de-airlines-v1-1-2

July 11, 2024

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.graph_objects as go
from plotly.subplots import make_subplots
import plotly.express as px
import warnings
from sklearn.preprocessing import StandardScaler
```

[2]:
```
from plotly import __version__
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.model_selection import cross_val_score, KFold
from sklearn.neighbors import KNeighborsClassifier
```

[3]:
```
import pandas as pd

path = r"C:\Users\Aadiluddin\OneDrive\Desktop\DE Project\train.csv"
df_Train = pd.read_csv(path)
df_Train.head()
```

[3]:
```
   Unnamed: 0      id  Gender      Customer Type  Age   Type of Travel  \
0           0   70172    Male     Loyal Customer   13  Personal Travel
1           1    5047    Male  disloyal Customer   25  Business travel
2           2  110028  Female     Loyal Customer   26  Business travel
3           3   24026  Female     Loyal Customer   25  Business travel
4           4  119299    Male     Loyal Customer   61  Business travel

      Class  Flight Distance  Inflight wifi service  \
0  Eco Plus              460                      3
1  Business              235                      3
2  Business             1142                      2
3  Business              562                      2
4  Business              214                      3
```

```
   Departure/Arrival time convenient  …  Inflight entertainment  \
0                                  4  …                       5
1                                  2  …                       1
2                                  2  …                       5
3                                  5  …                       2
4                                  3  …                       3

   On-board service  Leg room service  Baggage handling  Checkin service  \
0                 4                 3                 4                4
1                 1                 5                 3                1
2                 4                 3                 4                4
3                 2                 5                 3                1
4                 3                 4                 4                3

   Inflight service  Cleanliness  Departure Delay in Minutes  \
0                 5            5                          25
1                 4            1                           1
2                 4            5                           0
3                 4            2                          11
4                 3            3                           0

   Arrival Delay in Minutes             satisfaction
0                      18.0  neutral or dissatisfied
1                       6.0  neutral or dissatisfied
2                       0.0                satisfied
3                       9.0  neutral or dissatisfied
4                       0.0                satisfied

[5 rows x 25 columns]
```

[4]:
```
df_Train.shape
```

[4]:
```
(103904, 25)
```

[5]:
```
df_Train.info()  #checking the data types
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 103904 entries, 0 to 103903
Data columns (total 25 columns):
 #   Column                             Non-Null Count   Dtype
---  ------                             --------------   -----
 0   Unnamed: 0                         103904 non-null  int64
 1   id                                 103904 non-null  int64
 2   Gender                             103904 non-null  object
 3   Customer Type                      103904 non-null  object
 4   Age                                103904 non-null  int64
 5   Type of Travel                     103904 non-null  object
```

```
 6   Class                              103904 non-null  object
 7   Flight Distance                    103904 non-null  int64
 8   Inflight wifi service              103904 non-null  int64
 9   Departure/Arrival time convenient  103904 non-null  int64
 10  Ease of Online booking             103904 non-null  int64
 11  Gate location                      103904 non-null  int64
 12  Food and drink                     103904 non-null  int64
 13  Online boarding                    103904 non-null  int64
 14  Seat comfort                       103904 non-null  int64
 15  Inflight entertainment             103904 non-null  int64
 16  On-board service                   103904 non-null  int64
 17  Leg room service                   103904 non-null  int64
 18  Baggage handling                   103904 non-null  int64
 19  Checkin service                    103904 non-null  int64
 20  Inflight service                   103904 non-null  int64
 21  Cleanliness                        103904 non-null  int64
 22  Departure Delay in Minutes         103904 non-null  int64
 23  Arrival Delay in Minutes           103594 non-null  float64
 24  satisfaction                       103904 non-null  object
dtypes: float64(1), int64(19), object(5)
memory usage: 19.8+ MB
```

[6]:
```
df_Train["satisfaction"].value_counts()
```

[6]:
```
satisfaction
neutral or dissatisfied    58879
satisfied                  45025
Name: count, dtype: int64
```

[7]:
```
#Finding the missing values
df_Train.isnull().sum()
```

[7]:
```
Unnamed: 0                           0
id                                   0
Gender                               0
Customer Type                        0
Age                                  0
Type of Travel                       0
Class                                0
Flight Distance                      0
Inflight wifi service                0
Departure/Arrival time convenient    0
Ease of Online booking               0
Gate location                        0
Food and drink                       0
Online boarding                      0
Seat comfort                         0
```

```
Inflight entertainment                0
On-board service                      0
Leg room service                      0
Baggage handling                      0
Checkin service                       0
Inflight service                      0
Cleanliness                           0
Departure Delay in Minutes            0
Arrival Delay in Minutes            310
satisfaction                          0
dtype: int64
```

[8]:
```
#we have missing values in the "Arrival Delay in Minutes" column
```

[9]:
```
#Percentage of null values in every column
df_Train.isnull().sum()/df_Train.shape[0]*100
```

[9]:
```
Unnamed: 0                          0.000000
id                                  0.000000
Gender                              0.000000
Customer Type                       0.000000
Age                                 0.000000
Type of Travel                      0.000000
Class                               0.000000
Flight Distance                     0.000000
Inflight wifi service               0.000000
Departure/Arrival time convenient   0.000000
Ease of Online booking              0.000000
Gate location                       0.000000
Food and drink                      0.000000
Online boarding                     0.000000
Seat comfort                        0.000000
Inflight entertainment              0.000000
On-board service                    0.000000
Leg room service                    0.000000
Baggage handling                    0.000000
Checkin service                     0.000000
Inflight service                    0.000000
Cleanliness                         0.000000
Departure Delay in Minutes          0.000000
Arrival Delay in Minutes            0.298352
satisfaction                        0.000000
dtype: float64
```

[10]:
```
#Since the missing values is only 0.29% hence we are removing the null values
```

[11]:
```
df2_Train = df_Train.dropna(subset=['Arrival Delay in Minutes'])
```

[12]:
```
df2_Train.isnull().sum()
```

[12]:
```
Unnamed: 0                          0
id                                  0
Gender                              0
Customer Type                       0
Age                                 0
Type of Travel                      0
Class                               0
Flight Distance                     0
Inflight wifi service               0
Departure/Arrival time convenient   0
Ease of Online booking              0
Gate location                       0
Food and drink                      0
Online boarding                     0
Seat comfort                        0
Inflight entertainment              0
On-board service                    0
Leg room service                    0
Baggage handling                    0
Checkin service                     0
Inflight service                    0
Cleanliness                         0
Departure Delay in Minutes          0
Arrival Delay in Minutes            0
satisfaction                        0
dtype: int64
```

[13]:
```
#df_Train is now stored to df2_Train with no null values
```

[14]:
```
#Performing the same with Test dataset
```

[15]:
```
import pandas as pd

path = r"C:\Users\Aadiluddin\OneDrive\Desktop\DE Project\test.csv"
df_Test = pd.read_csv(path)
df_Test.head()
```

[15]:

	Unnamed: 0	id	Gender	Customer Type	Age	Type of Travel	\
0	0	19556	Female	Loyal Customer	52	Business travel	
1	1	90035	Female	Loyal Customer	36	Business travel	
2	2	12360	Male	disloyal Customer	20	Business travel	
3	3	77959	Male	Loyal Customer	44	Business travel	
4	4	36875	Female	Loyal Customer	49	Business travel	

	Class	Flight Distance	Inflight wifi service	\

```
0       Eco              160                       5
1  Business             2863                       1
2       Eco              192                       2
3  Business             3377                       0
4       Eco             1182                       2

   Departure/Arrival time convenient  …  Inflight entertainment  \
0                                  4  …                       5
1                                  1  …                       4
2                                  0  …                       2
3                                  0  …                       1
4                                  3  …                       2

   On-board service  Leg room service  Baggage handling  Checkin service  \
0                 5                 5                 5                2
1                 4                 4                 4                3
2                 4                 1                 3                2
3                 1                 1                 1                3
4                 2                 2                 2                4

   Inflight service  Cleanliness  Departure Delay in Minutes  \
0                 5            5                          50
1                 4            5                           0
2                 2            2                           0
3                 1            4                           0
4                 2            4                           0

   Arrival Delay in Minutes             satisfaction
0                      44.0                satisfied
1                       0.0                satisfied
2                       0.0  neutral or dissatisfied
3                       6.0                satisfied
4                      20.0                satisfied

[5 rows x 25 columns]
```

[16]:
```
df_Test.shape
```

[16]:
```
(25976, 25)
```

[17]:
```
df_Test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 25976 entries, 0 to 25975
Data columns (total 25 columns):
 #   Column                            Non-Null Count  Dtype
---  ------                            --------------  -----
```

```
 0   Unnamed: 0                         25976 non-null  int64
 1   id                                 25976 non-null  int64
 2   Gender                             25976 non-null  object
 3   Customer Type                      25976 non-null  object
 4   Age                                25976 non-null  int64
 5   Type of Travel                     25976 non-null  object
 6   Class                              25976 non-null  object
 7   Flight Distance                    25976 non-null  int64
 8   Inflight wifi service              25976 non-null  int64
 9   Departure/Arrival time convenient  25976 non-null  int64
 10  Ease of Online booking             25976 non-null  int64
 11  Gate location                      25976 non-null  int64
 12  Food and drink                     25976 non-null  int64
 13  Online boarding                    25976 non-null  int64
 14  Seat comfort                       25976 non-null  int64
 15  Inflight entertainment             25976 non-null  int64
 16  On-board service                   25976 non-null  int64
 17  Leg room service                   25976 non-null  int64
 18  Baggage handling                   25976 non-null  int64
 19  Checkin service                    25976 non-null  int64
 20  Inflight service                   25976 non-null  int64
 21  Cleanliness                        25976 non-null  int64
 22  Departure Delay in Minutes         25976 non-null  int64
 23  Arrival Delay in Minutes           25893 non-null  float64
 24  satisfaction                       25976 non-null  object
dtypes: float64(1), int64(19), object(5)
memory usage: 5.0+ MB
```

[18]:
```
df_Test["satisfaction"].value_counts()
```

[18]:
```
satisfaction
neutral or dissatisfied    14573
satisfied                  11403
Name: count, dtype: int64
```

[19]:
```
#Finding the missing values
df_Test.isnull().sum()
```

[19]:
```
Unnamed: 0                         0
id                                 0
Gender                             0
Customer Type                      0
Age                                0
Type of Travel                     0
Class                              0
Flight Distance                    0
Inflight wifi service              0
```

```
Departure/Arrival time convenient     0
Ease of Online booking                0
Gate location                         0
Food and drink                        0
Online boarding                       0
Seat comfort                          0
Inflight entertainment                0
On-board service                      0
Leg room service                      0
Baggage handling                      0
Checkin service                       0
Inflight service                      0
Cleanliness                           0
Departure Delay in Minutes            0
Arrival Delay in Minutes             83
satisfaction                          0
dtype: int64
```

[20]:
```
#we have missing values in the "Arrival Delay in Minutes" column
```

[21]:
```
#Percentage of null values in every column
df_Test.isnull().sum()/df_Test.shape[0]*100
```

[21]:
```
Unnamed: 0                          0.000000
id                                  0.000000
Gender                              0.000000
Customer Type                       0.000000
Age                                 0.000000
Type of Travel                      0.000000
Class                               0.000000
Flight Distance                     0.000000
Inflight wifi service               0.000000
Departure/Arrival time convenient   0.000000
Ease of Online booking              0.000000
Gate location                       0.000000
Food and drink                      0.000000
Online boarding                     0.000000
Seat comfort                        0.000000
Inflight entertainment              0.000000
On-board service                    0.000000
Leg room service                    0.000000
Baggage handling                    0.000000
Checkin service                     0.000000
Inflight service                    0.000000
Cleanliness                         0.000000
Departure Delay in Minutes          0.000000
Arrival Delay in Minutes            0.319526
```

```
satisfaction                         0.000000
dtype: float64
```

[22]:
```
#Since the missing values is only 0.31% hence we are removing the null values
```

[23]:
```
df2_Test = df_Test.dropna(subset=['Arrival Delay in Minutes'])
```

[24]:
```
df2_Test.isnull().sum()
```

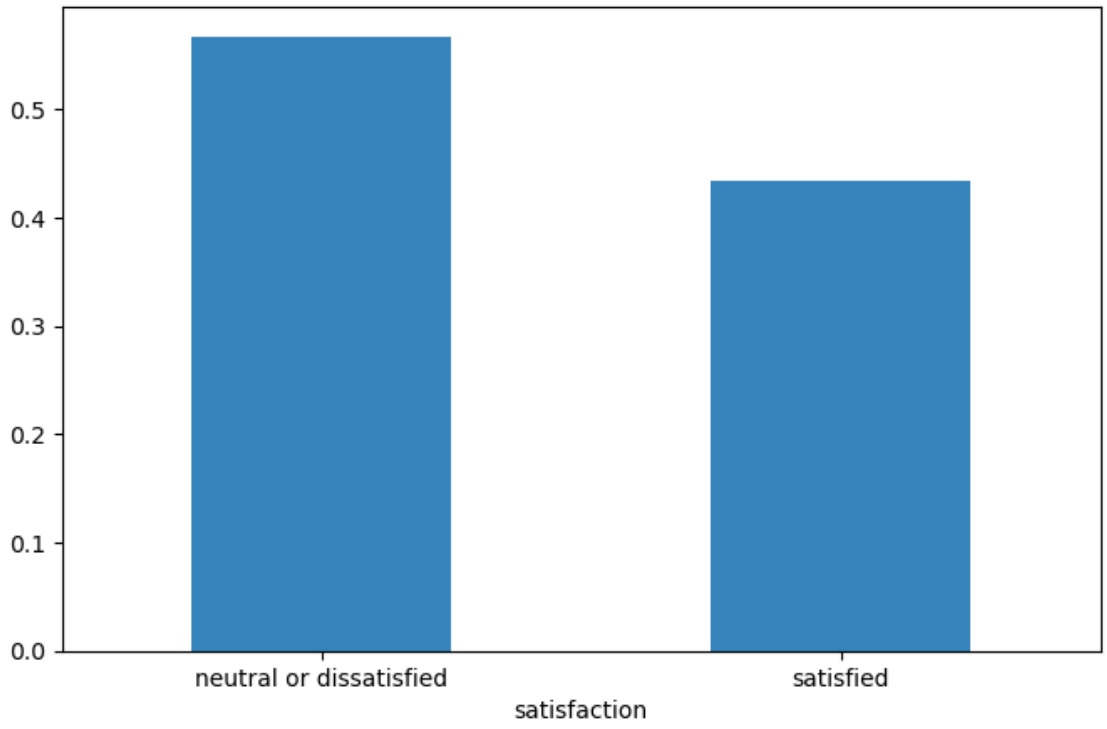
[24]:
```
Unnamed: 0                         0
id                                 0
Gender                             0
Customer Type                      0
Age                                0
Type of Travel                     0
Class                              0
Flight Distance                    0
Inflight wifi service              0
Departure/Arrival time convenient  0
Ease of Online booking             0
Gate location                      0
Food and drink                     0
Online boarding                    0
Seat comfort                       0
Inflight entertainment             0
On-board service                   0
Leg room service                   0
Baggage handling                   0
Checkin service                    0
Inflight service                   0
Cleanliness                        0
Departure Delay in Minutes         0
Arrival Delay in Minutes           0
satisfaction                       0
dtype: int64
```

[25]:
```
#df_Test is now stored to df2_Test with no null values
```

[26]:
```
#Target Variable= satisfaction column
```

##Checking for Imbalance

[27]:
```
fig = plt.figure(figsize = (8,5))
df2_Train.satisfaction.value_counts(normalize = True).plot(kind='bar', alpha =␣
↪0.9, rot=0)
plt.show()
```



[28]:
```
df2_Train["satisfaction"].value_counts()
```

[28]:
```
satisfaction
neutral or dissatisfied    58697
satisfied                  44897
Name: count, dtype: int64
```

[29]:
```
# The above plot shows a distribution of around 55%:45% between neutral/
 ↪dissatisfied passengers and satisfied passengers respectively.
#So the data is quite balanced and it does not require any special treatment/
 ↪resampling.
```

[30]:
```
#There are two columns Unnamed: 0 and id,These two columns add no value to␣
 ↪classification model, Hence we remove it
```

[31]:
```
df2_Train.columns
```

[31]:
```
Index(['Unnamed: 0', 'id', 'Gender', 'Customer Type', 'Age', 'Type of Travel',
       'Class', 'Flight Distance', 'Inflight wifi service',
       'Departure/Arrival time convenient', 'Ease of Online booking',
       'Gate location', 'Food and drink', 'Online boarding', 'Seat comfort',
       'Inflight entertainment', 'On-board service', 'Leg room service',
       'Baggage handling', 'Checkin service', 'Inflight service',
```

```
       'Cleanliness', 'Departure Delay in Minutes', 'Arrival Delay in Minutes',
       'satisfaction'],
      dtype='object')
```

[32]:
```
df2_Train.drop(['Unnamed: 0','id'],axis=1,inplace=True)
```

```
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\1278790529.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df2_Train.drop(['Unnamed: 0','id'],axis=1,inplace=True)
```

[33]:
```
df2_Train.columns
```

[33]:
```
Index(['Gender', 'Customer Type', 'Age', 'Type of Travel', 'Class',
       'Flight Distance', 'Inflight wifi service',
       'Departure/Arrival time convenient', 'Ease of Online booking',
       'Gate location', 'Food and drink', 'Online boarding', 'Seat comfort',
       'Inflight entertainment', 'On-board service', 'Leg room service',
       'Baggage handling', 'Checkin service', 'Inflight service',
       'Cleanliness', 'Departure Delay in Minutes', 'Arrival Delay in Minutes',
       'satisfaction'],
      dtype='object')
```

[34]:
```
df2_Train.columns = [c.replace(' ', '_') for c in df2_Train.columns]
```

[35]:
```
df2_Test.columns = [c.replace(' ', '_') for c in df2_Test.columns]
```

[36]:
```
#on the above two steps we have replaces the blanks in the column names with␣
↪"_" so that model dosent have any misunderstanding
```

[37]:
```
df2_Train.columns
```

[37]:
```
Index(['Gender', 'Customer_Type', 'Age', 'Type_of_Travel', 'Class',
       'Flight_Distance', 'Inflight_wifi_service',
       'Departure/Arrival_time_convenient', 'Ease_of_Online_booking',
       'Gate_location', 'Food_and_drink', 'Online_boarding', 'Seat_comfort',
       'Inflight_entertainment', 'On-board_service', 'Leg_room_service',
       'Baggage_handling', 'Checkin_service', 'Inflight_service',
       'Cleanliness', 'Departure_Delay_in_Minutes', 'Arrival_Delay_in_Minutes',
       'satisfaction'],
      dtype='object')
```

[38]:
```
df2_Test.columns
```

[38]:
```
Index(['Unnamed:_0', 'id', 'Gender', 'Customer_Type', 'Age', 'Type_of_Travel',
       'Class', 'Flight_Distance', 'Inflight_wifi_service',
       'Departure/Arrival_time_convenient', 'Ease_of_Online_booking',
       'Gate_location', 'Food_and_drink', 'Online_boarding', 'Seat_comfort',
       'Inflight_entertainment', 'On-board_service', 'Leg_room_service',
       'Baggage_handling', 'Checkin_service', 'Inflight_service',
       'Cleanliness', 'Departure_Delay_in_Minutes', 'Arrival_Delay_in_Minutes',
       'satisfaction'],
      dtype='object')
```

[39]:
```
df2_Test.drop(['Unnamed:_0','id'],axis=1,inplace=True)
```

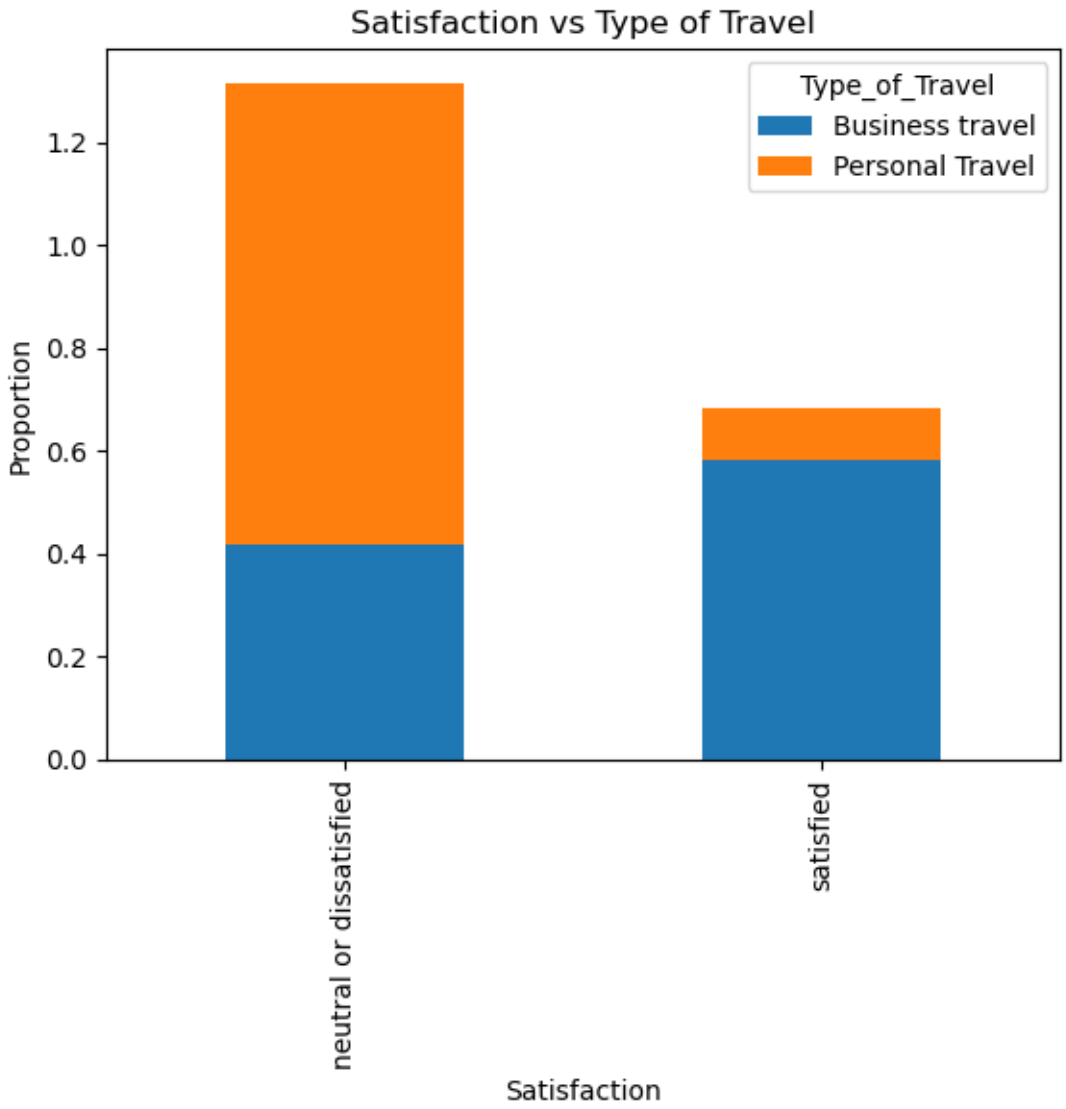
```
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\2939611551.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df2_Test.drop(['Unnamed:_0','id'],axis=1,inplace=True)
```

[40]:
```
df2_Test.columns
```

[40]:
```
Index(['Gender', 'Customer_Type', 'Age', 'Type_of_Travel', 'Class',
       'Flight_Distance', 'Inflight_wifi_service',
       'Departure/Arrival_time_convenient', 'Ease_of_Online_booking',
       'Gate_location', 'Food_and_drink', 'Online_boarding', 'Seat_comfort',
       'Inflight_entertainment', 'On-board_service', 'Leg_room_service',
       'Baggage_handling', 'Checkin_service', 'Inflight_service',
       'Cleanliness', 'Departure_Delay_in_Minutes', 'Arrival_Delay_in_Minutes',
       'satisfaction'],
      dtype='object')
```

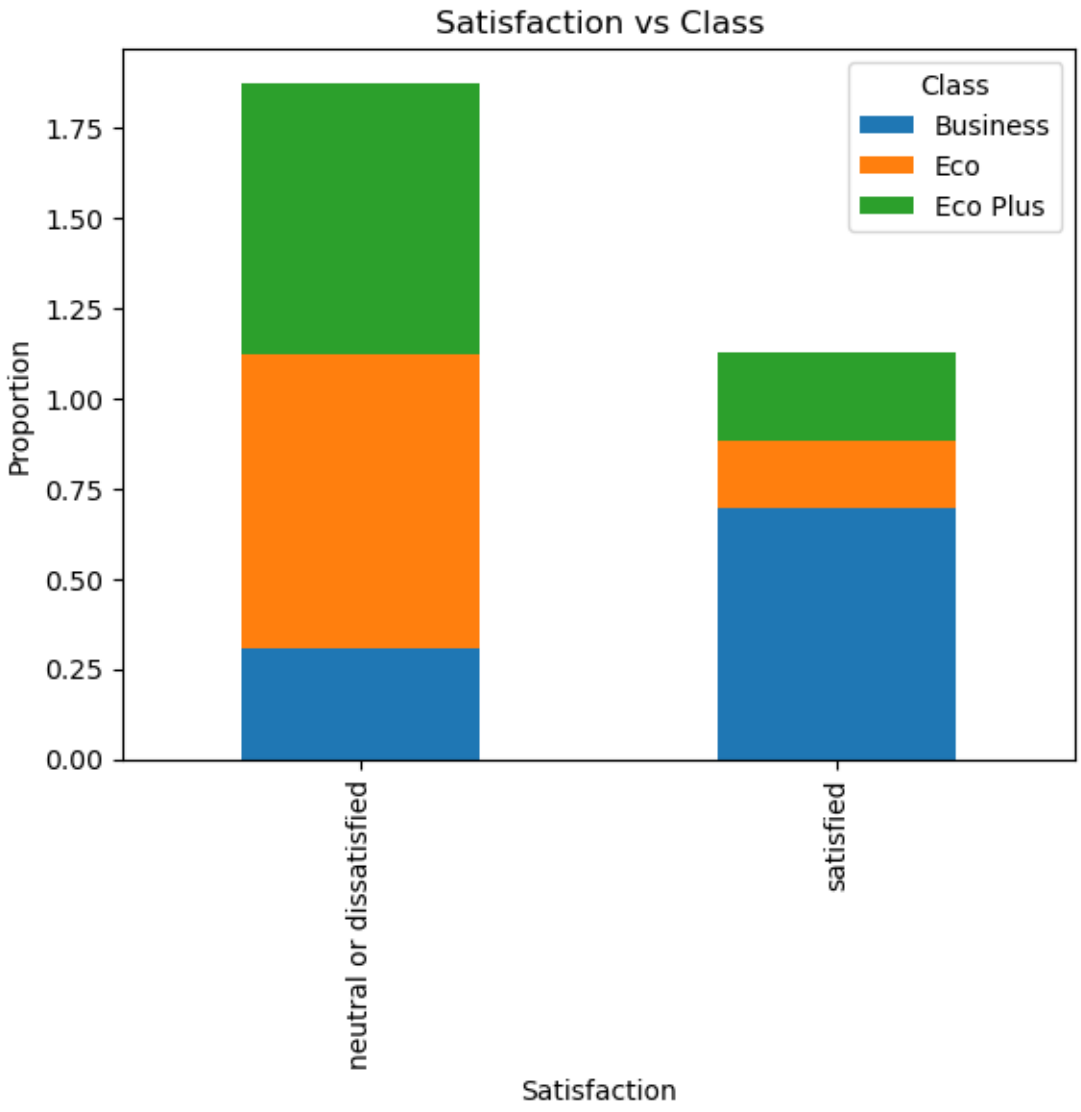
[41]:
```
#Identify 5 common trends/myths/observation
```

[42]:
```
# Cross-tabulation of satisfaction and type of travel
satisfaction_type_of_travel = pd.crosstab(df2_Train['satisfaction'],␣
 ↪df2_Train['Type_of_Travel'], normalize='columns')
satisfaction_type_of_travel.plot(kind='bar', stacked=True)
plt.title('Satisfaction vs Type of Travel')
plt.xlabel('Satisfaction')
plt.ylabel('Proportion')
plt.show()
```



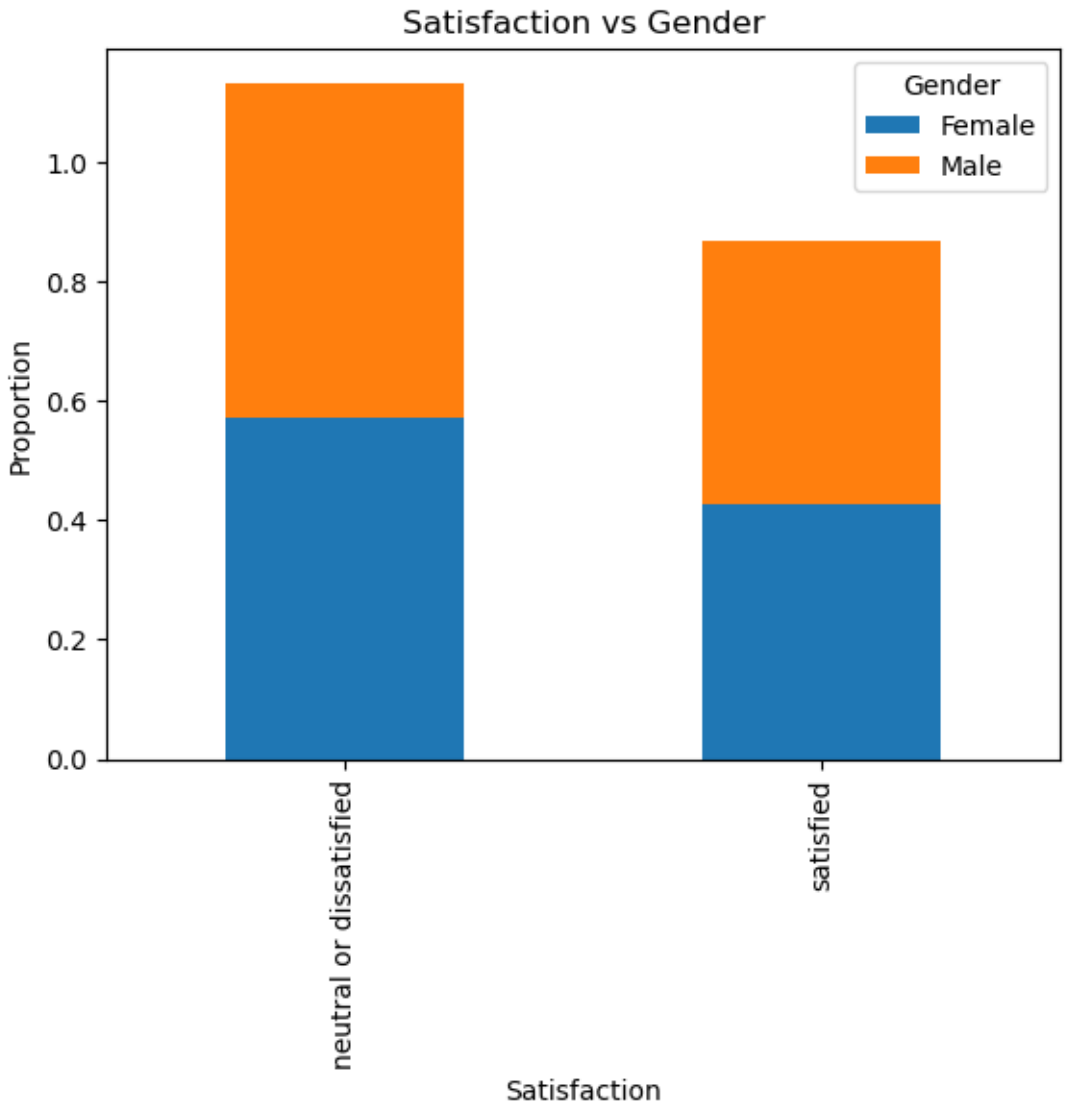
[43]:
```
#Business travelers are more likely to be satisfied than personal travelers
```

[44]:
```
# Cross-tabulation of satisfaction and class
satisfaction_class = pd.crosstab(df2_Train['satisfaction'], df2_Train['Class'],␣
↪normalize='columns')
satisfaction_class.plot(kind='bar', stacked=True)
plt.title('Satisfaction vs Class')
plt.xlabel('Satisfaction')
plt.ylabel('Proportion')
plt.show()
```



[45]:
```
#Passengers traveling in higher classes are more likely to be satisfied␣
 ↪compared to those in lower classes.
```

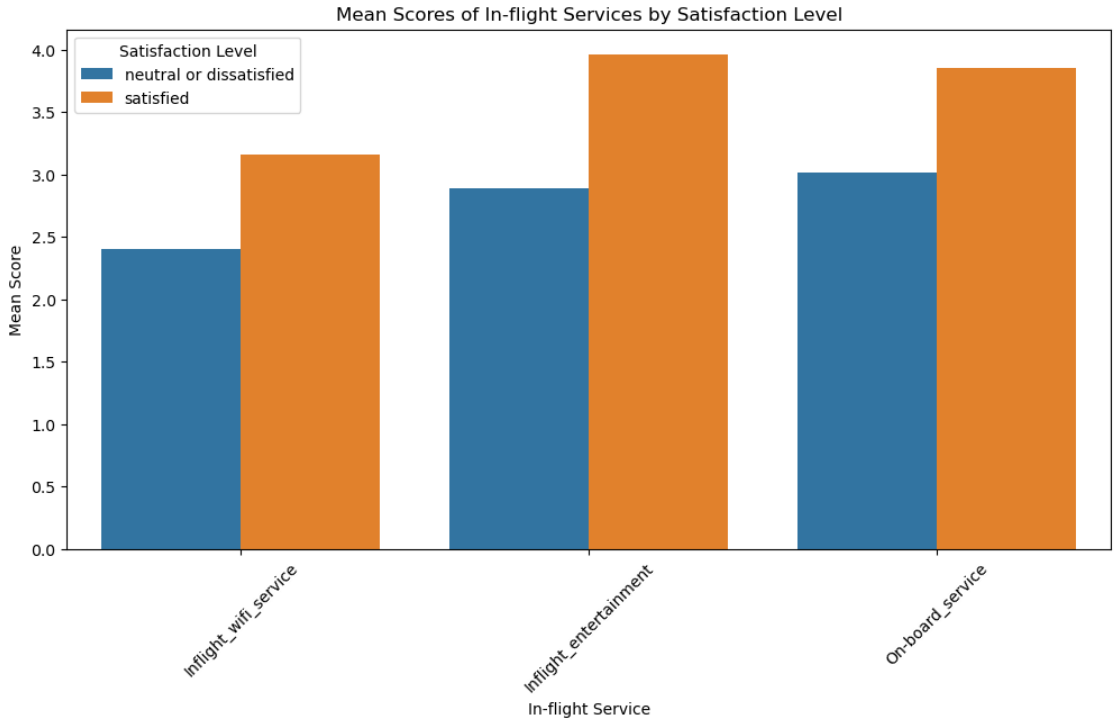
[46]:
```
# Cross-tabulation of satisfaction and gender
satisfaction_gender = pd.crosstab(df2_Train['satisfaction'],␣
 ↪df2_Train['Gender'], normalize='columns')
satisfaction_gender.plot(kind='bar', stacked=True)
plt.title('Satisfaction vs Gender')
plt.xlabel('Satisfaction')
plt.ylabel('Proportion')
plt.show()
```



[47]:
```
#There is no significant difference in satisfaction levels between male and␣
↪female passengers
```

[48]:
```
inflight_services = ['Inflight_wifi_service', 'Inflight_entertainment',␣
↪'On-board_service']


mean_scores = df2_Train.groupby('satisfaction')[inflight_services].mean().
↪reset_index()
```

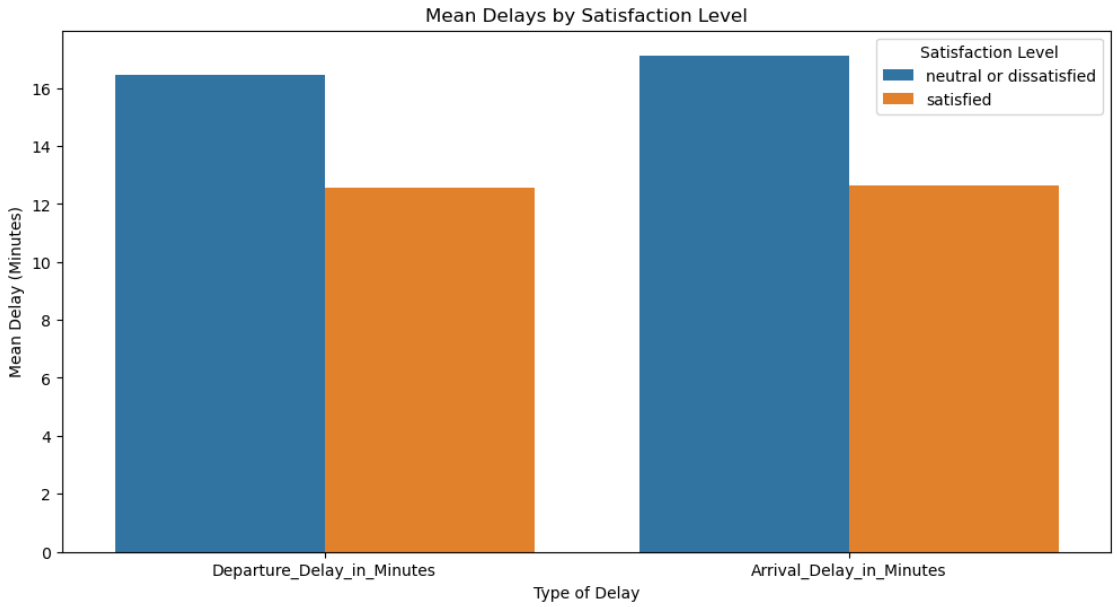
```
mean_scores_melted = mean_scores.melt(id_vars='satisfaction',␣
 ↪var_name='Service', value_name='Mean Score')


plt.figure(figsize=(12, 6))
sns.barplot(data=mean_scores_melted, x='Service', y='Mean Score',␣
 ↪hue='satisfaction')
plt.title('Mean Scores of In-flight Services by Satisfaction Level')
plt.ylabel('Mean Score')
plt.xlabel('In-flight Service')
plt.legend(title='Satisfaction Level')
plt.xticks(rotation=45)
plt.show()
```



[49]:
```
#Higher ratings in in-flight services ( 'Inflight wifi service', 'Inflight␣
 ↪entertainment', 'On-board service') correlate with higher satisfaction.
```

[50]:
```
mean_delays = df2_Train.groupby('satisfaction')[['Departure_Delay_in_Minutes',␣
 ↪'Arrival_Delay_in_Minutes']].mean().reset_index()
mean_delays_melted = mean_delays.melt(id_vars='satisfaction', var_name='Delay␣
 ↪Type', value_name='Mean Delay')
plt.figure(figsize=(12, 6))
```

```
sns.barplot(data=mean_delays_melted, x='Delay Type', y='Mean Delay',␣
 ↪hue='satisfaction')
plt.title('Mean Delays by Satisfaction Level')
plt.ylabel('Mean Delay (Minutes)')
plt.xlabel('Type of Delay')
plt.legend(title='Satisfaction Level')
plt.show()
```



[51]:
```
#Higher ratings in in-flight services ( 'Inflight wifi service', 'Inflight␣
 ↪entertainment', 'On-board service') correlate with higher satisfaction.
```

[52]:
```
from scipy.stats import chi2_contingency

#Null hupothesis HO: There is no significant association between Type of Travel␣
 ↪and Satisfaction.
#Alt Hupothesis Ha: There is a significant association between Type of Travel␣
 ↪and Satisfaction.

contingency_table = pd.crosstab(df2_Train['Type_of_Travel'],␣
 ↪df2_Train['satisfaction'])

chi2, p, dof, expected = chi2_contingency(contingency_table)

print(f"Chi-square statistic: {chi2}, p-value: {p:.6f}")

if p < 0.05:
```

```
    print("Reject the null hypothesis: There is a significant association␣
 ↪between Type of Travel and Satisfaction.")
else:
    print("Fail to reject the null hypothesis: No significant association␣
 ↪between Type of Travel and Satisfaction.")
```

```
Chi-square statistic: 20882.2212853913, p-value: 0.000000
Reject the null hypothesis: There is a significant association between Type of
Travel and Satisfaction.
```

[53]:
```
contingency_table = pd.crosstab(df2_Train['Class'], df2_Train['satisfaction'])
#Null hupothesis HO: There is no significant association between Class and␣
 ↪Satisfaction.
#Alt Hupothesis Ha: There is a significant association between Class and␣
 ↪Satisfaction.

chi2, p, dof, expected = chi2_contingency(contingency_table)
print(f"Chi-square statistic: {chi2}, p-value: {p:.6f}")
if p < 0.05:
    print("Reject the null hypothesis: There is a significant association␣
 ↪between Class and Satisfaction.")
else:
    print("Fail to reject the null hypothesis: No significant association␣
 ↪between Class and Satisfaction.")
```

```
Chi-square statistic: 26402.22202396346, p-value: 0.000000
Reject the null hypothesis: There is a significant association between Class and
Satisfaction.
```

[54]:
```
# Create a contingency table
contingency_table = pd.crosstab(df2_Train['Gender'], df2_Train['satisfaction'])

#Null hupothesis HO: There is no significant association between Gender and␣
 ↪Satisfaction.
#Alt Hupothesis Ha: There is a significant association between Gender and␣
 ↪Satisfaction.

chi2, p, dof, expected = chi2_contingency(contingency_table)
print(f"Chi-square statistic: {chi2}, p-value: {p}")

if p < 0.05:
    print("Reject the null hypothesis: There is a significant association␣
 ↪between Gender and Satisfaction.")
else:
    print("Fail to reject the null hypothesis: No significant association␣
 ↪between Gender and Satisfaction.")
```

```
Chi-square statistic: 15.765917970126587, p-value: 7.168224693815838e-05
Reject the null hypothesis: There is a significant association between Gender
and Satisfaction.
```

[55]:
```
from scipy.stats import ttest_ind

inflight_services = ['Inflight_wifi_service', 'Inflight_entertainment',␣
 ↪'On-board_service']

satisfied = df2_Train[df2_Train['satisfaction'] == 'satisfied']
dissatisfied = df2_Train[df2_Train['satisfaction'] == 'neutral or dissatisfied']

for service in inflight_services:
    t_stat, p_value = ttest_ind(satisfied[service], dissatisfied[service])
    print(f"{service}: t-statistic={t_stat}, p-value={p_value}")

    if p_value < 0.05:
        print(f"Reject the null hypothesis: {service} is significantly␣
 ↪different between Satisfaction levels.")
    else:
        print(f"Fail to reject the null hypothesis: No significant difference␣
 ↪in {service} between Satisfaction levels.")
```

```
Inflight_wifi_service: t-statistic=95.39229581572593, p-value=0.0
Reject the null hypothesis: Inflight_wifi_service is significantly different
between Satisfaction levels.
Inflight_entertainment: t-statistic=139.71977480916846, p-value=0.0
Reject the null hypothesis: Inflight_entertainment is significantly different
between Satisfaction levels.
On-board_service: t-statistic=109.63914679640678, p-value=0.0
Reject the null hypothesis: On-board_service is significantly different between
Satisfaction levels.
```

[56]:
```
from scipy.stats import ttest_ind

delays = ['Departure_Delay_in_Minutes', 'Arrival_Delay_in_Minutes']

satisfied = df2_Train[df2_Train['satisfaction'] == 'satisfied']
dissatisfied = df2_Train[df2_Train['satisfaction'] == 'neutral or dissatisfied']

for delay in delays:
    t_stat, p_value = ttest_ind(satisfied[delay], dissatisfied[delay])
    print(f"{delay}: t-statistic={t_stat}, p-value={p_value}")

    if p_value < 0.05:
        print(f"Reject the null hypothesis: {delay} is significantly different␣
 ↪between Satisfaction levels.")
```

```
    else:
        print(f"Fail to reject the null hypothesis: No significant difference␣
↪in {delay} between Satisfaction levels.")
```

```
Departure_Delay_in_Minutes: t-statistic=-16.27942175542609,
p-value=1.638513167620699e-59
Reject the null hypothesis: Departure_Delay_in_Minutes is significantly
different between Satisfaction levels.
Arrival_Delay_in_Minutes: t-statistic=-18.56392087692533,
p-value=8.391469906707979e-77
Reject the null hypothesis: Arrival_Delay_in_Minutes is significantly different
between Satisfaction levels.
```

Encoding of Categorical Variables

[57]:
```
def transform_gender(x):
    if x == 'Female':
        return 1
    elif x == 'Male':
        return 0
    else:
        return -1

def transform_customer_type(x):
    if x == 'Loyal Customer':
        return 1
    elif x == 'disloyal Customer':
        return 0
    else:
        return -1

def transform_travel_type(x):
    if x == 'Business travel':
        return 1
    elif x == 'Personal Travel':
        return 0
    else:
        return -1

def transform_class(x):
    if x == 'Business':
        return 2
    elif x == 'Eco Plus':
        return 1
    elif x == 'Eco':
        return 0
    else:
        return -1
```

```
def transform_satisfaction(x):
    if x == 'satisfied':
        return 1
    elif x == 'neutral or dissatisfied':
        return 0
    else:
        return -1

def process_data(df):
    df['Gender'] = df['Gender'].apply(transform_gender)
    df['Customer_Type'] = df['Customer_Type'].apply(transform_customer_type)
    df['Type_of_Travel'] = df['Type_of_Travel'].apply(transform_travel_type)
    df['Class'] = df['Class'].apply(transform_class)
    df['satisfaction'] = df['satisfaction'].apply(transform_satisfaction)

    return df

df2_Train = process_data(df2_Train)
df2_Test = process_data(df2_Test)
```

```
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\24403049.py:44:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Gender'] = df['Gender'].apply(transform_gender)
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\24403049.py:45:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Customer_Type'] = df['Customer_Type'].apply(transform_customer_type)
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\24403049.py:46:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Type_of_Travel'] = df['Type_of_Travel'].apply(transform_travel_type)
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\24403049.py:47:
SettingWithCopyWarning:
```

```
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Class'] = df['Class'].apply(transform_class)
C:\Users\Aadiluddin\AppData\Local\Temp\ipykernel_22600\24403049.py:48:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['satisfaction'] = df['satisfaction'].apply(transform_satisfaction)
```

[58]:
```
df2_Train
```

[58]:

	Gender	Customer_Type	Age	Type_of_Travel	Class	Flight_Distance	\
0	0	1	13	0	1	460	
1	0	0	25	1	2	235	
2	1	1	26	1	2	1142	
3	1	1	25	1	2	562	
4	0	1	61	1	2	214	
…	…	…	…	…	…	…	
103899	1	0	23	1	0	192	
103900	0	1	49	1	2	2347	
103901	0	0	30	1	2	1995	
103902	1	0	22	1	0	1000	
103903	0	1	27	1	2	1723	

	Inflight_wifi_service	Departure/Arrival_time_convenient	\
0	3	4	
1	3	2	
2	2	2	
3	2	5	
4	3	3	
…	…	…	
103899	2	1	
103900	4	4	
103901	1	1	
103902	1	1	
103903	1	3	

	Ease_of_Online_booking	Gate_location	…	Inflight_entertainment	\
0	3	1	…	5	
1	3	3	…	1	
2	2	2	…	5	

```
3                          5              5  …                      2
4                          3              3  …                      3
…                        …              …  …                    …
103899                     2              3  …                      2
103900                     4              4  …                      5
103901                     1              3  …                      4
103902                     1              5  …                      1
103903                     3              3  …                      1

        On-board_service  Leg_room_service  Baggage_handling  Checkin_service  \
0                      4                 3                 4                4
1                      1                 5                 3                1
2                      4                 3                 4                4
3                      2                 5                 3                1
4                      3                 4                 4                3
…                    …                 …                 …              …
103899                 3                 1                 4                2
103900                 5                 5                 5                5
103901                 3                 2                 4                5
103902                 4                 5                 1                5
103903                 1                 1                 4                4

        Inflight_service  Cleanliness  Departure_Delay_in_Minutes  \
0                      5            5                          25
1                      4            1                           1
2                      4            5                           0
3                      4            2                          11
4                      3            3                           0
…                    …          …                         …
103899                 3            2                           3
103900                 5            4                           0
103901                 5            4                           7
103902                 4            1                           0
103903                 3            1                           0

        Arrival_Delay_in_Minutes  satisfaction
0                           18.0             0
1                            6.0             0
2                            0.0             1
3                            9.0             0
4                            0.0             1
…                          …               …
103899                       0.0             0
103900                       0.0             1
103901                      14.0             0
103902                       0.0             0
103903                       0.0             0
```

```
[103594 rows x 23 columns]
```

[59]:
```
df2_Test
```

[59]:
```
        Gender  Customer_Type  Age  Type_of_Travel  Class  Flight_Distance  \
0            1              1   52               1      0              160
1            1              1   36               1      2             2863
2            0              0   20               1      0              192
3            0              1   44               1      2             3377
4            1              1   49               1      0             1182
…          …              …  …              …    …              …
25971        0              0   34               1      2              526
25972        0              1   23               1      2              646
25973        1              1   17               0      0              828
25974        0              1   14               1      2             1127
25975        1              1   42               0      0              264

        Inflight_wifi_service  Departure/Arrival_time_convenient  \
0                           5                                 4
1                           1                                 1
2                           2                                 0
3                           0                                 0
4                           2                                 3
…                         …                               …
25971                       3                                 3
25972                       4                                 4
25973                       2                                 5
25974                       3                                 3
25975                       2                                 5

        Ease_of_Online_booking  Gate_location  …  Inflight_entertainment  \
0                            3              4  …                       5
1                            3              1  …                       4
2                            2              4  …                       2
3                            0              2  …                       1
4                            4              3  …                       2
…                          …            …  …                     …
25971                        3              1  …                       4
25972                        4              4  …                       4
25973                        1              5  …                       2
25974                        3              3  …                       4
25975                        2              5  …                       1

        On-board_service  Leg_room_service  Baggage_handling  Checkin_service  \
0                      5                 5                 5                2
1                      4                 4                 4                3
```

```
2                    4                  1                  3                  2
3                    1                  1                  1                  3
4                    2                  2                  2                  4
…                  …                  …                  …                  …
25971                3                  2                  4                  4
25972                4                  5                  5                  5
25973                4                  3                  4                  5
25974                3                  2                  5                  4
25975                1                  2                  1                  1

       Inflight_service  Cleanliness  Departure_Delay_in_Minutes  \
0                     5            5                          50
1                     4            5                           0
2                     2            2                           0
3                     1            4                           0
4                     2            4                           0
…                   …          …                           …
25971                 5            4                           0
25972                 5            4                           0
25973                 4            2                           0
25974                 5            4                           0
25975                 1            1                           0

       Arrival_Delay_in_Minutes  satisfaction
0                          44.0             1
1                           0.0             1
2                           0.0             0
3                           6.0             1
4                          20.0             1
…                          …              …
25971                       0.0             0
25972                       0.0             1
25973                       0.0             0
25974                       0.0             1
25975                       0.0             0

[25893 rows x 23 columns]
```

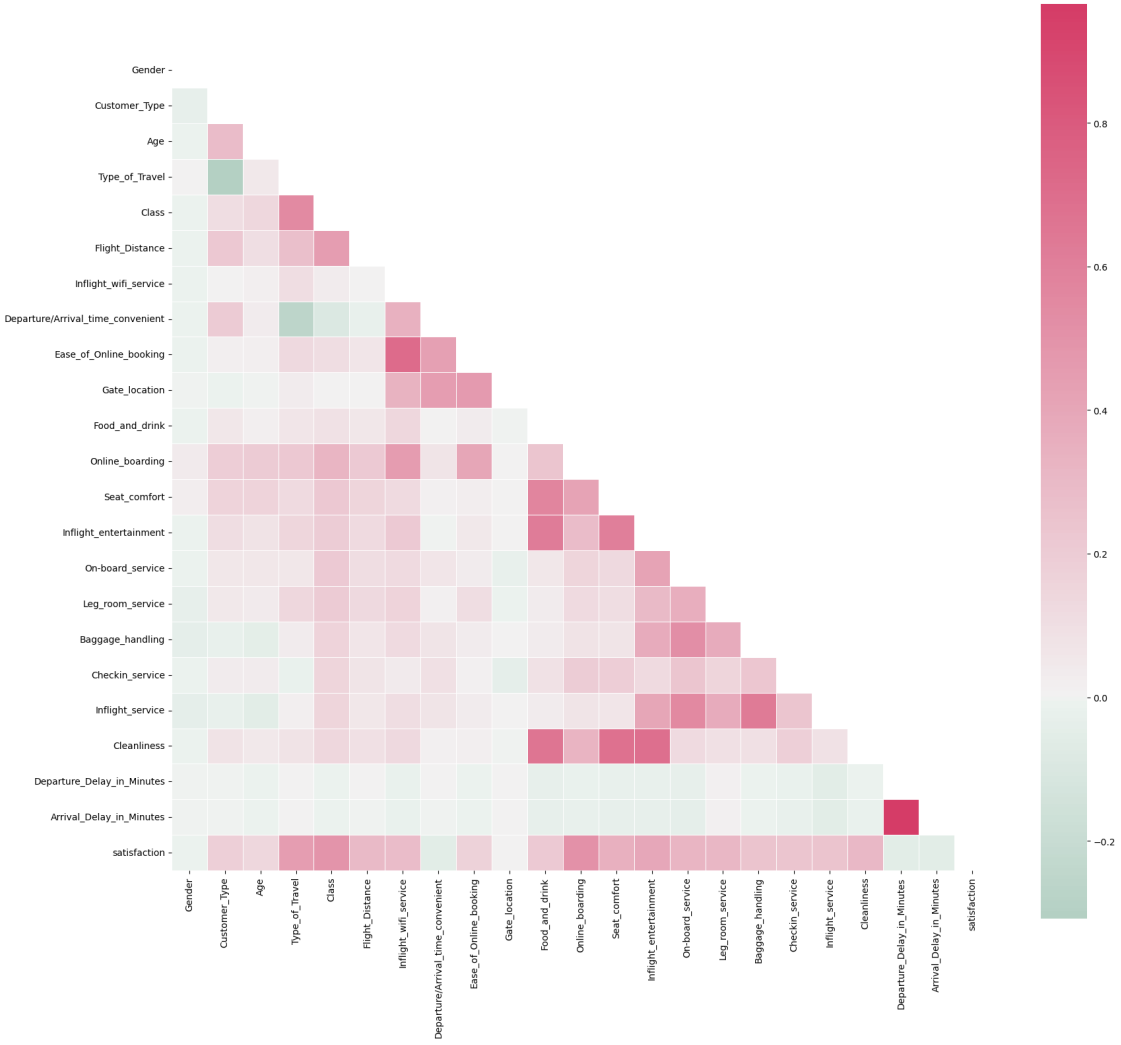
Correlation among Features

[60]:
```
corr = df2_Train.corr()
mask = np.triu(np.ones_like(corr, dtype=bool))
f, ax = plt.subplots(figsize=(20, 20))
cmap = sns.diverging_palette(150, 1, as_cmap=True)
sns.heatmap(corr, mask=mask, cmap=cmap, vmax=None, center=0,square=True,␣
 ↪annot=True, linewidths=.5, cbar_kws={"shrink": .9},annot_kws={"size": 10})
```

```
C:\Users\Aadiluddin\anaconda3\Lib\site-packages\seaborn\matrix.py:260:
```

```
FutureWarning: Format strings passed to MaskedConstant are ignored, but in
future may error or produce different behavior
  annotation = ("{:" + self.fmt + "}").format(val)
```

[60]: <Axes: >



[61]:
```
df2_Train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 103594 entries, 0 to 103903
Data columns (total 23 columns):
 #   Column                            Non-Null Count   Dtype
---  ------                            --------------   -----
 0   Gender                            103594 non-null  int64
 1   Customer_Type                     103594 non-null  int64
 2   Age                               103594 non-null  int64
```

```
 3   Type_of_Travel                     103594 non-null  int64
 4   Class                              103594 non-null  int64
 5   Flight_Distance                    103594 non-null  int64
 6   Inflight_wifi_service              103594 non-null  int64
 7   Departure/Arrival_time_convenient  103594 non-null  int64
 8   Ease_of_Online_booking             103594 non-null  int64
 9   Gate_location                      103594 non-null  int64
 10  Food_and_drink                     103594 non-null  int64
 11  Online_boarding                    103594 non-null  int64
 12  Seat_comfort                       103594 non-null  int64
 13  Inflight_entertainment             103594 non-null  int64
 14  On-board_service                   103594 non-null  int64
 15  Leg_room_service                   103594 non-null  int64
 16  Baggage_handling                   103594 non-null  int64
 17  Checkin_service                    103594 non-null  int64
 18  Inflight_service                   103594 non-null  int64
 19  Cleanliness                        103594 non-null  int64
 20  Departure_Delay_in_Minutes         103594 non-null  int64
 21  Arrival_Delay_in_Minutes           103594 non-null  float64
 22  satisfaction                       103594 non-null  int64
dtypes: float64(1), int64(22)
memory usage: 19.0 MB
```

[62]:
```
#"Ease_of_Online_booking" is highly correlated with "Inflight_wifi_service".␣
 ↪Also "Inflight_service" is highly correlated
#with "Baggage_handling". But no pair is having corr. coefficient exactly equal␣
 ↪to 1.
#So there is no perfect multicollinearity. Hence we are not discarding any␣
 ↪variable.
```

Feature Scaling

[85]:
```
X_train = df2_Train.drop('satisfaction', axis = 1)
y_train = df2_Train.satisfaction

X_test =df2_Test.drop('satisfaction', axis=1)
y_test = df2_Test.satisfaction
```

[86]:
```
s = StandardScaler()
X_train = s.fit_transform(X_train)
X_test = s.transform(X_test)
```

Model

[87]:
```
#Random Forest
```

[88]:
```
classifier1 =␣
 ↪RandomForestClassifier(n_estimators=100,criterion='entropy',random_state=0,n_jobs=-1)
```

```
classifier1.fit(X_train,y_train)
```

[88]:
```
RandomForestClassifier(criterion='entropy', n_jobs=-1, random_state=0)
```

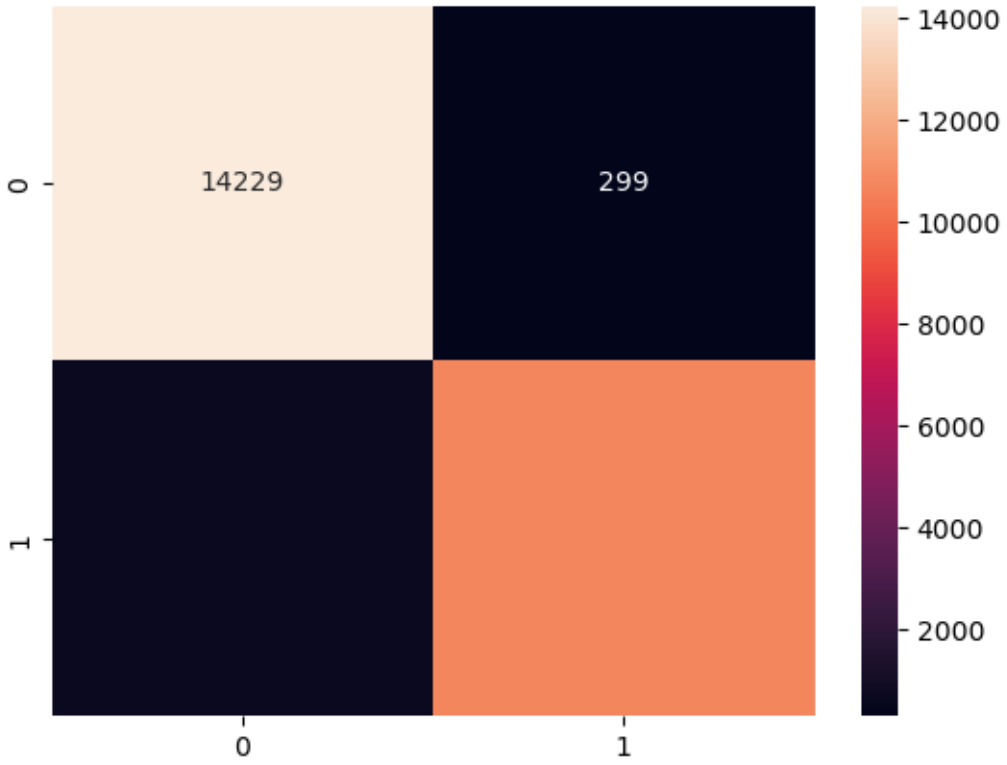
[89]:
```
y_pred = classifier1.predict(X_test)
```

[90]:
```
from sklearn.metrics import␣
  ↪classification_report,confusion_matrix,accuracy_score
print(classification_report(y_test,y_pred))
print('\n\n\n')
print('Confusion matrix : \n{}'.format(confusion_matrix(y_test,y_pred)))
print('\n')
print('Accuracy score : {}'.format(accuracy_score(y_test,y_pred)))
acc_random_forest = accuracy_score(y_test,y_pred)
```

```
              precision    recall  f1-score   support

           0       0.96      0.98      0.97     14528
           1       0.97      0.94      0.96     11365

    accuracy                           0.96     25893
   macro avg       0.96      0.96      0.96     25893
weighted avg       0.96      0.96      0.96     25893
```

```
Confusion matrix :
[[14229   299]
 [  663 10702]]


Accuracy score : 0.9628471015332329
```

[92]:
```
cm=confusion_matrix(y_test,y_pred)
sns.heatmap(cm,annot=True,fmt="d")
plt.show()
```



[ ]:

[93]:
```
classifier2 = XGBClassifier(n_estimators = 500,n_jobs=-1)
classifier2.fit(X_train,y_train)
```

[93]:
```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              multi_strategy=None, n_estimators=500, n_jobs=-1,
              num_parallel_tree=None, random_state=None, …)
```

[94]:
```
y_pred_2 = classifier2.predict(X_test)
```

[95]:
```
print(classification_report(y_test,y_pred_2))
print('\n\n\n')
print('Confusion matrix : \n{}'.format(confusion_matrix(y_test,y_pred)))
```

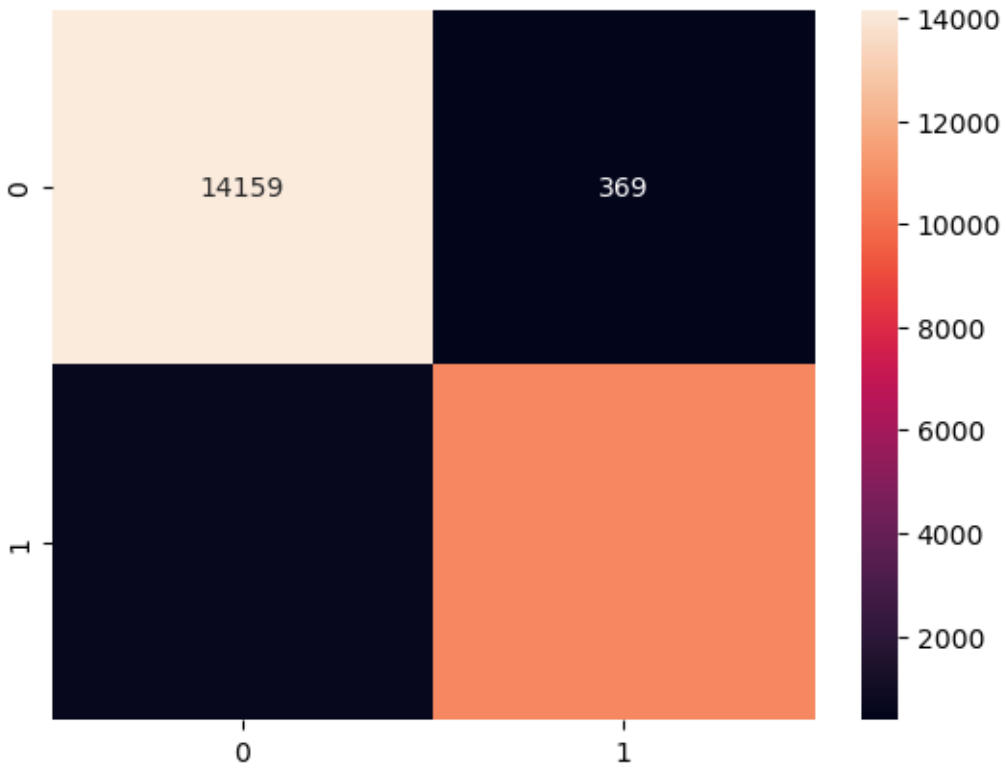
```
print('\n')
print('Accuracy score : {}'.format(accuracy_score(y_test,y_pred_2)))
acc_xgboost = accuracy_score(y_test,y_pred_2)
```

```
              precision    recall  f1-score   support

           0       0.96      0.97      0.97     14528
           1       0.97      0.95      0.96     11365

    accuracy                           0.96     25893
   macro avg       0.96      0.96      0.96     25893
weighted avg       0.96      0.96      0.96     25893
```

```
Confusion matrix :
[[14229   299]
 [  663 10702]]
```

```
Accuracy score : 0.9617271077125091
```

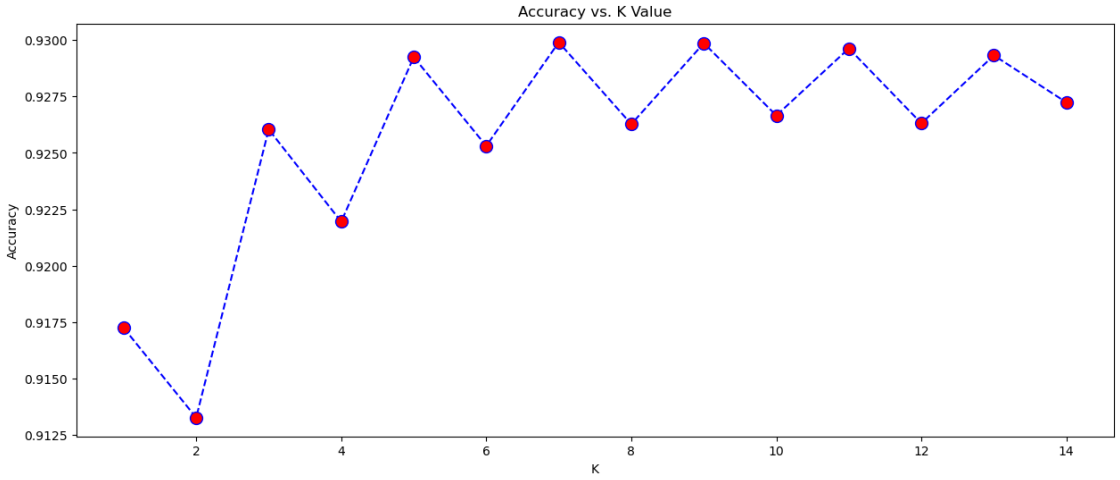
[96]:
```
cm=confusion_matrix(y_test,y_pred_2)
sns.heatmap(cm,annot=True,fmt="d")
plt.show()
```



[ ]:

[97]:
```
accuracy = []
for i in range(1,15):

    knn = KNeighborsClassifier(n_neighbors=i)
    knn.fit(X_train,y_train)
    pred_i = knn.predict(X_test)
    accuracy_i = accuracy_score(y_test, pred_i)
    accuracy.append(accuracy_i)
```

[98]:
```
plt.figure(figsize=(15,6))
plt.plot(range(1,15, 1), accuracy, color='blue', linestyle='dashed',␣
 ↪marker='o',markerfacecolor='red', markersize=10)
plt.title('Accuracy vs. K Value')
plt.xlabel('K')
plt.ylabel('Accuracy')
plt.show()
```

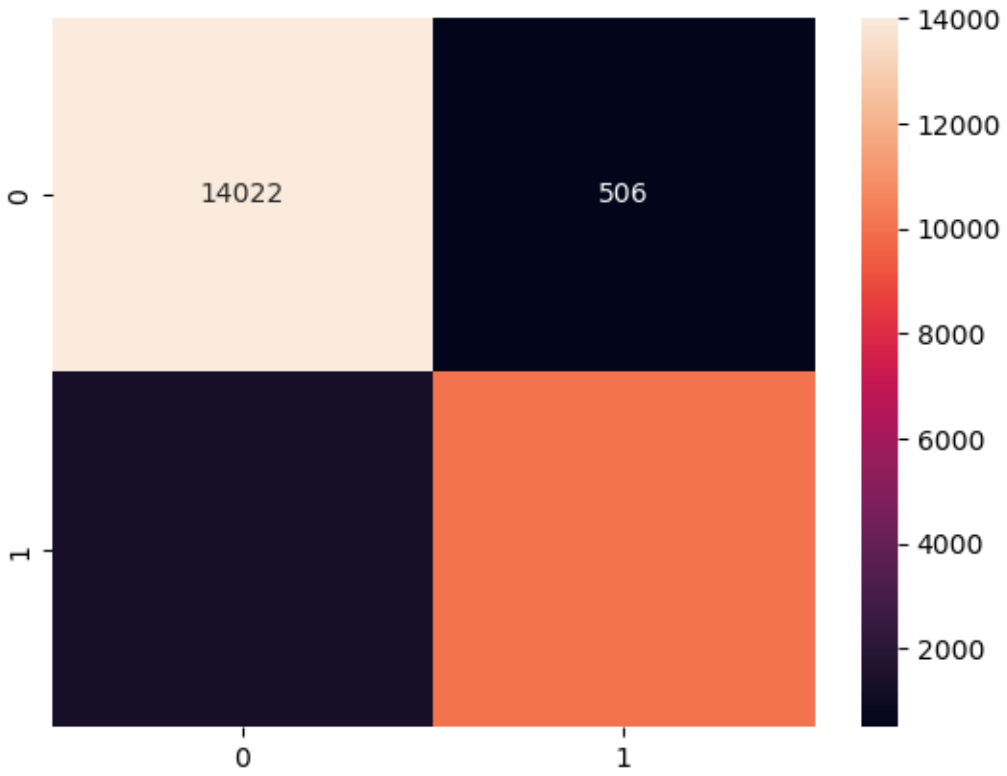


[99]:
```
knn = KNeighborsClassifier(n_neighbors = 7)
knn.fit(X_train, y_train)
y_pred_4 = knn.predict(X_test)
```

[100]:
```
print(classification_report(y_test,y_pred_4))
print('\n\n\n')
print('Confusion matrix : \n{}'.format(confusion_matrix(y_test,y_pred_4)))
print('\n')
print('Accuracy score : {}'.format(accuracy_score(y_test,y_pred_4)))
acc_knn = accuracy_score(y_test,y_pred_4)
```

```
              precision    recall  f1-score   support

           0       0.91      0.97      0.94     14528
           1       0.95      0.88      0.92     11365

    accuracy                           0.93     25893
   macro avg       0.93      0.92      0.93     25893
weighted avg       0.93      0.93      0.93     25893



Confusion matrix :
[[14022   506]
 [ 1309 10056]]


Accuracy score : 0.9299038350133241
```

[101]:
```
cm=confusion_matrix(y_test,y_pred_4)
sns.heatmap(cm,annot=True,fmt="d")
plt.show()
```



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