PCA_of_Hotel_Booking_proj

July 29, 2021

[1]:
```
pip install missingno
```

```
Requirement already satisfied: missingno in /opt/conda/lib/python3.7/site-
packages (0.5.0)
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.7/site-
packages (from missingno) (3.2.1)
Requirement already satisfied: seaborn in /opt/conda/lib/python3.7/site-packages
(from missingno) (0.10.1)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages
(from missingno) (1.4.1)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(from missingno) (1.16.5)
Requirement already satisfied: kiwisolver>=1.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib->missingno) (1.2.0)
Requirement already satisfied: python-dateutil>=2.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib->missingno) (2.8.1)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.7/site-
packages (from matplotlib->missingno) (0.10.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib->missingno) (2.4.7)
Requirement already satisfied: pandas>=0.22.0 in /opt/conda/lib/python3.7/site-
packages (from seaborn->missingno) (1.0.3)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.7/site-
packages (from python-dateutil>=2.1->matplotlib->missingno) (1.14.0)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.7/site-
packages (from pandas>=0.22.0->seaborn->missingno) (2020.1)
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
pip install plotly
```

```
Requirement already satisfied: plotly in /opt/conda/lib/python3.7/site-packages
(5.1.0)
Requirement already satisfied: tenacity>=6.2.0 in /opt/conda/lib/python3.7/site-
packages (from plotly) (8.0.1)
Requirement already satisfied: six in /opt/conda/lib/python3.7/site-packages
(from plotly) (1.14.0)
Note: you may need to restart the kernel to use updated packages.
```

[3]:
```
pip install xgboost
```

```
Requirement already satisfied: xgboost in /opt/conda/lib/python3.7/site-packages
(1.4.2)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages
(from xgboost) (1.4.1)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(from xgboost) (1.16.5)
Note: you may need to restart the kernel to use updated packages.
```

[4]:
```
pip install pycountry
```

```
Requirement already satisfied: pycountry in /opt/conda/lib/python3.7/site-
packages (20.7.3)
Note: you may need to restart the kernel to use updated packages.
```

[5]:
```
pip install catboost
```

```
Requirement already satisfied: catboost in /opt/conda/lib/python3.7/site-
packages (0.26)
Requirement already satisfied: pandas>=0.24.0 in /opt/conda/lib/python3.7/site-
packages (from catboost) (1.0.3)
Requirement already satisfied: matplotlib in /opt/conda/lib/python3.7/site-
packages (from catboost) (3.2.1)
Requirement already satisfied: numpy>=1.16.0 in /opt/conda/lib/python3.7/site-
packages (from catboost) (1.16.5)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages
(from catboost) (1.4.1)
Requirement already satisfied: six in /opt/conda/lib/python3.7/site-packages
(from catboost) (1.14.0)
Requirement already satisfied: plotly in /opt/conda/lib/python3.7/site-packages
(from catboost) (5.1.0)
Requirement already satisfied: graphviz in /opt/conda/lib/python3.7/site-
packages (from catboost) (0.17)
Requirement already satisfied: python-dateutil>=2.6.1 in
/opt/conda/lib/python3.7/site-packages (from pandas>=0.24.0->catboost) (2.8.1)
Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.7/site-
packages (from pandas>=0.24.0->catboost) (2020.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib->catboost) (1.2.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/opt/conda/lib/python3.7/site-packages (from matplotlib->catboost) (2.4.7)
Requirement already satisfied: cycler>=0.10 in /opt/conda/lib/python3.7/site-
packages (from matplotlib->catboost) (0.10.0)
Requirement already satisfied: tenacity>=6.2.0 in /opt/conda/lib/python3.7/site-
packages (from plotly->catboost) (8.0.1)
Note: you may need to restart the kernel to use updated packages.
```

[6]:
```
pip install lightgbm
```

```
Requirement already satisfied: lightgbm in /opt/conda/lib/python3.7/site-
packages (3.2.1)
Requirement already satisfied: wheel in /opt/conda/lib/python3.7/site-packages
(from lightgbm) (0.34.2)
Requirement already satisfied: scikit-learn!=0.22.0 in
/opt/conda/lib/python3.7/site-packages (from lightgbm) (0.24.2)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages
(from lightgbm) (1.4.1)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(from lightgbm) (1.16.5)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/opt/conda/lib/python3.7/site-packages (from scikit-learn!=0.22.0->lightgbm)
(2.2.0)
Requirement already satisfied: joblib>=0.11 in /opt/conda/lib/python3.7/site-
packages (from scikit-learn!=0.22.0->lightgbm) (0.15.1)
Note: you may need to restart the kernel to use updated packages.
```

[7]:
```
pip install folium
```

```
Requirement already satisfied: folium in /opt/conda/lib/python3.7/site-packages
(0.12.1)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(from folium) (1.16.5)
Requirement already satisfied: branca>=0.3.0 in /opt/conda/lib/python3.7/site-
packages (from folium) (0.4.2)
Requirement already satisfied: jinja2>=2.9 in /opt/conda/lib/python3.7/site-
packages (from folium) (2.11.2)
Requirement already satisfied: requests in /opt/conda/lib/python3.7/site-
packages (from folium) (2.23.0)
Requirement already satisfied: MarkupSafe>=0.23 in
/opt/conda/lib/python3.7/site-packages (from jinja2>=2.9->folium) (1.1.1)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
/opt/conda/lib/python3.7/site-packages (from requests->folium) (1.25.9)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.7/site-
packages (from requests->folium) (2.9)
Requirement already satisfied: certifi>=2017.4.17 in
/opt/conda/lib/python3.7/site-packages (from requests->folium) (2020.4.5.2)
Requirement already satisfied: chardet<4,>=3.0.2 in
/opt/conda/lib/python3.7/site-packages (from requests->folium) (3.0.4)
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import missingno as msno
import xgboost as xgb
import pycountry as pc
import warnings
warnings.filterwarnings('ignore')
from pandas import DataFrame, read_csv
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score, confusion_matrix,␣
 ↪classification_report
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import GradientBoostingClassifier
from xgboost import XGBClassifier
from catboost import CatBoostClassifier
from sklearn.ensemble import ExtraTreesClassifier
from lightgbm import LGBMClassifier
from sklearn.ensemble import VotingClassifier
import matplotlib.ticker as mtick
pd.options.display.max_columns = None

import folium
from folium.plugins import HeatMap
#import plotly.express as px
%matplotlib inline

plt.style.use('fivethirtyeight')
%matplotlib inline
pd.set_option('display.max_columns', 32)
```

[3]:

```
df = pd.read_csv('hotel_bookings.csv')
print(df)
```

```
                hotel  is_canceled  lead_time  arrival_date_year  \
0        Resort Hotel            0        342               2015
1        Resort Hotel            0        737               2015
2        Resort Hotel            0          7               2015
3        Resort Hotel            0         13               2015
4        Resort Hotel            0         14               2015
…                 …          …          …                 …
119385     City Hotel            0         23               2017
```

```
119386    City Hotel            0        102               2017
119387    City Hotel            0         34               2017
119388    City Hotel            0        109               2017
119389    City Hotel            0        205               2017

       arrival_date_month  arrival_date_week_number  \
0                    July                        27
1                    July                        27
2                    July                        27
3                    July                        27
4                    July                        27
…                   …                       …
119385             August                        35
119386             August                        35
119387             August                        35
119388             August                        35
119389             August                        35

        arrival_date_day_of_month  stays_in_weekend_nights  \
0                               1                        0
1                               1                        0
2                               1                        0
3                               1                        0
4                               1                        0
…                           …                      …
119385                         30                        2
119386                         31                        2
119387                         31                        2
119388                         31                        2
119389                         29                        2

        stays_in_week_nights  adults  children  babies meal country  \
0                          0       2       0.0       0   BB     PRT
1                          0       2       0.0       0   BB     PRT
2                          1       1       0.0       0   BB     GBR
3                          1       1       0.0       0   BB     GBR
4                          2       2       0.0       0   BB     GBR
…                      …     …       …     …  …     …
119385                     5       2       0.0       0   BB     BEL
119386                     5       3       0.0       0   BB     FRA
119387                     5       2       0.0       0   BB     DEU
119388                     5       2       0.0       0   BB     GBR
119389                     7       2       0.0       0   HB     DEU

       market_segment distribution_channel  is_repeated_guest  \
0              Direct               Direct                  0
1              Direct               Direct                  0
2              Direct               Direct                  0
```

```
3           Corporate           Corporate                  0
4           Online TA               TA/TO                  0
…               …                  …                …
119385  Offline TA/TO               TA/TO                  0
119386      Online TA               TA/TO                  0
119387      Online TA               TA/TO                  0
119388      Online TA               TA/TO                  0
119389      Online TA               TA/TO                  0

        previous_cancellations  previous_bookings_not_canceled  \
0                            0                               0
1                            0                               0
2                            0                               0
3                            0                               0
4                            0                               0
…                        …                             …
119385                       0                               0
119386                       0                               0
119387                       0                               0
119388                       0                               0
119389                       0                               0

       reserved_room_type assigned_room_type  booking_changes deposit_type  \
0                       C                  C                3   No Deposit
1                       C                  C                4   No Deposit
2                       A                  C                0   No Deposit
3                       A                  A                0   No Deposit
4                       A                  A                0   No Deposit
…                   …                …              …          …
119385                  A                  A                0   No Deposit
119386                  E                  E                0   No Deposit
119387                  D                  D                0   No Deposit
119388                  A                  A                0   No Deposit
119389                  A                  A                0   No Deposit

        agent  company  days_in_waiting_list customer_type     adr  \
0         NaN      NaN                     0     Transient    0.00
1         NaN      NaN                     0     Transient    0.00
2         NaN      NaN                     0     Transient   75.00
3       304.0      NaN                     0     Transient   75.00
4       240.0      NaN                     0     Transient   98.00
…       …      …                   …           …     …
119385  394.0      NaN                     0     Transient   96.14
119386    9.0      NaN                     0     Transient  225.43
119387    9.0      NaN                     0     Transient  157.71
119388   89.0      NaN                     0     Transient  104.40
119389    9.0      NaN                     0     Transient  151.20
```

```
        required_car_parking_spaces  total_of_special_requests  \
0                                 0                          0
1                                 0                          0
2                                 0                          0
3                                 0                          0
4                                 0                          1
…                             …                        …
119385                            0                          0
119386                            0                          2
119387                            0                          4
119388                            0                          0
119389                            0                          2

       reservation_status reservation_status_date
0               Check-Out              2015-07-01
1               Check-Out              2015-07-01
2               Check-Out              2015-07-02
3               Check-Out              2015-07-02
4               Check-Out              2015-07-03
…                   …                      …
119385          Check-Out              2017-09-06
119386          Check-Out              2017-09-07
119387          Check-Out              2017-09-07
119388          Check-Out              2017-09-07
119389          Check-Out              2017-09-07

[119390 rows x 32 columns]
```

[4]:

```
df.head()
```

[4]:

```
          hotel  is_canceled  lead_time  arrival_date_year arrival_date_month  \
0  Resort Hotel            0        342               2015               July
1  Resort Hotel            0        737               2015               July
2  Resort Hotel            0          7               2015               July
3  Resort Hotel            0         13               2015               July
4  Resort Hotel            0         14               2015               July

   arrival_date_week_number  arrival_date_day_of_month  \
0                        27                          1
1                        27                          1
2                        27                          1
3                        27                          1
4                        27                          1

   stays_in_weekend_nights  stays_in_week_nights  adults  children  babies  \
0                        0                     0       2       0.0       0
1                        0                     0       2       0.0       0
```

```
2                        0                     1       1       0.0       0
3                        0                     1       1       0.0       0
4                        0                     2       2       0.0       0

  meal country market_segment distribution_channel  is_repeated_guest  \
0   BB     PRT         Direct               Direct                  0
1   BB     PRT         Direct               Direct                  0
2   BB     GBR         Direct               Direct                  0
3   BB     GBR      Corporate            Corporate                  0
4   BB     GBR      Online TA                TA/TO                  0

   previous_cancellations  previous_bookings_not_canceled reserved_room_type  \
0                       0                               0                  C
1                       0                               0                  C
2                       0                               0                  A
3                       0                               0                  A
4                       0                               0                  A

  assigned_room_type  booking_changes deposit_type  agent  company  \
0                  C                3   No Deposit    NaN      NaN
1                  C                4   No Deposit    NaN      NaN
2                  C                0   No Deposit    NaN      NaN
3                  A                0   No Deposit  304.0      NaN
4                  A                0   No Deposit  240.0      NaN

   days_in_waiting_list customer_type   adr  required_car_parking_spaces  \
0                     0     Transient   0.0                            0
1                     0     Transient   0.0                            0
2                     0     Transient  75.0                            0
3                     0     Transient  75.0                            0
4                     0     Transient  98.0                            0

   total_of_special_requests reservation_status reservation_status_date
0                          0          Check-Out              2015-07-01
1                          0          Check-Out              2015-07-01
2                          0          Check-Out              2015-07-02
3                          0          Check-Out              2015-07-02
4                          1          Check-Out              2015-07-03
```

[5]:
```
df.shape
```

[5]:
```
(119390, 32)
```

[6]:
```
df.describe()
```

[6]:
```
         is_canceled      lead_time  arrival_date_year  \
count  119390.000000  119390.000000      119390.000000
```

```
mean        0.370416     104.011416        2016.156554
std         0.482918     106.863097           0.707476
min         0.000000       0.000000        2015.000000
25%         0.000000      18.000000        2016.000000
50%         0.000000      69.000000        2016.000000
75%         1.000000     160.000000        2017.000000
max         1.000000     737.000000        2017.000000

       arrival_date_week_number  arrival_date_day_of_month  \
count             119390.000000              119390.000000
mean                  27.165173                  15.798241
std                   13.605138                   8.780829
min                    1.000000                   1.000000
25%                   16.000000                   8.000000
50%                   28.000000                  16.000000
75%                   38.000000                  23.000000
max                   53.000000                  31.000000

       stays_in_weekend_nights  stays_in_week_nights         adults  \
count            119390.000000         119390.000000  119390.000000
mean                  0.927599              2.500302       1.856403
std                   0.998613              1.908286       0.579261
min                   0.000000              0.000000       0.000000
25%                   0.000000              1.000000       2.000000
50%                   1.000000              2.000000       2.000000
75%                   2.000000              3.000000       2.000000
max                  19.000000             50.000000      55.000000

            children         babies  is_repeated_guest  \
count  119386.000000  119390.000000      119390.000000
mean        0.103890       0.007949           0.031912
std         0.398561       0.097436           0.175767
min         0.000000       0.000000           0.000000
25%         0.000000       0.000000           0.000000
50%         0.000000       0.000000           0.000000
75%         0.000000       0.000000           0.000000
max        10.000000      10.000000           1.000000

       previous_cancellations  previous_bookings_not_canceled  \
count           119390.000000                   119390.000000
mean                 0.087118                        0.137097
std                  0.844336                        1.497437
min                  0.000000                        0.000000
25%                  0.000000                        0.000000
50%                  0.000000                        0.000000
75%                  0.000000                        0.000000
max                 26.000000                       72.000000
```

```
       booking_changes          agent      company  days_in_waiting_list  \
count    119390.000000  103050.000000  6797.000000         119390.000000
mean          0.221124      86.693382   189.266735              2.321149
std           0.652306     110.774548   131.655015             17.594721
min           0.000000       1.000000     6.000000              0.000000
25%           0.000000       9.000000    62.000000              0.000000
50%           0.000000      14.000000   179.000000              0.000000
75%           0.000000     229.000000   270.000000              0.000000
max          21.000000     535.000000   543.000000            391.000000

                 adr  required_car_parking_spaces  total_of_special_requests
count  119390.000000                119390.000000              119390.000000
mean      101.831122                     0.062518                   0.571363
std        50.535790                     0.245291                   0.792798
min        -6.380000                     0.000000                   0.000000
25%        69.290000                     0.000000                   0.000000
50%        94.575000                     0.000000                   0.000000
75%       126.000000                     0.000000                   1.000000
max      5400.000000                     8.000000                   5.000000
```

37 % of the people have cancelled their booking as per the dataset. Avg. lead time is 104 days, that is almost 3.5 months. Each booking has on an average 1.8 adults and 0.1 children. Only 3% of the guests are repeated. Median lead time is 69 days.

MAJOR OBSERVATIONS:

1.Number of bookings made were highest in the month of July and August and lowest in January. 2.Bookings were more for the City hotel than the Resort hotel. 3.41.7% of the total bookings were cancelled for City hotel and 21.7% for the Resort hotel. 4.Number of days that elapsed between the entering date of the booking and the arrival date is less for the people who cancelled. 5.As the hotels are in Portugal Europe, the bookings are mostly with European countries, Highest is Portugal with 48.59k bookings. 6.77% of the bookings are made with bed and breakfast. 7.Only 3% are repeated guests.

EXPLORATORY DATA ANALYSIS

[7]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 119390 entries, 0 to 119389
Data columns (total 32 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   hotel                           119390 non-null  object
 1   is_canceled                     119390 non-null  int64
 2   lead_time                       119390 non-null  int64
 3   arrival_date_year               119390 non-null  int64
 4   arrival_date_month              119390 non-null  object
 5   arrival_date_week_number        119390 non-null  int64
 6   arrival_date_day_of_month       119390 non-null  int64
 7   stays_in_weekend_nights         119390 non-null  int64
 8   stays_in_week_nights            119390 non-null  int64
 9   adults                          119390 non-null  int64
 10  children                        119386 non-null  float64
 11  babies                          119390 non-null  int64
 12  meal                            119390 non-null  object
 13  country                         118902 non-null  object
 14  market_segment                  119390 non-null  object
 15  distribution_channel            119390 non-null  object
 16  is_repeated_guest               119390 non-null  int64
 17  previous_cancellations          119390 non-null  int64
 18  previous_bookings_not_canceled  119390 non-null  int64
 19  reserved_room_type              119390 non-null  object
 20  assigned_room_type              119390 non-null  object
 21  booking_changes                 119390 non-null  int64
 22  deposit_type                    119390 non-null  object
 23  agent                           103050 non-null  float64
 24  company                         6797 non-null    float64
 25  days_in_waiting_list            119390 non-null  int64
 26  customer_type                   119390 non-null  object
 27  adr                             119390 non-null  float64
 28  required_car_parking_spaces     119390 non-null  int64
 29  total_of_special_requests       119390 non-null  int64
 30  reservation_status              119390 non-null  object
 31  reservation_status_date         119390 non-null  object
dtypes: float64(4), int64(16), object(12)
memory usage: 29.1+ MB
```

[8]:

```
# dealing with null values
null = pd.DataFrame({'Count of Missing values' : df.isna().sum(), 'Percentage␣
 ↪of missing values' : (df.isna().sum()) / (df.shape[0]) * (100)})
null
```

[8]:

```
                                Count of Missing values  \
hotel                                                 0
is_canceled                                           0
lead_time                                             0
arrival_date_year                                     0
arrival_date_month                                    0
arrival_date_week_number                              0
arrival_date_day_of_month                             0
stays_in_weekend_nights                               0
stays_in_week_nights                                  0
adults                                                0
children                                              4
```

```
babies                                                0
meal                                                  0
country                                             488
market_segment                                        0
distribution_channel                                  0
is_repeated_guest                                     0
previous_cancellations                                0
previous_bookings_not_canceled                        0
reserved_room_type                                    0
assigned_room_type                                    0
booking_changes                                       0
deposit_type                                          0
agent                                             16340
company                                          112593
days_in_waiting_list                                  0
customer_type                                         0
adr                                                   0
required_car_parking_spaces                           0
total_of_special_requests                             0
reservation_status                                    0
reservation_status_date                               0

                                Percentage of missing values
hotel                                               0.000000
is_canceled                                         0.000000
lead_time                                           0.000000
arrival_date_year                                   0.000000
arrival_date_month                                  0.000000
arrival_date_week_number                            0.000000
arrival_date_day_of_month                           0.000000
stays_in_weekend_nights                             0.000000
stays_in_week_nights                                0.000000
adults                                              0.000000
children                                            0.003350
babies                                              0.000000
meal                                                0.000000
country                                             0.408744
market_segment                                      0.000000
distribution_channel                                0.000000
is_repeated_guest                                   0.000000
previous_cancellations                              0.000000
previous_bookings_not_canceled                      0.000000
reserved_room_type                                  0.000000
assigned_room_type                                  0.000000
booking_changes                                     0.000000
deposit_type                                        0.000000
agent                                              13.686238
```

```
company                                             94.306893
days_in_waiting_list                                 0.000000
customer_type                                        0.000000
adr                                                  0.000000
required_car_parking_spaces                          0.000000
total_of_special_requests                            0.000000
reservation_status                                   0.000000
reservation_status_date                              0.000000
```

There are 32 columns, 12 were Categorical and 20 Numerical There are 4 columns with the missing values namely- country, agent, company, children 'company' column has maximum null values which is 94Dealing with missing values

[9]:
```python
hotel = df.drop(columns=['company'])
hotel
```

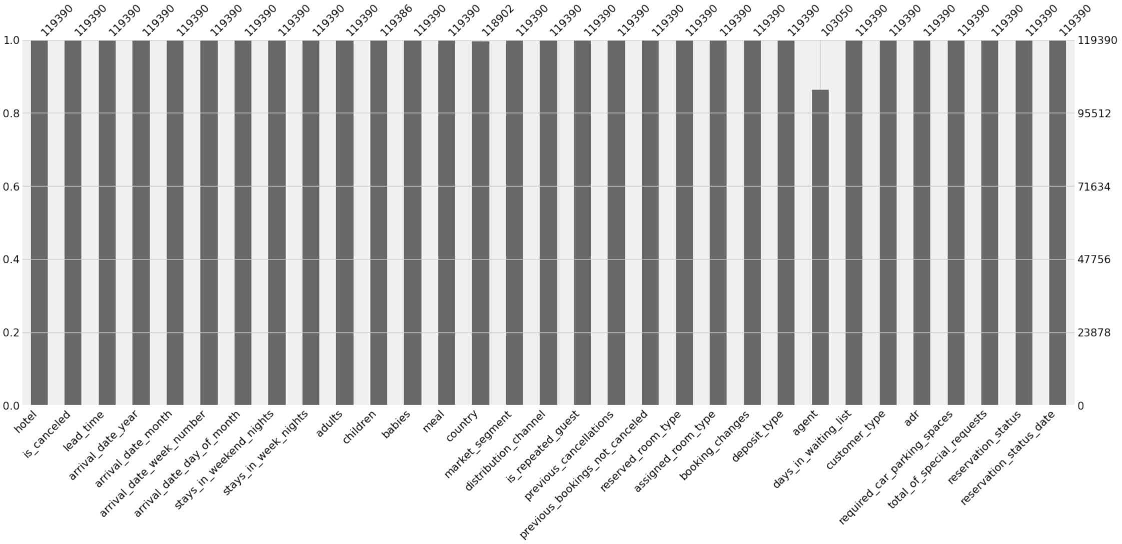
[9]:
```
               hotel  is_canceled  lead_time  arrival_date_year  \
0       Resort Hotel            0        342               2015
1       Resort Hotel            0        737               2015
2       Resort Hotel            0          7               2015
3       Resort Hotel            0         13               2015
4       Resort Hotel            0         14               2015
…              …          …        …                …
119385    City Hotel            0         23               2017
119386    City Hotel            0        102               2017
119387    City Hotel            0         34               2017
119388    City Hotel            0        109               2017
119389    City Hotel            0        205               2017

       arrival_date_month  arrival_date_week_number  \
0                    July                        27
1                    July                        27
2                    July                        27
3                    July                        27
4                    July                        27
…                    …                        …
119385             August                        35
119386             August                        35
119387             August                        35
119388             August                        35
119389             August                        35

        arrival_date_day_of_month  stays_in_weekend_nights  \
0                               1                        0
1                               1                        0
2                               1                        0
3                               1                        0
```

```
4                               1                        0
…                           …                      …
119385                         30                        2
119386                         31                        2
119387                         31                        2
119388                         31                        2
119389                         29                        2

        stays_in_week_nights  adults  children  babies meal country  \
0                          0       2       0.0       0   BB     PRT
1                          0       2       0.0       0   BB     PRT
2                          1       1       0.0       0   BB     GBR
3                          1       1       0.0       0   BB     GBR
4                          2       2       0.0       0   BB     GBR
…                      …     …       …     …  …     …
119385                     5       2       0.0       0   BB     BEL
119386                     5       3       0.0       0   BB     FRA
119387                     5       2       0.0       0   BB     DEU
119388                     5       2       0.0       0   BB     GBR
119389                     7       2       0.0       0   HB     DEU

       market_segment distribution_channel  is_repeated_guest  \
0              Direct               Direct                  0
1              Direct               Direct                  0
2              Direct               Direct                  0
3           Corporate            Corporate                  0
4           Online TA                TA/TO                  0
…               …                  …                …
119385  Offline TA/TO                TA/TO                  0
119386      Online TA                TA/TO                  0
119387      Online TA                TA/TO                  0
119388      Online TA                TA/TO                  0
119389      Online TA                TA/TO                  0

        previous_cancellations  previous_bookings_not_canceled  \
0                            0                               0
1                            0                               0
2                            0                               0
3                            0                               0
4                            0                               0
…                        …                             …
119385                       0                               0
119386                       0                               0
119387                       0                               0
119388                       0                               0
119389                       0                               0
```

```
       reserved_room_type assigned_room_type  booking_changes deposit_type  \
0                       C                  C                3   No Deposit
1                       C                  C                4   No Deposit
2                       A                  C                0   No Deposit
3                       A                  A                0   No Deposit
4                       A                  A                0   No Deposit
…                   …                …              …          …
119385                  A                  A                0   No Deposit
119386                  E                  E                0   No Deposit
119387                  D                  D                0   No Deposit
119388                  A                  A                0   No Deposit
119389                  A                  A                0   No Deposit

        agent  days_in_waiting_list customer_type     adr  \
0         NaN                     0     Transient    0.00
1         NaN                     0     Transient    0.00
2         NaN                     0     Transient   75.00
3       304.0                     0     Transient   75.00
4       240.0                     0     Transient   98.00
…       …                   …           …     …
119385  394.0                     0     Transient   96.14
119386    9.0                     0     Transient  225.43
119387    9.0                     0     Transient  157.71
119388   89.0                     0     Transient  104.40
119389    9.0                     0     Transient  151.20

        required_car_parking_spaces  total_of_special_requests   \
0                                 0                          0
1                                 0                          0
2                                 0                          0
3                                 0                          0
4                                 0                          1
…                              …                        …
119385                            0                          0
119386                            0                          2
119387                            0                          4
119388                            0                          0
119389                            0                          2

       reservation_status reservation_status_date
0               Check-Out              2015-07-01
1               Check-Out              2015-07-01
2               Check-Out              2015-07-02
3               Check-Out              2015-07-02
4               Check-Out              2015-07-03
…                   …                      …
119385          Check-Out              2017-09-06
```

```
119386          Check-Out               2017-09-07
119387          Check-Out               2017-09-07
119388          Check-Out               2017-09-07
119389          Check-Out               2017-09-07

[119390 rows x 31 columns]
```

[10]:
```
#Lets use Missingno library which offers a fair visualization of the␣
↪distribution of NaN values.
msno.bar(hotel)
plt.show()
```



We have almost 120,000 observations, its kind of difficult to make any observation regarding the columns containing NaN values. So, we shall check the distribution of these coloumns individually.

[11]:
```
hotel['children'].value_counts()
```

[11]:
```
0.0     110796
1.0       4861
2.0       3652
3.0         76
10.0         1
Name: children, dtype: int64
```

[12]:
```
hotel['children'].fillna(0,inplace=True) #In order to deal with the missing␣
↪information in childres's column, we fill it with 0 as we see maximum␣
↪travellers had 0 children
```

[13]:
```
hotel['country'].value_counts()
```

```
[13]: PRT    48590
      GBR    12129
      FRA    10415
      ESP     8568
      DEU     7287
             …
      BDI        1
      MLI        1
      NIC        1
      NAM        1
      SMR        1
      Name: country, Length: 177, dtype: int64
```

```
[14]: hotel['country'].fillna(hotel['country'].mode()[0], inplace=True) # Since, only␣
       ↪0.4% rows are missing from 'country' column we shall replace it using its␣
       ↪mode value
```

```
[15]: hotel['agent'].value_counts()
```

```
[15]: 9.0      31961
      240.0    13922
      1.0       7191
      14.0      3640
      7.0       3539
                …
      213.0        1
      433.0        1
      197.0        1
      367.0        1
      337.0        1
      Name: agent, Length: 333, dtype: int64
```

```
[16]: hotel['agent'].fillna(0,inplace=True) # For the sake of simplicity, we shall␣
       ↪replace the 13% Nan values in column agent with '0'
```

```
[17]: #Rechecking if the null values are handled properly
      missing = pd.DataFrame({'Count of Missing values' : hotel.isna().sum()})
      missing
```

```
[17]:                                 Count of Missing values
      hotel                                                 0
      is_canceled                                           0
      lead_time                                             0
      arrival_date_year                                     0
      arrival_date_month                                    0
      arrival_date_week_number                              0
      arrival_date_day_of_month                             0
```

```
stays_in_weekend_nights                               0
stays_in_week_nights                                  0
adults                                                0
children                                              0
babies                                                0
meal                                                  0
country                                               0
market_segment                                        0
distribution_channel                                  0
is_repeated_guest                                     0
previous_cancellations                                0
previous_bookings_not_canceled                        0
reserved_room_type                                    0
assigned_room_type                                    0
booking_changes                                       0
deposit_type                                          0
agent                                                 0
days_in_waiting_list                                  0
customer_type                                         0
adr                                                   0
required_car_parking_spaces                           0
total_of_special_requests                             0
reservation_status                                    0
reservation_status_date                               0
```

[18]:

```
# There are a few rows where  number of adults is zero, Hence, trying to remove␣
 ↪such rows
filter = (hotel.children == 0) & (hotel.adults == 0) & (hotel.babies == 0)
hotel[filter]
```

[18]:

```
               hotel  is_canceled  lead_time  arrival_date_year  \
2224    Resort Hotel            0          1               2015
2409    Resort Hotel            0          0               2015
3181    Resort Hotel            0         36               2015
3684    Resort Hotel            0        165               2015
3708    Resort Hotel            0        165               2015
…              …          …        …                …
115029    City Hotel            0        107               2017
115091    City Hotel            0          1               2017
116251    City Hotel            0         44               2017
116534    City Hotel            0          2               2017
117087    City Hotel            0        170               2017

       arrival_date_month  arrival_date_week_number  \
2224              October                        41
2409              October                        42
3181             November                        47
```

```
3684             December                        53
3708             December                        53
…                   …                       …
115029               June                        26
115091               June                        26
116251               July                        28
116534               July                        28
117087               July                        30

        arrival_date_day_of_month  stays_in_weekend_nights  \
2224                            6                        0
2409                           12                        0
3181                           20                        1
3684                           30                        1
3708                           30                        2
…                            …                       …
115029                         27                        0
115091                         30                        0
116251                         15                        1
116534                         15                        2
117087                         27                        0

        stays_in_week_nights  adults  children  babies meal country  \
2224                       3       0       0.0       0   SC     PRT
2409                       0       0       0.0       0   SC     PRT
3181                       2       0       0.0       0   SC     ESP
3684                       4       0       0.0       0   SC     PRT
3708                       4       0       0.0       0   SC     PRT
…                      …     …       …     …  …     …
115029                     3       0       0.0       0   BB     CHE
115091                     1       0       0.0       0   SC     PRT
116251                     1       0       0.0       0   SC     SWE
116534                     5       0       0.0       0   SC     RUS
117087                     2       0       0.0       0   BB     BRA

       market_segment distribution_channel  is_repeated_guest  \
2224        Corporate            Corporate                  0
2409        Corporate            Corporate                  0
3181           Groups                TA/TO                  0
3684           Groups                TA/TO                  0
3708           Groups                TA/TO                  0
…                 …                   …                …
115029      Online TA                TA/TO                  0
115091  Complementary               Direct                  0
116251      Online TA                TA/TO                  0
116534      Online TA                TA/TO                  0
117087  Offline TA/TO                TA/TO                  0
```

```
        previous_cancellations  previous_bookings_not_canceled  \
2224                         0                               0
2409                         0                               0
3181                         0                               0
3684                         0                               0
3708                         0                               0
…                        …                             …
115029                       0                               0
115091                       0                               0
116251                       0                               0
116534                       0                               0
117087                       0                               0

       reserved_room_type assigned_room_type  booking_changes deposit_type  \
2224                    A                  I                1   No Deposit
2409                    A                  I                0   No Deposit
3181                    A                  C                0   No Deposit
3684                    A                  A                1   No Deposit
3708                    A                  C                1   No Deposit
…                   …                …              …          …
115029                  A                  A                1   No Deposit
115091                  E                  K                0   No Deposit
116251                  A                  K                2   No Deposit
116534                  A                  K                1   No Deposit
117087                  A                  A                0   No Deposit

        agent  days_in_waiting_list    customer_type     adr  \
2224      0.0                     0  Transient-Party    0.00
2409      0.0                     0        Transient    0.00
3181     38.0                     0  Transient-Party    0.00
3684    308.0                   122  Transient-Party    0.00
3708    308.0                   122  Transient-Party    0.00
…       …                   …              …     …
115029    7.0                     0        Transient  100.80
115091    0.0                     0        Transient    0.00
116251  425.0                     0        Transient   73.80
116534    9.0                     0  Transient-Party   22.86
117087   52.0                     0        Transient    0.00

        required_car_parking_spaces  total_of_special_requests  \
2224                              0                          0
2409                              0                          0
3181                              0                          0
3684                              0                          0
3708                              0                          0
…                             …                        …
```

```
115029                            0                          0
115091                            1                          1
116251                            0                          0
116534                            0                          1
117087                            0                          0

       reservation_status reservation_status_date
2224            Check-Out              2015-10-06
2409            Check-Out              2015-10-12
3181            Check-Out              2015-11-23
3684            Check-Out              2016-01-04
3708            Check-Out              2016-01-05
…                   …                     …
115029          Check-Out              2017-06-30
115091          Check-Out              2017-07-01
116251          Check-Out              2017-07-17
116534          Check-Out              2017-07-22
117087          Check-Out              2017-07-29

[180 rows x 31 columns]
```

[19]:

```
#Removing these rows with 0 adults, 0 children and babies
hotel = hotel[~filter]
hotel
```

[19]:

```
               hotel  is_canceled  lead_time  arrival_date_year   \
0       Resort Hotel            0        342               2015
1       Resort Hotel            0        737               2015
2       Resort Hotel            0          7               2015
3       Resort Hotel            0         13               2015
4       Resort Hotel            0         14               2015
…              …          …        …                …
119385    City Hotel            0         23               2017
119386    City Hotel            0        102               2017
119387    City Hotel            0         34               2017
119388    City Hotel            0        109               2017
119389    City Hotel            0        205               2017

       arrival_date_month  arrival_date_week_number  \
0                    July                        27
1                    July                        27
2                    July                        27
3                    July                        27
4                    July                        27
…                   …                       …
119385             August                        35
119386             August                        35
```

```
119387             August                        35
119388             August                        35
119389             August                        35

        arrival_date_day_of_month  stays_in_weekend_nights  \
0                               1                        0
1                               1                        0
2                               1                        0
3                               1                        0
4                               1                        0
…                           …                      …
119385                         30                        2
119386                         31                        2
119387                         31                        2
119388                         31                        2
119389                         29                        2

        stays_in_week_nights  adults  children  babies meal country  \
0                          0       2       0.0       0   BB     PRT
1                          0       2       0.0       0   BB     PRT
2                          1       1       0.0       0   BB     GBR
3                          1       1       0.0       0   BB     GBR
4                          2       2       0.0       0   BB     GBR
…                      …     …       …     …  …     …
119385                     5       2       0.0       0   BB     BEL
119386                     5       3       0.0       0   BB     FRA
119387                     5       2       0.0       0   BB     DEU
119388                     5       2       0.0       0   BB     GBR
119389                     7       2       0.0       0   HB     DEU

       market_segment distribution_channel  is_repeated_guest  \
0              Direct               Direct                  0
1              Direct               Direct                  0
2              Direct               Direct                  0
3           Corporate            Corporate                  0
4           Online TA                TA/TO                  0
…               …                  …                …
119385  Offline TA/TO                TA/TO                  0
119386      Online TA                TA/TO                  0
119387      Online TA                TA/TO                  0
119388      Online TA                TA/TO                  0
119389      Online TA                TA/TO                  0

        previous_cancellations  previous_bookings_not_canceled  \
0                            0                               0
1                            0                               0
2                            0                               0
```

```
3                            0                               0
4                            0                               0
…                        …                             …
119385                       0                               0
119386                       0                               0
119387                       0                               0
119388                       0                               0
119389                       0                               0

       reserved_room_type assigned_room_type  booking_changes deposit_type  \
0                       C                  C                3   No Deposit
1                       C                  C                4   No Deposit
2                       A                  C                0   No Deposit
3                       A                  A                0   No Deposit
4                       A                  A                0   No Deposit
…                   …                …              …          …
119385                  A                  A                0   No Deposit
119386                  E                  E                0   No Deposit
119387                  D                  D                0   No Deposit
119388                  A                  A                0   No Deposit
119389                  A                  A                0   No Deposit

        agent  days_in_waiting_list customer_type     adr  \
0         0.0                     0     Transient    0.00
1         0.0                     0     Transient    0.00
2         0.0                     0     Transient   75.00
3       304.0                     0     Transient   75.00
4       240.0                     0     Transient   98.00
…       …                   …           …     …
119385  394.0                     0     Transient   96.14
119386    9.0                     0     Transient  225.43
119387    9.0                     0     Transient  157.71
119388   89.0                     0     Transient  104.40
119389    9.0                     0     Transient  151.20

        required_car_parking_spaces  total_of_special_requests  \
0                                 0                          0
1                                 0                          0
2                                 0                          0
3                                 0                          0
4                                 0                          1
…                             …                        …
119385                            0                          0
119386                            0                          2
119387                            0                          4
119388                            0                          0
119389                            0                          2
```

```
       reservation_status reservation_status_date
0               Check-Out              2015-07-01
1               Check-Out              2015-07-01
2               Check-Out              2015-07-02
3               Check-Out              2015-07-02
4               Check-Out              2015-07-03
…                     …                     …
119385          Check-Out              2017-09-06
119386          Check-Out              2017-09-07
119387          Check-Out              2017-09-07
119388          Check-Out              2017-09-07
119389          Check-Out              2017-09-07

[119210 rows x 31 columns]
```

After dealing with the null values and dropping few unwanted rows the new shape of our dataset is **(119210,31)**

[20]:

```
## Converting Datatype: Children are listed as float datatypre but in reality␣
 ↪its interger, so needs to be changed
hotel['is_canceled'] = hotel['is_canceled'].astype('object')
hotel['children'] = hotel['children'].astype('int64')
hotel['agent'] = hotel['agent'].astype('int64')
hotel['country'] = hotel['country'].astype('str')
hotel ['reservation_status_date'] = hotel['reservation_status_date'].
 ↪astype('datetime64')
#looking at the reservation_status_date we can see it doesnt have correct␣
 ↪Dtype, hence we need to change it to datetime 64
hotel.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 119210 entries, 0 to 119389
Data columns (total 31 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   hotel                           119210 non-null  object
 1   is_canceled                     119210 non-null  object
 2   lead_time                       119210 non-null  int64
 3   arrival_date_year               119210 non-null  int64
 4   arrival_date_month              119210 non-null  object
 5   arrival_date_week_number        119210 non-null  int64
 6   arrival_date_day_of_month       119210 non-null  int64
 7   stays_in_weekend_nights         119210 non-null  int64
 8   stays_in_week_nights            119210 non-null  int64
 9   adults                          119210 non-null  int64
 10  children                        119210 non-null  int64
 11  babies                          119210 non-null  int64
 12  meal                            119210 non-null  object
 13  country                         119210 non-null  object
 14  market_segment                  119210 non-null  object
 15  distribution_channel            119210 non-null  object
 16  is_repeated_guest               119210 non-null  int64
 17  previous_cancellations          119210 non-null  int64
 18  previous_bookings_not_canceled  119210 non-null  int64
 19  reserved_room_type              119210 non-null  object
 20  assigned_room_type              119210 non-null  object
 21  booking_changes                 119210 non-null  int64
 22  deposit_type                    119210 non-null  object
 23  agent                           119210 non-null  int64
 24  days_in_waiting_list            119210 non-null  int64
 25  customer_type                   119210 non-null  object
 26  adr                             119210 non-null  float64
 27  required_car_parking_spaces     119210 non-null  int64
 28  total_of_special_requests       119210 non-null  int64
 29  reservation_status              119210 non-null  object
 30  reservation_status_date         119210 non-null  datetime64[ns]
dtypes: datetime64[ns](1), float64(1), int64(17), object(12)
memory usage: 29.1+ MB
```

[22]:

```
hotel = hotel.drop(['reservation_status_date'], axis = 1)
```

[23]:

```
from sklearn import preprocessing

label_encoder = preprocessing.LabelEncoder()

# Encode labels in all the categorical columns
hotel['hotel']= label_encoder.fit_transform(hotel['hotel'])
hotel['arrival_date_month']= label_encoder.
 ↪fit_transform(hotel['arrival_date_month'])
hotel['meal']= label_encoder.fit_transform(hotel['meal'])
hotel['country']= label_encoder.fit_transform(hotel['country'])
hotel['market_segment']= label_encoder.fit_transform(hotel['market_segment'])
hotel['distribution_channel']= label_encoder.
 ↪fit_transform(hotel['distribution_channel'])
hotel['is_repeated_guest']= label_encoder.
 ↪fit_transform(hotel['is_repeated_guest'])
hotel['reserved_room_type']= label_encoder.
 ↪fit_transform(hotel['reserved_room_type'])
hotel['assigned_room_type']= label_encoder.fit_transform(hotel['deposit_type'])
hotel['deposit_type']= label_encoder.fit_transform(hotel['is_repeated_guest'])
hotel['agent']= label_encoder.fit_transform(hotel['agent'])
hotel['customer_type']= label_encoder.fit_transform(hotel['customer_type'])
```

```
hotel['reservation_status']= label_encoder.
 ↪fit_transform(hotel['reservation_status'])
```

[24]:
```
hotel.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 119210 entries, 0 to 119389
Data columns (total 30 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   hotel                           119210 non-null  int64
 1   is_canceled                     119210 non-null  object
 2   lead_time                       119210 non-null  int64
 3   arrival_date_year               119210 non-null  int64
 4   arrival_date_month              119210 non-null  int64
 5   arrival_date_week_number        119210 non-null  int64
 6   arrival_date_day_of_month       119210 non-null  int64
 7   stays_in_weekend_nights         119210 non-null  int64
 8   stays_in_week_nights            119210 non-null  int64
 9   adults                          119210 non-null  int64
 10  children                        119210 non-null  int64
 11  babies                          119210 non-null  int64
 12  meal                            119210 non-null  int64
 13  country                         119210 non-null  int64
 14  market_segment                  119210 non-null  int64
 15  distribution_channel            119210 non-null  int64
 16  is_repeated_guest               119210 non-null  int64
 17  previous_cancellations          119210 non-null  int64
 18  previous_bookings_not_canceled  119210 non-null  int64
 19  reserved_room_type              119210 non-null  int64
 20  assigned_room_type              119210 non-null  int64
 21  booking_changes                 119210 non-null  int64
 22  deposit_type                    119210 non-null  int64
 23  agent                           119210 non-null  int64
 24  days_in_waiting_list            119210 non-null  int64
 25  customer_type                   119210 non-null  int64
 26  adr                             119210 non-null  float64
 27  required_car_parking_spaces     119210 non-null  int64
 28  total_of_special_requests       119210 non-null  int64
 29  reservation_status              119210 non-null  int64
dtypes: float64(1), int64(28), object(1)
memory usage: 28.2+ MB
```

[25]:
```
y = hotel.iloc[:,1]
y=y.astype('int')
X = pd.concat([hotel.iloc[:,0],hotel.iloc[:,2:29]], axis=1)
```

[26]:
```
y.shape
```

[26]:
```
(119210,)
```

[27]:
```
#performing preprocessing part
from sklearn import decomposition
pca = decomposition.PCA(n_components=3)
X_pca1 = pca.fit_transform(X)
print("Shape of data after PCA = ", X_pca1.shape)
```

```
Shape of data after PCA =  (119210, 3)
```

[28]:
```
X_pca = pd.DataFrame(X_pca1)
X_pca.columns= ['PC1','PC2','PC3']
X_pca.shape
```

[28]:
```
(119210, 3)
```

[29]:
```
# Splitting the X and Y into Training set and Testing set
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X_pca, y, test_size = 0.2,␣
 ↪random_state = 0)
```

[30]:
```
standardScalerX = StandardScaler()
X_train = standardScalerX.fit_transform(X_train)
X_test = standardScalerX.fit_transform(X_test)
```

Model Building

[31]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import ExtraTreesClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.ensemble import VotingClassifier

from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
```

[32]:
```
# Random Forest Model Building

rfc_model = RandomForestClassifier (min_samples_leaf = 6, min_samples_split =␣
 ↪6, n_estimators = 100)

#fitting and prediction of model
```

```
rfc_model.fit(X_train, y_train)
predict_rfc = rfc_model.predict(X_test)
```

[33]:
```
# Decision Tree  Model Building

dtc_model = DecisionTreeClassifier (criterion = 'gini', min_samples_leaf = 4,␣
 ↪min_samples_split = 8, max_features = 'auto')

#fitting and prediction of model
dtc_model.fit(X_train, y_train)
predict_dtc = dtc_model.predict(X_test)
```

[34]:
```
# Extreme Gradient Boosting Model Building

xgb_model = XGBClassifier (criterion = 'gini', learning_rate = 0.01, max_depth␣
 ↪= 5, n_estimators = 100, objective = 'binary:logistic', subsample = 1.000)

#fitting and prediction of model
xgb_model.fit(X_train, y_train)
predict_xgb = xgb_model.predict(X_test)
```

```
[00:17:04] WARNING: ../src/learner.cc:573:
Parameters: { "criterion" } might not be used.

  This may not be accurate due to some parameters are only used in language
bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[00:17:05] WARNING: ../src/learner.cc:1095: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

[35]:
```
# Extra Trees Classifier Model Building

etc_model = ExtraTreesClassifier ( min_samples_leaf = 7, min_samples_split = 2,␣
 ↪n_estimators = 200 )

#fitting and prediction of model
etc_model.fit(X_train, y_train)
predict_etc = etc_model.predict(X_test)
```

Classification Report

[36]:

```
print("RF", classification_report(y_test, predict_rfc))
print("DTC",classification_report(y_test, predict_dtc))
print("XGB", classification_report(y_test, predict_xgb))
print("ETC", classification_report(y_test, predict_etc))
```

```
RF               precision    recall  f1-score   support

           0       0.73      0.90      0.81     14919
           1       0.73      0.43      0.54      8923

    accuracy                           0.73     23842
   macro avg       0.73      0.67      0.67     23842
weighted avg       0.73      0.73      0.71     23842

DTC               precision    recall  f1-score   support

           0       0.71      0.81      0.76     14919
           1       0.58      0.44      0.50      8923

    accuracy                           0.67     23842
   macro avg       0.65      0.63      0.63     23842
weighted avg       0.66      0.67      0.66     23842

XGB               precision    recall  f1-score   support

           0       0.69      0.93      0.79     14919
           1       0.72      0.30      0.43      8923

    accuracy                           0.69     23842
   macro avg       0.70      0.62      0.61     23842
weighted avg       0.70      0.69      0.66     23842

ETC               precision    recall  f1-score   support

           0       0.65      1.00      0.79     14919
           1       0.99      0.09      0.17      8923

    accuracy                           0.66     23842
   macro avg       0.82      0.55      0.48     23842
weighted avg       0.78      0.66      0.56     23842
```

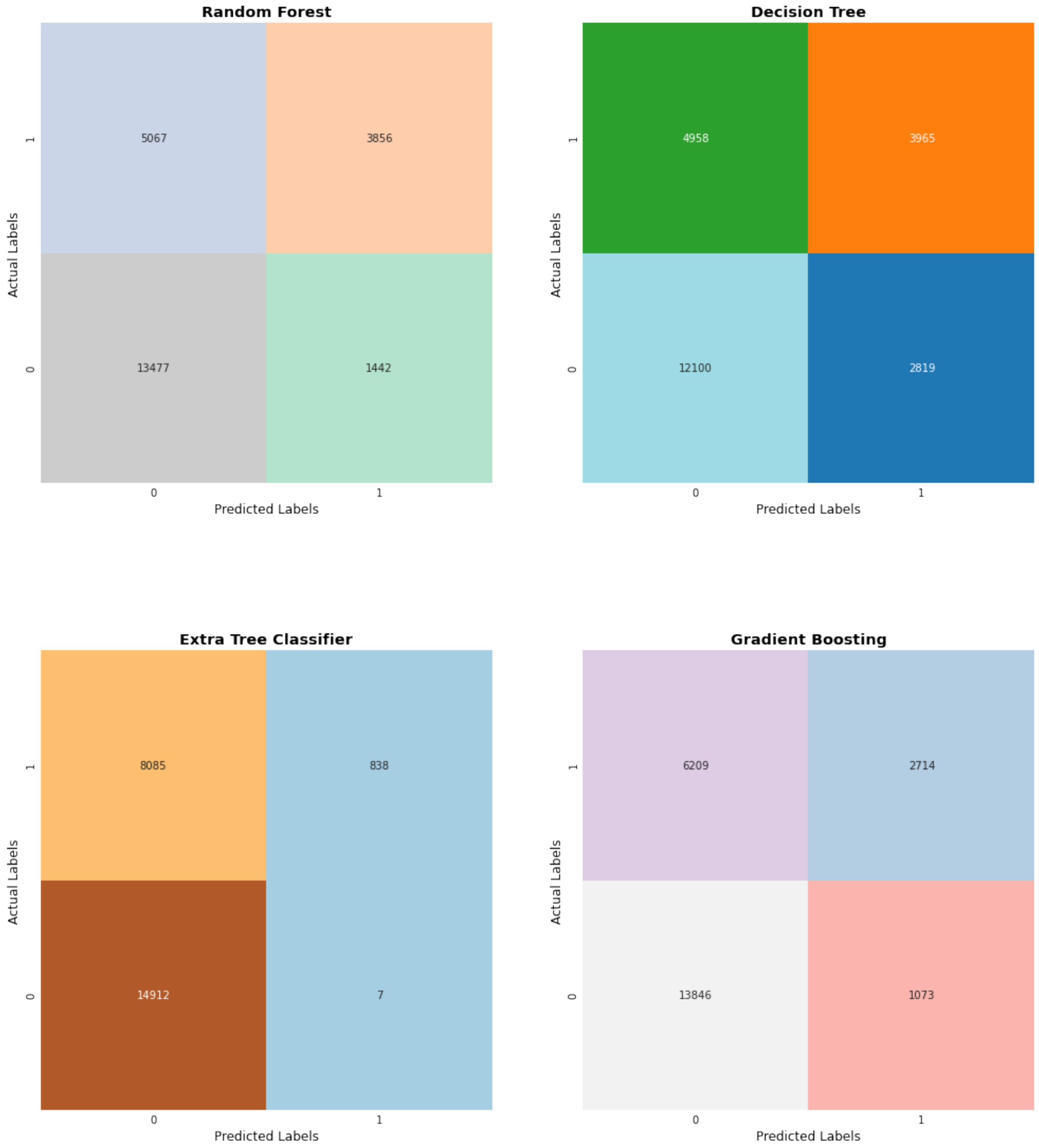
Confusion Matrix

[37]:

```
RF_matrix = confusion_matrix(y_test, predict_rfc)
DTC_matrix = confusion_matrix(y_test, predict_dtc)
XGB_matrix = confusion_matrix(y_test, predict_xgb)
ETC_matrix = confusion_matrix(y_test, predict_etc)
```

```
fig, ax = plt.subplots(1, 2, figsize=(15, 8))

sns.heatmap(RF_matrix,annot=True, fmt="d", cbar=False, cmap="Pastel2",  ax =␣
 ↪ax[0]).set_ylim([0,2])
ax[0].set_title("Random Forest", weight='bold')
ax[0].set_xlabel('Predicted Labels')
ax[0].set_ylabel('Actual Labels')

sns.heatmap(DTC_matrix,annot=True, fmt="d" ,cbar=False, cmap="tab20", ax =␣
 ↪ax[1]).set_ylim([0,2])
ax[1].set_title("Decision Tree", weight='bold')
ax[1].set_xlabel('Predicted Labels')
ax[1].set_ylabel('Actual Labels')

################

fig, axe = plt.subplots(1, 2, figsize=(15, 8))

sns.heatmap(XGB_matrix,annot=True, fmt="d", cbar=False, cmap="Pastel1", ax =␣
 ↪axe[1]).set_ylim([0,2])
axe[1].set_title("Gradient Boosting", weight='bold')
axe[1].set_xlabel('Predicted Labels')
axe[1].set_ylabel('Actual Labels')

sns.heatmap(ETC_matrix,annot=True, fmt="d", cbar=False, cmap="Paired", ax =␣
 ↪axe[0]).set_ylim([0,2])
axe[0].set_title("Extra Tree Classifier", weight='bold')
axe[0].set_xlabel('Predicted Labels')
axe[0].set_ylabel('Actual Labels')
```

```
[37]: Text(68.9, 0.5, 'Actual Labels')
```



SMOTE OVERSAMPLING

[38]:
```
pip install -U imbalanced-learn
```

```
Requirement already up-to-date: imbalanced-learn in
/opt/conda/lib/python3.7/site-packages (0.8.0)
Requirement already satisfied, skipping upgrade: scikit-learn>=0.24 in
/opt/conda/lib/python3.7/site-packages (from imbalanced-learn) (0.24.2)
Requirement already satisfied, skipping upgrade: scipy>=0.19.1 in
/opt/conda/lib/python3.7/site-packages (from imbalanced-learn) (1.4.1)
```

```
Requirement already satisfied, skipping upgrade: numpy>=1.13.3 in
/opt/conda/lib/python3.7/site-packages (from imbalanced-learn) (1.16.5)
Requirement already satisfied, skipping upgrade: joblib>=0.11 in
/opt/conda/lib/python3.7/site-packages (from imbalanced-learn) (0.15.1)
Requirement already satisfied, skipping upgrade: threadpoolctl>=2.0.0 in
/opt/conda/lib/python3.7/site-packages (from scikit-learn>=0.24->imbalanced-
learn) (2.2.0)
Note: you may need to restart the kernel to use updated packages.
```

[39]:
```
pip install imblearn
```

```
Requirement already satisfied: imblearn in /opt/conda/lib/python3.7/site-
packages (0.0)
Requirement already satisfied: imbalanced-learn in
/opt/conda/lib/python3.7/site-packages (from imblearn) (0.8.0)
Requirement already satisfied: joblib>=0.11 in /opt/conda/lib/python3.7/site-
packages (from imbalanced-learn->imblearn) (0.15.1)
Requirement already satisfied: numpy>=1.13.3 in /opt/conda/lib/python3.7/site-
packages (from imbalanced-learn->imblearn) (1.16.5)
Requirement already satisfied: scikit-learn>=0.24 in
/opt/conda/lib/python3.7/site-packages (from imbalanced-learn->imblearn)
(0.24.2)
Requirement already satisfied: scipy>=0.19.1 in /opt/conda/lib/python3.7/site-
packages (from imbalanced-learn->imblearn) (1.4.1)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/opt/conda/lib/python3.7/site-packages (from scikit-learn>=0.24->imbalanced-
learn->imblearn) (2.2.0)
Note: you may need to restart the kernel to use updated packages.
```

[41]:
```
from collections import Counter
```

[42]:
```
pip install delayed
```

```
Requirement already satisfied: delayed in /opt/conda/lib/python3.7/site-packages
(0.11.0b1)
Requirement already satisfied: hiredis in /opt/conda/lib/python3.7/site-packages
(from delayed) (2.0.0)
Requirement already satisfied: redis in /opt/conda/lib/python3.7/site-packages
(from delayed) (3.5.3)
Note: you may need to restart the kernel to use updated packages.
```

[43]:
```
from imblearn.over_sampling import SMOTE
```

[45]:
```
sm = SMOTE(random_state = 10)
X_sm, y_sm = sm.fit_resample(X_pca, y)
```

[46]:
```
X_sm.shape
```

[46]:
```
(150022, 3)
```

[47]:
```
y_sm.shape
```

[47]:
```
(150022,)
```

[48]:
```
print('After OverSampling, the shape of train_X: {}'.format(X_sm.shape))
print('After OverSampling, the shape of train_y: {} \n'.format(y_sm.shape))

print("After OverSampling, counts of label '1': {}".format(sum(y_sm == 1)))
print("After OverSampling, counts of label '0': {}".format(sum(y_sm == 0)))
```

```
After OverSampling, the shape of train_X: (150022, 3)
After OverSampling, the shape of train_y: (150022,)

After OverSampling, counts of label '1': 75011
After OverSampling, counts of label '0': 75011
```

[49]:
```
X_train_res, X_test_res, y_train_res, y_test_res = train_test_split(X_sm, y_sm,␣
 ↪test_size=0.25, random_state=27,stratify=None)
```

[50]:
```
standardScalerX = StandardScaler()
X_train_res = standardScalerX.fit_transform(X_train_res)
X_test_res = standardScalerX.fit_transform(X_test_res)
```

[59]:
```
from sklearn.model_selection import StratifiedKFold
kfold_cv1 = StratifiedKFold( n_splits = 5, random_state = 27, shuffle = True)

for train_index1, test_index1 in kfold_cv1.split(X_sm,y_sm):
    X_train_res, X_test_res = X_sm.iloc[train_index1], X_sm.iloc[test_index1]
    y_train_res, y_test_res = y_sm.iloc[train_index1], y_sm.iloc[test_index1]
```

[52]:
```
# Random Forest Model Building

rfc_model1 = RandomForestClassifier (min_samples_leaf = 6, min_samples_split =␣
 ↪6, n_estimators = 100)

#fitting and prediction of model
rfc_model1.fit(X_train_res, y_train_res)
predict_rfc1 = rfc_model1.predict(X_test_res)
```

[53]:
```
# Decision Tree  Model Building

dtc_model1 = DecisionTreeClassifier (criterion = 'gini', min_samples_leaf = 4,␣
 ↪min_samples_split = 8, max_features = 'auto')

#fitting and prediction of model
```

```
dtc_model1.fit(X_train_res, y_train_res)
predict_dtc1 = dtc_model1.predict(X_test_res)
```

[54]:
```
# Extreme Gradient Boosting Model Building

xgb_model1 = XGBClassifier (criterion = 'gini', learning_rate = 0.01, max_depth␣
 ↪= 5, n_estimators = 100, objective = 'binary:logistic', subsample = 1.000)

#fitting and prediction of model
xgb_model1.fit(X_train_res, y_train_res)
predict_xgb1 = xgb_model1.predict(X_test_res)
```

```
[00:20:21] WARNING: ../src/learner.cc:573:
Parameters: { "criterion" } might not be used.

  This may not be accurate due to some parameters are only used in language
bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[00:20:22] WARNING: ../src/learner.cc:1095: Starting in XGBoost 1.3.0, the
default evaluation metric used with the objective 'binary:logistic' was changed
from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore
the old behavior.
```

[55]:
```
# Extra Trees Classifier Model Building

etc_model1 = ExtraTreesClassifier ( min_samples_leaf = 7, min_samples_split =␣
 ↪2, n_estimators = 200 )

#fitting and prediction of model
etc_model1.fit(X_train_res, y_train_res)
predict_etc1 = etc_model1.predict(X_test_res)
```

[56]:
```
print("RF1", classification_report(y_test_res, predict_rfc1))
print("DTC1",classification_report(y_test_res, predict_dtc1))
print("XGB1", classification_report(y_test_res, predict_xgb1))
print("ETC1", classification_report(y_test_res, predict_etc1))
```

```
RF1                precision    recall  f1-score   support

           0       0.75      0.81      0.78     18804
           1       0.80      0.73      0.76     18702

    accuracy                           0.77     37506
```

```
   macro avg       0.77      0.77      0.77     37506
weighted avg       0.77      0.77      0.77     37506

DTC1               precision    recall  f1-score   support

           0       0.67      0.78      0.72     18804
           1       0.73      0.61      0.67     18702

    accuracy                           0.69     37506
   macro avg       0.70      0.69      0.69     37506
weighted avg       0.70      0.69      0.69     37506

XGB1               precision    recall  f1-score   support

           0       0.73      0.53      0.62     18804
           1       0.63      0.80      0.71     18702

    accuracy                           0.67     37506
   macro avg       0.68      0.67      0.66     37506
weighted avg       0.68      0.67      0.66     37506

ETC1               precision    recall  f1-score   support

           0       0.70      0.79      0.74     18804
           1       0.76      0.67      0.71     18702

    accuracy                           0.73     37506
   macro avg       0.73      0.73      0.73     37506
weighted avg       0.73      0.73      0.73     37506
```