
3    2555
4     478
8      79
6      19
7       7
5       6
Name: OperatingSystems, dtype: int64
2     7961
1     2462
4      736
5      467
6      174
10     163
8      135
3      105
13      61
7       49
12      10
11       6
9        1
Name: Browser, dtype: int64
1    4780
3    2403
4    1182
2    1136
6     805
7     761
9     511
8     434
5     318
Name: Region, dtype: int64
```

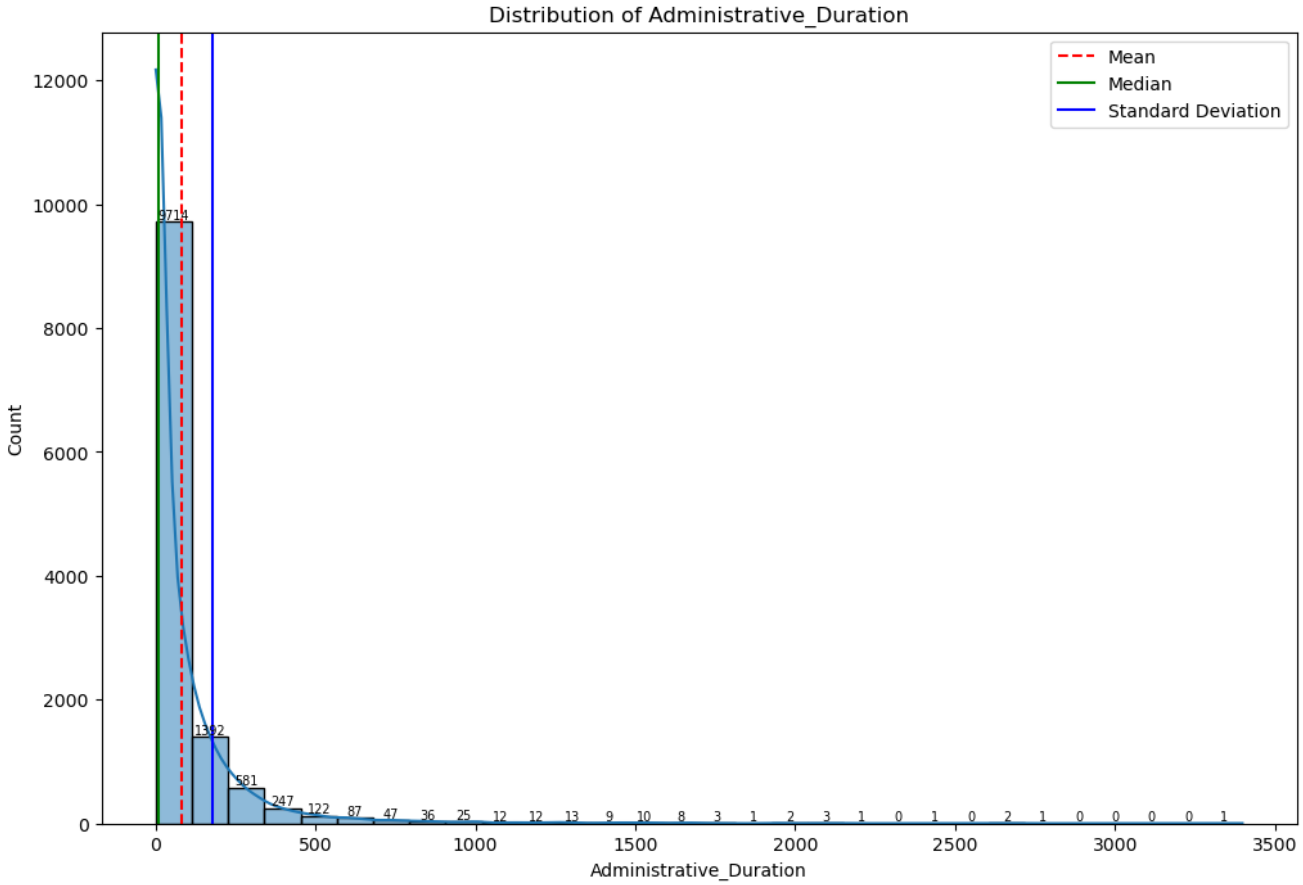
```
2     3913
1     2451
3     2052
4     1069
13     738
10     450
6      444
8      343
5      260
11     247
20     198
9       42
7       40
15      38
19      17
14      13
18      10
16       3
12       1
17       1
Name: TrafficType, dtype: int64
Returning_Visitor    10551
New_Visitor           1694
Other                   85
Name: VisitorType, dtype: int64
False    9462
True     2868
Name: Weekend, dtype: int64
False    10422
True      1908
Name: Revenue, dtype: int64
```

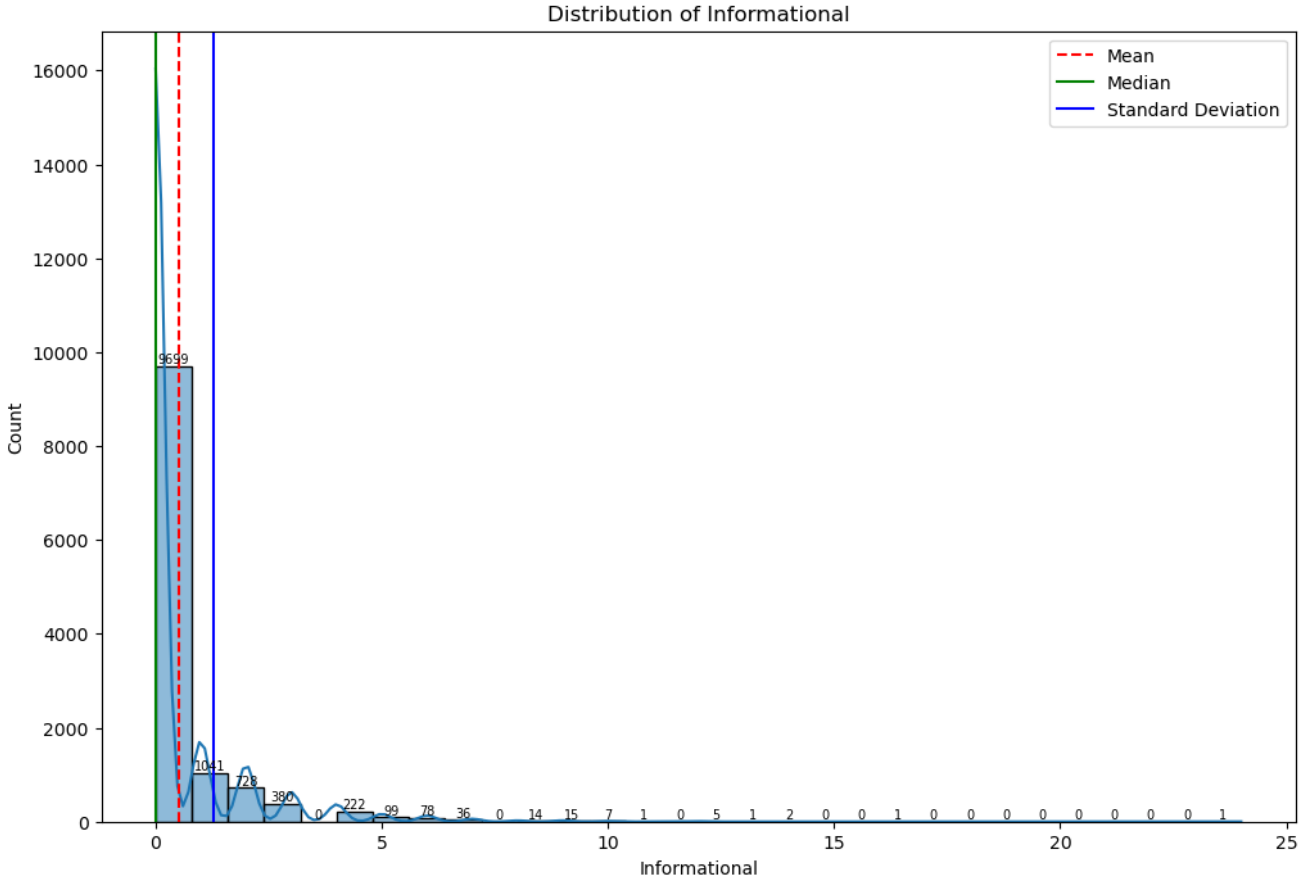
Task 1.1: Removing all values for which the SpecialDay values are not 0 or 1

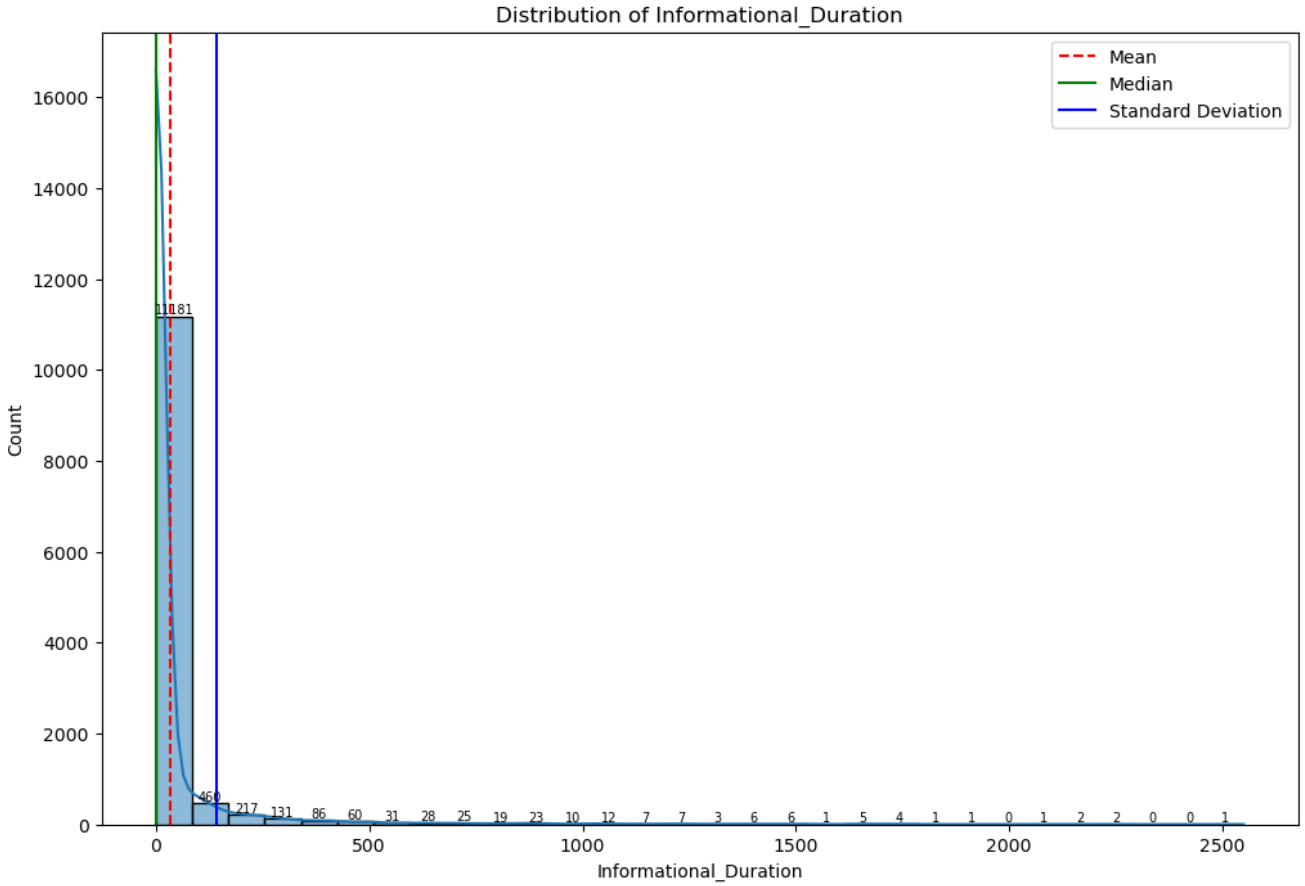
2.2 Descriptive Statistics Visualization

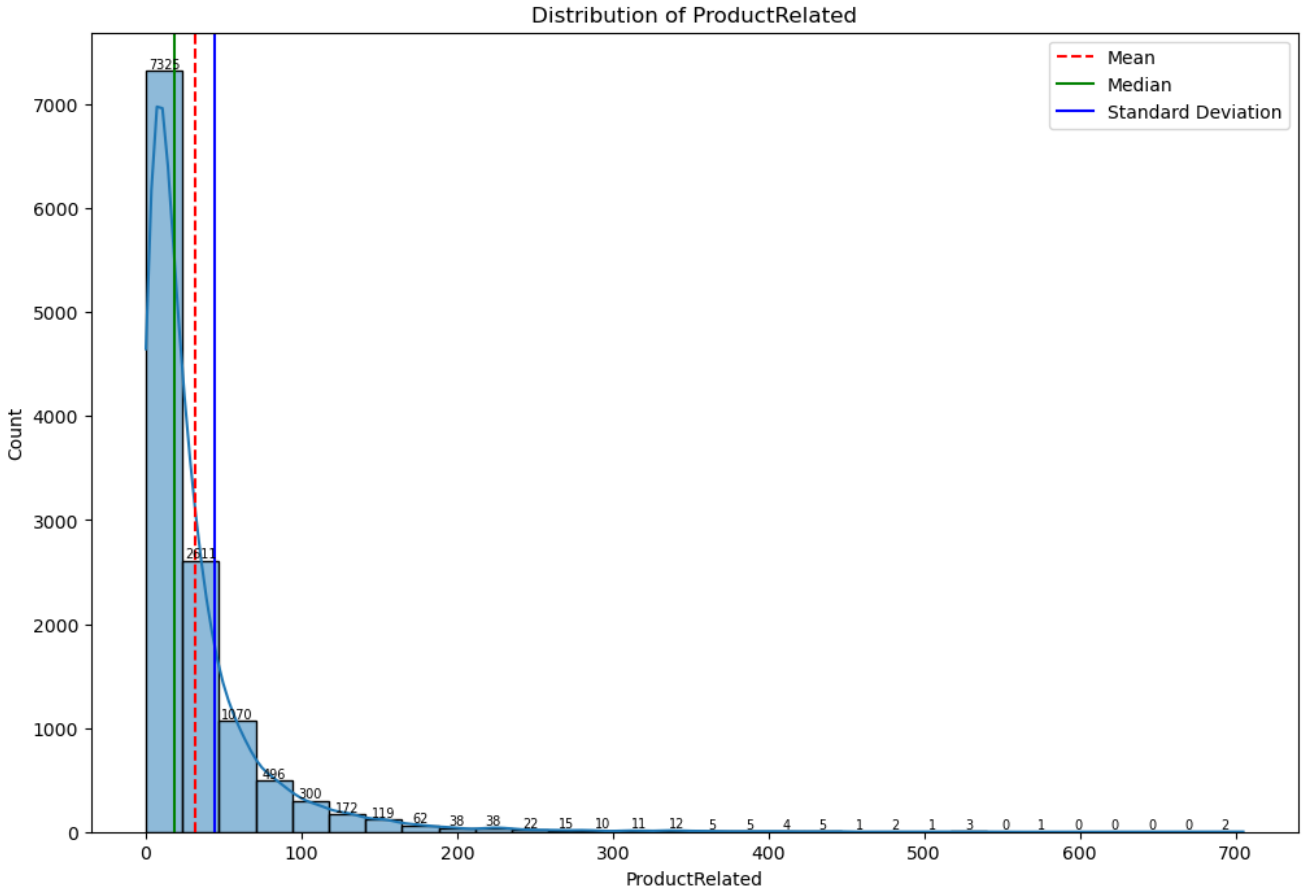
In [5]:
```
# Statistics for numerical columns
num_cols = ['Administrative', 'Administrative_Duration', 'Informational', 'Informational_Duration', 'ProductRela
for column in num_cols:
    plt.figure(figsize=(12,8))
    ax = sns.histplot(df[column], kde=True, bins=30)
    plt.title('Distribution of '+ column)
    plt.axvline(df[column].mean(), color='r', linestyle='--', label='Mean')
    plt.axvline(df[column].median(), color='g', linestyle='-', label='Median')
    plt.axvline(df[column].std(), color='b', linestyle='-', label='Standard Deviation')
    plt.legend()

    for p in ax.patches:
        ax.annotate(f'{p.get_height().astype(int)}', (p.get_x()+p.get_width()/2., p.get_height()+0.5), ha='cente
    plt.show()

# Even though the Revenue is the target variable, I am classing it as a kind of categorical column to see the sp
cat_cols = ['Month', 'OperatingSystems', 'Browser', 'Region', 'TrafficType', 'VisitorType', 'Weekend', 'Revenue'
for column in cat_cols:
    plt.figure(figsize=(12,8))
    ax = sns.countplot(x=column, data=df)
    plt.title('Count of '+ column)
    plt.xticks(rotation=90)

    for p in ax.patches:
        ax.annotate(f'{p.get_height()}', (p.get_x()+p.get_width()/2., p.get_height()+0.5), ha='center', va='bott
    plt.show()

```

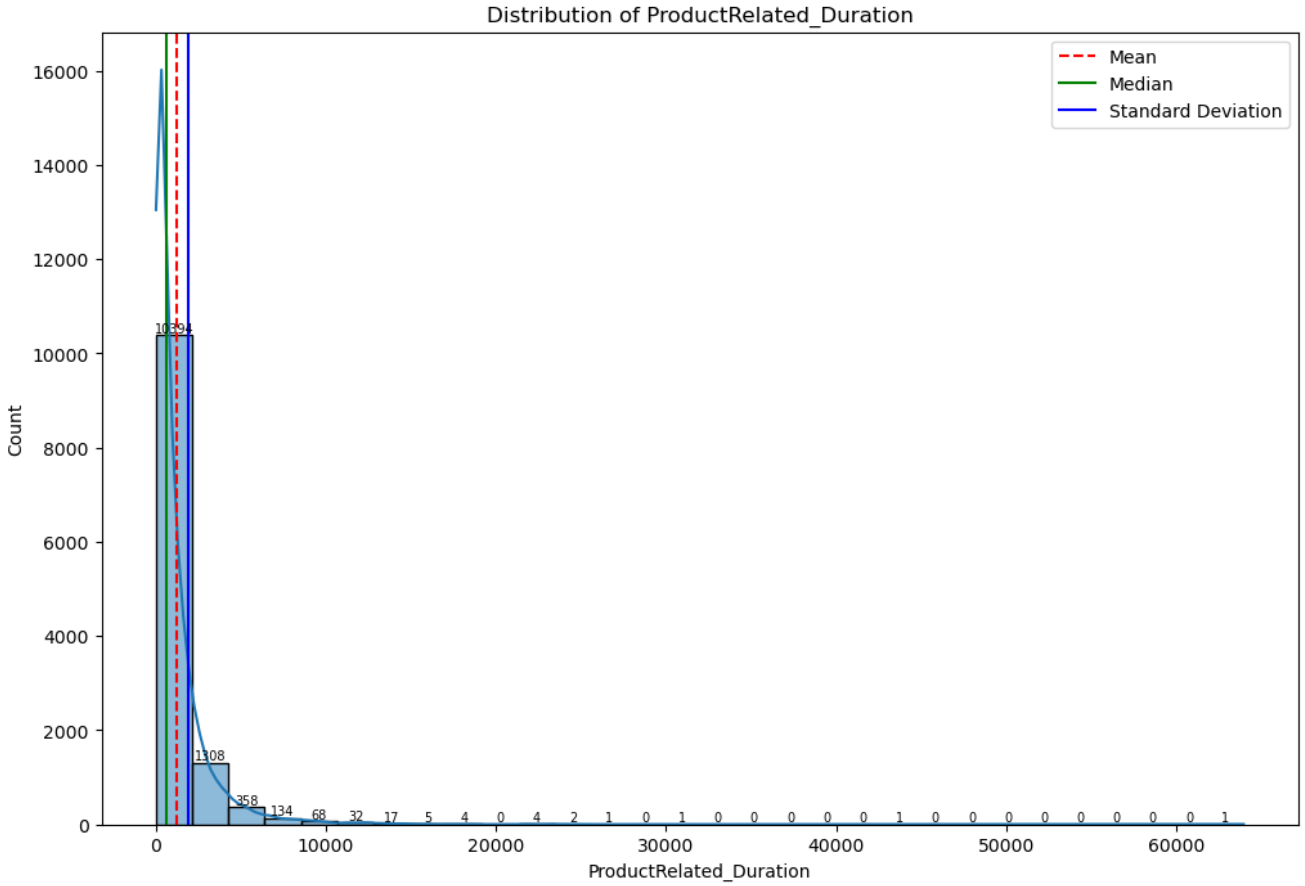


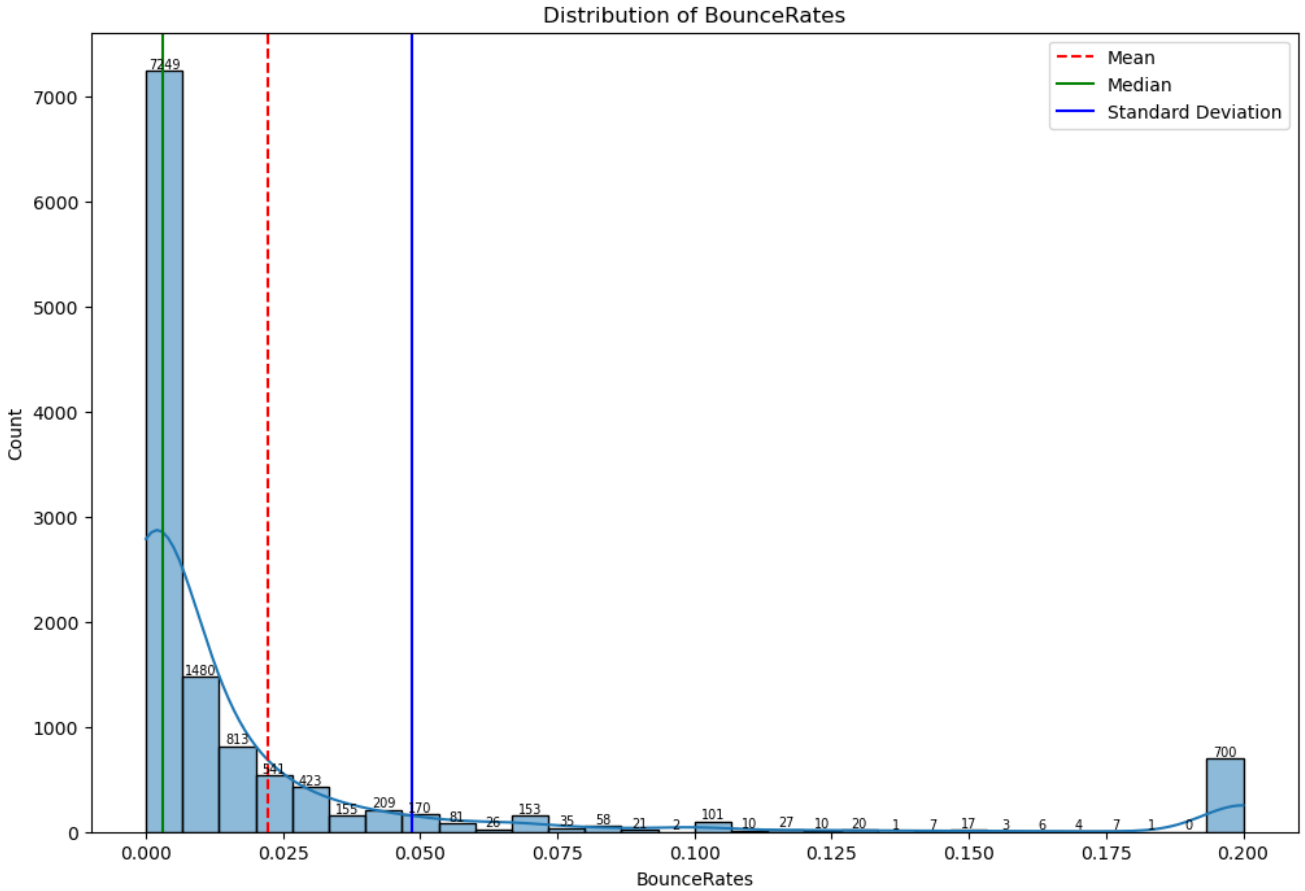

Distribution of Administrative_Duration
Mean
Median
Standard Deviation
Count
Administrative_Duration
0
500
1000
1500
2000
2500
3000
3500
2000
4000
6000
8000
10000
12000
9714
1392
581
247
122
87
47
36
25
12
12
13
9
10
8
3
1
2
3
1
0
1
0
2
1
0
0
0
0
1

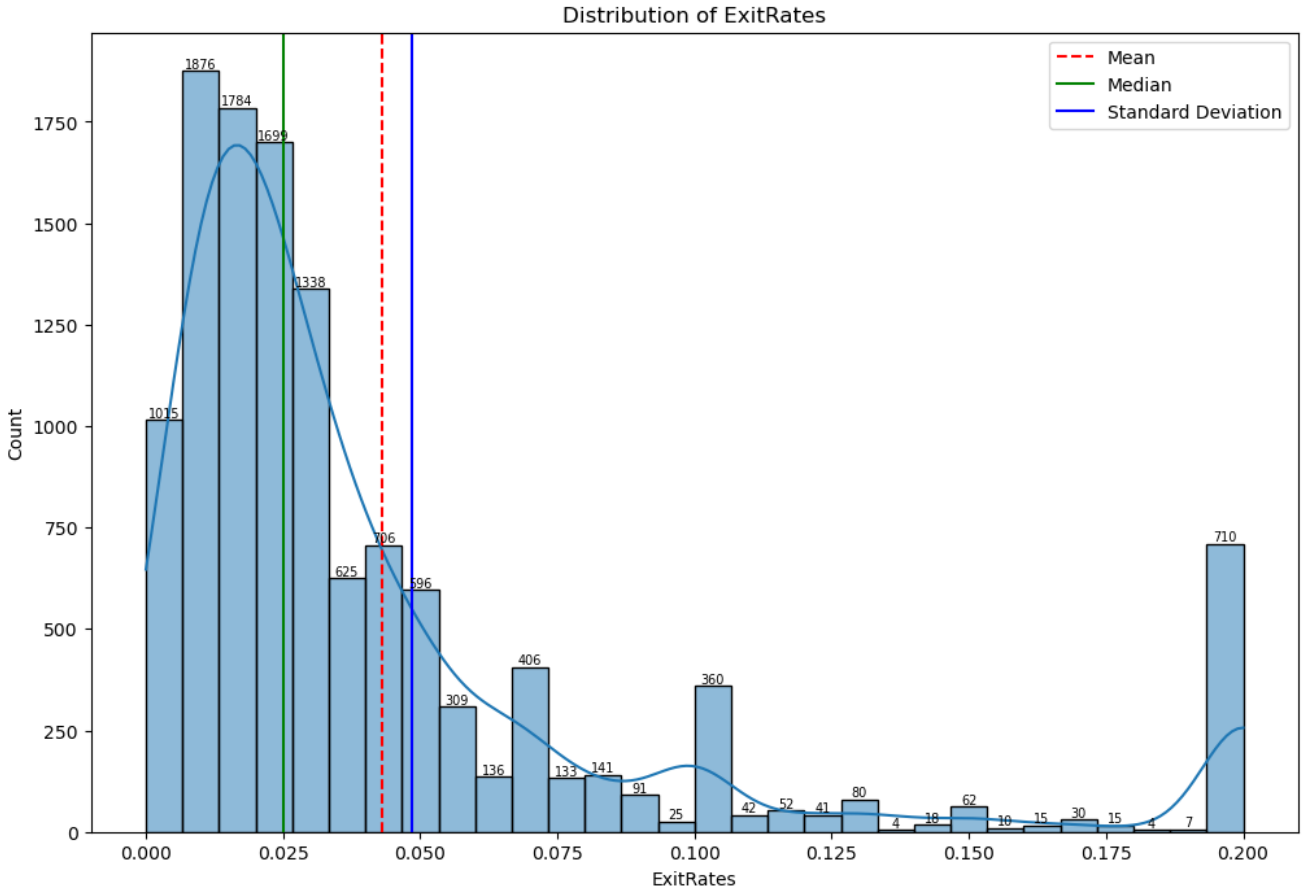

Distribution of Informational
Mean
Median
Standard Deviation
Count
Informational
0
5
10
15
20
25
2000
4000
6000
8000
10000
12000
14000
16000
9699
1041
728
380
0
222
99
78
36
0
14
15
7
1
0
5
1
2
0
0
1
0
0
0
0
0
0
0
0
1

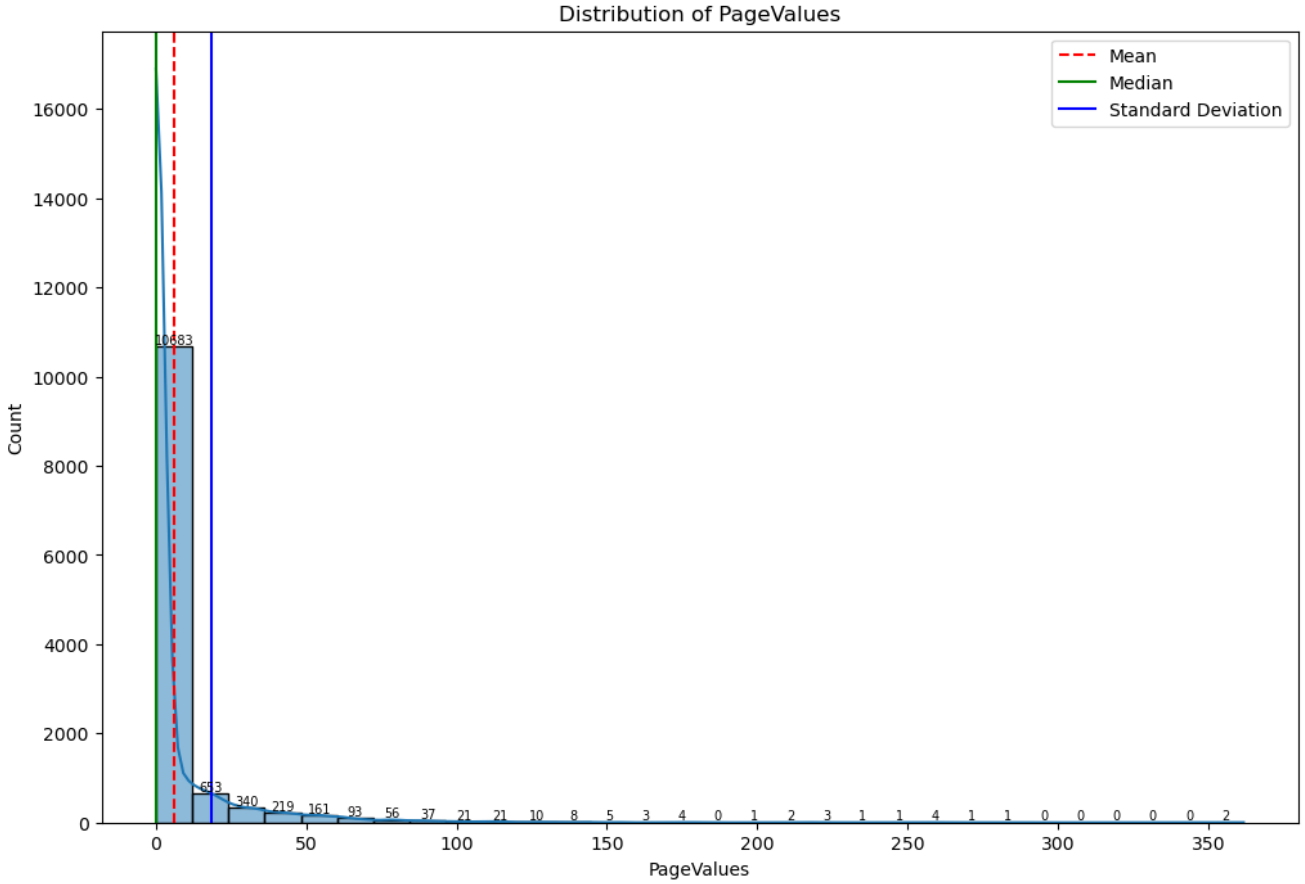

Distribution of Informational_Duration
Mean
Median
Standard Deviation
Count
Informational_Duration
0
500
1000
1500
2000
2500
2000
4000
6000
8000
10000
12000
14000
16000
11181
460
217
131
86
60
31
28
25
19
23
10
12
7
7
3
6
6
1
5
4
1
1
0
1
2
2
0
0
1

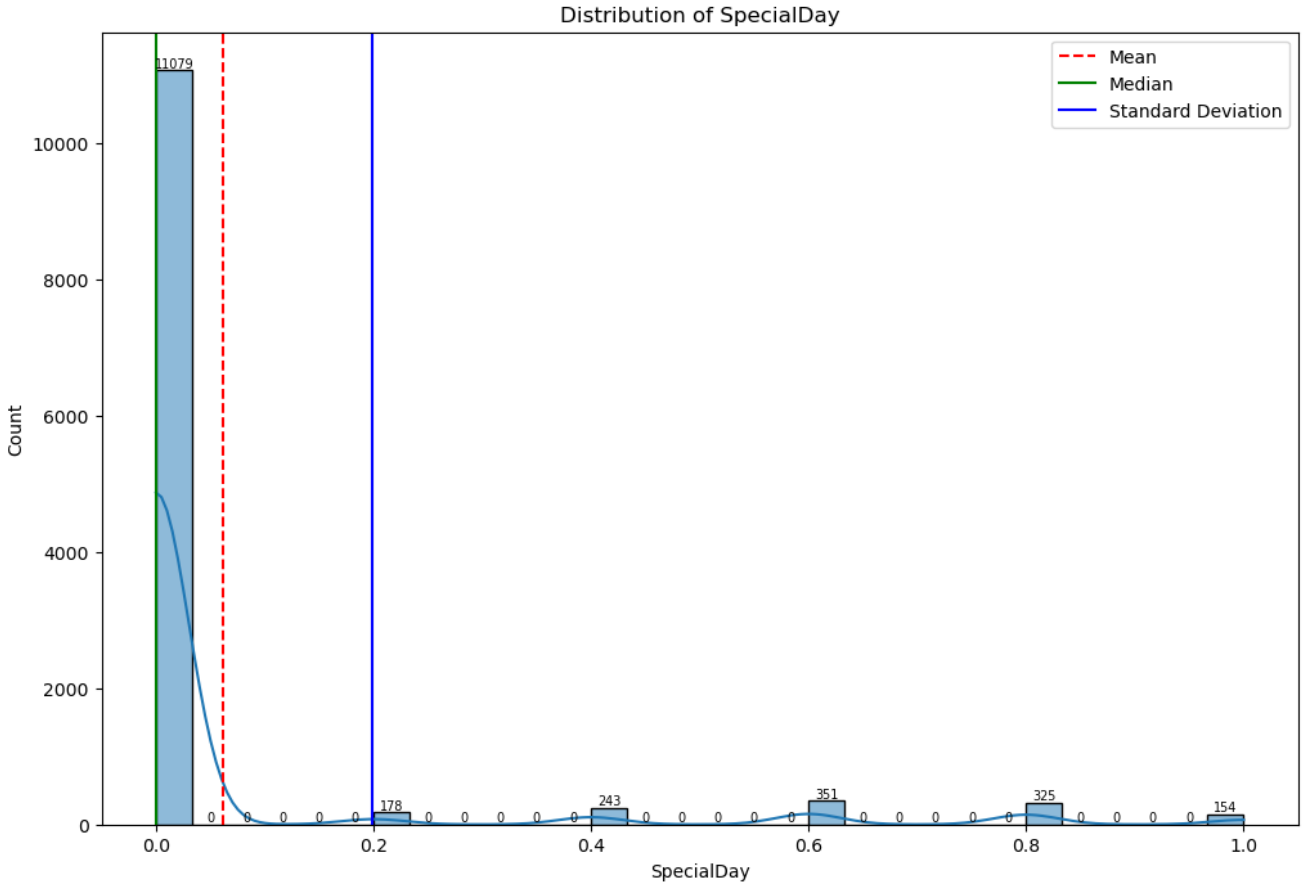

Distribution of ProductRelated
Mean
Median
Standard Deviation
Count
ProductRelated
0
100
200
300
400
500
600
700
1000
2000
3000
4000
5000
6000
7000
7326
2611
1070
496
300
172
119
62
38
38
22
15
10
11
12
5
5
4
5
1
2
1
3
0
1
0
0
0
0
2

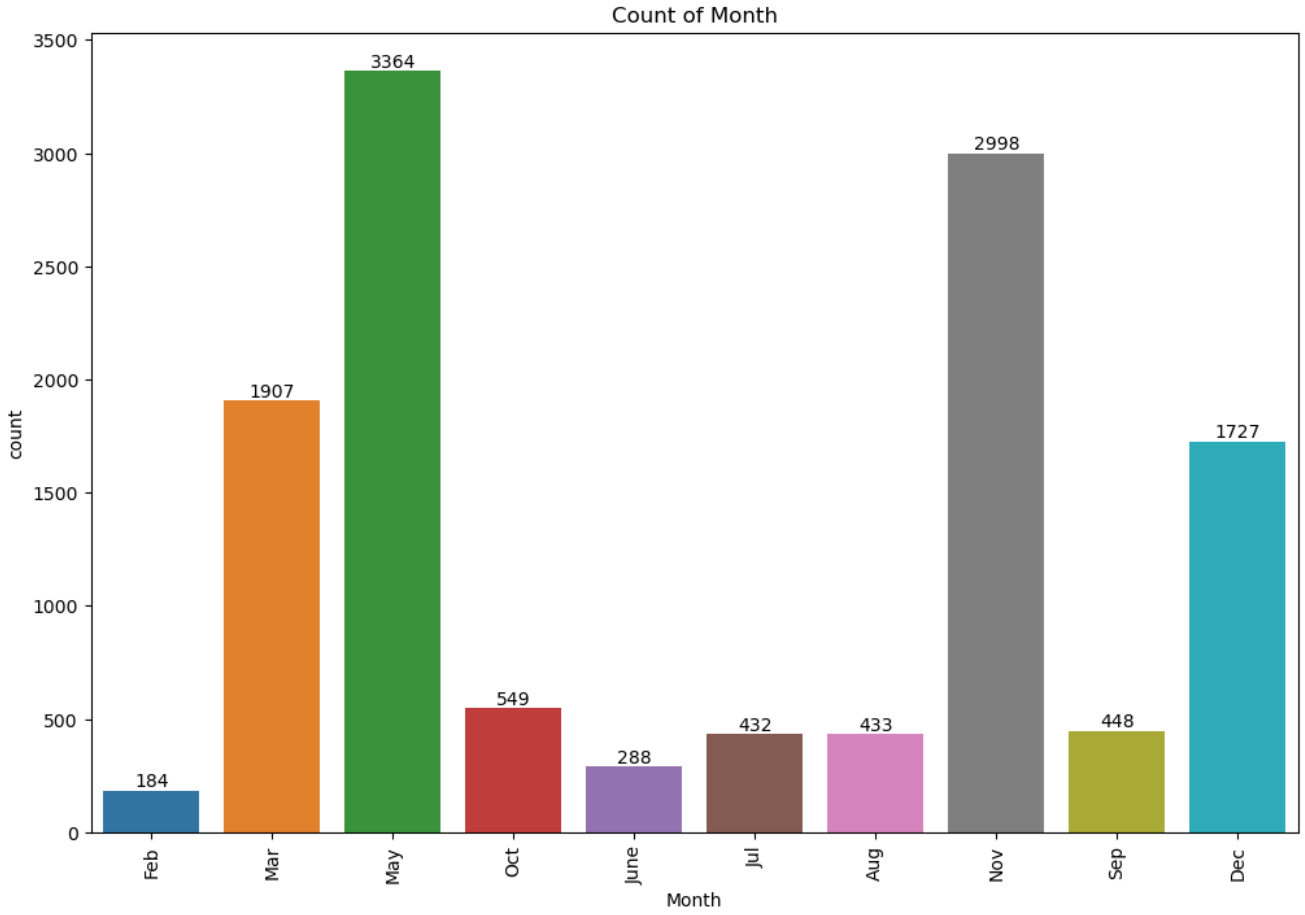

Distribution of ProductRelated_Duration
Mean
Median
Standard Deviation
Count
ProductRelated_Duration
0
10000
20000
30000
40000
50000
60000
2000
4000
6000
8000
10000
12000
14000
16000
1308
358
134
68
32
17
5
4
0
4
2
1
0
1
0
0
0
0
0
1
0
0
0
0
0
0
0
1

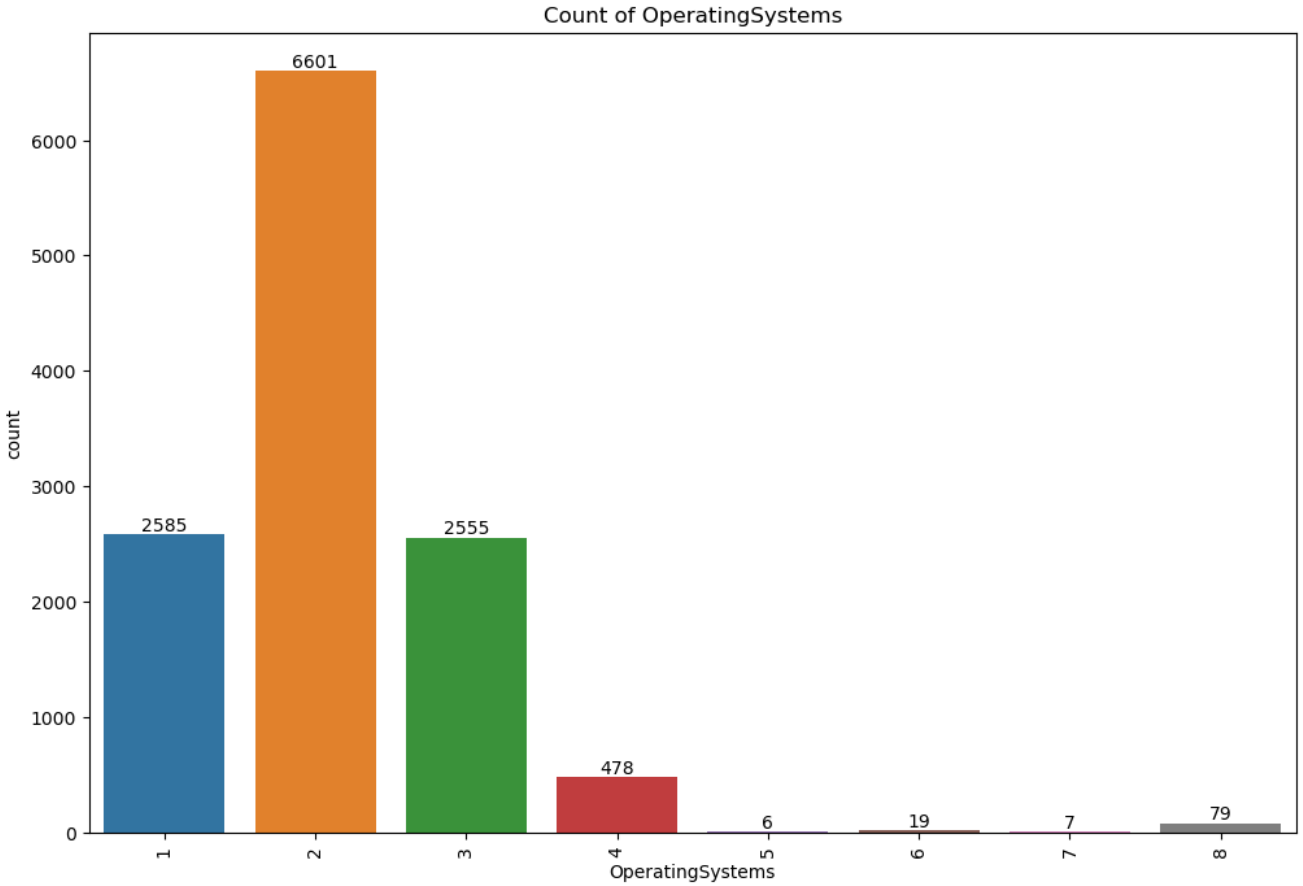

Distribution of BounceRates
Mean
Median
Standard Deviation
Count
BounceRates
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
1000
2000
3000
4000
5000
6000
7000
7249
1480
813
521
423
155
209
170
81
26
153
35
58
21
2
101
10
27
10
20
1
7
17
3
6
4
7
1
0
700

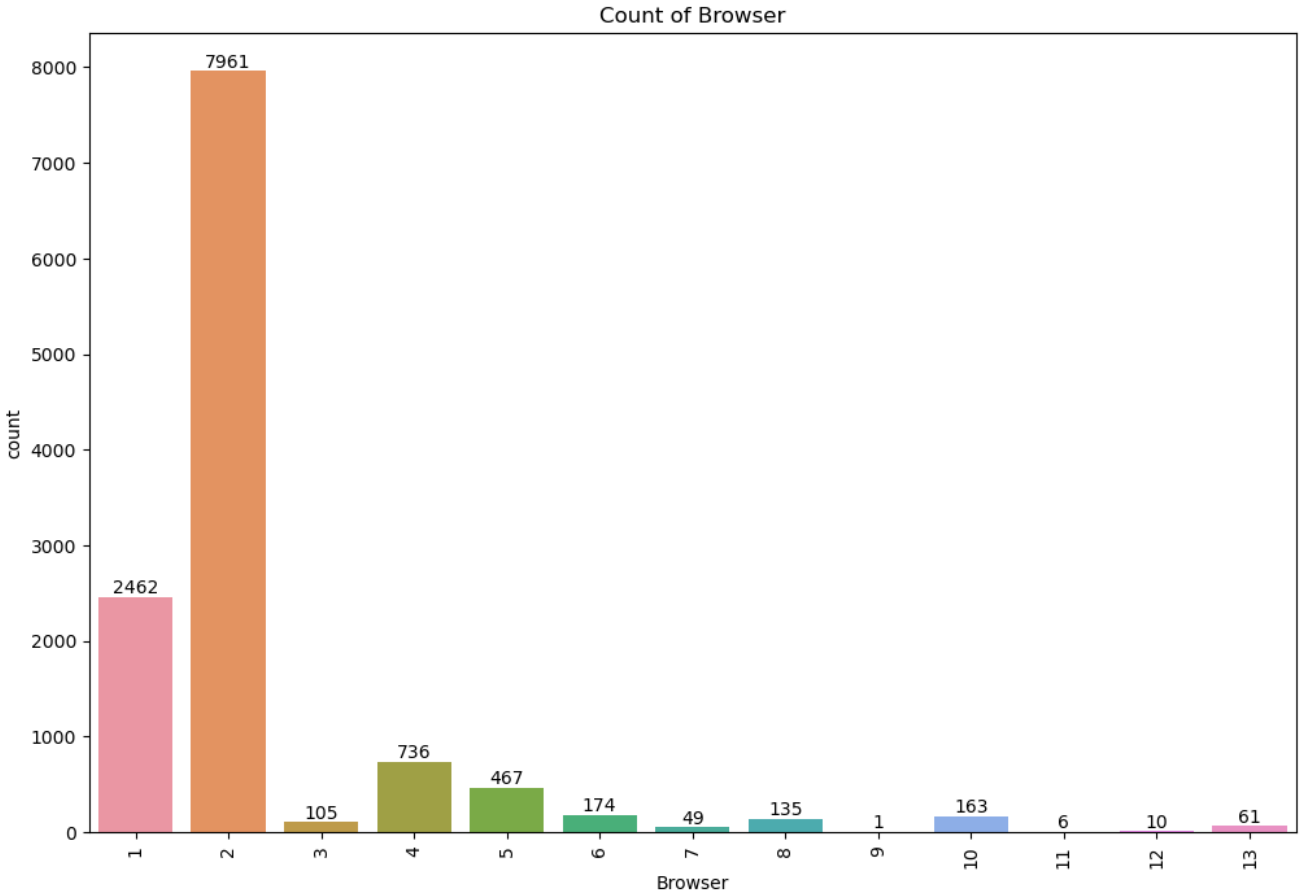

Distribution of ExitRates
Mean
Median
Standard Deviation
Count
ExitRates
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0
250
500
750
1000
1250
1500
1750
1876
1784
1699
1338
1015
706
625
596
406
360
309
136
133
141
91
25
42
52
41
80
4
18
62
10
15
30
15
4
7
710

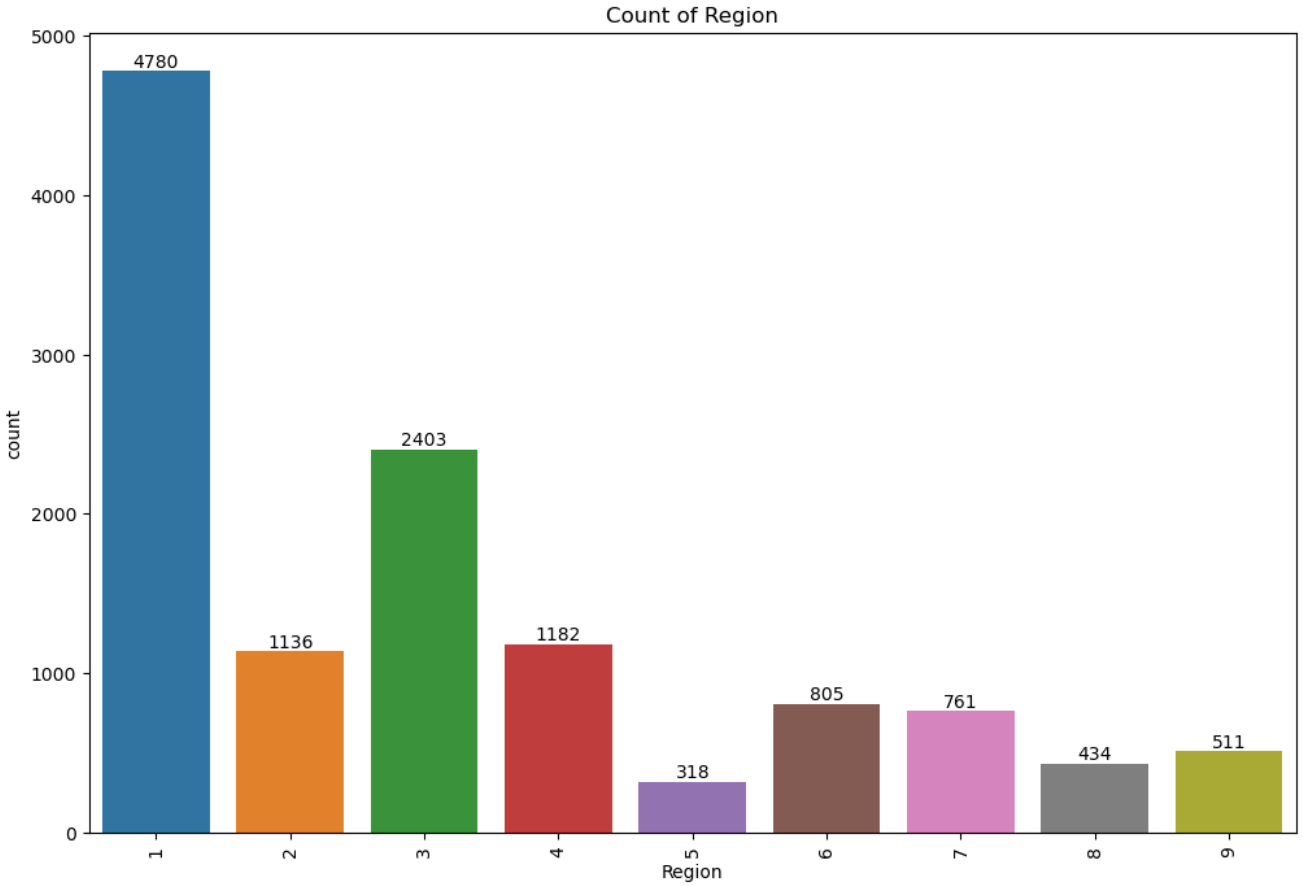

Distribution of PageValues
Mean
Median
Standard Deviation
Count
PageValues
0
50
100
150
200
250
300
350
0
2000
4000
6000
8000
10000
12000
14000
16000
10683
653
340
219
161
93
56
37
21
21
10
8
5
3
4
0
1
2
3
1
1
4
1
1
0
0
0
0
0
2

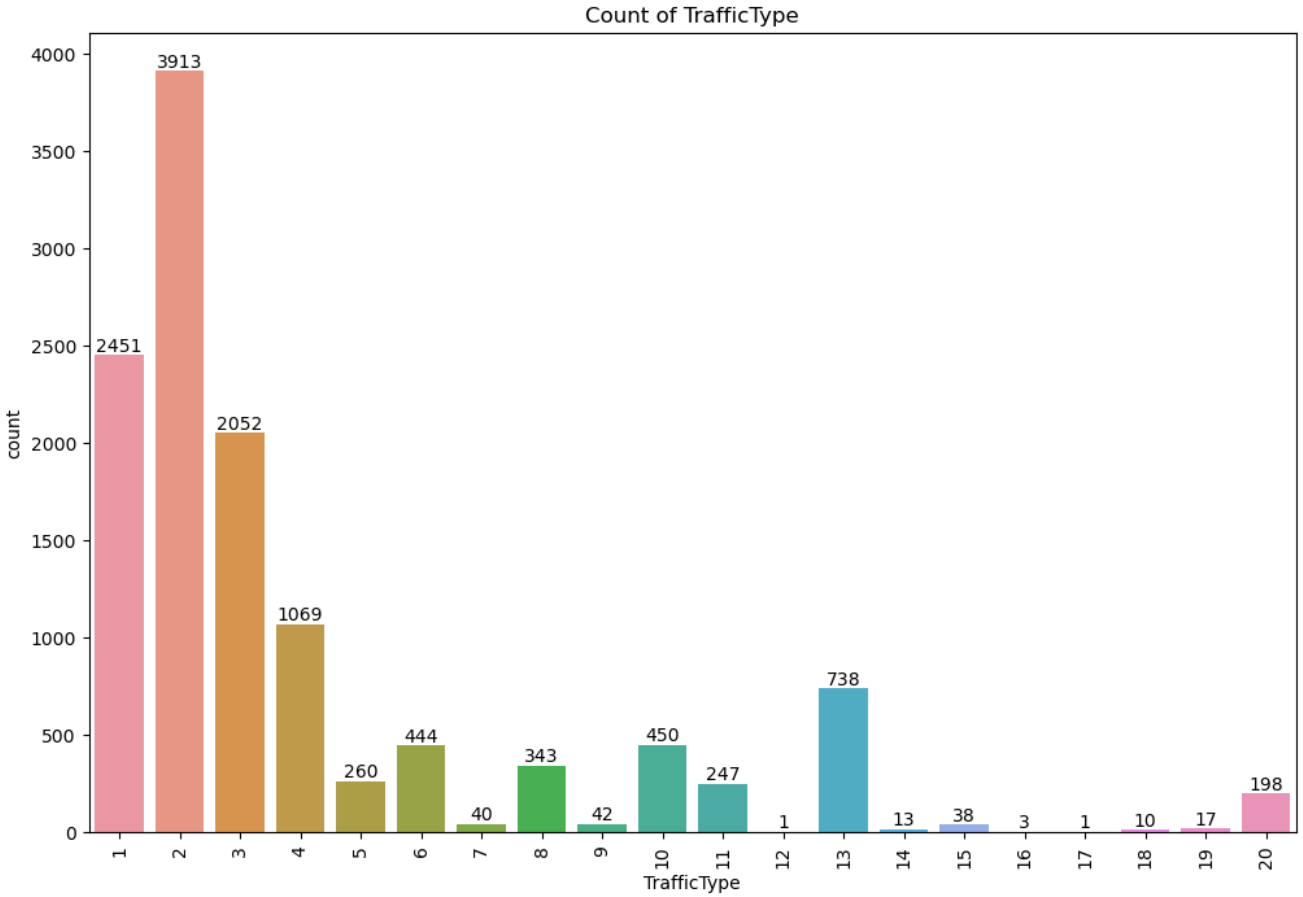

Distribution of SpecialDay
Mean
Median
Standard Deviation
Count
SpecialDay
11079
178
243
351
325
154

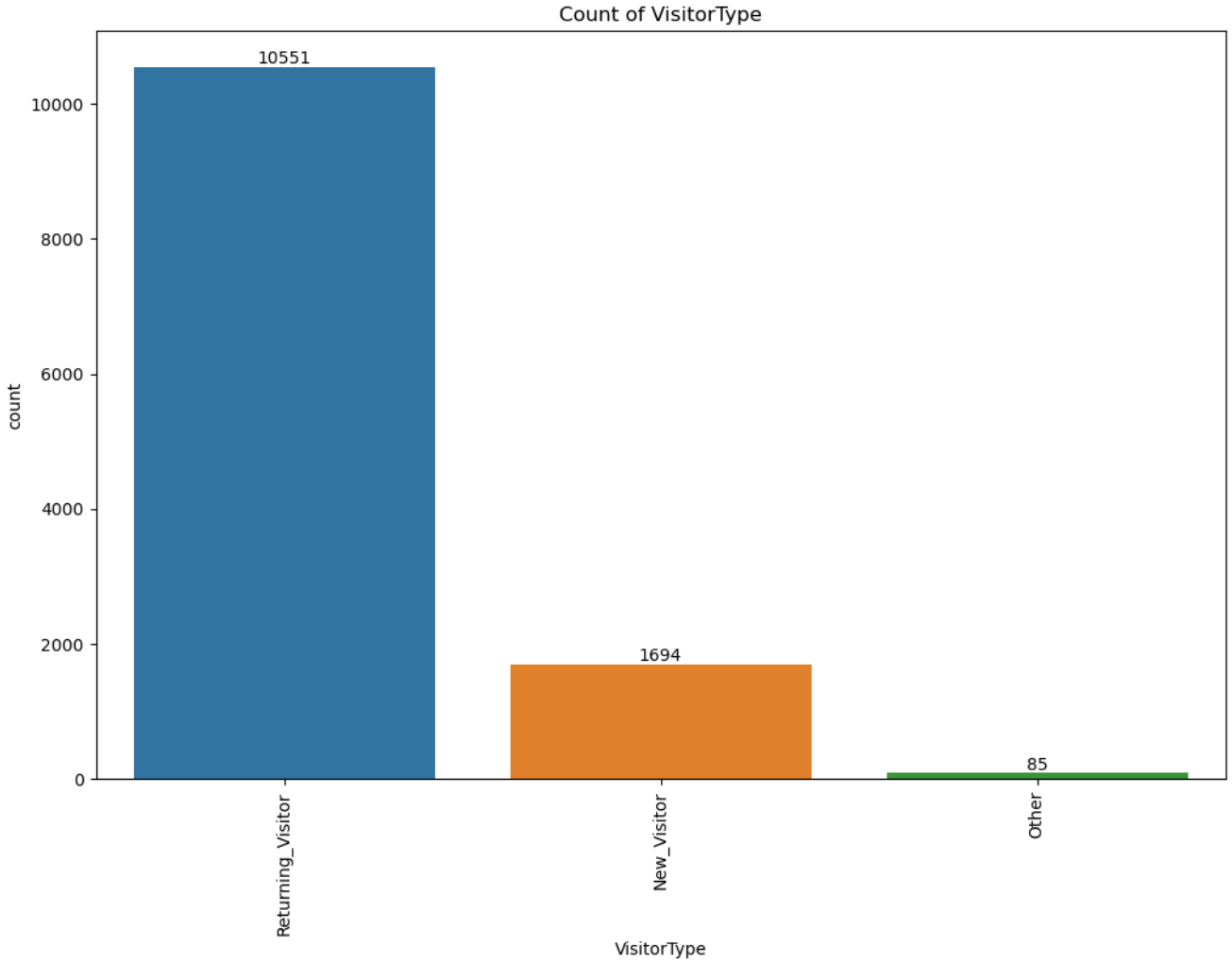

Count of Month
count
Month
184
1907
3364
549
288
432
433
2998
448
1727
Feb
Mar
May
Oct
June
Jul
Aug
Nov
Sep
Dec

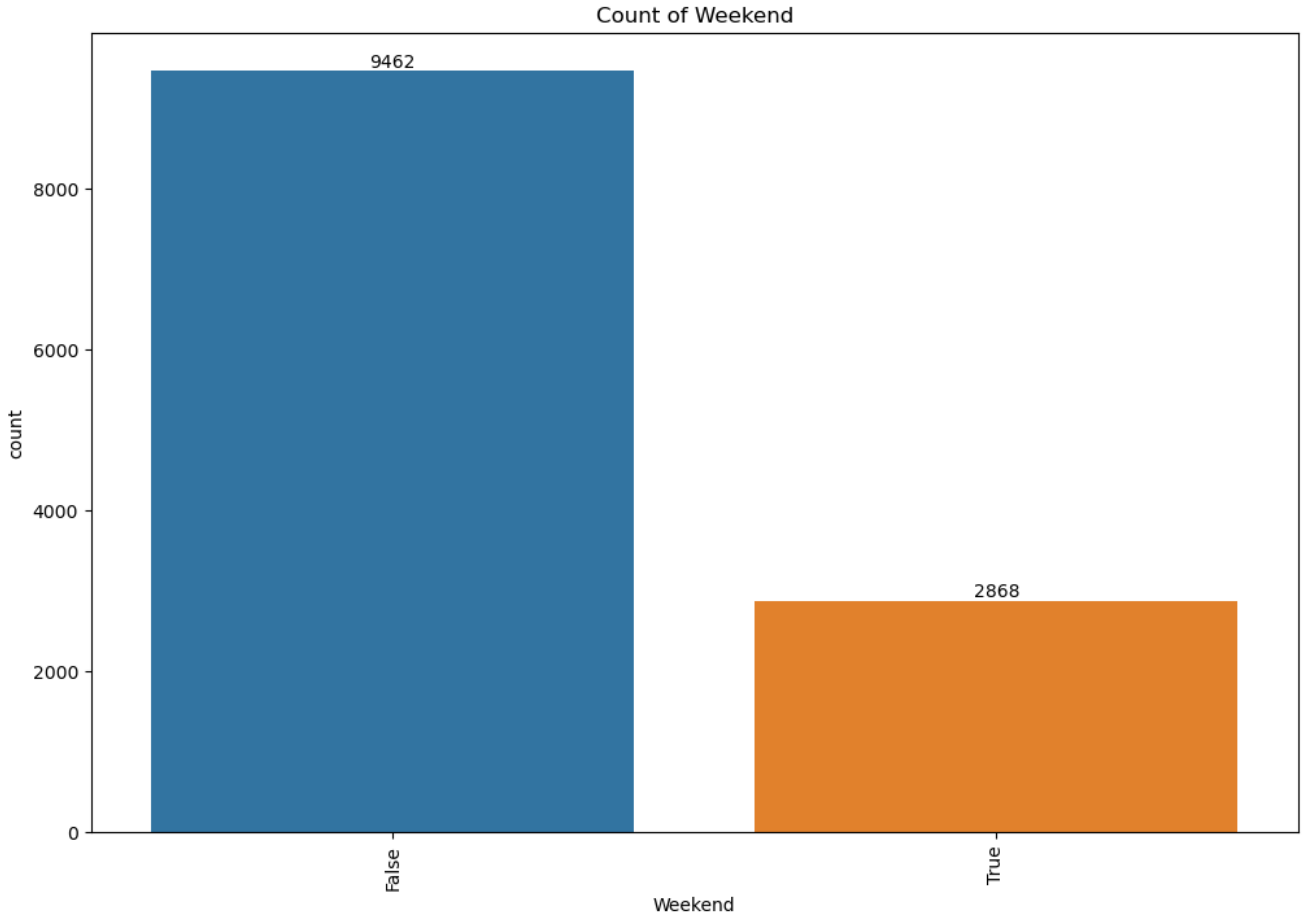

Count of OperatingSystems
count
OperatingSystems
6601
2585
2555
478
6
19
7
79
0
1000
2000
3000
4000
5000
6000
1
2
3
4
5
6
7
8

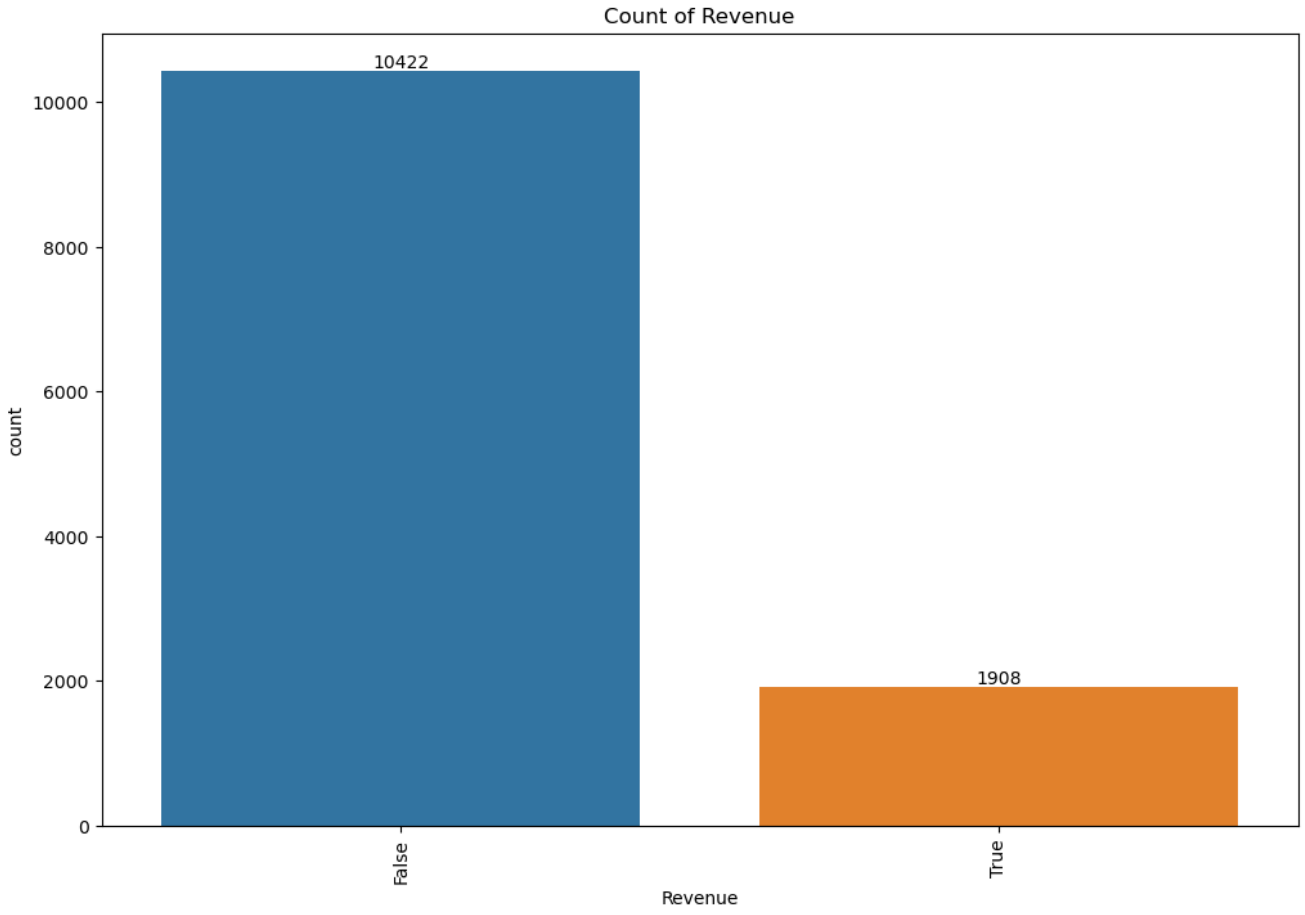

Count of Browser
count
Browser
7961
2462
105
736
467
174
49
135
1
163
6
10
61
0
1000
2000
3000
4000
5000
6000
7000
8000
1
2
3
4
5
6
7
8
9
10
11
12
13


Count of Region
count
Region
4780
1136
2403
1182
318
805
761
434
511


Count of TrafficType
count
TrafficType
2451
3913
2052
1069
260
444
40
343
42
450
247
1
738
13
38
3
1
10
17
198


Count of VisitorType
10551
1694
85
10000
8000
6000
4000
2000
0
count
Returning_Visitor
New_Visitor
Other
VisitorType

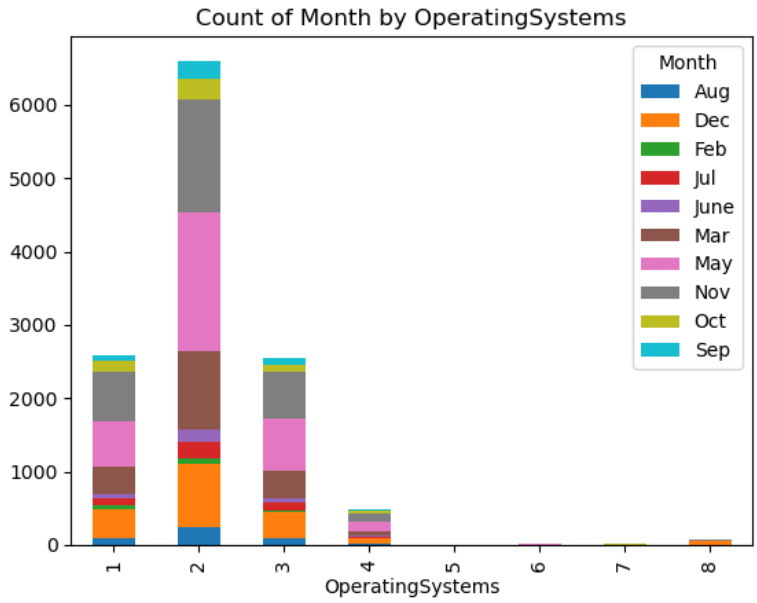

Count of Weekend
9462
2868
8000
6000
4000
2000
0
count
False
True
Weekend


Count of Revenue
10422
1908
10000
8000
6000
4000
2000
0
count
False
True
Revenue

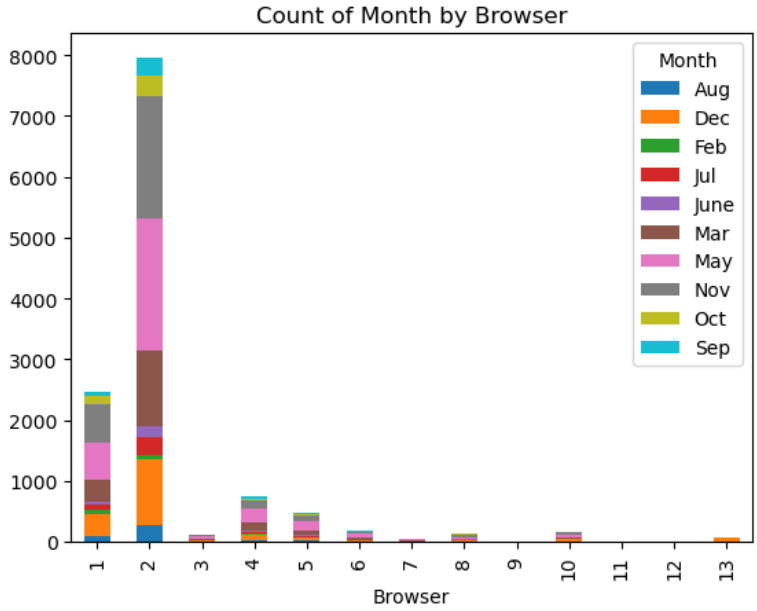
In [6]:

```
compare_with = ['Month', 'Region', 'Revenue']

for var in compare_with:
    other_vars = [col for col in cat_cols if col != var]
    for other_var in other_vars:
        plt.figure(figsize=(19,9))
        df.groupby(var)[other_var].value_counts().unstack(0).plot(kind='bar', stacked=True)
        plt.title(f'Count of {var} by {other_var}')
        plt.xticks(rotation=90)
        plt.show()

```

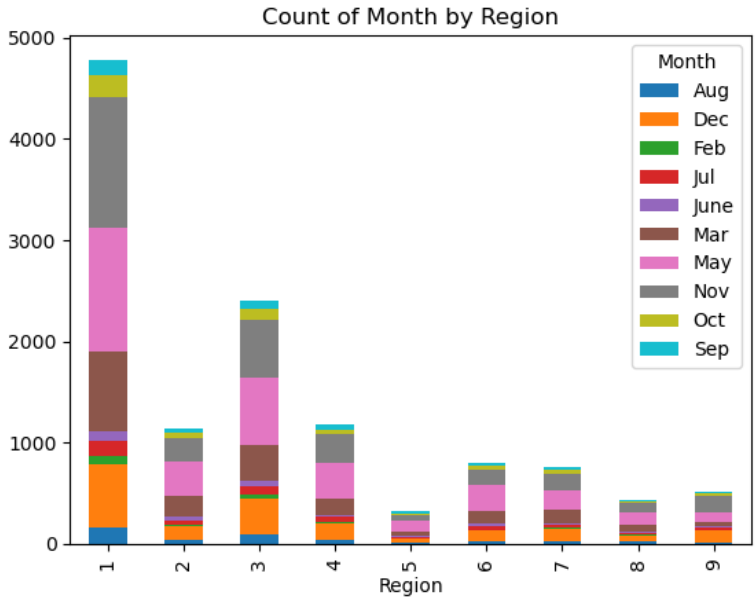
```
<Figure size 1900x900 with 0 Axes>
```



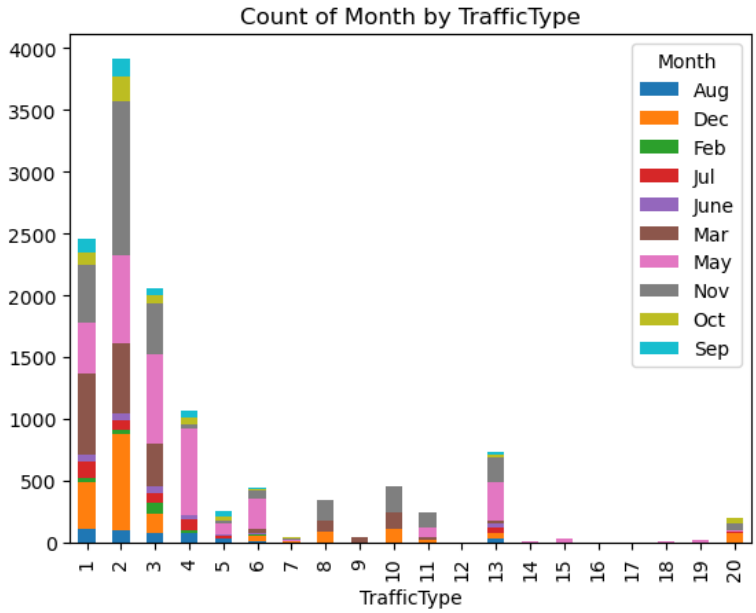

```
<Figure size 1900x900 with 0 Axes>
```



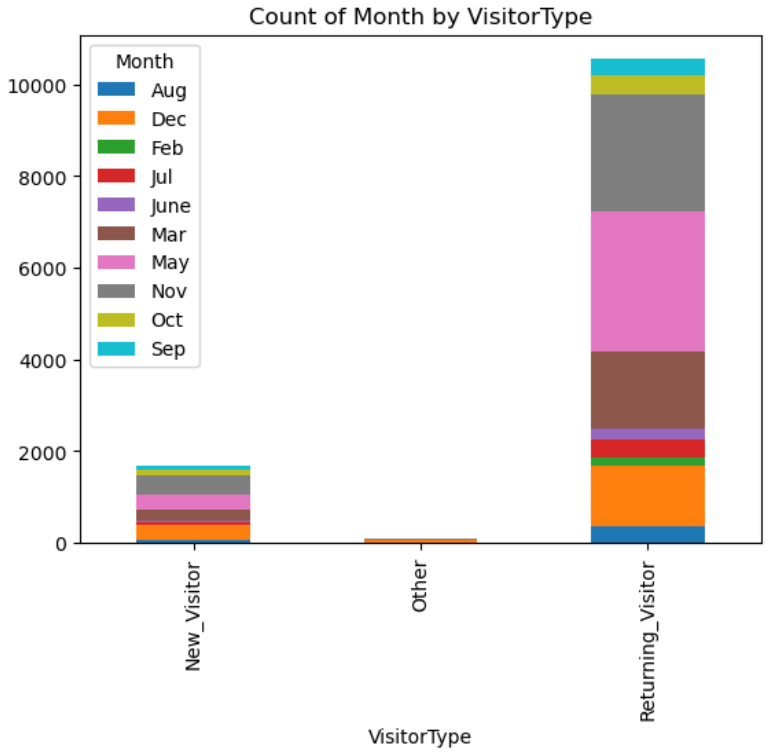

```
<Figure size 1900x900 with 0 Axes>
```




```
<Figure size 1900x900 with 0 Axes>
```




```
<Figure size 1900x900 with 0 Axes>
```

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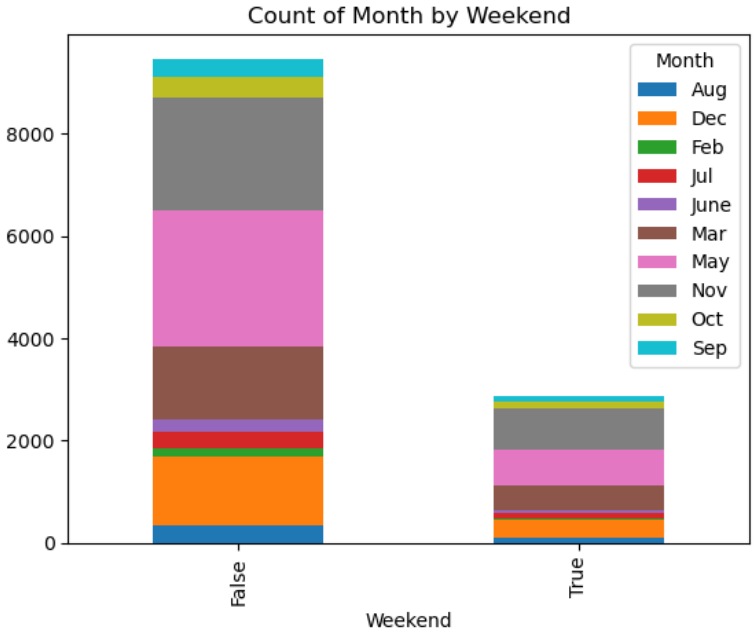


```
<Figure size 1900x900 with 0 Axes>
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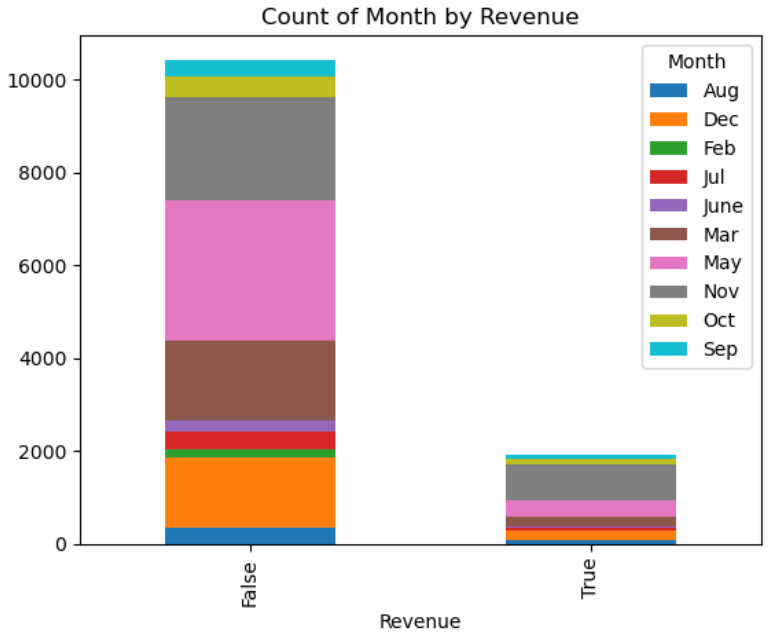
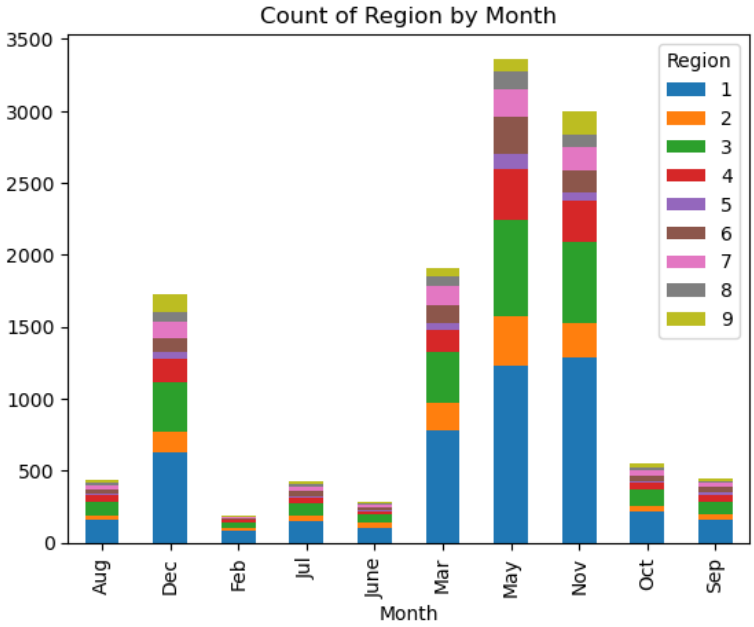


<Figure size 1900x900 with 0 Axes>



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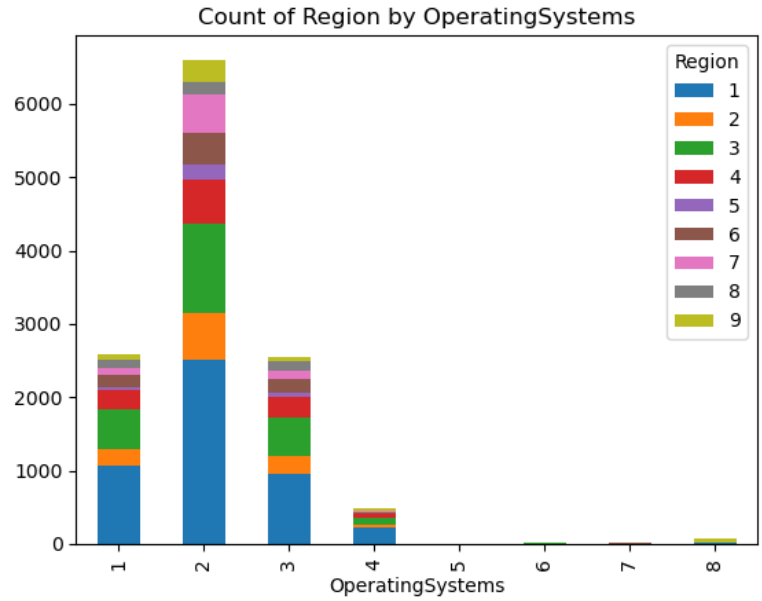


```
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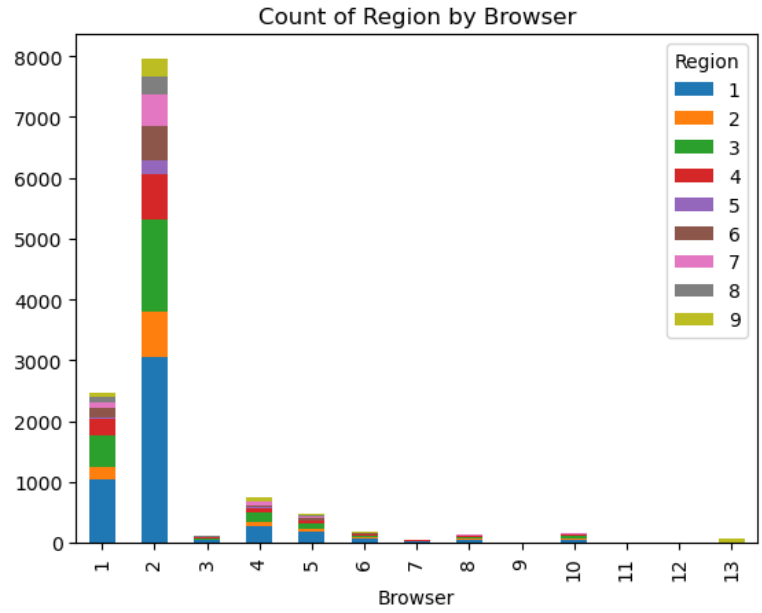


```
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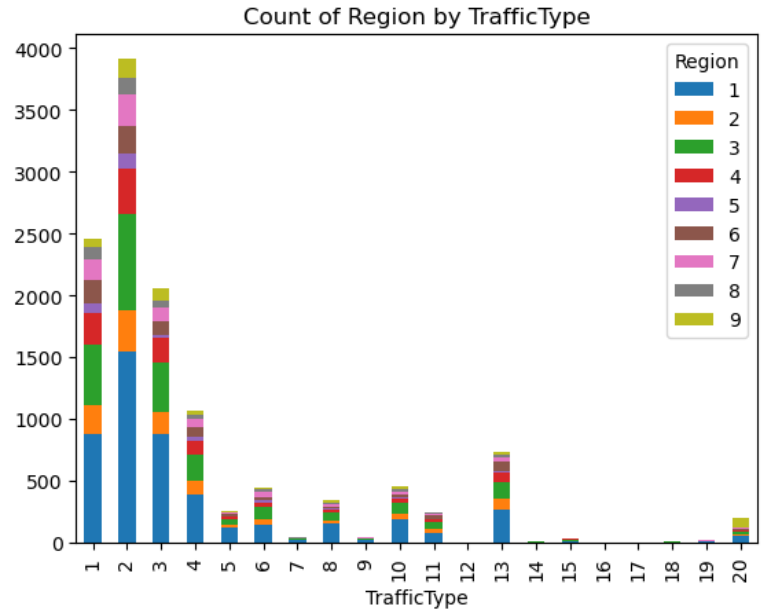


```
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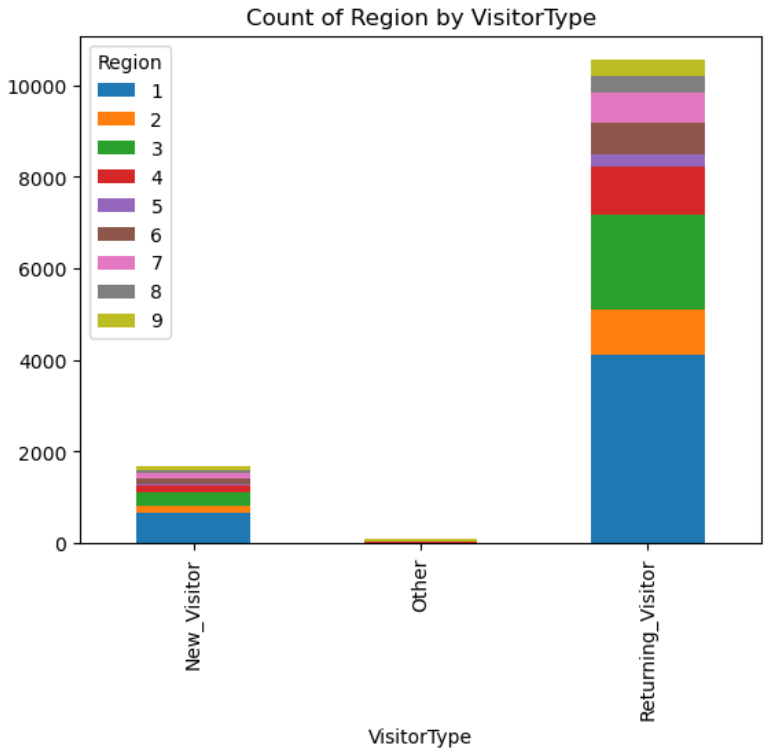


```
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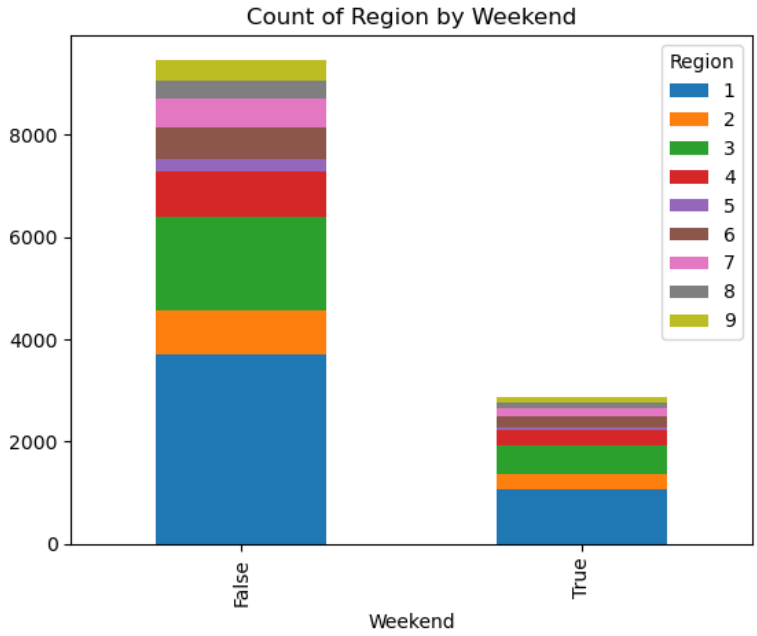

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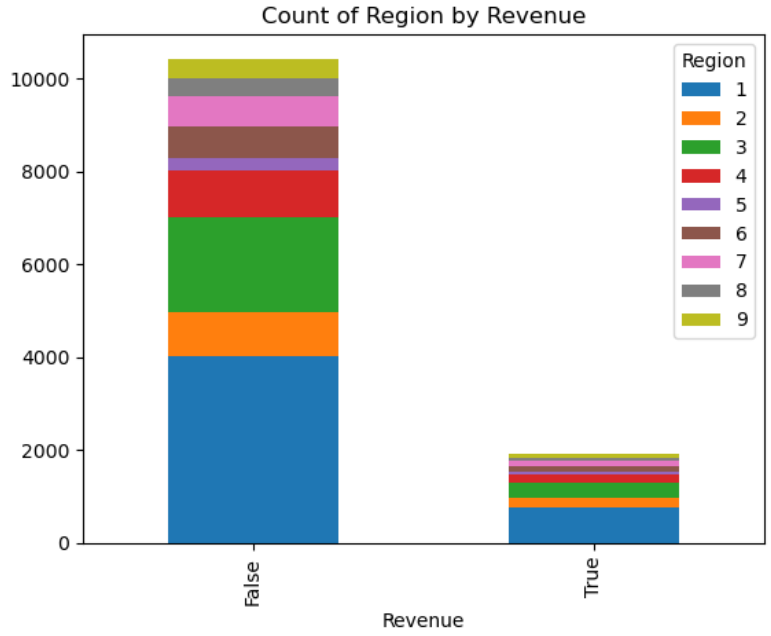
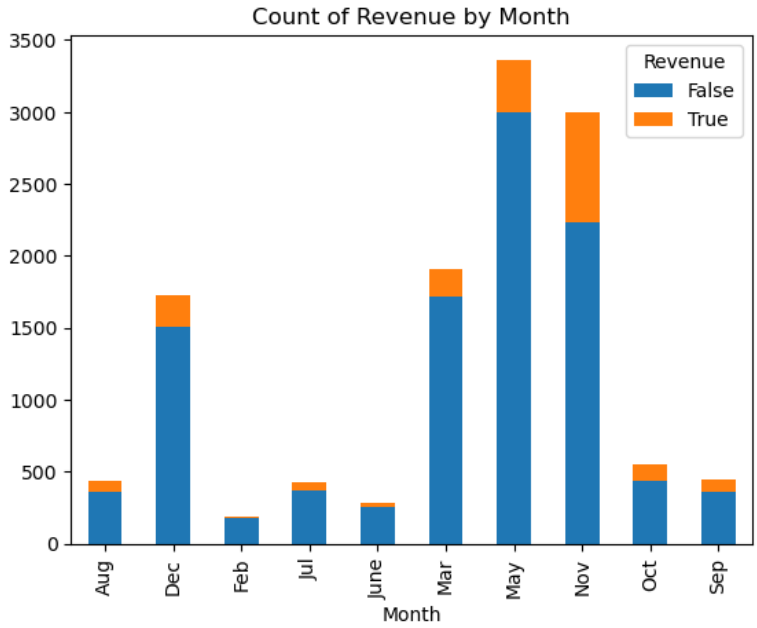


<Figure size 1900x900 with 0 Axes>




```
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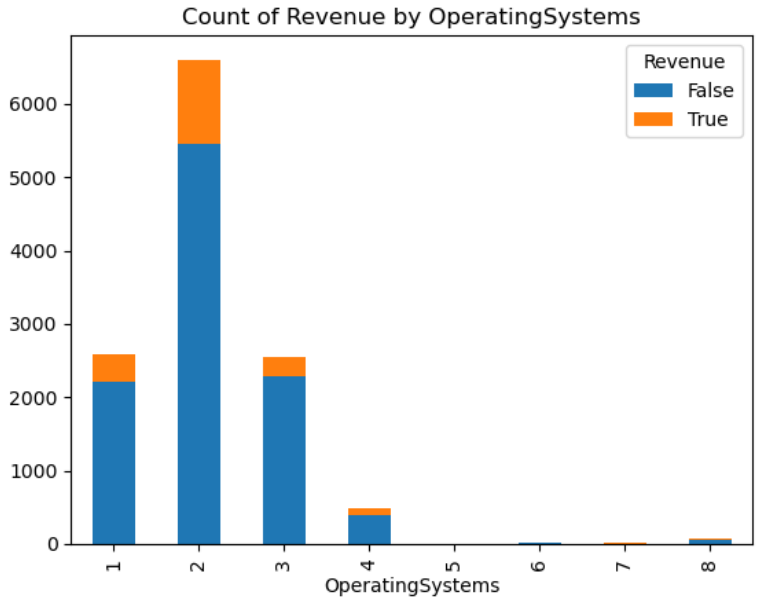


```
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```
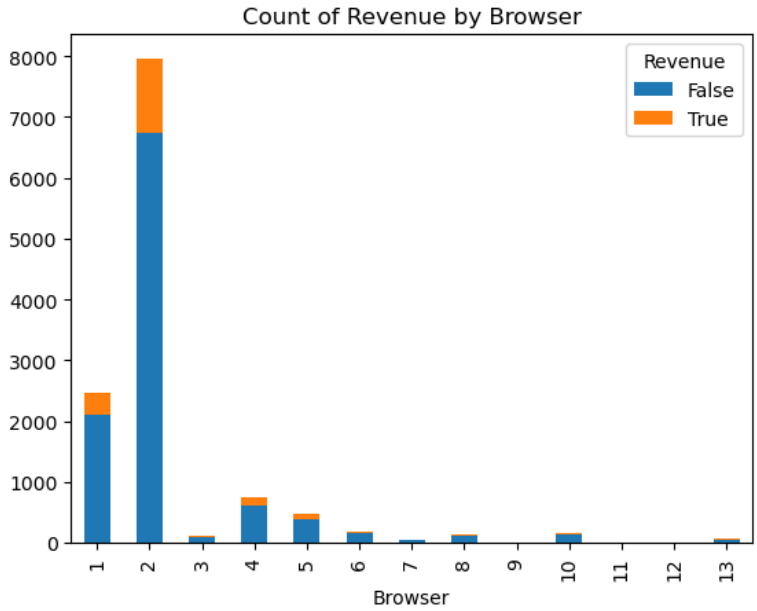
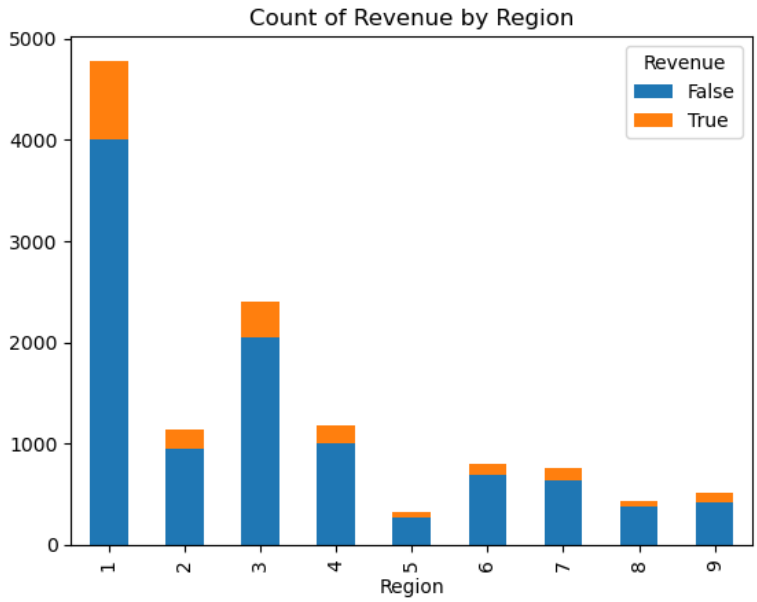
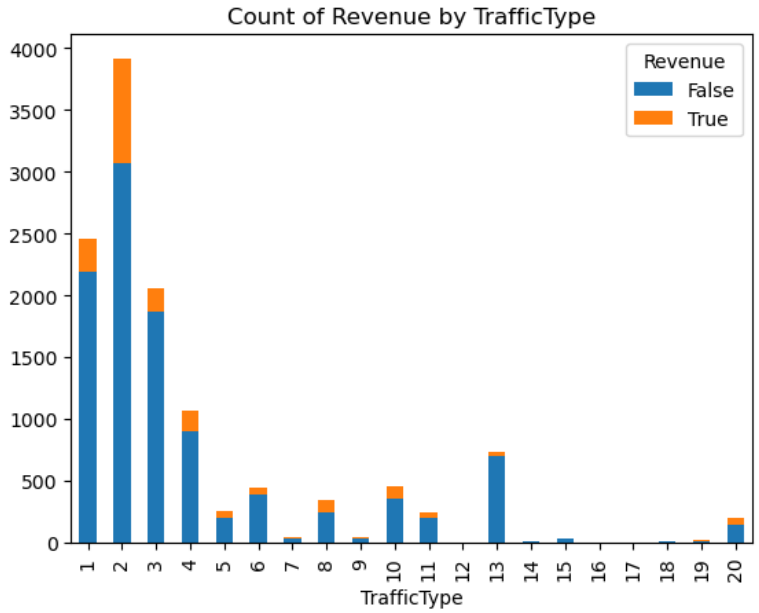




```
<Figure size 1900x900 with 0 Axes>
```




```
<Figure size 1900x900 with 0 Axes>
```




```
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```
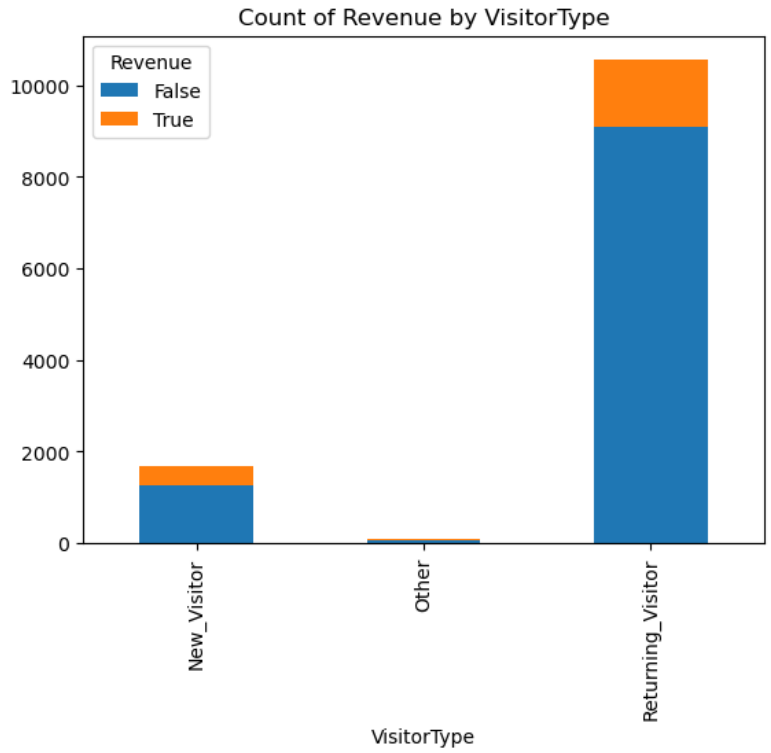
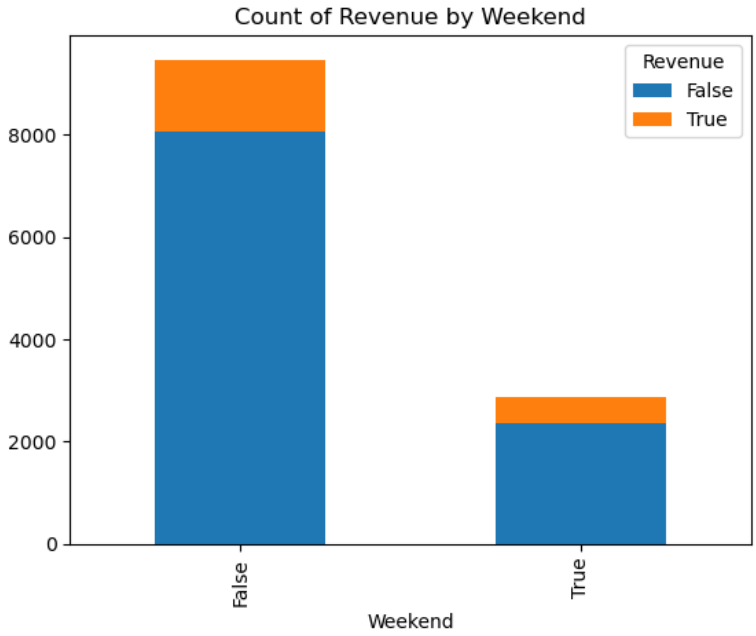
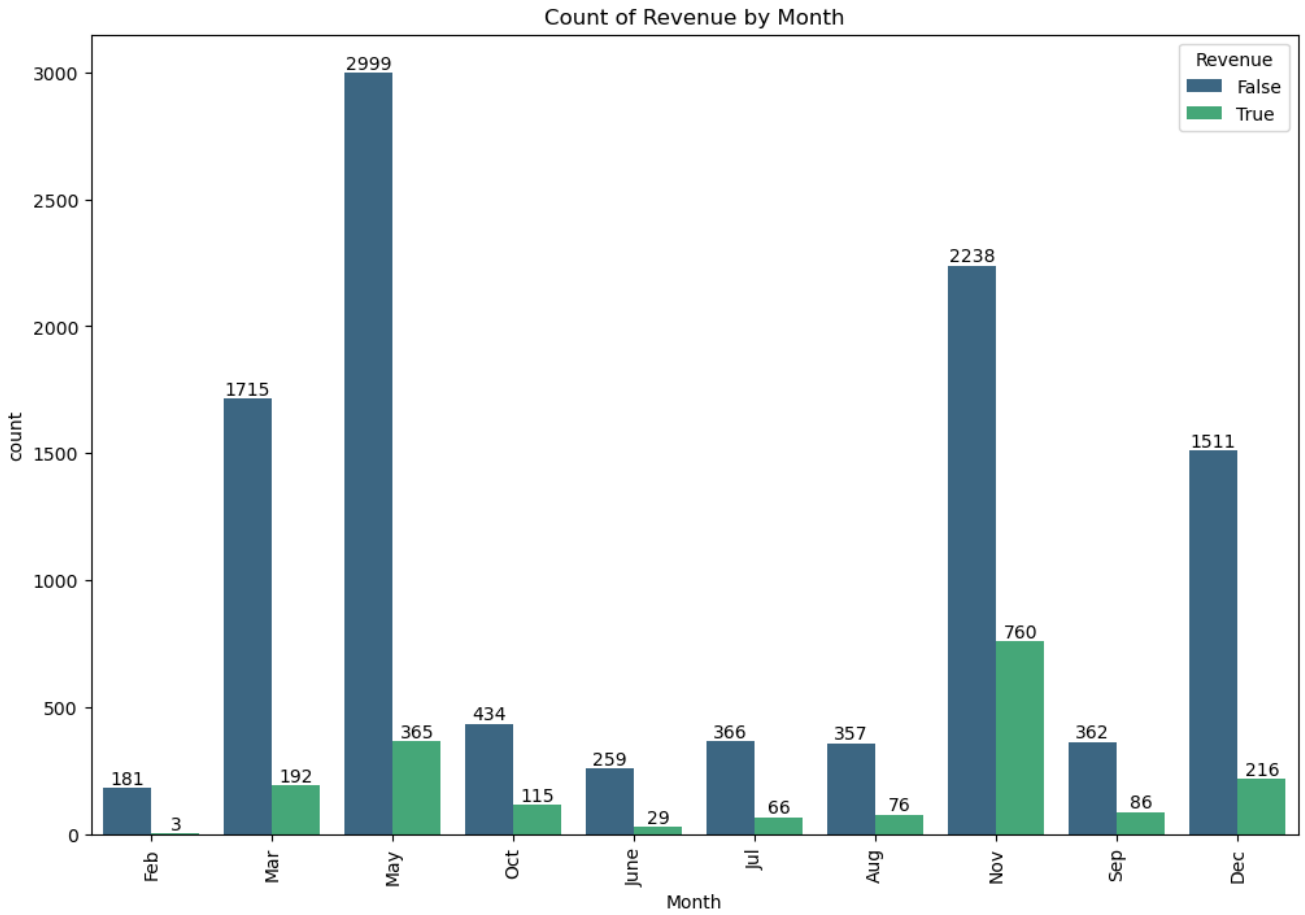




```
<Figure size 1900x900 with 0 Axes>
```



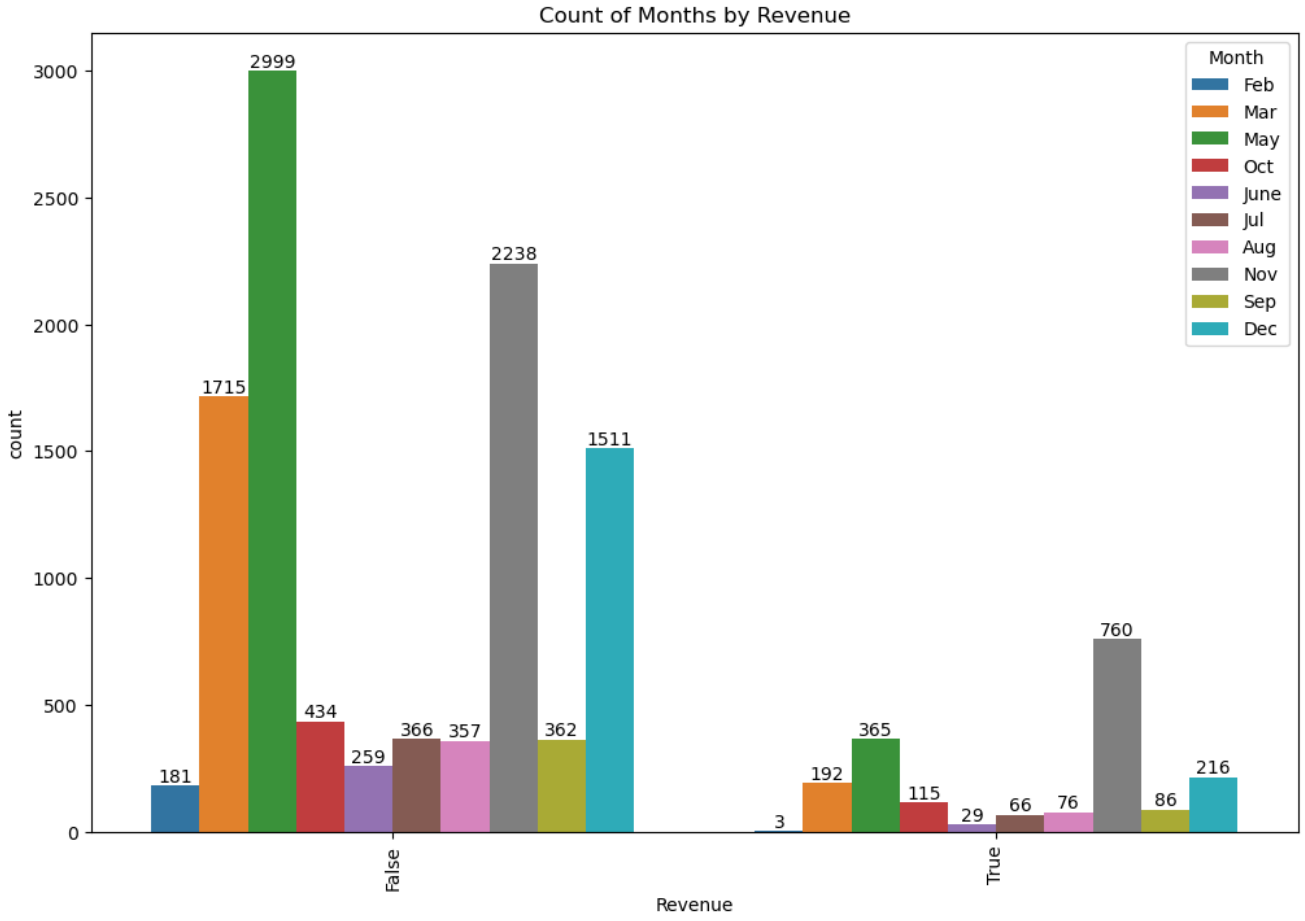
In [7]:

```
plt.figure(figsize=(12,8))
ax = sns.countplot(x='Month', hue='Revenue', data=df, palette='viridis')
plt.title('Count of Revenue by Month')
plt.xticks(rotation=90)

# Display frequency above each bar
for p in ax.patches:
    ax.annotate(f'{p.get_height()}', (p.get_x()+p.get_width()/2., p.get_height()+0.5), ha='center', va='bottom'
plt.show()

```



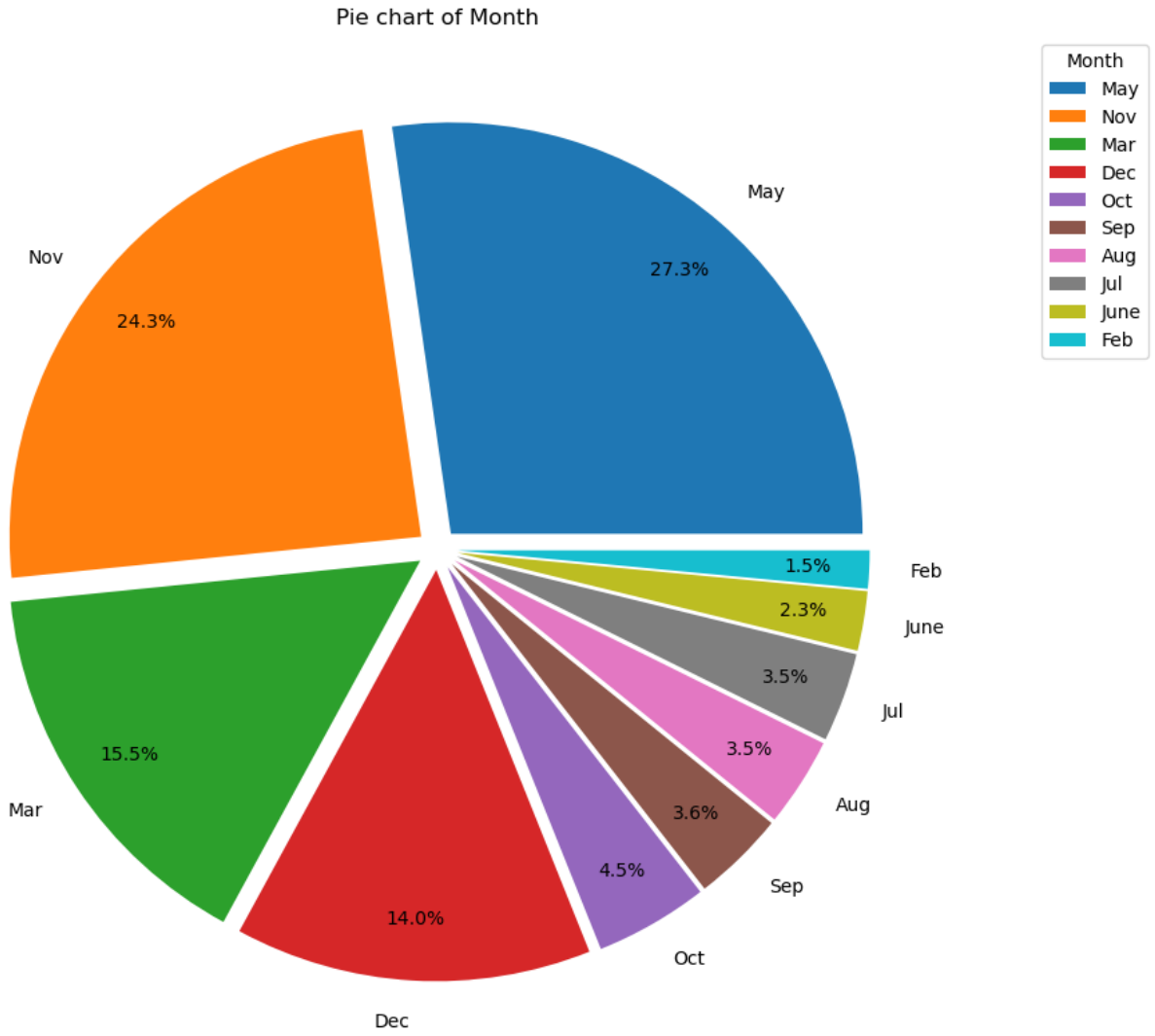
In [8]:

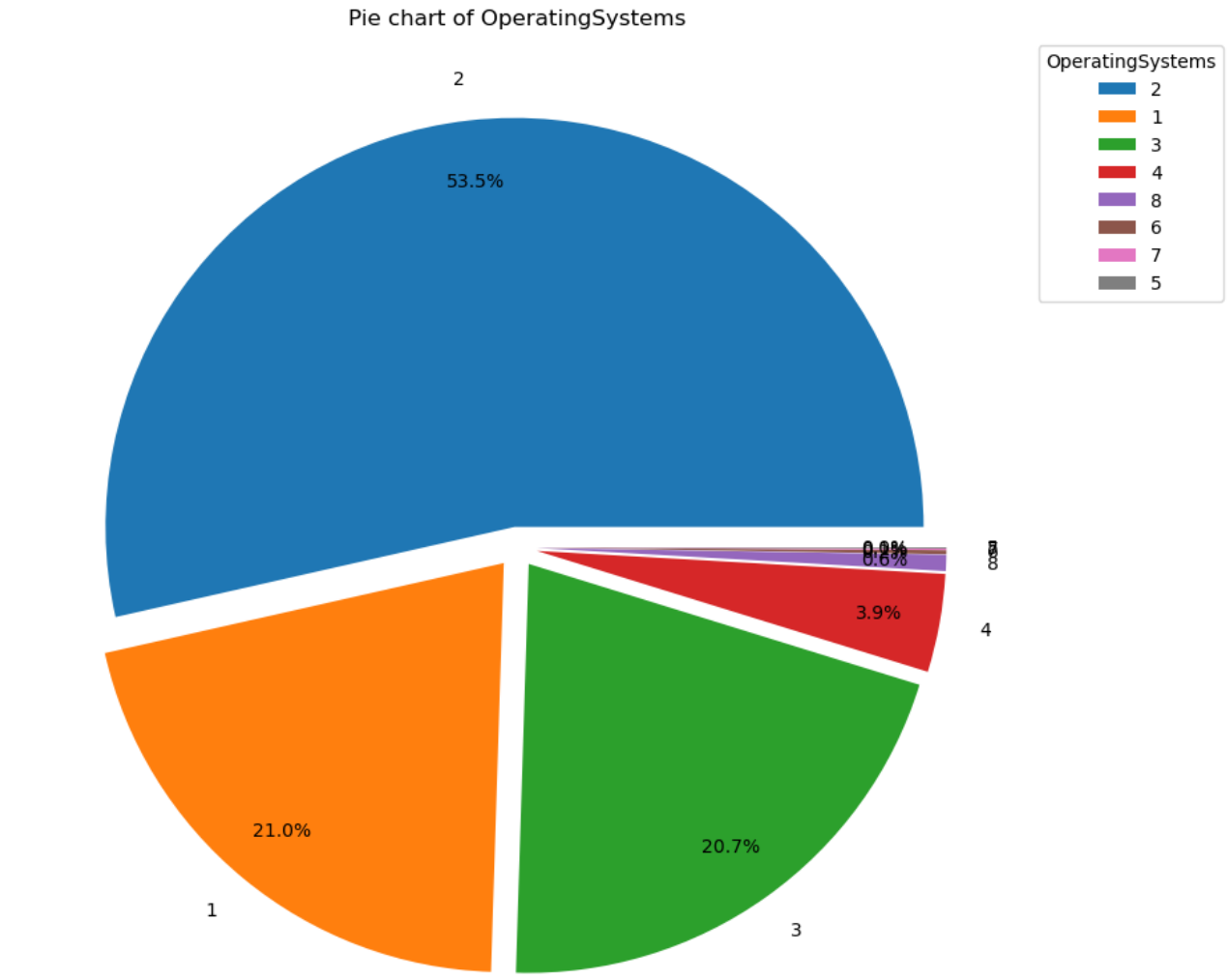
```
plt.figure(figsize=(12,8))
ax = sns.countplot(x='Revenue', hue='Month', data=df, palette='tab10')
plt.title('Count of Months by Revenue')
plt.xticks(rotation=90)

# Displaying the frequency above each bar
for p in ax.patches:
    ax.annotate(f'{p.get_height()}', (p.get_x()+p.get_width()/2., p.get_height()+0.5), ha='center', va='bottom'
plt.show()

```

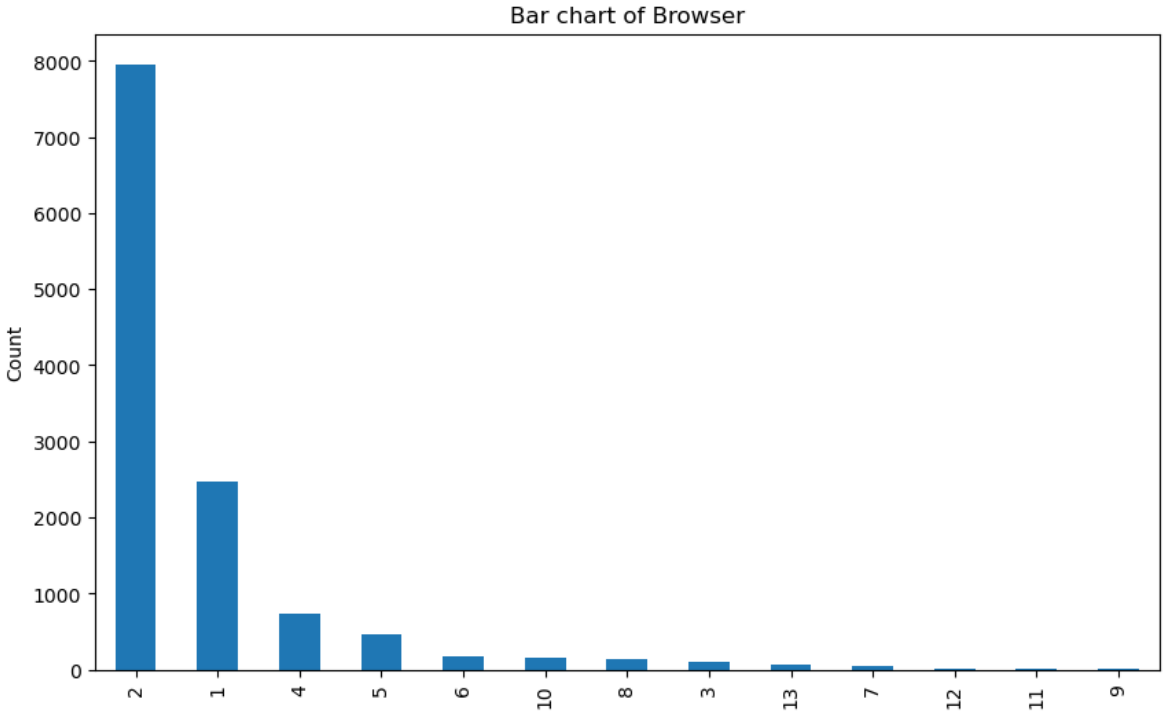


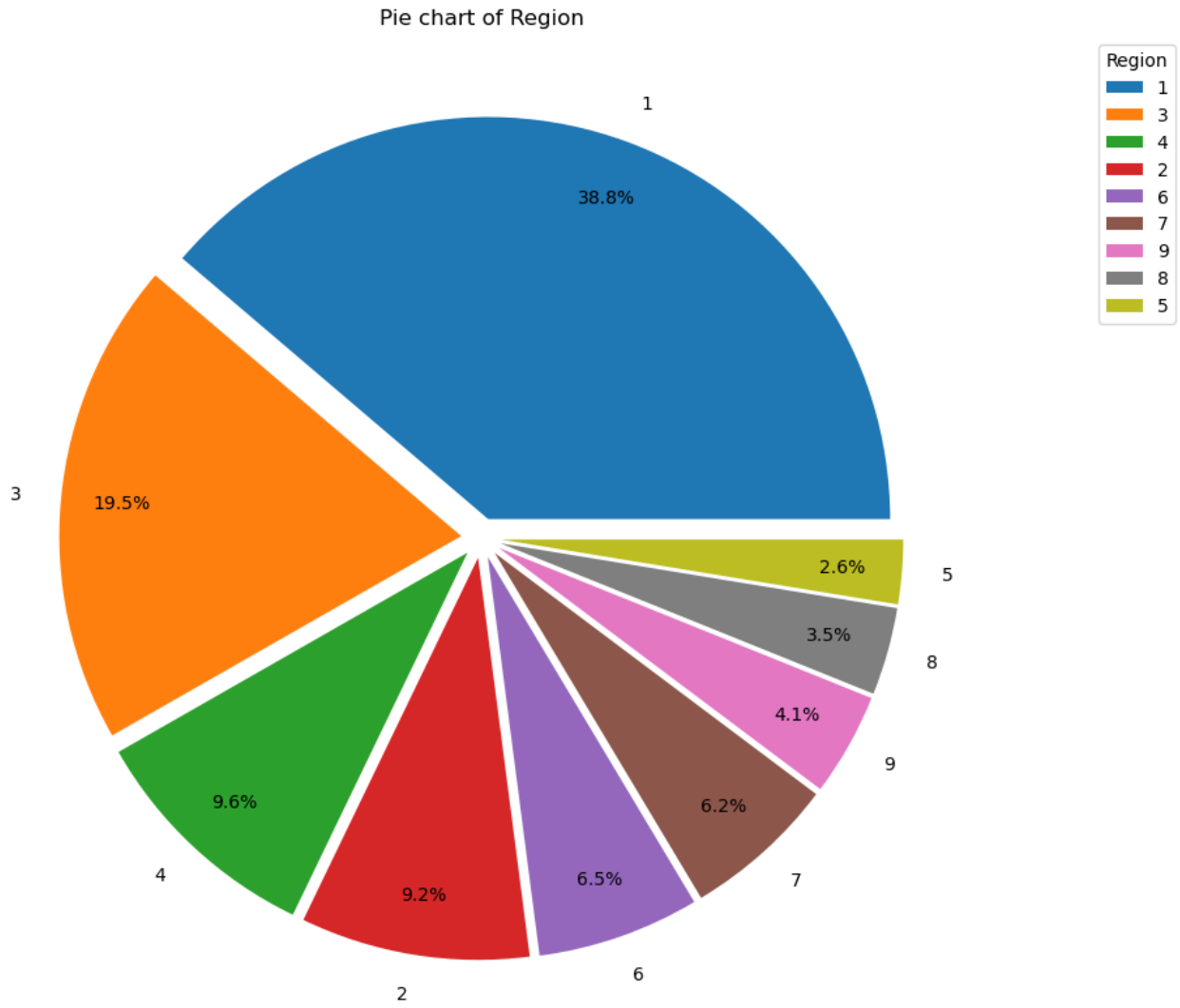
In [9]:

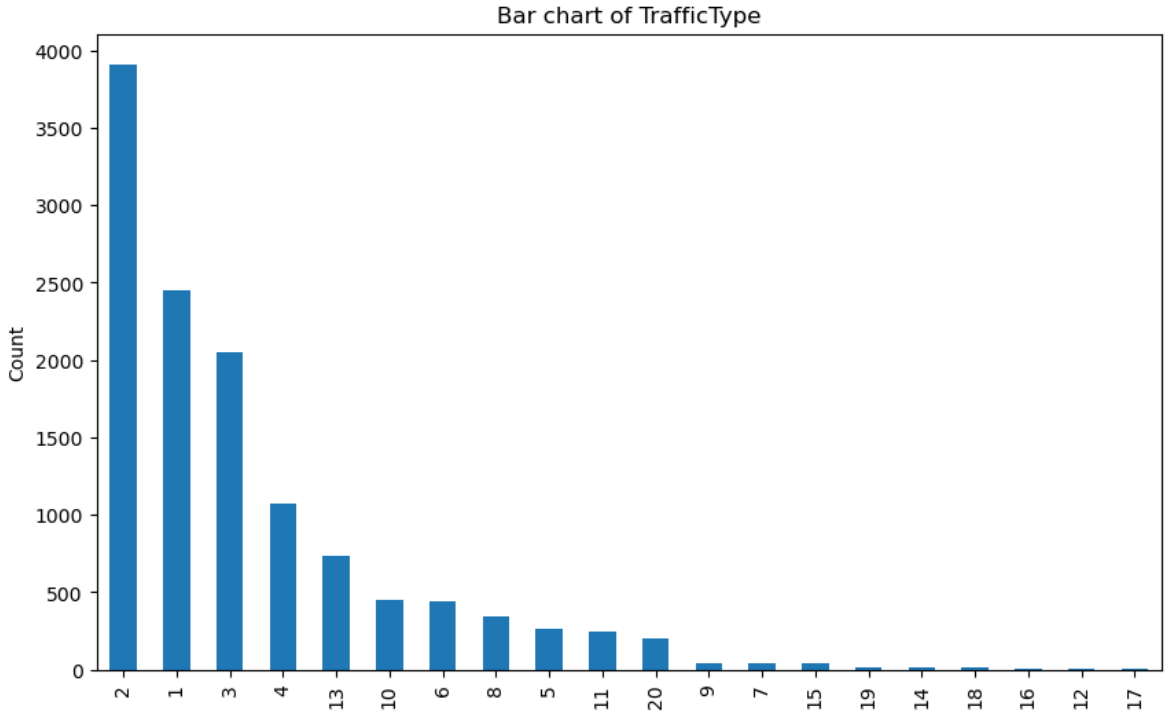
```
# For categorical columns
# if more than 10 columns, there will be a bar chart
cat_cols = ['Month', 'OperatingSystems', 'Browser', 'Region', 'TrafficType', 'VisitorType', 'Weekend', 'Revenue
for column in cat_cols:
    if len(df[column].value_counts()) > 10:
        plt.figure(figsize=(10,6))
        df[column].value_counts().plot(kind='bar')
        plt.title('Bar chart of '+ column)
        plt.ylabel('Count')
    else:
        plt.figure(figsize=(10,10))
        explode = [0.05]*len(df[column].value_counts())
        df[column].value_counts().plot(kind='pie', autopct='%1.1f%%', explode=explode, pctdistance=0.85)
        plt.title('Pie chart of '+ column)
        plt.ylabel('')
        plt.legend(title=column, loc='upper right', bbox_to_anchor=(1.2, 1))
    plt.show()

```

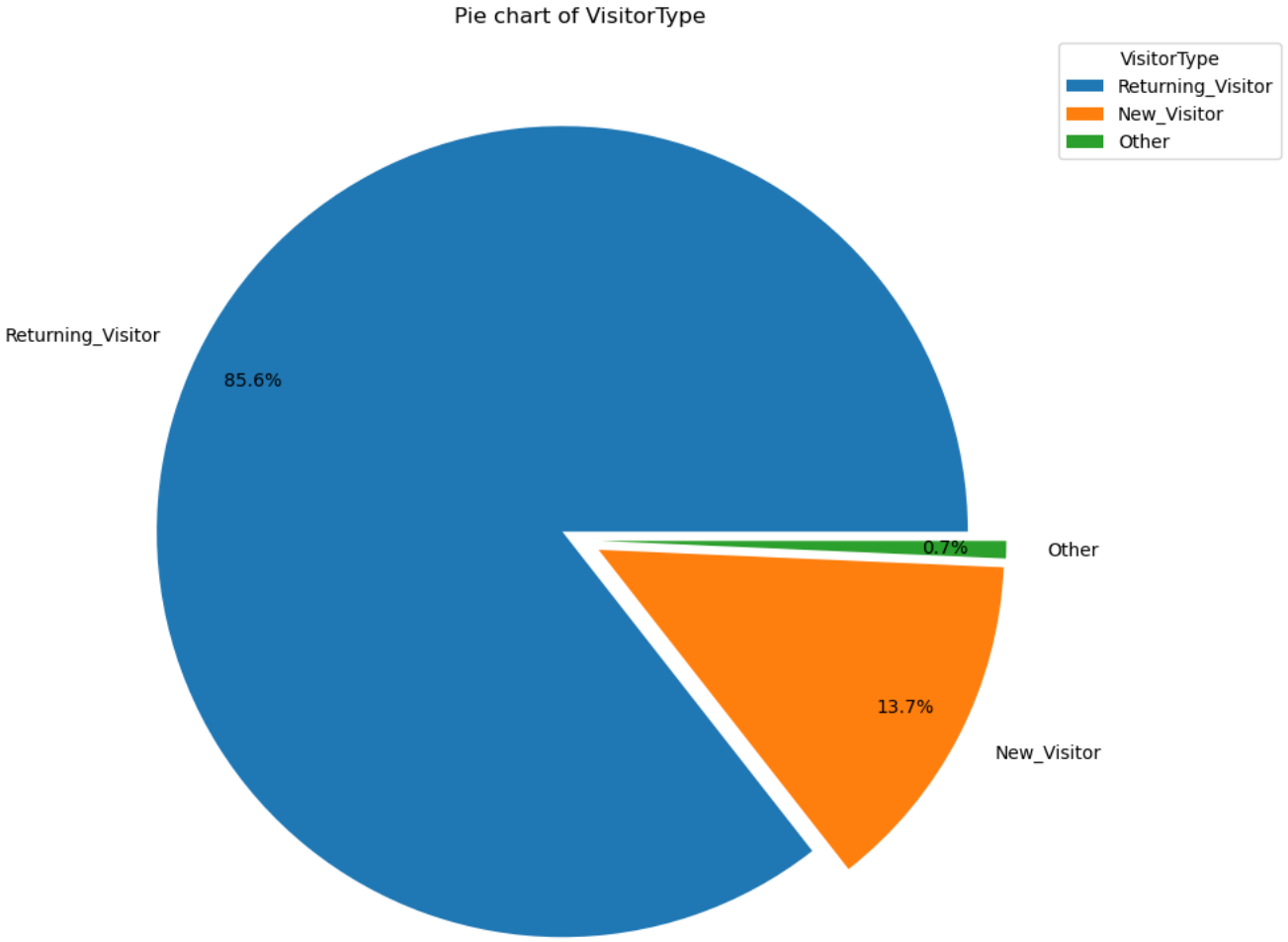


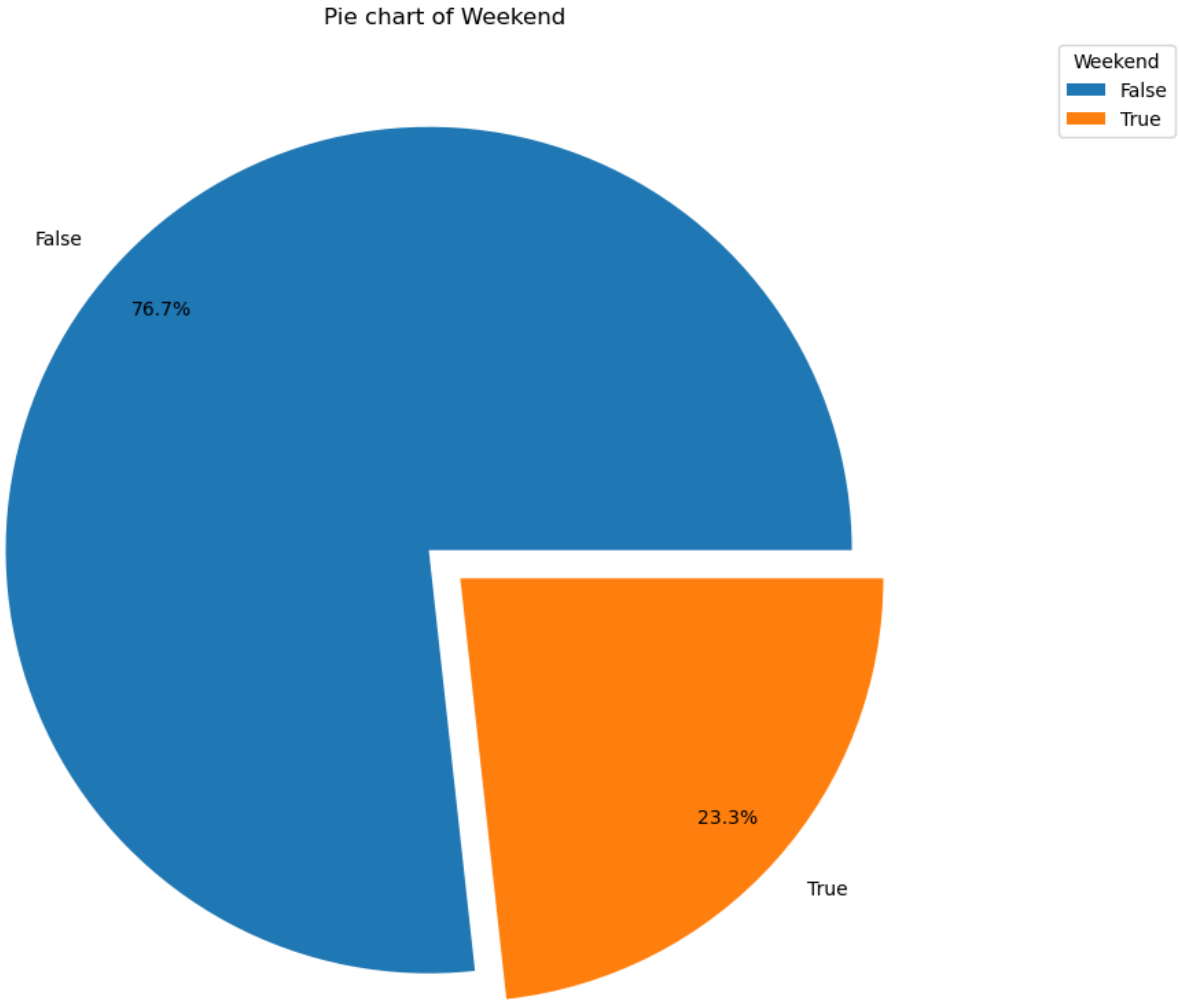

Pie chart of OperatingSystems
OperatingSystems
2
1
3
4
8
6
7
5
2
53.5%
21.0%
20.7%
3.9%
1
3
4

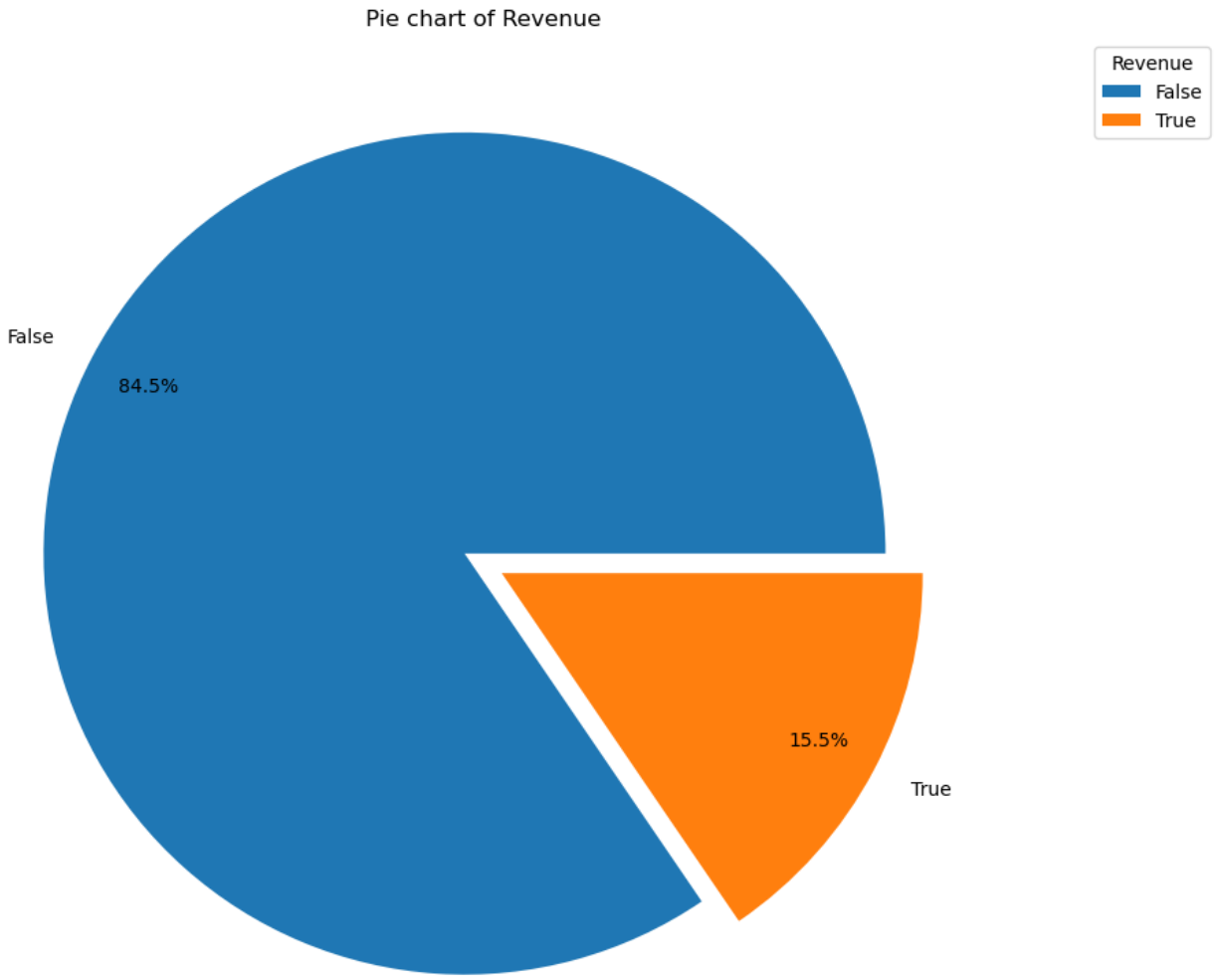

Bar chart of Browser
Count
8000
7000
6000
5000
4000
3000
2000
1000
0
2
1
4
5
6
10
8
3
13
7
12
11
9


Pie chart of Region
Region
1
3
4
2
6
7
9
8
5
38.8%
19.5%
9.6%
9.2%
6.5%
6.2%
4.1%
3.5%
2.6%


Bar chart of TrafficType
Count
4000
3500
3000
2500
2000
1500
1000
500
0
2
1
3
4
13
10
6
8
5
11
20
9
7
15
19
14
18
16
12
17


Pie chart of VisitorType
VisitorType
Returning_Visitor
New_Visitor
Other
Returning_Visitor
85.6%
0.7%
Other
13.7%
New_Visitor

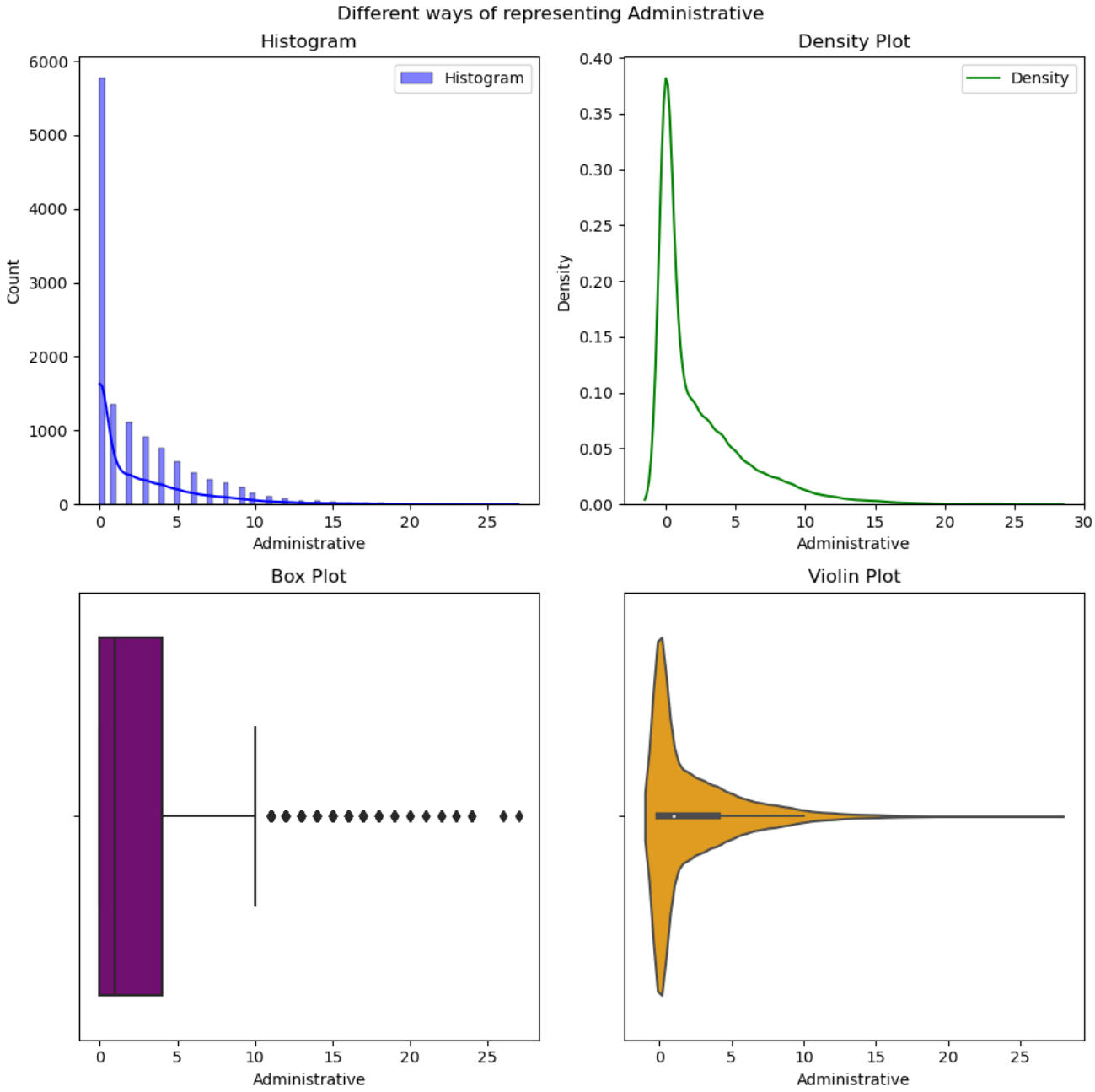

Pie chart of Weekend
Weekend
False
True
False
76.7%
23.3%
True

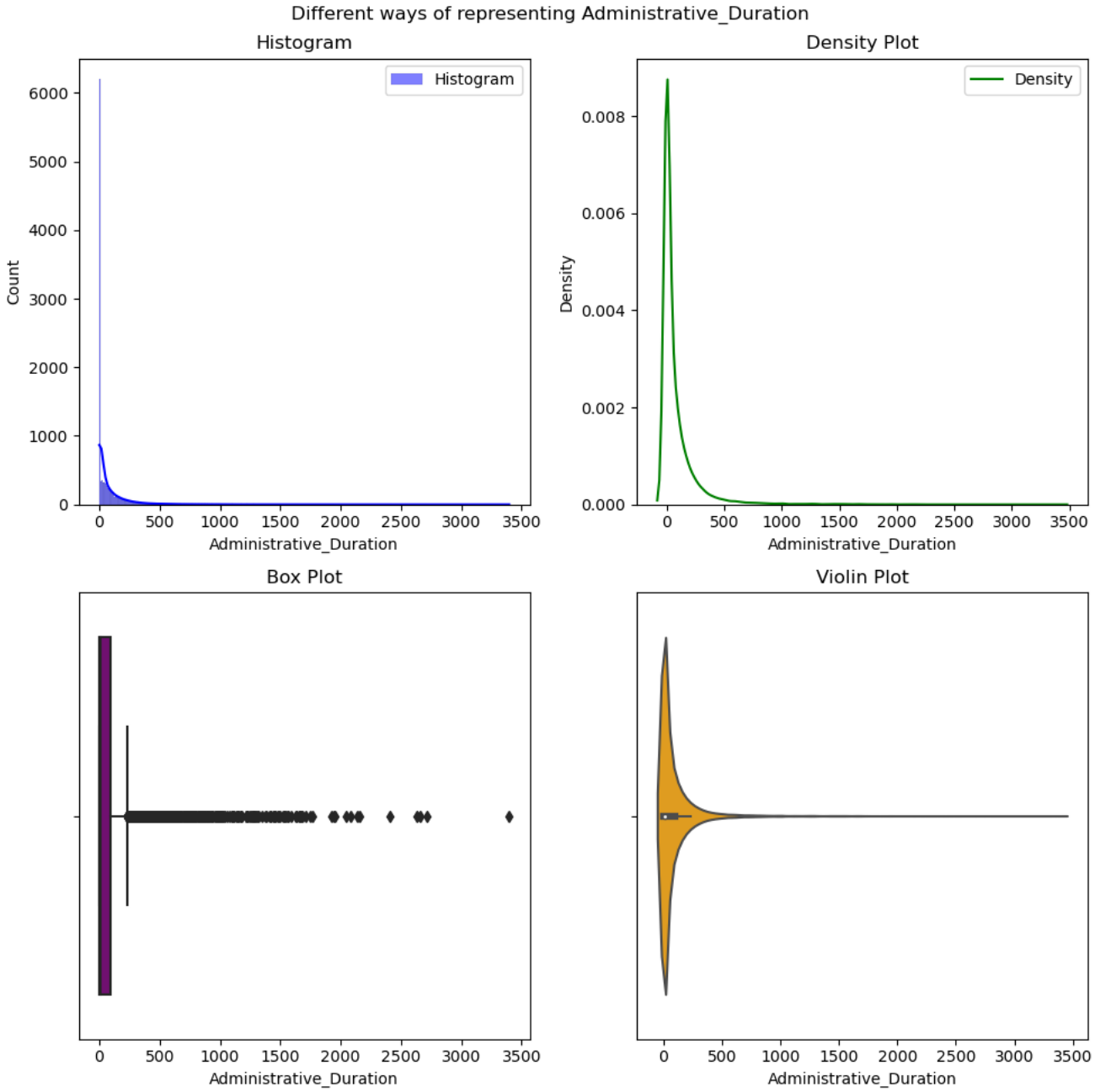


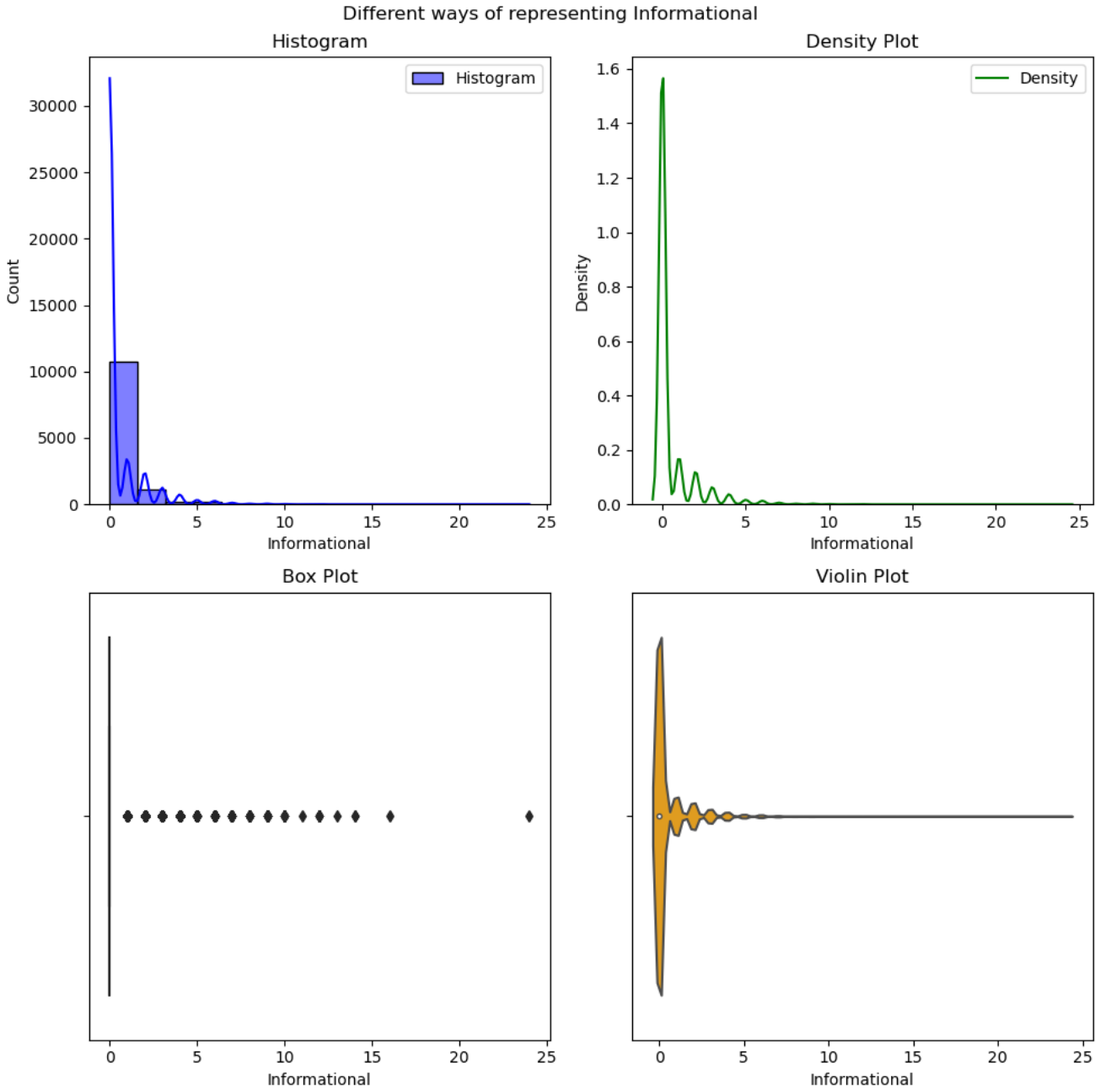
Task 1.1 Checking for Outliers in the Numerical Variables

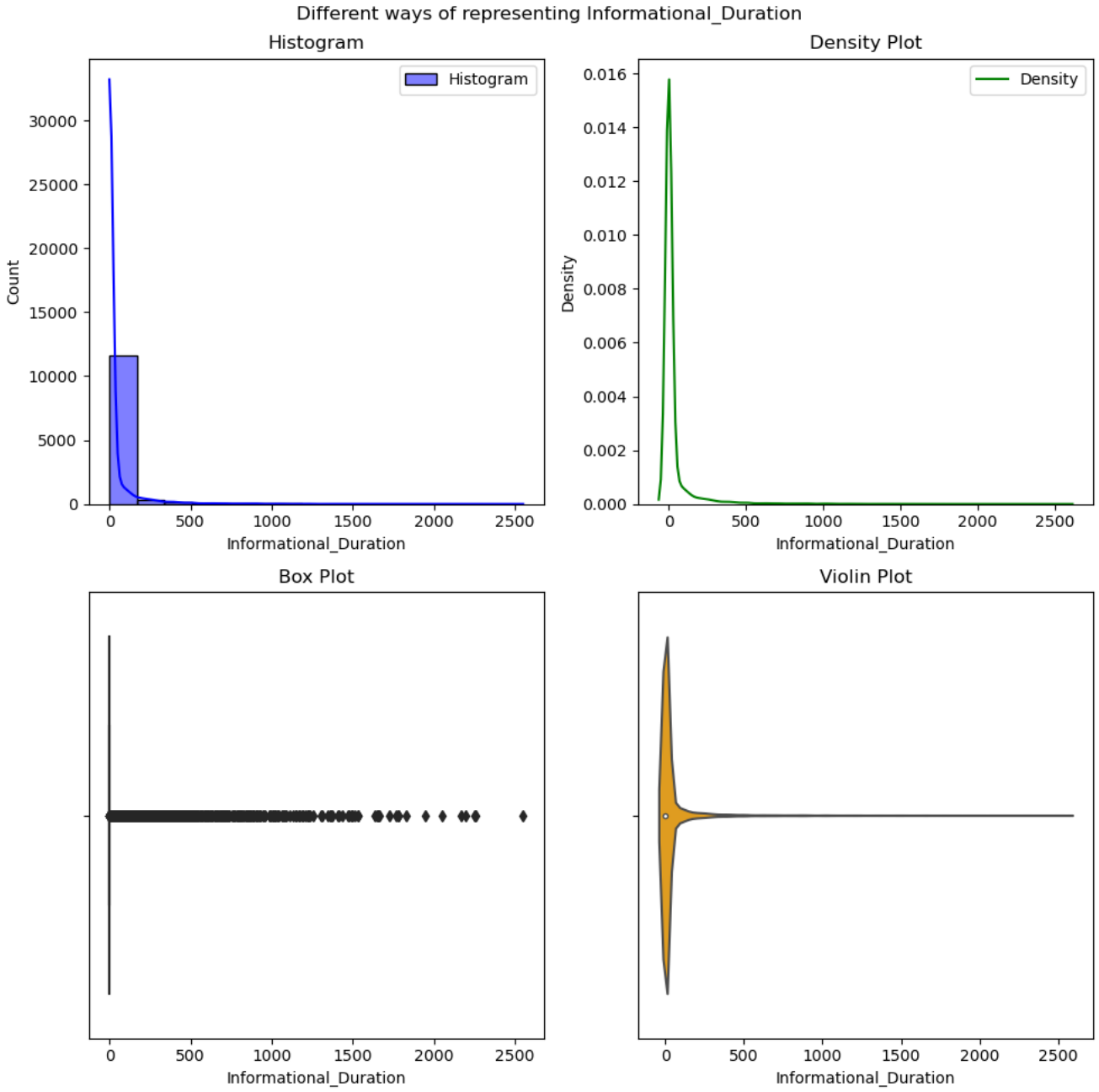
In [10]:

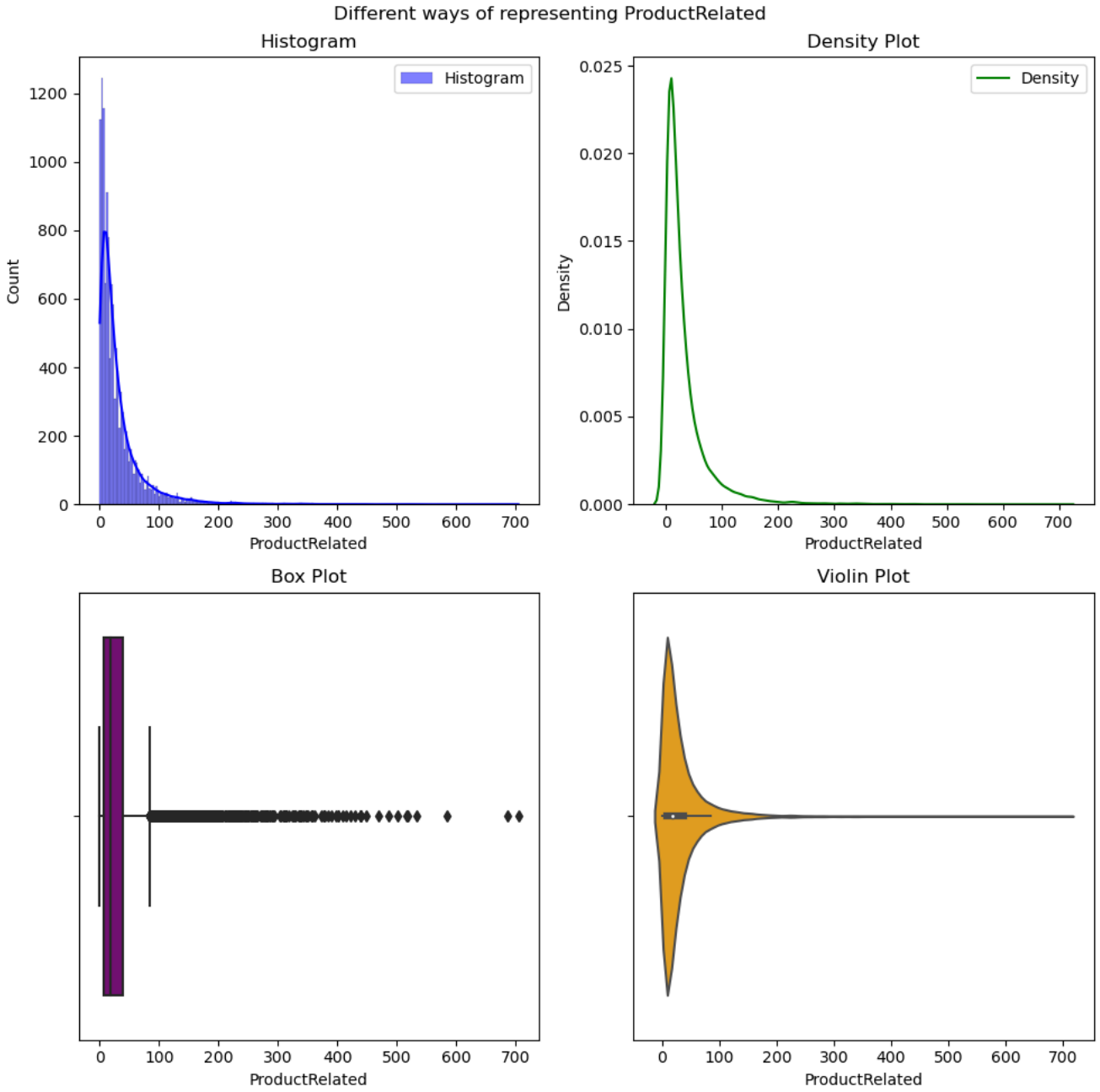
```
import seaborn as sns
import matplotlib.pyplot as plt

# This is for checking and viewing the spread of outliers across the Numerical Variables
num_cols = ['Administrative', 'Administrative_Duration', 'Informational', 'Informational_Duration', 'ProductRela

for column in num_cols:
    fig, axs = plt.subplots(2, 2, figsize=(10, 10))
    fig.suptitle('Different ways of representing ' + column)

    # Code for Histogram
    sns.histplot(df[column], ax=axs[0, 0], kde=True, color='blue', label='Histogram')
    axs[0, 0].set_title('Histogram')
    axs[0, 0].legend()

    # Code for Density plot
    sns.kdeplot(df[column], ax=axs[0, 1], color='green', label='Density')
    axs[0, 1].set_title('Density Plot')
    axs[0, 1].legend()

    # Code for Box plot
    sns.boxplot(x=df[column], ax=axs[1, 0], color='purple')
    axs[1, 0].set_title('Box Plot')

    # Code for Violin plot
    sns.violinplot(x=df[column], ax=axs[1, 1], color='orange')
    axs[1, 1].set_title('Violin Plot')

    plt.tight_layout()
    plt.show()

```

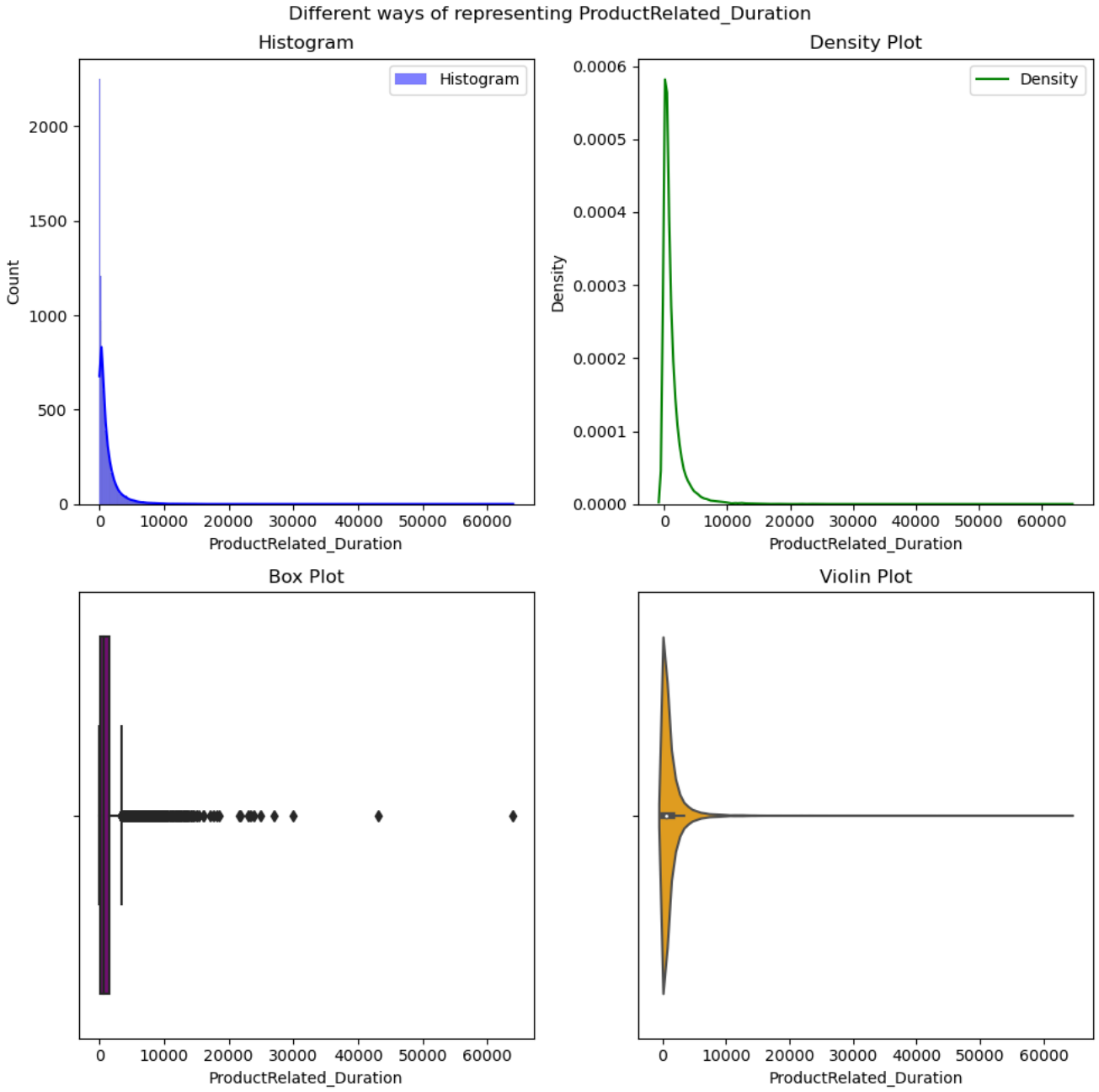

Different ways of representing Administrative
Histogram
Histogram
Count
Administrative
Density Plot
Density
Density
Administrative
Box Plot
Administrative
Violin Plot
Administrative

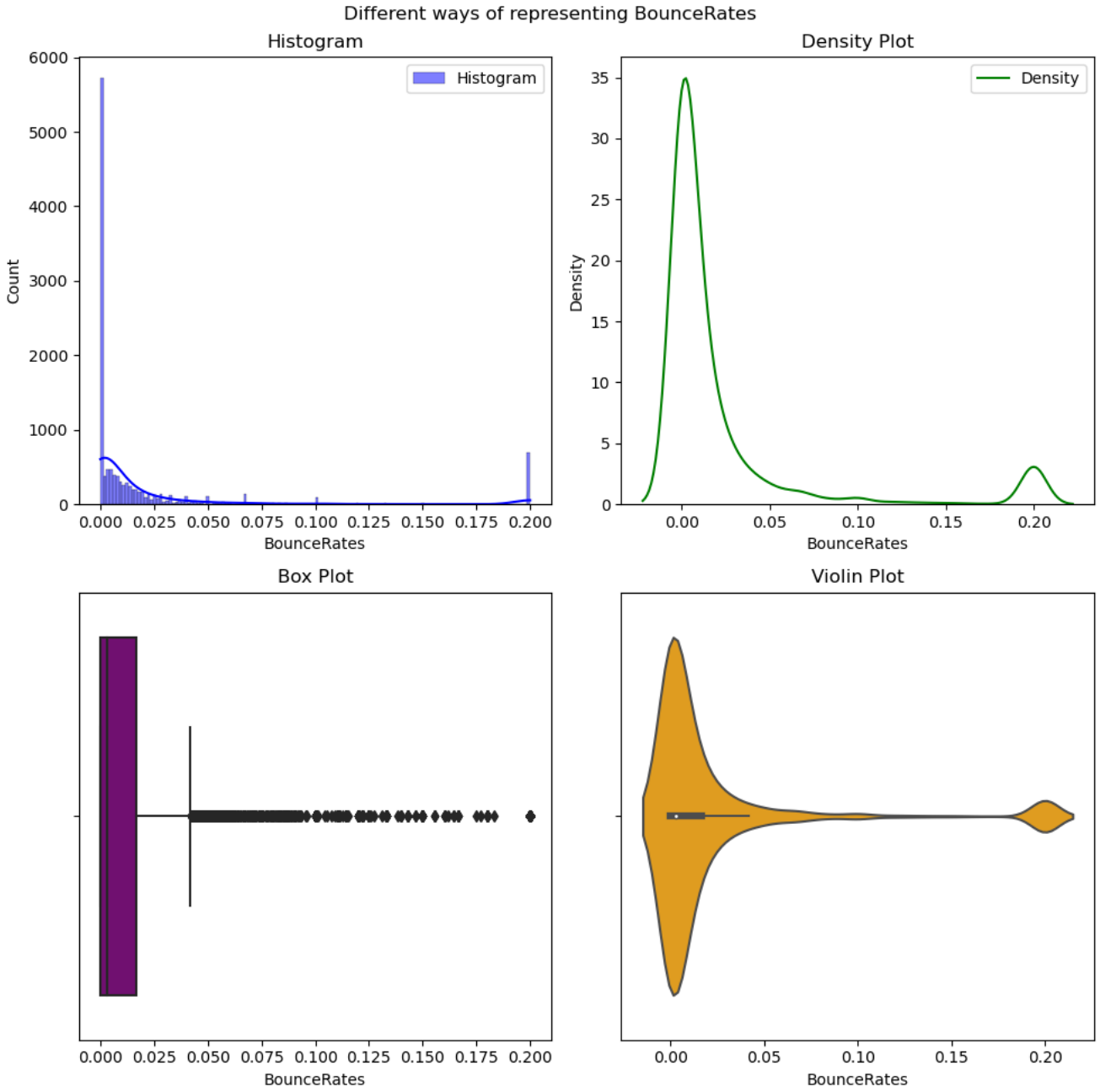

Different ways of representing Administrative_Duration
Histogram
Histogram
Count
Administrative_Duration
Density Plot
Density
Density
Administrative_Duration
Box Plot
Administrative_Duration
Violin Plot
Administrative_Duration

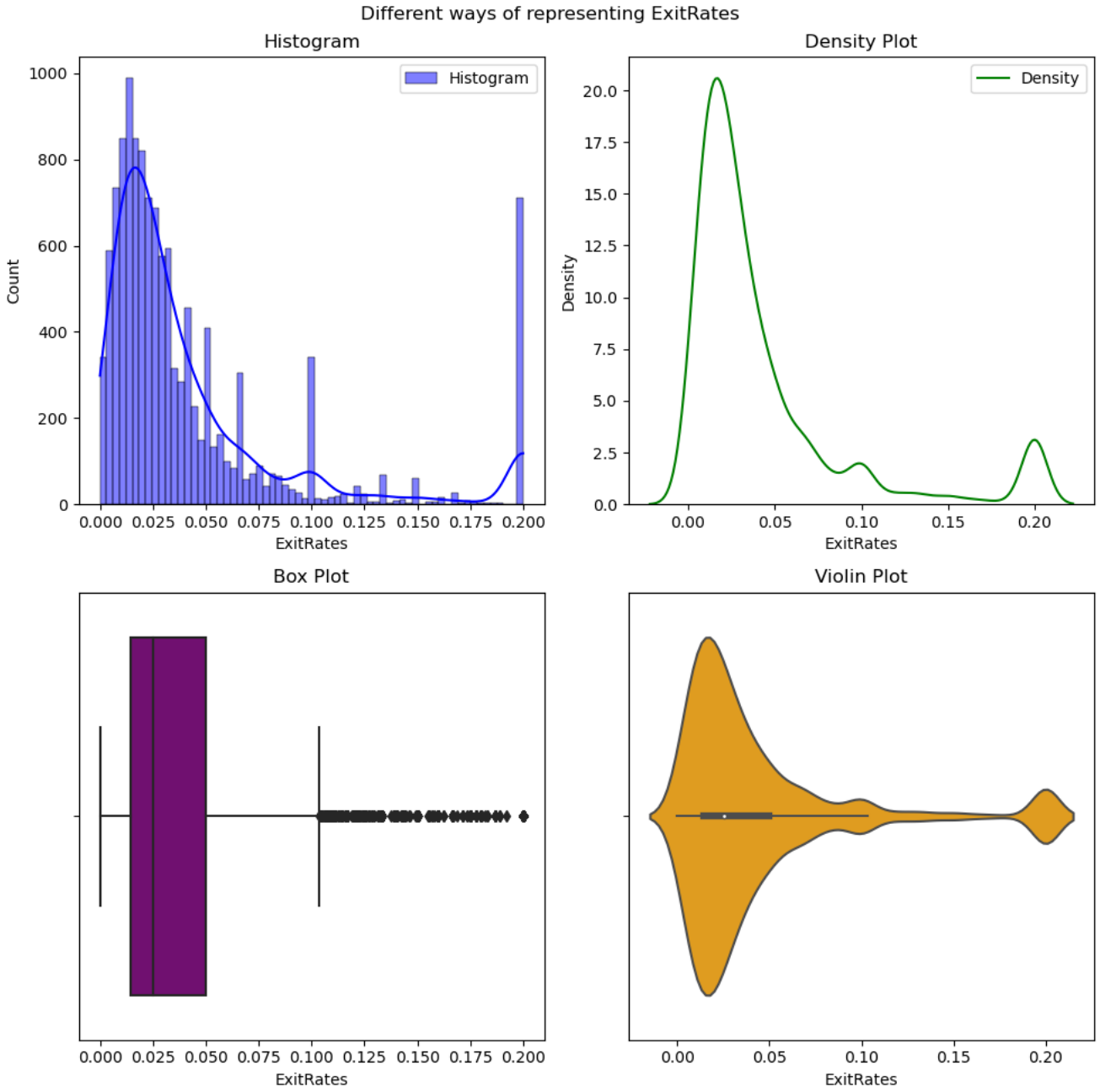

Different ways of representing Informational
Histogram
Histogram
Count
Informational
Density Plot
Density
Density
Informational
Box Plot
Informational
Violin Plot
Informational

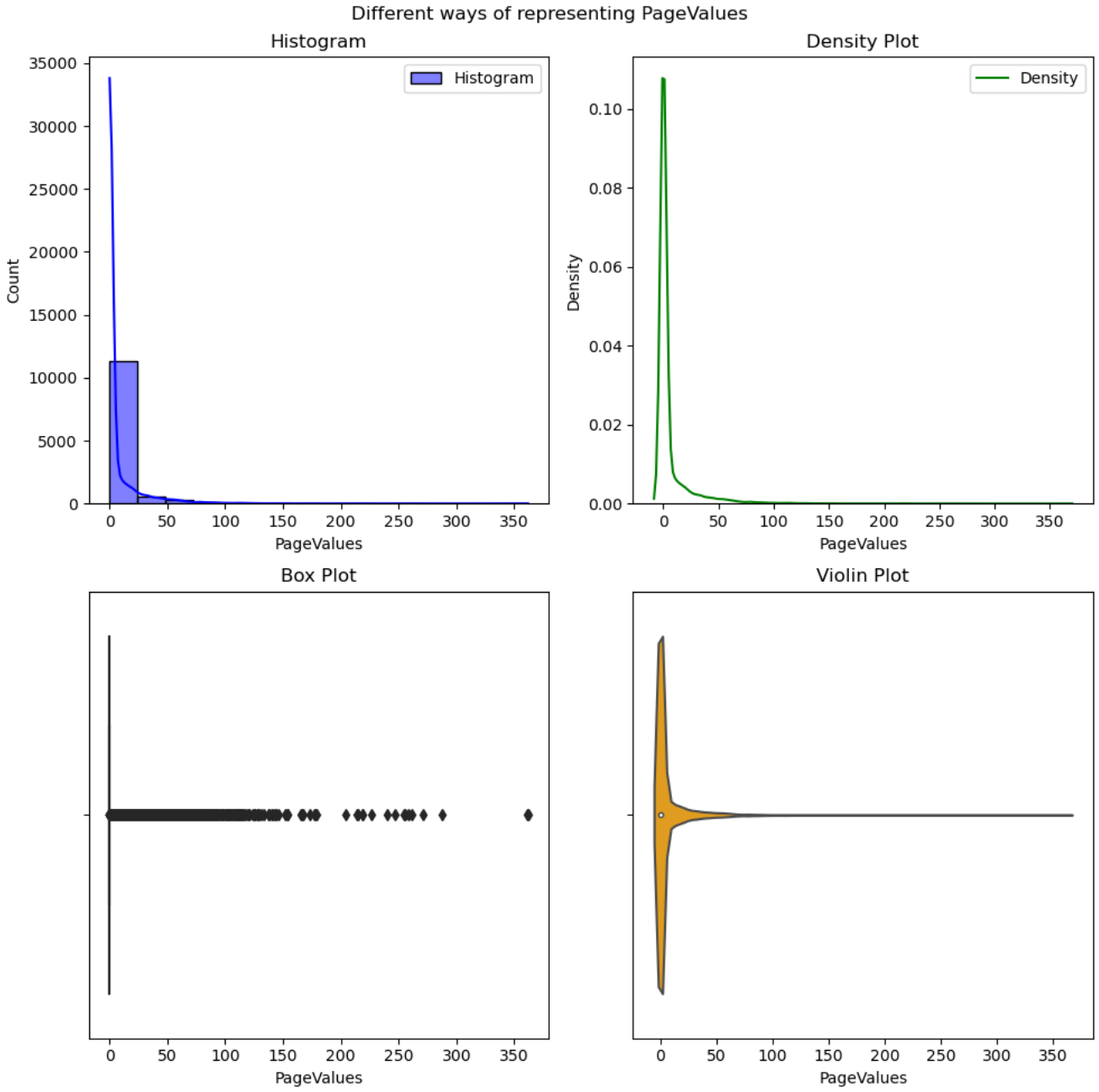

Different ways of representing Informational_Duration
Histogram
Histogram
Count
Informational_Duration
Density Plot
Density
Density
Informational_Duration
Box Plot
Informational_Duration
Violin Plot
Informational_Duration

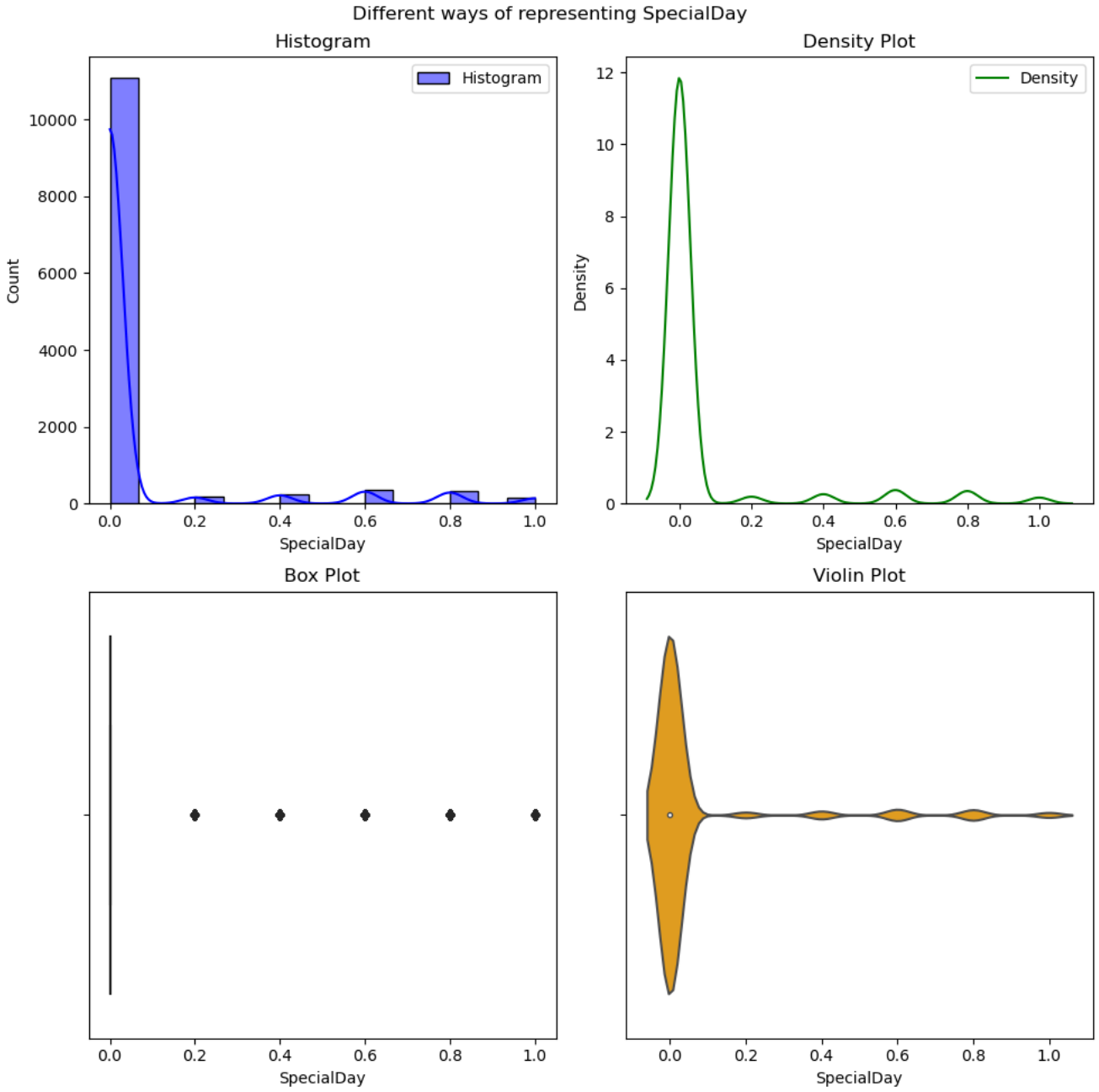

Different ways of representing ProductRelated
Histogram
Histogram
Count
ProductRelated
Density Plot
Density
Density
ProductRelated
Box Plot
ProductRelated
Violin Plot
ProductRelated


Different ways of representing ProductRelated_Duration
Histogram
Histogram
Count
ProductRelated_Duration
Density Plot
Density
Density
ProductRelated_Duration
Box Plot
ProductRelated_Duration
Violin Plot
ProductRelated_Duration


Different ways of representing BounceRates
Histogram
Histogram
Count
BounceRates
Density Plot
Density
Density
BounceRates
Box Plot
BounceRates
Violin Plot
BounceRates


Different ways of representing ExitRates
Histogram
Histogram
Count
ExitRates
Density Plot
Density
Density
ExitRates
Box Plot
ExitRates
Violin Plot
ExitRates

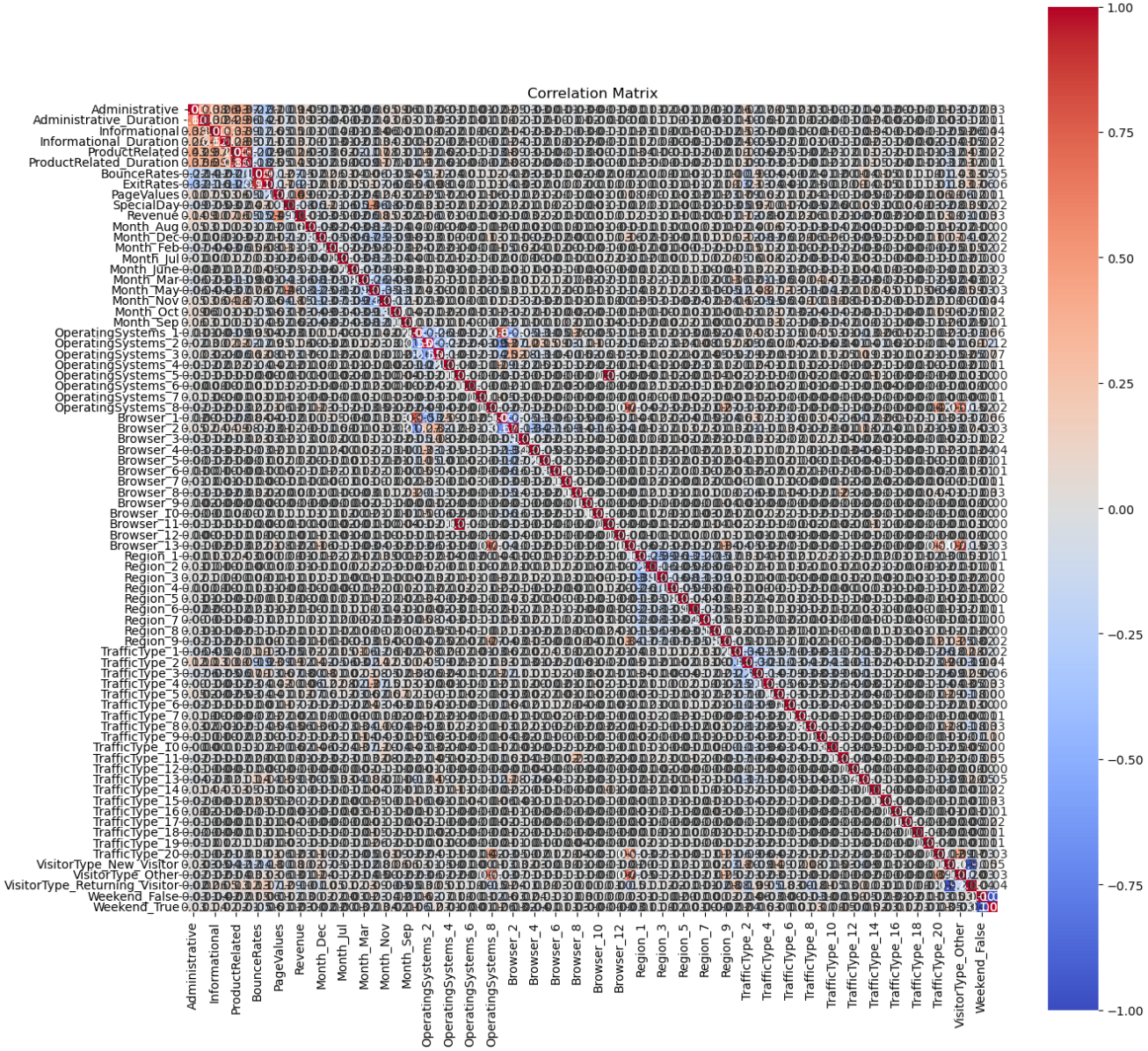

Different ways of representing PageValues
Histogram
Histogram
Count
PageValues
Density Plot
Density
Density
PageValues
Box Plot
PageValues
Violin Plot
PageValues



Task 3: Data Modelling - Correlation Matrix

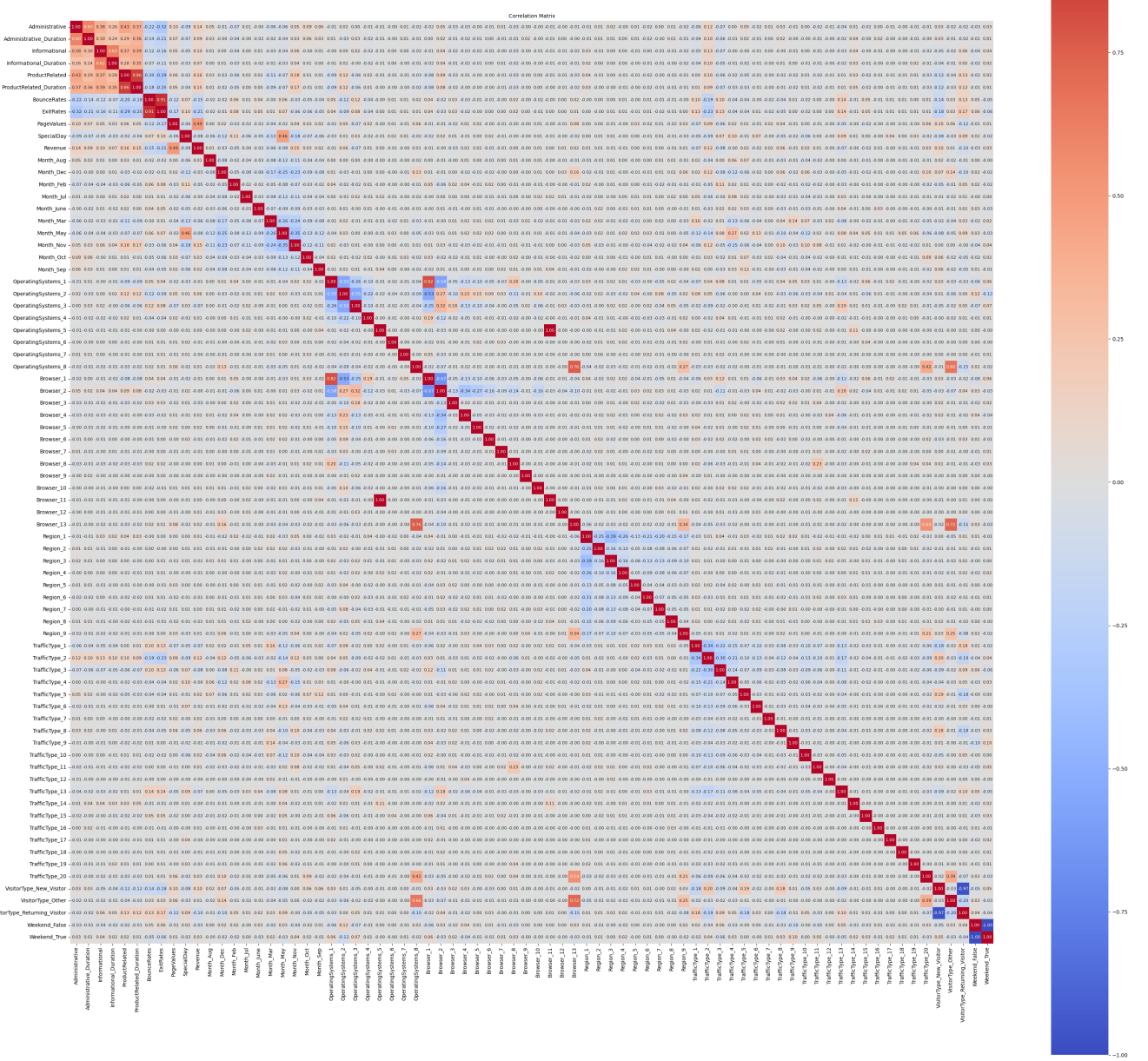
In [11]:

```
# Creating dummy variables for the categorical columns
df_encoded = pd.get_dummies(df, columns=['Month', 'OperatingSystems', 'Browser', 'Region', 'TrafficType', 'Visi

# Converting 'Revenue' to integer type (False to 0, True to 1)
df_encoded['Revenue'] = df_encoded['Revenue'].astype(int)

# Now I am taking a look at the correlation matrix
corr_matrix = df_encoded.corr()

# Now, I am plotting a heatmap of the correlation matrix
plt.figure(figsize=(15, 15))
sns.heatmap(corr_matrix, annot=True, fmt=".2f", cmap='coolwarm', square=True)
plt.title('Correlation Matrix')
plt.show()

```



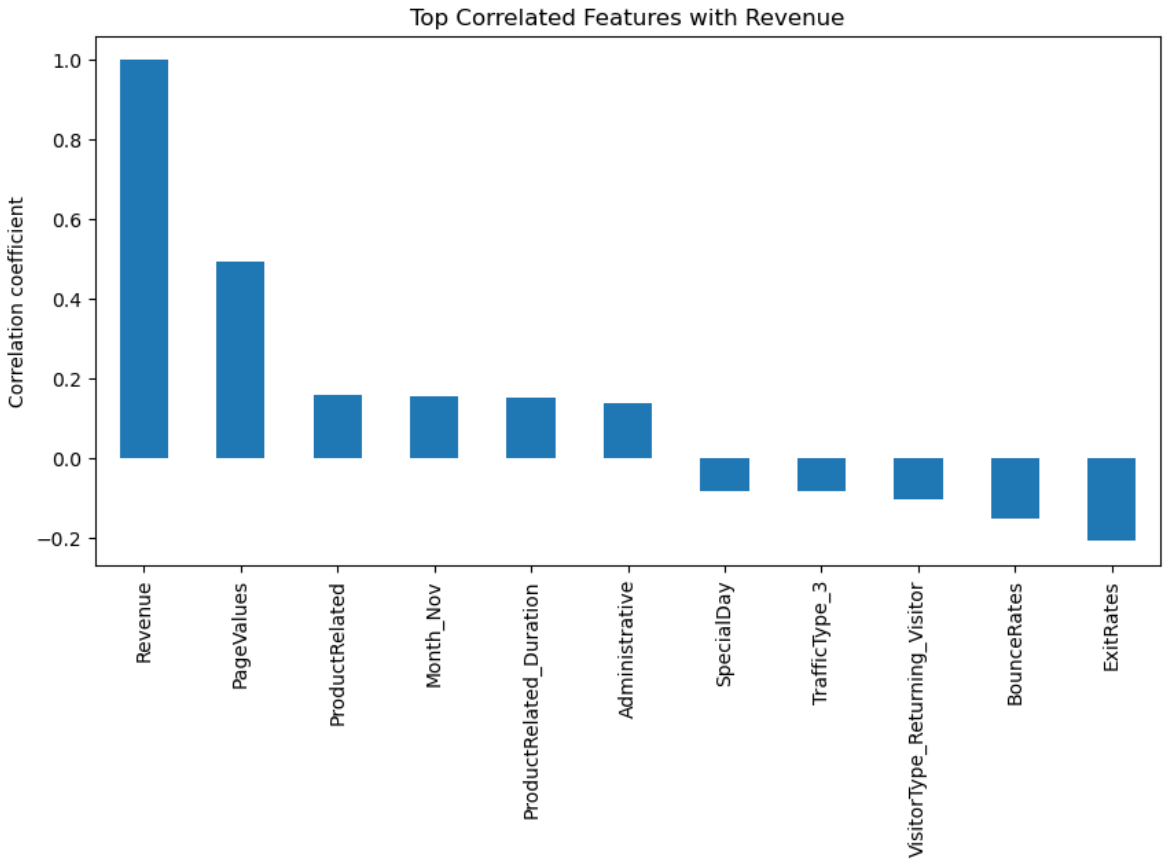
In [12]:

```
#larger plot
plt.figure(figsize=(40, 40))
sns.heatmap(corr_matrix, annot=True, fmt=".2f", cmap='coolwarm', square=True, annot_kws={"size": 8})
plt.title('Correlation Matrix', fontsize=10)
plt.show()
```



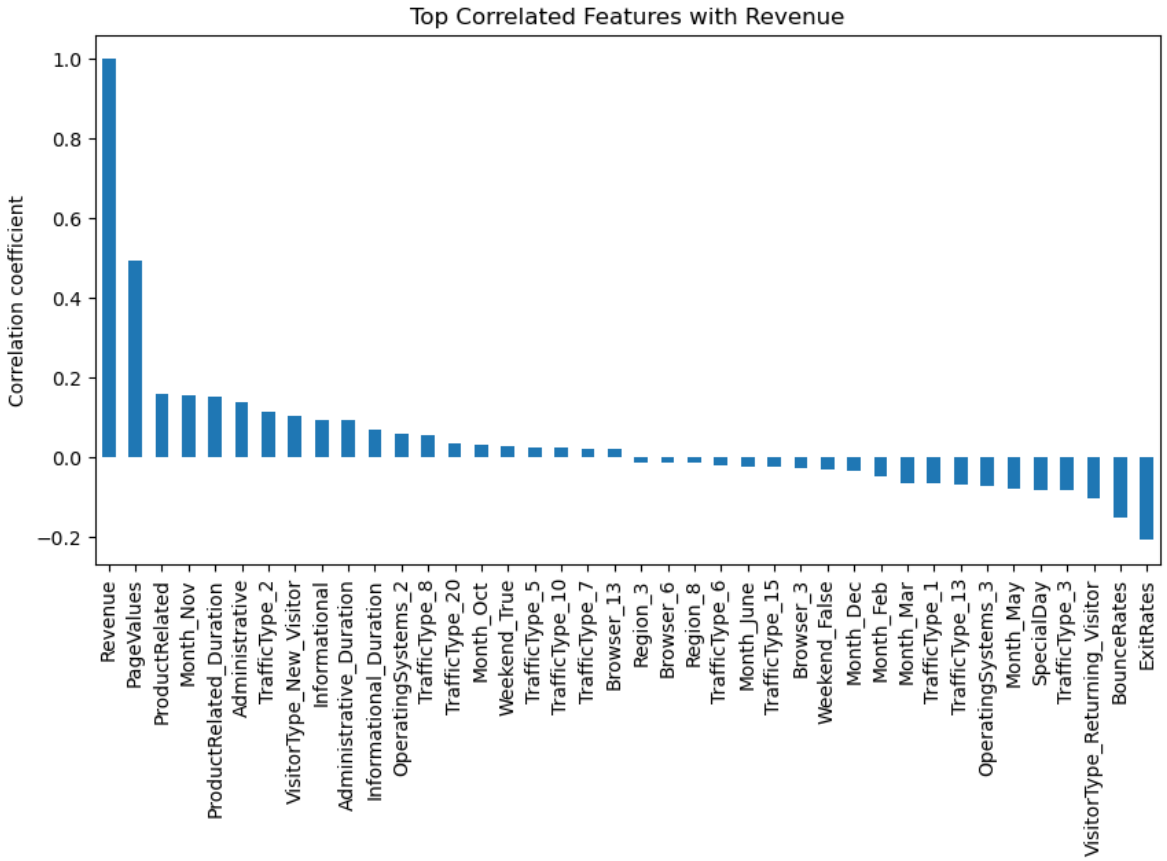
In [13]:

```
# Compute the correlation with 'Revenue' for all variables
correlation_with_revenue = df_encoded.corr()['Revenue'].sort_values(ascending=False)

# Select top 10 most correlated features
top_corr_features = pd.concat([correlation_with_revenue.head(6), correlation_with_revenue.tail(5)])

plt.figure(figsize=(10,5))
top_corr_features.plot(kind='bar')
plt.title('Top Correlated Features with Revenue')
plt.ylabel('Correlation coefficient')
plt.show()

```



In [14]:

```
# Compute the correlation with 'Revenue' for all variables
correlation_with_revenue = df_encoded.corr()['Revenue'].sort_values(ascending=False)

top_corr_features = pd.concat([correlation_with_revenue.head(20), correlation_with_revenue.tail(20)])

plt.figure(figsize=(10,5))
top_corr_features.plot(kind='bar')
plt.title('Top Correlated Features with Revenue')
plt.ylabel('Correlation coefficient')
plt.show()
```



Task 3: Machine Learning (KNN) for prediction with ~ 10 features

In [15]:

```
correlation_with_revenue = df_encoded.corr()['Revenue'].sort_values(ascending=False)

top_corr_features = pd.concat([correlation_with_revenue.head(20), correlation_with_revenue.tail(20)])

print("Top Correlated Features with Revenue:")
print(top_corr_features)

```

```
Top Correlated Features with Revenue:
Revenue                          1.000000
PageValues                       0.492569
ProductRelated                   0.158538
Month_Nov                        0.154774
ProductRelated_Duration          0.152373
Administrative                   0.138917
TrafficType_2                    0.116347
VisitorType_New_Visitor          0.104136
Informational                    0.095200
Administrative_Duration          0.093587
Informational_Duration           0.070345
OperatingSystems_2               0.060040
TrafficType_8                    0.057167
TrafficType_20                   0.034540
Month_Oct                        0.032666
Weekend_True                     0.029295
TrafficType_5                    0.024609
TrafficType_10                   0.024354
TrafficType_7                    0.022913
Browser_13                       0.020969
Region_3                        -0.012937
Browser_6                       -0.013167
Region_8                        -0.013579
TrafficType_6                   -0.018905
Month_June                      -0.023112
TrafficType_15                  -0.023790
Browser_3                       -0.027451
Weekend_False                   -0.029295
Month_Dec                       -0.033112
Month_Feb                       -0.047114
Month_Mar                       -0.063941
TrafficType_1                   -0.065901
TrafficType_13                  -0.067310
OperatingSystems_3              -0.070472
Month_May                       -0.078320
SpecialDay                      -0.082305
TrafficType_3                   -0.082808
VisitorType_Returning_Visitor   -0.103843
BounceRates                     -0.150673
ExitRates                       -0.207071
Name: Revenue, dtype: float64
```

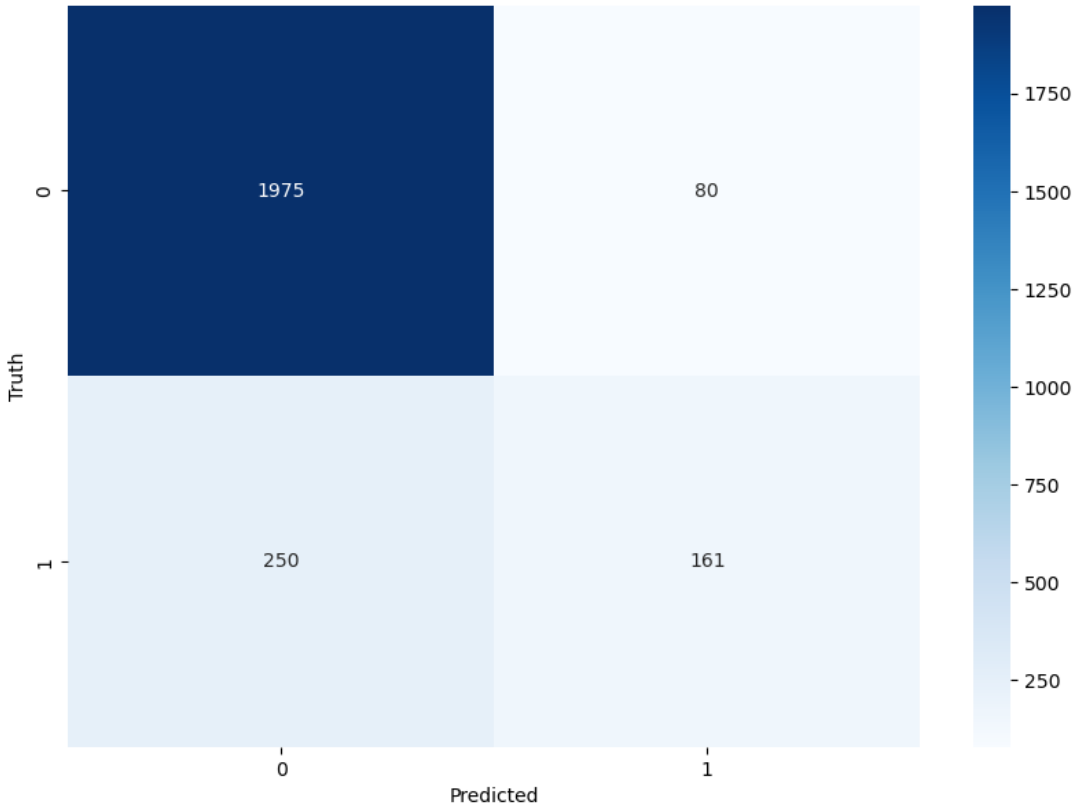
In [16]:

```
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import classification_report, confusion_matrix

X = df_encoded[['PageValues', 'ProductRelated', 'ProductRelated_Duration', 'Month_Nov', 'Administrative', 'Traf

# Selecting the target
y = df_encoded['Revenue']

# Splitting the data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Creating the classifier
knn = KNeighborsClassifier(n_neighbors=5)

# Training the classifier
knn.fit(X_train, y_train)

# Making predictions on the test set
y_pred = knn.predict(X_test)

# Printing the classification report
print(classification_report(y_test, y_pred))

# Printing the confusion matrix
print(confusion_matrix(y_test, y_pred))

```

```
              precision    recall  f1-score   support

           0       0.89      0.96      0.92      2055
           1       0.67      0.39      0.49       411

    accuracy                           0.87      2466
   macro avg       0.78      0.68      0.71      2466
weighted avg       0.85      0.87      0.85      2466

[[1975   80]
 [ 250  161]]
```

In [17]:

```
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix

# Compute confusion matrix
cm = confusion_matrix(y_test, y_pred)

# Use seaborn to plot confusion matrix
plt.figure(figsize=(10,7))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.show()

```



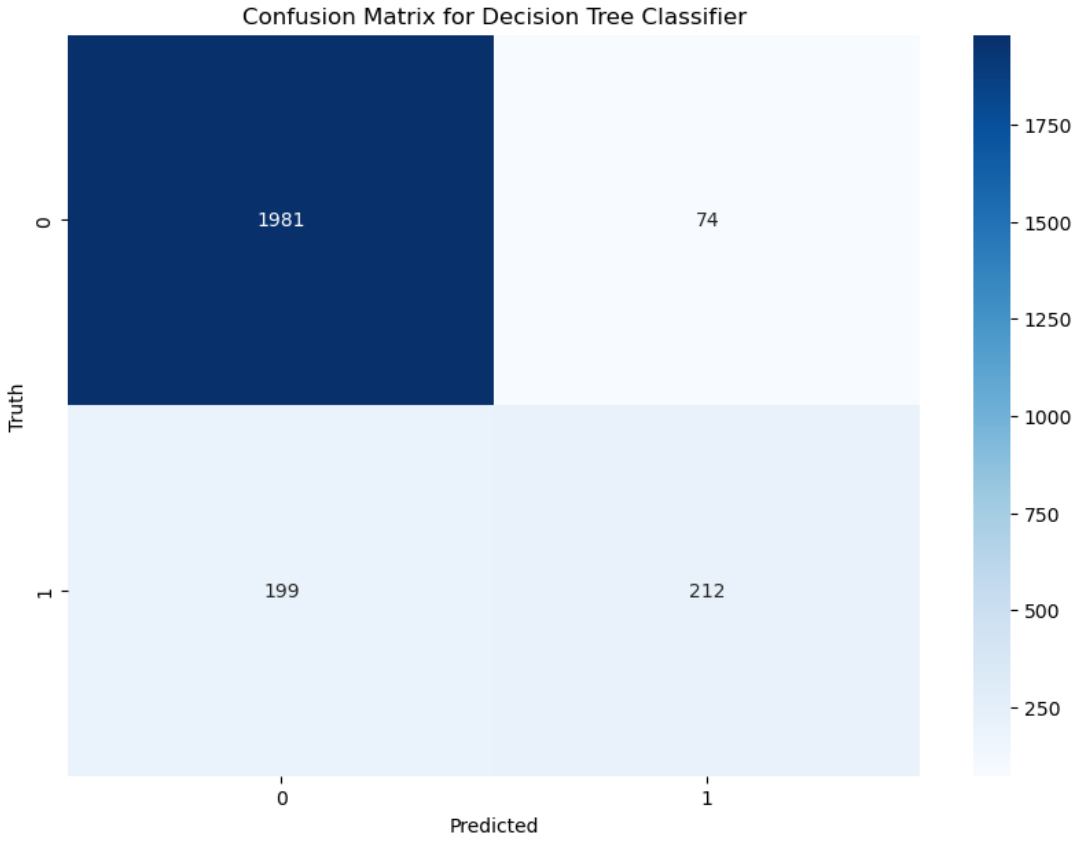
In [18]:

```
from sklearn.tree import DecisionTreeClassifier

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

y_pred = dtree.predict(X_test)

print(classification_report(y_test, y_pred))

print(confusion_matrix(y_test, y_pred))

```

```
              precision    recall  f1-score   support

           0       0.91      0.96      0.94      2055
           1       0.74      0.52      0.61       411

    accuracy                           0.89      2466
   macro avg       0.82      0.74      0.77      2466
weighted avg       0.88      0.89      0.88      2466

[[1981   74]
 [ 199  212]]
```

In [19]:

```
# Compute confusion matrix for Decision Tree
cm_dtree = confusion_matrix(y_test, y_pred)

# Use seaborn to plot confusion matrix
plt.figure(figsize=(10,7))
sns.heatmap(cm_dtree, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for Decision Tree Classifier')
plt.show()

```



In [20]:

```
from sklearn.model_selection import GridSearchCV

# Defining the parameter values that should be searched
param_grid = {
    'max_depth': [None, 5, 10, 15, 20],
    'min_samples_split': [2, 5, 10, 20],
    'min_samples_leaf': [1, 2, 5, 10],
    'max_features': [None, 'sqrt', 'log2']
}

# Instantiating the grid
grid = GridSearchCV(DecisionTreeClassifier(), param_grid, cv=5, scoring='accuracy')

# Fitting grid
grid.fit(X_train, y_train)

# Viewing complete results
print(grid.cv_results_)

# Viewing best params for the model found using grid search
print("Best parameters: ", grid.best_params_)

y_pred = grid.predict(X_test)

print(classification_report(y_test, y_pred))

print(confusion_matrix(y_test, y_pred))

```

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Best parameters:  {'max_depth': 5, 'max_features': None, 'min_samples_leaf': 10, 'min_samples_split': 2}
              precision    recall  f1-score   support

           0       0.91      0.96      0.94      2055
           1       0.75      0.52      0.61       411

    accuracy                           0.89      2466
   macro avg       0.83      0.74      0.77      2466
weighted avg       0.88      0.89      0.88      2466

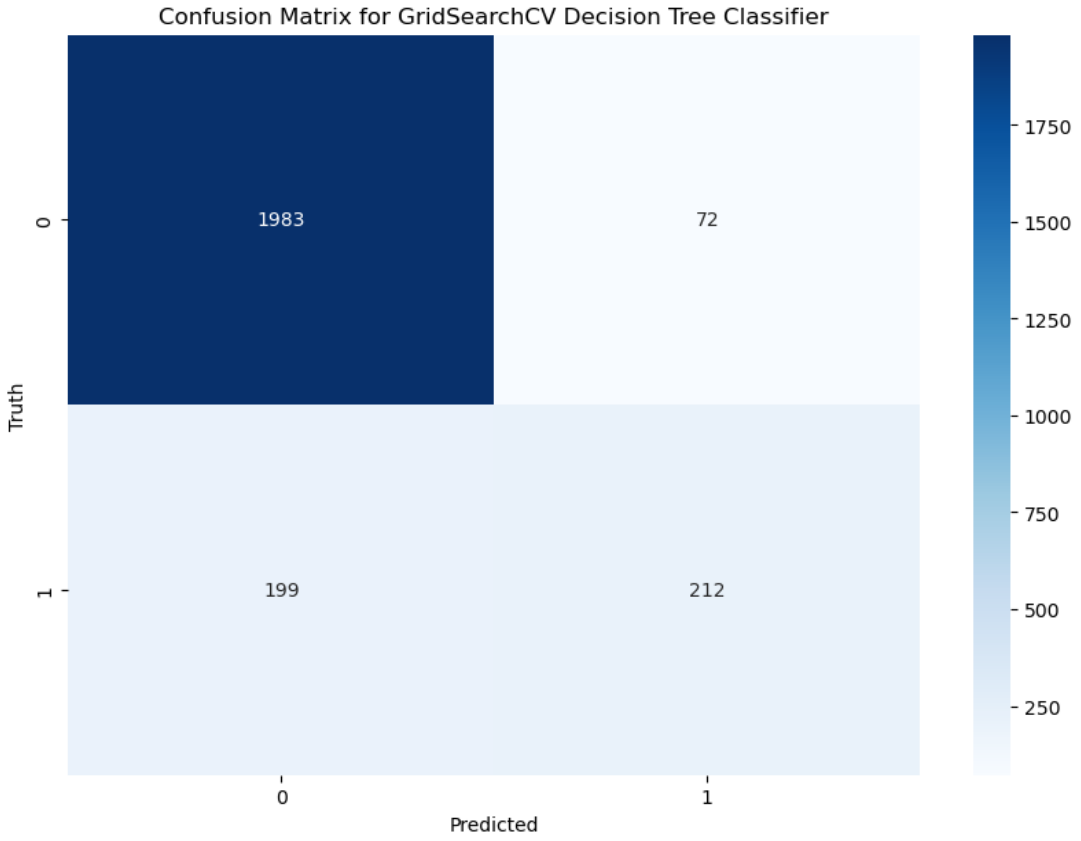
[[1983   72]
 [ 199  212]]
```

In [21]:

```
cm_grid = confusion_matrix(y_test, y_pred)

plt.figure(figsize=(10,7))
sns.heatmap(cm_grid, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for GridSearchCV Decision Tree Classifier')
plt.show()

```



In [22]:

```
#this is inspired by the original paper Sakar 2018
from imblearn.over_sampling import SMOTE
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

# Oversampling the minority class
smote = SMOTE(random_state=42)
X_res, y_res = smote.fit_resample(X, y)

# Splitting the resampled data into training and test sets
X_train_res, X_test_res, y_train_res, y_test_res = train_test_split(X_res, y_res, test_size=0.2, random_state=42

# Creating the classifier
rfc = RandomForestClassifier(n_estimators=100, random_state=42)

rfc.fit(X_train_res, y_train_res)

y_pred_res = rfc.predict(X_test_res)

print(classification_report(y_test_res, y_pred_res))

print(confusion_matrix(y_test_res, y_pred_res))

print("Accuracy: ", accuracy_score(y_test_res, y_pred_res))

```

```
              precision    recall  f1-score   support

           0       0.94      0.89      0.91      2062
           1       0.90      0.94      0.92      2107

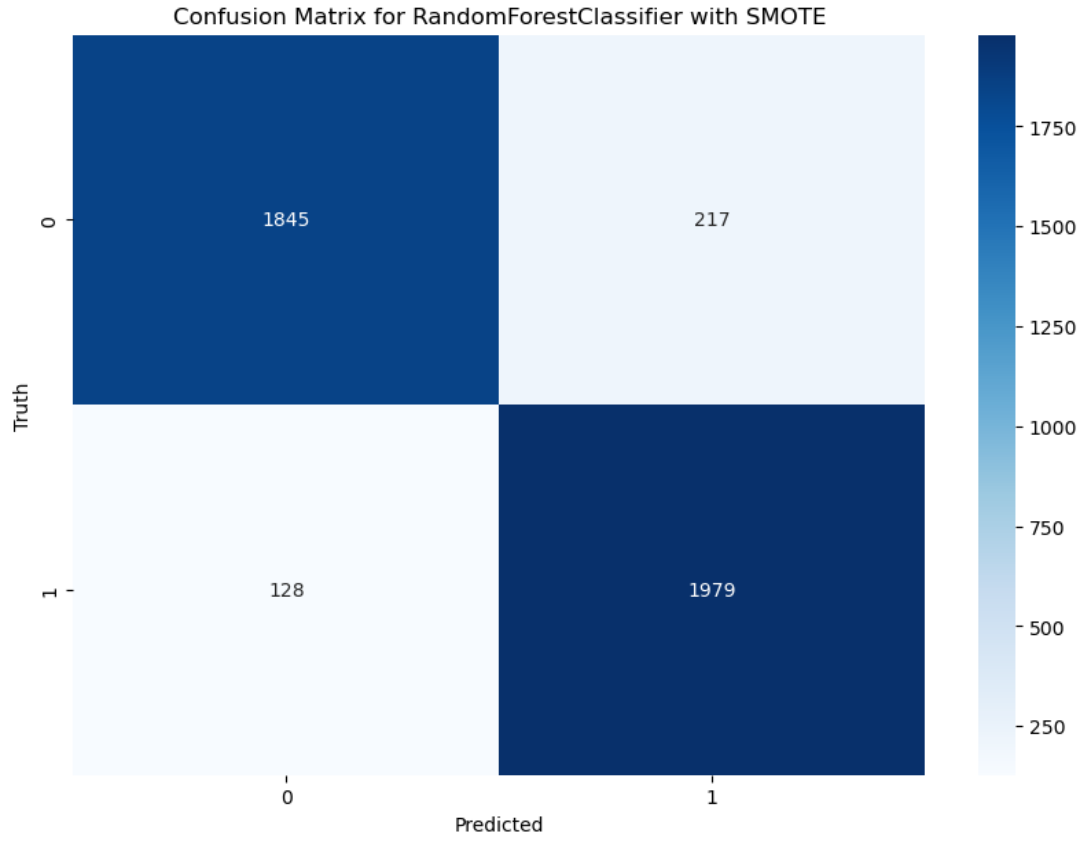
    accuracy                           0.92      4169
   macro avg       0.92      0.92      0.92      4169
weighted avg       0.92      0.92      0.92      4169

[[1845  217]
 [ 128 1979]]
Accuracy:  0.9172463420484529
```

In [23]:
```
cm_rfc = confusion_matrix(y_test_res, y_pred_res)

plt.figure(figsize=(10,7))
sns.heatmap(cm_rfc, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for RandomForestClassifier with SMOTE')
plt.show()

```



In [24]:
```
!pip install -U imbalanced-learn

```

```
Requirement already satisfied: imbalanced-learn in /Users/amayiyer/Desktop/DatSci_Python/anaconda3/lib/python3.9/
site-packages (0.10.1)
Requirement already satisfied: scikit-learn>=1.0.2 in /Users/amayiyer/Desktop/DatSci_Python/anaconda3/lib/python
3.9/site-packages (from imbalanced-learn) (1.2.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /Users/amayiyer/Desktop/DatSci_Python/anaconda3/lib/python
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e-packages (from imbalanced-learn) (1.21.5)
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e-packages (from imbalanced-learn) (1.2.0)
Requirement already satisfied: scipy>=1.3.2 in /Users/amayiyer/Desktop/DatSci_Python/anaconda3/lib/python3.9/site
-packages (from imbalanced-learn) (1.9.1)
```

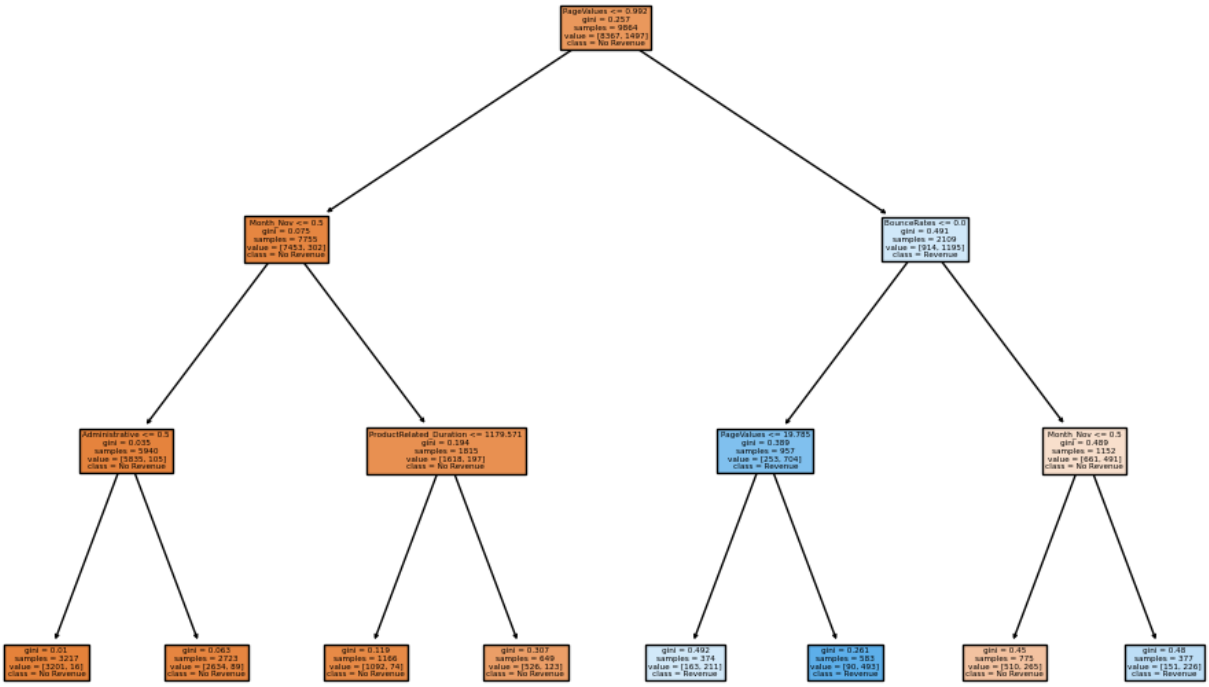
In [25]:

```
from sklearn.tree import DecisionTreeClassifier, plot_tree

dtree = DecisionTreeClassifier(max_depth=3)
dtree.fit(X_train, y_train)

plt.figure(figsize=(12,8))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True)
plt.show()

```



Task 3: Machine Learning Model (KNN) with ~ 12-13 features

In [26]:
```
rn.model_selection import train_test_split
rn.neighbors import KNeighborsClassifier
rn.metrics import classification_report, confusion_matrix

oded[['PageValues', 'ProductRelated', 'ProductRelated_Duration', 'Month_Nov', 'Administrative', 'TrafficType_2', 'Vi

oded['Revenue']

_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

ghborsClassifier(n_neighbors=5)

train, y_train)

n.predict(X_test)

sification_report(y_test, y_pred))

usion_matrix(y_test, y_pred))
```

```
              precision    recall  f1-score   support

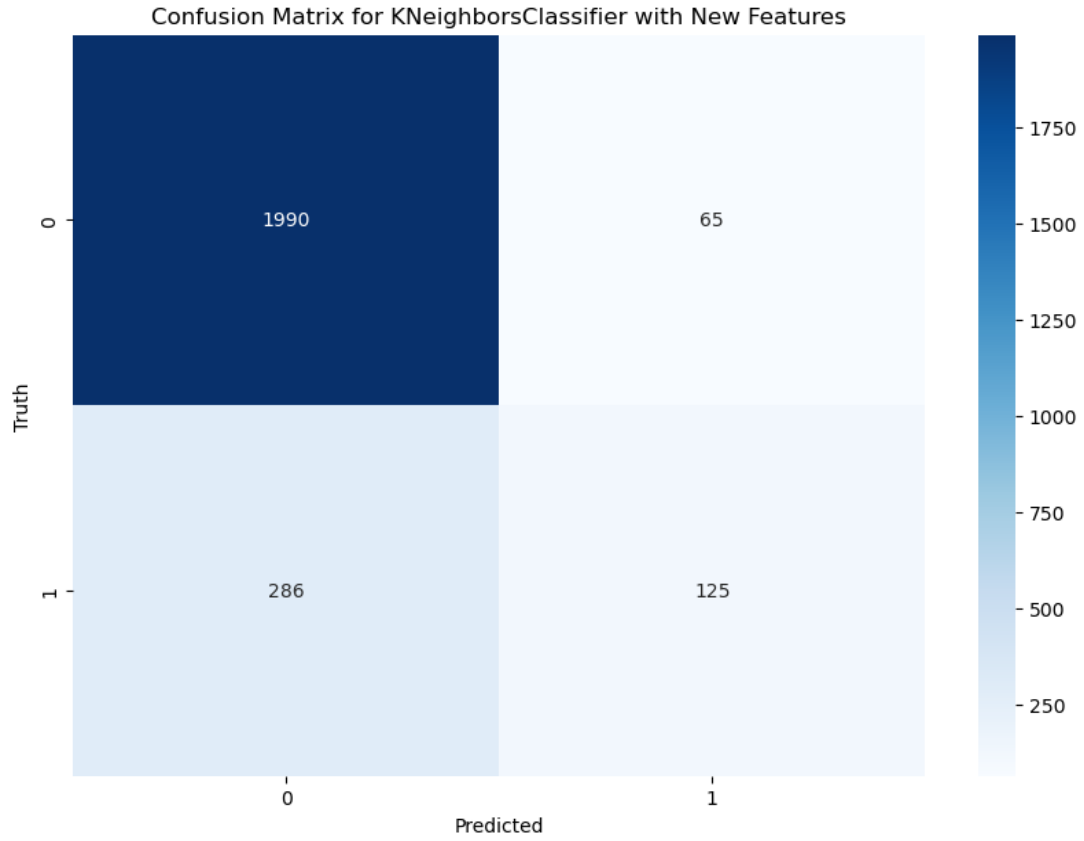
           0       0.87      0.97      0.92      2055
           1       0.66      0.30      0.42       411

    accuracy                           0.86      2466
   macro avg       0.77      0.64      0.67      2466
weighted avg       0.84      0.86      0.84      2466

[[1990   65]
 [ 286  125]]
```

In [27]:
```
cm_knn = confusion_matrix(y_test, y_pred)

plt.figure(figsize=(10,7))
sns.heatmap(cm_knn, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for KNeighborsClassifier with New Features')
plt.show()
```



In [28]:
```
from sklearn.tree import DecisionTreeClassifier

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

y_pred = dtree.predict(X_test)

print(classification_report(y_test, y_pred))

print(confusion_matrix(y_test, y_pred))

```

```
              precision    recall  f1-score   support

           0       0.90      0.97      0.94      2055
           1       0.75      0.49      0.59       411

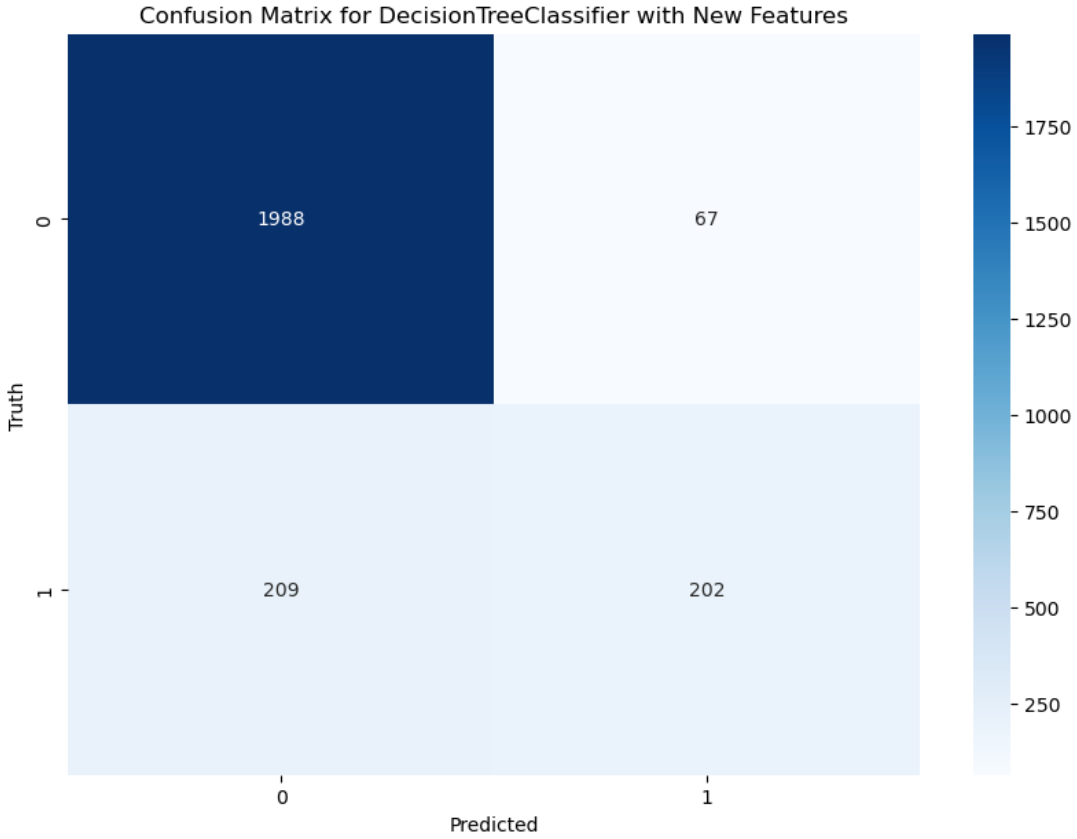
    accuracy                           0.89      2466
   macro avg       0.83      0.73      0.76      2466
weighted avg       0.88      0.89      0.88      2466

[[1988   67]
 [ 209  202]]
```

In [29]:
```
cm_dtree = confusion_matrix(y_test, y_pred)

plt.figure(figsize=(10,7))
sns.heatmap(cm_dtree, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for DecisionTreeClassifier with New Features')
plt.show()

```



In [30]:

```
from sklearn.model_selection import GridSearchCV

param_grid = {
    'max_depth': [None, 5, 10, 15, 20],
    'min_samples_split': [2, 5, 10, 20],
    'min_samples_leaf': [1, 2, 5, 10],
    'max_features': [None, 'sqrt', 'log2']
}

grid = GridSearchCV(DecisionTreeClassifier(), param_grid, cv=5, scoring='accuracy')

grid.fit(X_train, y_train)

print(grid.cv_results_)

print("Best parameters: ", grid.best_params_)

y_pred = grid.predict(X_test)

print(classification_report(y_test, y_pred))

print(confusion_matrix(y_test, y_pred))

```

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       137, 120,  31, 100,  44,  33,  55, 124,  91, 112,  25, 143,  41,
       129,  69,  68, 170, 182,  80,  77, 102, 162,  21, 119,  17,  48,
       117, 220, 210, 205, 172, 194, 198, 184, 161, 166, 139, 145, 104,
        40,  35,  29,  36, 231, 234, 211, 141, 189, 130, 174, 150,  92,
       156,  78, 118,  47,  28,  75, 109, 215, 221, 185, 155, 181, 180,
       159,  63,  74,  90, 127,  82,  46, 105,  32,  20, 235, 227, 218,
       186, 217, 209, 204, 167, 160, 153, 168, 107,  52,  37,  56,  58,
       236, 228, 219, 176, 191, 195, 178,  85,  71, 123,  62, 148,  64,
        49,  23,  98, 233, 222, 175, 113, 226, 193, 183,  89,  76, 154,
       125, 122,  61,  73,  43,  22], dtype=int32)}
Best parameters:  {'max_depth': 5, 'max_features': None, 'min_samples_leaf': 10, 'min_samples_split': 2}
              precision    recall  f1-score   support

           0       0.90      0.97      0.94      2055
           1       0.75      0.49      0.59       411

    accuracy                           0.89      2466
   macro avg       0.83      0.73      0.77      2466
weighted avg       0.88      0.89      0.88      2466

[[1989   66]
 [ 209  202]]
```
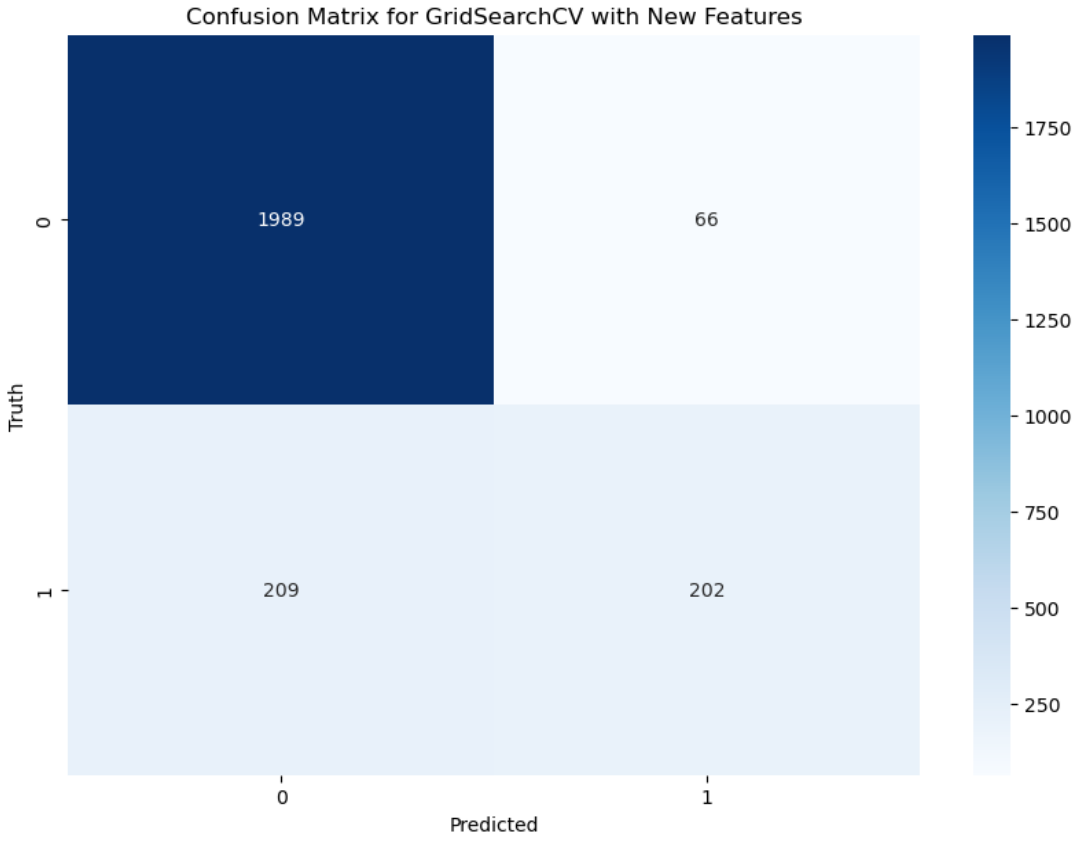

In [31]:

```
cm_grid = confusion_matrix(y_test, y_pred)

plt.figure(figsize=(10,7))
sns.heatmap(cm_grid, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for GridSearchCV with New Features')
plt.show()

```



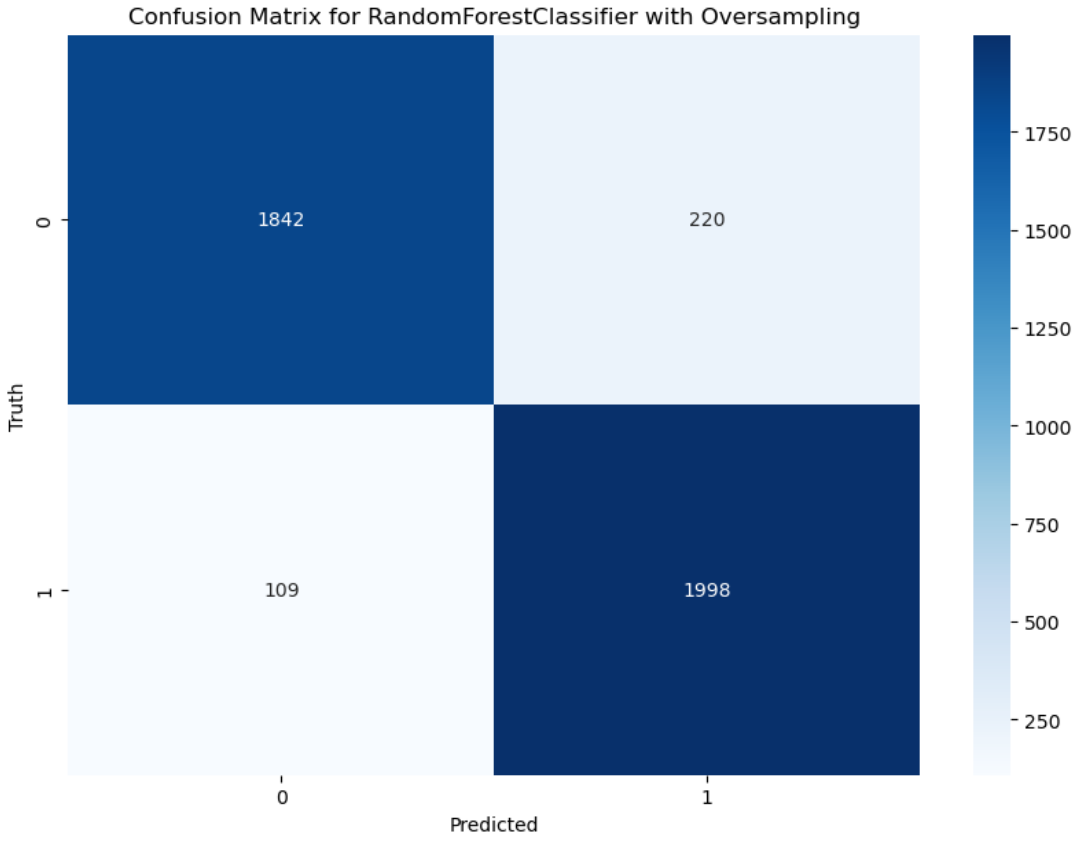
In [32]:

```
from imblearn.over_sampling import SMOTE
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

smote = SMOTE(random_state=42)
X_res, y_res = smote.fit_resample(X, y)

X_train_res, X_test_res, y_train_res, y_test_res = train_test_split(X_res, y_res, test_size=0.2, random_state=42

rfc = RandomForestClassifier(n_estimators=100, random_state=42)

rfc.fit(X_train_res, y_train_res)

y_pred_res = rfc.predict(X_test_res)

print(classification_report(y_test_res, y_pred_res))

print(confusion_matrix(y_test_res, y_pred_res))

print("Accuracy: ", accuracy_score(y_test_res, y_pred_res))

```

```
              precision    recall  f1-score   support

           0       0.94      0.89      0.92      2062
           1       0.90      0.95      0.92      2107

    accuracy                           0.92      4169
   macro avg       0.92      0.92      0.92      4169
weighted avg       0.92      0.92      0.92      4169

[[1842  220]
 [ 109 1998]]
Accuracy:  0.9210841928520028
```

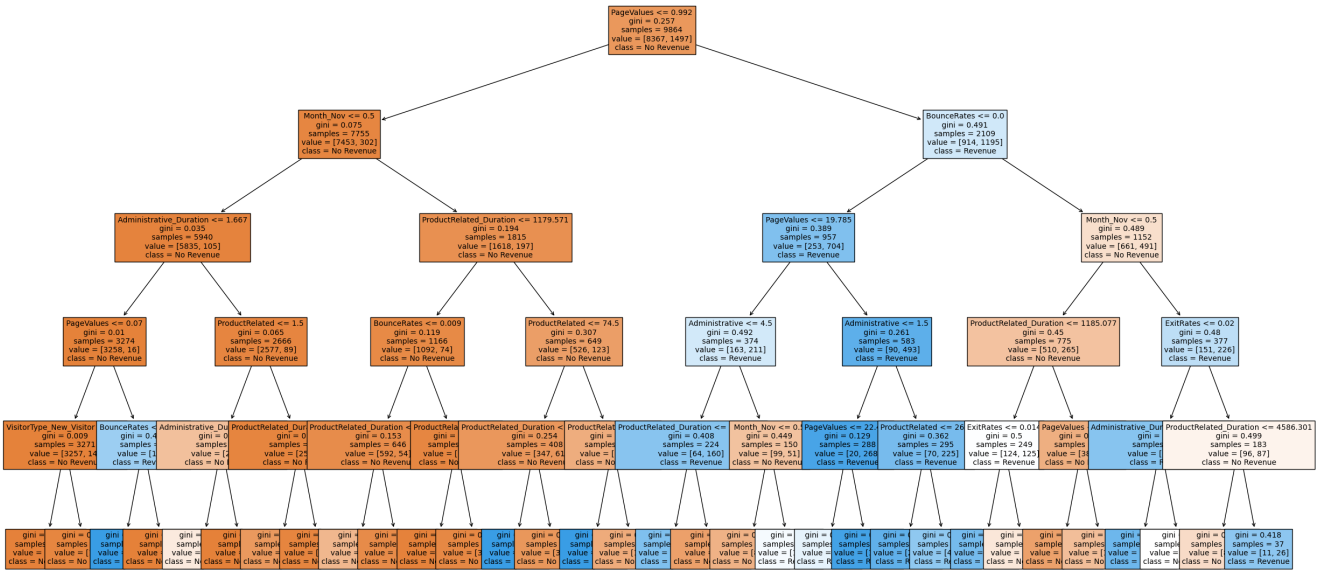
In [33]:

```
cm_rfc = confusion_matrix(y_test_res, y_pred_res)

plt.figure(figsize=(10,7))
sns.heatmap(cm_rfc, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Truth')
plt.title('Confusion Matrix for RandomForestClassifier with Oversampling')
plt.show()

```



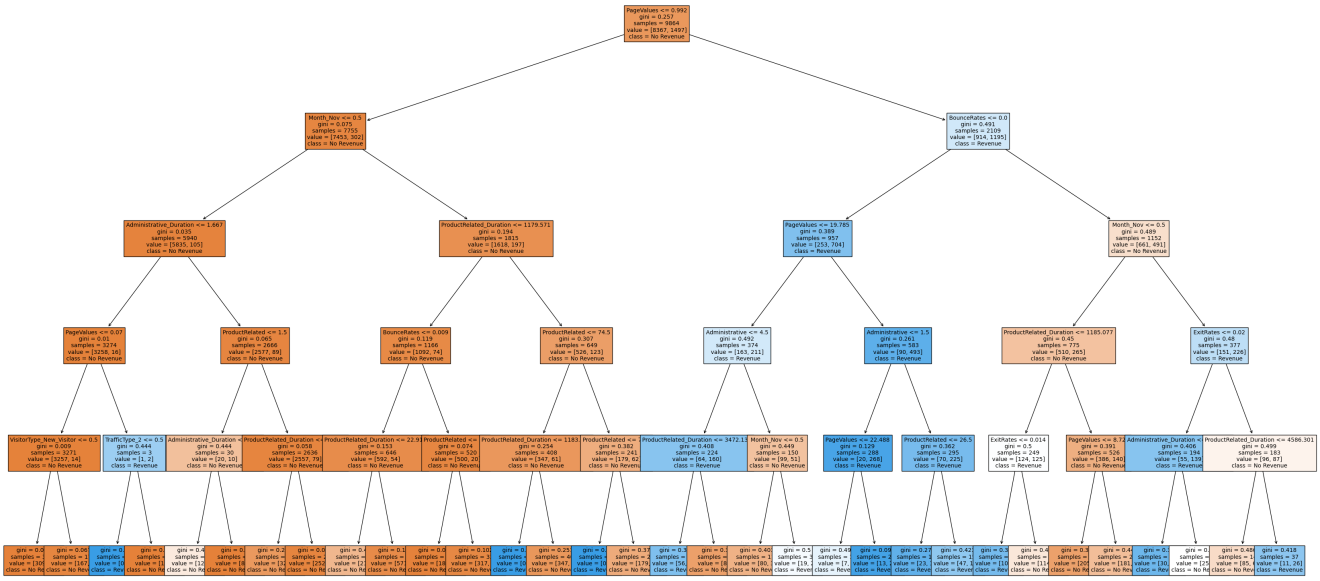
In [34]:

```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

plt.figure(figsize=(30,15))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True, fontsize=10
plt.show()

```



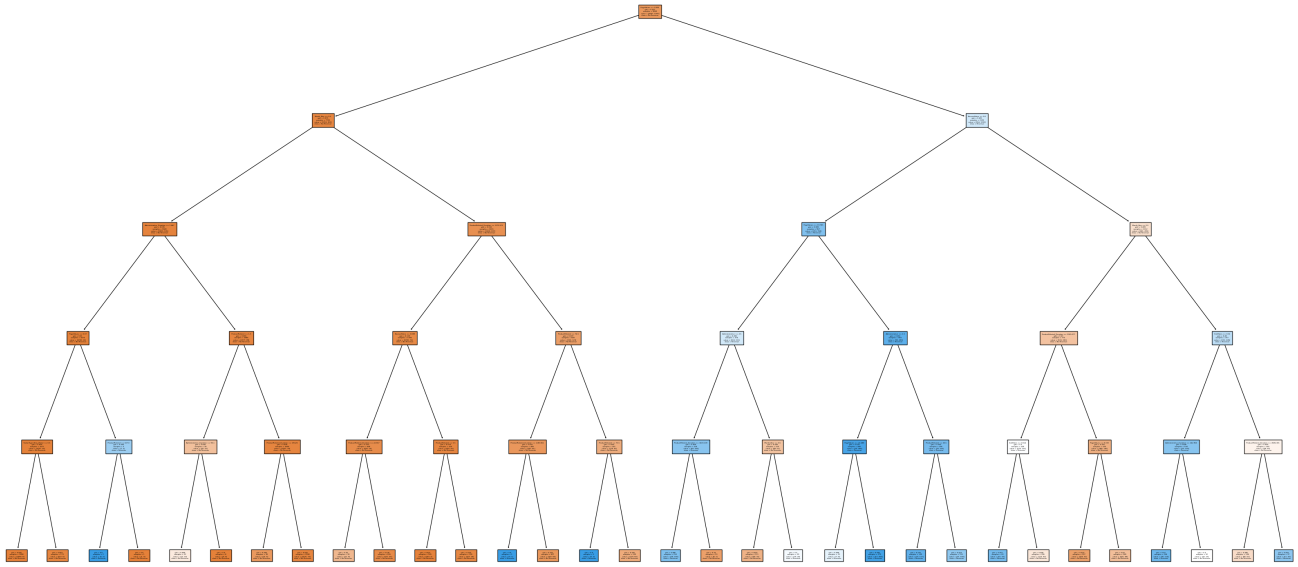
In [35]:

```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

plt.figure(figsize=(40,20))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True, fontsize=10
plt.subplots_adjust(left=0.1, right=0.9, top=0.9, bottom=0.1)
plt.show()

```



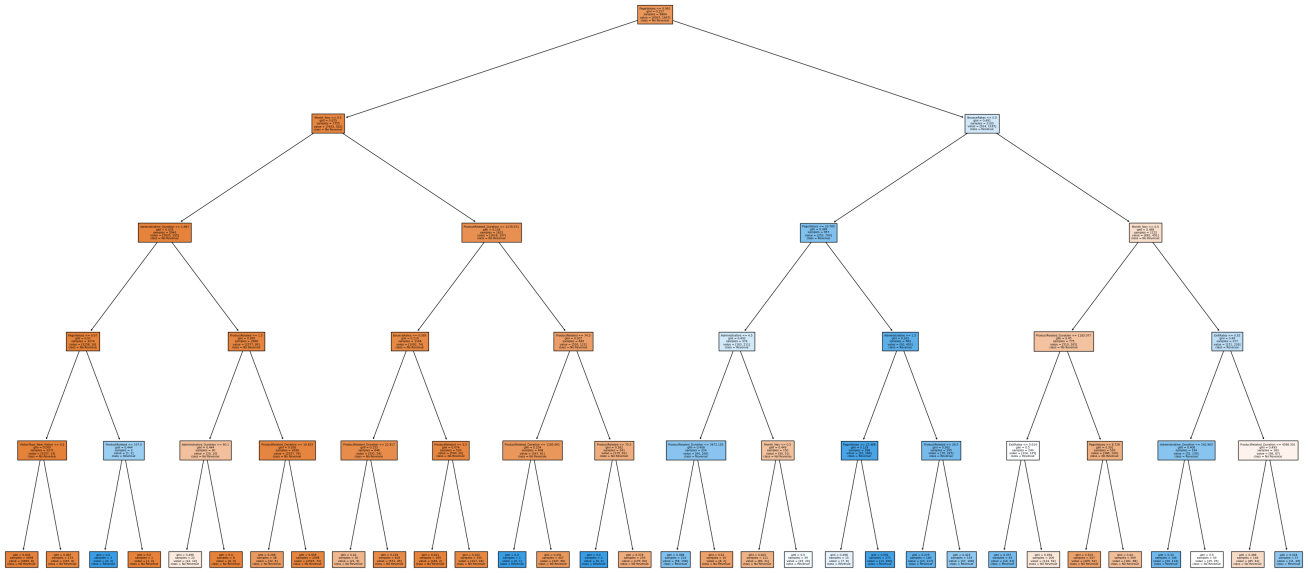
In [36]:

```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

plt.figure(figsize=(40,20))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True, fontsize=3)
plt.subplots_adjust(left=0.1, right=0.9, top=0.9, bottom=0.1)
plt.show()

```



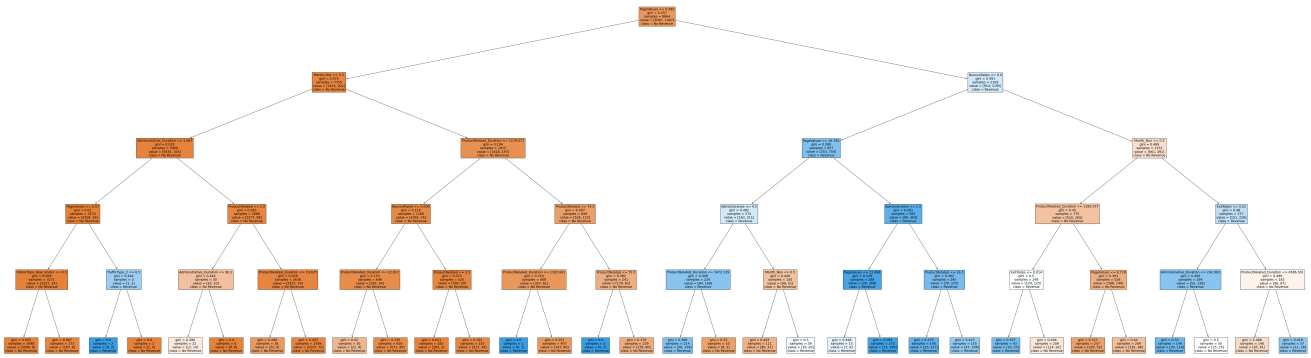
In [37]:

```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

plt.figure(figsize=(40,20))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True, fontsize=5)
plt.subplots_adjust(left=0.1, right=0.9, top=0.9, bottom=0.1)
plt.savefig("decision_tree.png", dpi=500)

plt.show()

```



In [38]:

```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

plt.figure(figsize=(100,30))
plot_tree(dtree, feature_names=X_train.columns, class_names=['No Revenue', 'Revenue'], filled=True, fontsize=14
plt.subplots_adjust(left=0.1, right=0.9, top=0.9, bottom=0.1)

plt.savefig("decision_tree.png", dpi=600)

plt.show()

```



In [39]:

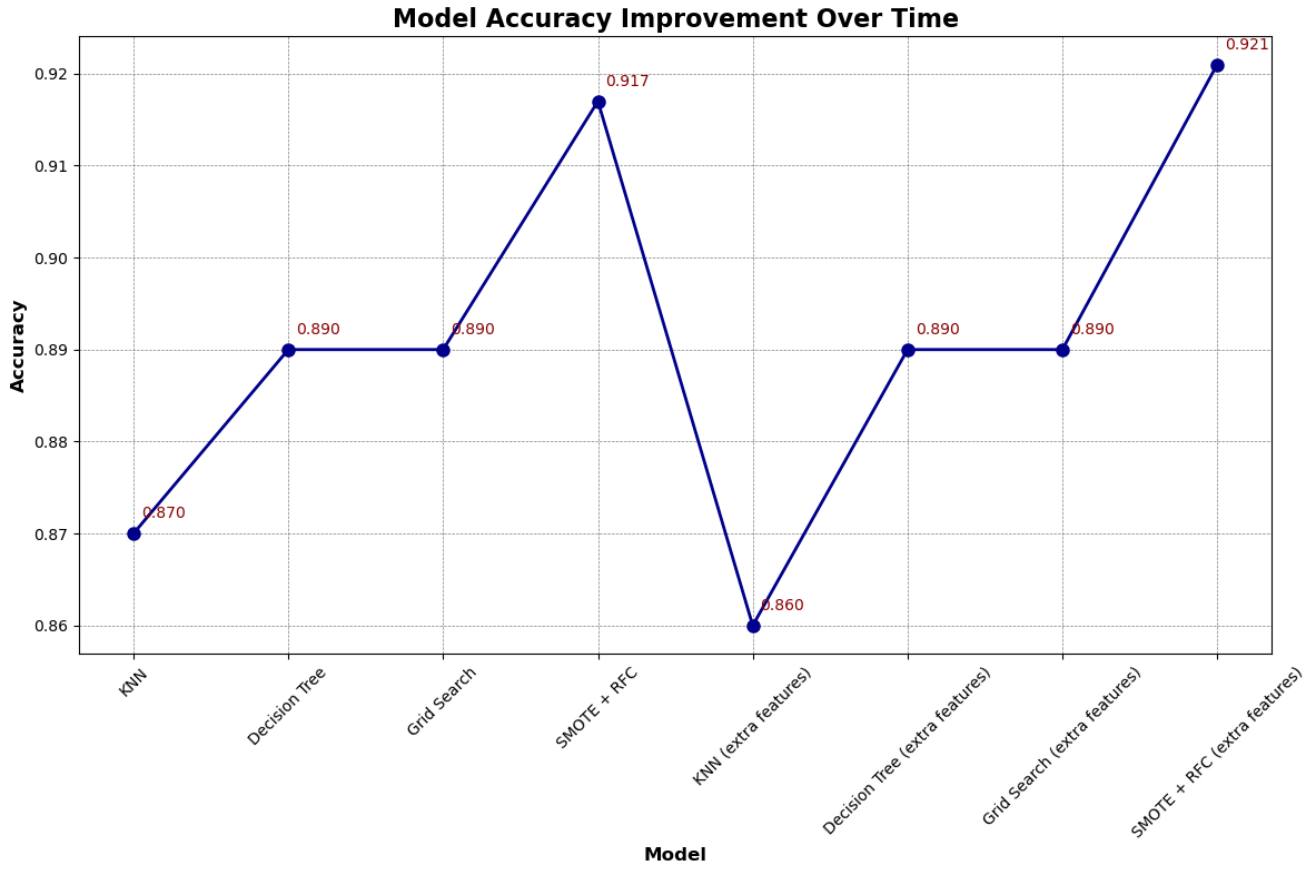
```
from sklearn.tree import DecisionTreeClassifier, export_text

dtree = DecisionTreeClassifier(max_depth=5)

dtree.fit(X_train, y_train)

tree_text = export_text(dtree, feature_names=list(X_train.columns))
print(tree_text)

```

```
|--- PageValues <= 0.99
|   |--- Month_Nov <= 0.50
|   |   |--- Administrative_Duration <= 1.67
|   |   |   |--- PageValues <= 0.07
|   |   |   |   |--- VisitorType_New_Visitor <= 0.50
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- VisitorType_New_Visitor >  0.50
|   |   |   |   |   |--- class: 0
|   |   |   |--- PageValues >  0.07
|   |   |   |   |--- ProductRelated <= 107.00
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ProductRelated >  107.00
|   |   |   |   |   |--- class: 0
|   |   |--- Administrative_Duration >  1.67
|   |   |   |--- ProductRelated <= 1.50
|   |   |   |   |--- Administrative_Duration <= 90.10
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- Administrative_Duration >  90.10
|   |   |   |   |   |--- class: 0
|   |   |   |--- ProductRelated >  1.50
|   |   |   |   |--- ProductRelated_Duration <= 19.62
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- ProductRelated_Duration >  19.62
|   |   |   |   |   |--- class: 0
|   |--- Month_Nov >  0.50
|   |   |--- ProductRelated_Duration <= 1179.57
|   |   |   |--- BounceRates <= 0.01
|   |   |   |   |--- ProductRelated_Duration <= 22.92
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- ProductRelated_Duration >  22.92
|   |   |   |   |   |--- class: 0
|   |   |   |--- BounceRates >  0.01
|   |   |   |   |--- ProductRelated <= 5.50
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- ProductRelated >  5.50
|   |   |   |   |   |--- class: 0
|   |   |--- ProductRelated_Duration >  1179.57
|   |   |   |--- ProductRelated <= 74.50
|   |   |   |   |--- ProductRelated_Duration <= 1183.06
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ProductRelated_Duration >  1183.06
|   |   |   |   |   |--- class: 0
|   |   |   |--- ProductRelated >  74.50
|   |   |   |   |--- ProductRelated <= 75.50
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ProductRelated >  75.50
|   |   |   |   |   |--- class: 0
|--- PageValues >  0.99
|   |--- BounceRates <= 0.00
|   |   |--- PageValues <= 19.78
|   |   |   |--- Administrative <= 4.50
|   |   |   |   |--- ProductRelated_Duration <= 3472.14
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ProductRelated_Duration >  3472.14
|   |   |   |   |   |--- class: 0
|   |   |   |--- Administrative >  4.50
|   |   |   |   |--- Month_Nov <= 0.50
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- Month_Nov >  0.50
|   |   |   |   |   |--- class: 1
|   |   |--- PageValues >  19.78
|   |   |   |--- Administrative <= 1.50
|   |   |   |   |--- PageValues <= 22.49
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- PageValues >  22.49
|   |   |   |   |   |--- class: 1
|   |   |   |--- Administrative >  1.50
|   |   |   |   |--- ProductRelated <= 26.50
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ProductRelated >  26.50
|   |   |   |   |   |--- class: 1
|   |--- BounceRates >  0.00
|   |   |--- Month_Nov <= 0.50
|   |   |   |--- ProductRelated_Duration <= 1185.08
|   |   |   |   |--- ExitRates <= 0.01
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- ExitRates >  0.01
|   |   |   |   |   |--- class: 0
|   |   |   |--- ProductRelated_Duration >  1185.08
|   |   |   |   |--- PageValues <= 8.73
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- PageValues >  8.73
|   |   |   |   |   |--- class: 0
```

```
|   |   |--- Month_Nov >  0.50
|   |   |   |--- ExitRates <= 0.02
|   |   |   |   |--- Administrative_Duration <= 242.96
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- Administrative_Duration >  242.96
|   |   |   |   |   |--- class: 0
|   |   |   |--- ExitRates >  0.02
|   |   |   |   |--- ProductRelated_Duration <= 4586.30
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- ProductRelated_Duration >  4586.30
|   |   |   |   |   |--- class: 1
```

In [40]:

```python
import matplotlib.pyplot as plt

accuracy_values = [0.87, 0.89, 0.89, 0.917, 0.86, 0.89, 0.89, 0.921]

models = ['KNN', 'Decision Tree', 'Grid Search', 'SMOTE + RFC', 'KNN (extra features)', 'Decision Tree (extra fe

plt.figure(figsize=(12, 8))
plt.plot(models, accuracy_values, marker='o', linestyle='-', color='darkblue', linewidth=2, markersize=8)

for i, txt in enumerate(accuracy_values):
    plt.annotate(f'{txt:.3f}', (models[i], accuracy_values[i]), xytext=(5,10), textcoords='offset points', fonts

plt.title('Model Accuracy Improvement Over Time', fontsize=16, fontweight='bold')
plt.xlabel('Model', fontsize=12, fontweight='bold')
plt.ylabel('Accuracy', fontsize=12, fontweight='bold')

plt.xticks(rotation=45)

plt.grid(color='gray', linestyle='--', linewidth=0.5)

plt.tight_layout()
plt.show()

```



In [ ]:

```python

```

In [ ]:

```python

```