04_Merged_Data_Pretraining

April 15, 2022

0.1 Predicting Airline Delays

Notebook: Data Preparation Notebook

Team: Jimmy Nguyen, Maha Jayapal, Roberto Cancel

[1]:
```
!pip install --upgrade numpy #ensure numpy and pandas are upgraded to same␣
 ↪versions for easier exploration (avoiding errors)
!pip install --upgrade pandas #ensure numpy and pandas are upgraded to same␣
 ↪versions for easier exploration (avoiding errors)

import boto3 # AWS SDK for Python
import io # for encoding issues with raw data sets
from io import StringIO # converting dataframe to csv and uploading to s3␣
 ↪bucket /tranformed folder

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
```

```
/opt/conda/lib/python3.7/site-packages/secretstorage/dhcrypto.py:16:
CryptographyDeprecationWarning: int_from_bytes is deprecated, use int.from_bytes
instead
  from cryptography.utils import int_from_bytes
/opt/conda/lib/python3.7/site-packages/secretstorage/util.py:25:
CryptographyDeprecationWarning: int_from_bytes is deprecated, use int.from_bytes
instead
  from cryptography.utils import int_from_bytes
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(1.21.5)
WARNING: Running pip as the 'root' user can result in broken permissions

and conflicting behaviour with the system package manager. It is recommended to

use a virtual environment instead: https://pip.pypa.io/warnings/venv

/opt/conda/lib/python3.7/site-packages/secretstorage/dhcrypto.py:16:
CryptographyDeprecationWarning: int_from_bytes is deprecated, use int.from_bytes
```

```
instead
  from cryptography.utils import int_from_bytes
/opt/conda/lib/python3.7/site-packages/secretstorage/util.py:25:
CryptographyDeprecationWarning: int_from_bytes is deprecated, use int.from_bytes
instead
  from cryptography.utils import int_from_bytes
Requirement already satisfied: pandas in /opt/conda/lib/python3.7/site-packages
(1.3.5)
Requirement already satisfied: pytz>=2017.3 in /opt/conda/lib/python3.7/site-
packages (from pandas) (2021.3)
Requirement already satisfied: python-dateutil>=2.7.3 in
/opt/conda/lib/python3.7/site-packages (from pandas) (2.8.1)
Requirement already satisfied: numpy>=1.17.3 in /opt/conda/lib/python3.7/site-
packages (from pandas) (1.21.5)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.7/site-
packages (from python-dateutil>=2.7.3->pandas) (1.14.0)
WARNING: Running pip as the 'root' user can result in broken permissions

and conflicting behaviour with the system package manager. It is recommended to

use a virtual environment instead: https://pip.pypa.io/warnings/venv
```

[2]:

```python
# INGEST Merged DATA

s3_client = boto3.client("s3")

BUCKET='ads-508-airline'
KEY='merged/Dec_modeling.csv'

response = s3_client.get_object(Bucket=BUCKET, Key=KEY)
dec_merged = pd.read_csv(response.get("Body"))
dec_merged.head()
```

[2]:

```
   DAY_OF_MONTH  DAY_OF_WEEK OP_UNIQUE_CARRIER TAIL_NUM  ORIGIN_AIRPORT_ID  \
0             8            7                WN   N8651A              15016
1             8            7                WN   N939WN              15016
2             8            7                WN   N7741C              15016
3             8            7                WN   N550WN              15016
4             8            7                WN   N8319F              15016

  ORIGIN DEST  DEP_DEL15 DEP_TIME_BLK ARR_TIME_BLK  …  \
0    STL  SAN        0.0    1100-1159    1300-1359  …
1    STL  SAT        0.0    1200-1259    1400-1459  …
2    STL  SAT        0.0    2100-2159    0001-0559  …
3    STL  SEA        0.0    0900-0959    1200-1259  …
4    STL  SFO        1.0    1800-1859    2000-2059  …
```

```
            CARRIER_NAME  PILOTS_COPILOTS  PASSENGER_HANDLING  \
0  Southwest Airlines Co.             8989                9668
1  Southwest Airlines Co.             8989                9668
2  Southwest Airlines Co.             8989                9668
3  Southwest Airlines Co.             8989                9668
4  Southwest Airlines Co.             8989                9668

   PASS_GEN_SVC_ADMIN  MAINTENANCE  PRCP  SNOW  SNWD  TMAX  AWND
0               15475         2482  0.02   0.0   0.0  58.0  9.84
1               15475         2482  0.02   0.0   0.0  58.0  9.84
2               15475         2482  0.02   0.0   0.0  58.0  9.84
3               15475         2482  0.02   0.0   0.0  58.0  9.84
4               15475         2482  0.02   0.0   0.0  58.0  9.84

[5 rows x 25 columns]
```

[3]:
```
dec_merged.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 558026 entries, 0 to 558025
Data columns (total 25 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   DAY_OF_MONTH        558026 non-null  int64
 1   DAY_OF_WEEK         558026 non-null  int64
 2   OP_UNIQUE_CARRIER   558026 non-null  object
 3   TAIL_NUM            558026 non-null  object
 4   ORIGIN_AIRPORT_ID   558026 non-null  int64
 5   ORIGIN              558026 non-null  object
 6   DEST                558026 non-null  object
 7   DEP_DEL15           558026 non-null  float64
 8   DEP_TIME_BLK        558026 non-null  object
 9   ARR_TIME_BLK        558026 non-null  object
 10  CANCELLED           558026 non-null  float64
 11  CRS_ELAPSED_TIME    558026 non-null  float64
 12  DISTANCE            558026 non-null  float64
 13  DISTANCE_GROUP      558026 non-null  int64
 14  AIRLINE_ID          558026 non-null  int64
 15  CARRIER_NAME        558026 non-null  object
 16  PILOTS_COPILOTS     558026 non-null  int64
 17  PASSENGER_HANDLING  558026 non-null  int64
 18  PASS_GEN_SVC_ADMIN  558026 non-null  int64
 19  MAINTENANCE         558026 non-null  int64
 20  PRCP                558026 non-null  float64
 21  SNOW                558026 non-null  float64
 22  SNWD                558026 non-null  float64
 23  TMAX                558026 non-null  float64
 24  AWND                558026 non-null  float64
dtypes: float64(9), int64(9), object(7)
memory usage: 106.4+ MB
```

[4]:
```
dec_merged.shape
```

[4]:
```
(558026, 25)
```

1 Data Cleaning

All missing values were imputed or dropped, as described above. Since our data has been validated by the Bureau of Transportation Statistics and Climate Data Online, outliers were investigated by reviewing the summary statistics of our data set.

[5]:
```
dec_merged.describe()
```

[5]:
```
        DAY_OF_MONTH    DAY_OF_WEEK  ORIGIN_AIRPORT_ID      DEP_DEL15  \
count  558026.000000  558026.000000      558026.000000  558026.000000
mean       15.830902       3.938745       12666.002996       0.208399
std         8.957760       2.085336        1514.187330       0.406164
min         1.000000       1.000000       10140.000000       0.000000
25%         8.000000       2.000000       11292.000000       0.000000
50%        16.000000       4.000000       12889.000000       0.000000
75%        23.000000       6.000000       13931.000000       0.000000
max        31.000000       7.000000       15919.000000       1.000000

       CANCELLED  CRS_ELAPSED_TIME       DISTANCE  DISTANCE_GROUP  \
count   558026.0     558026.000000  558026.000000   558026.000000
mean         0.0        148.552937     843.568687        3.844704
std          0.0         74.475448     604.827406        2.372199
min          0.0         34.000000      66.000000        1.000000
25%          0.0         94.000000     400.000000        2.000000
50%          0.0        130.000000     680.000000        3.000000
75%          0.0        179.000000    1075.000000        5.000000
max          0.0        705.000000    5095.000000       11.000000

          AIRLINE_ID  PILOTS_COPILOTS  PASSENGER_HANDLING  PASS_GEN_SVC_ADMIN  \
count  558026.000000    558026.000000       558026.000000       558026.000000
mean    19954.738880      6132.518447         7380.776432         9991.061352
std       368.971181      3163.783165         5905.764240         6417.203879
min     19393.000000       586.000000            0.000000          154.000000
25%     19790.000000      2444.000000         1407.000000         3592.000000
50%     19930.000000      7637.000000         8586.000000        15237.000000
75%     20314.000000      8989.000000         9668.000000        15502.000000
max     20436.000000      9293.000000        16888.000000        15809.000000

         MAINTENANCE           PRCP           SNOW           SNWD  \
count  558026.000000  558026.000000  558026.000000  558026.000000
mean     3576.673642       0.116641       0.048059       0.121935
std      3092.215270       0.352309       0.347030       0.806783
min        34.000000       0.000000       0.000000       0.000000
25%       898.000000       0.000000       0.000000       0.000000
50%      2482.000000       0.000000       0.000000       0.000000
75%      6122.000000       0.040000       0.000000       0.000000
max      9677.000000       7.130000      13.300000      18.100000

                TMAX           AWND
count  558026.000000  558026.000000
mean       56.160668       8.137934
std        14.612596       4.014022
min         8.000000       0.000000
25%        45.000000       4.920000
50%        56.000000       7.610000
75%        67.000000      10.510000
max        87.000000      25.720000
```

Evaluation of min and max values indicate that outliers do not exist. Also, thanks to the preprocessing of our datasets before merging, duplicates and formatting issues were already resolved.

1.1 1. Feature Selection

- We will disregard columns with IDs
- Also drop any redundant columns such as having only 1 distinct value
- Since we have both the distance and distance group column, it is redundant or DEP_TIME_BLK vs. ARR_TIME_BLK

```
[6]: dec_merged.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 558026 entries, 0 to 558025
Data columns (total 25 columns):
 #   Column             Non-Null Count   Dtype
---  ------             --------------   -----
 0   DAY_OF_MONTH       558026 non-null  int64
 1   DAY_OF_WEEK        558026 non-null  int64
 2   OP_UNIQUE_CARRIER  558026 non-null  object
 3   TAIL_NUM           558026 non-null  object
 4   ORIGIN_AIRPORT_ID  558026 non-null  int64
 5   ORIGIN             558026 non-null  object
 6   DEST               558026 non-null  object
 7   DEP_DEL15          558026 non-null  float64
 8   DEP_TIME_BLK       558026 non-null  object
 9   ARR_TIME_BLK       558026 non-null  object
 10  CANCELLED          558026 non-null  float64
 11  CRS_ELAPSED_TIME   558026 non-null  float64
 12  DISTANCE           558026 non-null  float64
 13  DISTANCE_GROUP     558026 non-null  int64
 14  AIRLINE_ID         558026 non-null  int64
 15  CARRIER_NAME       558026 non-null  object
 16  PILOTS_COPILOTS    558026 non-null  int64
 17  PASSENGER_HANDLING 558026 non-null  int64
 18  PASS_GEN_SVC_ADMIN 558026 non-null  int64
 19  MAINTENANCE        558026 non-null  int64
 20  PRCP               558026 non-null  float64
 21  SNOW               558026 non-null  float64
 22  SNWD               558026 non-null  float64
 23  TMAX               558026 non-null  float64
 24  AWND               558026 non-null  float64
dtypes: float64(9), int64(9), object(7)
memory usage: 106.4+ MB
```

Of the 24 features remaining in our dataset, several were redundant upon inspection. ORIGIN_AIRPORT_ID is redundant with ORIGIN. ARR_TIME_BLK, which represents the arrival time block, is redundant with the combination of DEP_TIME_BLK and CRS_ELAPSED_TIME, or the schedule length of the flight, and DISTANCE_GROUP, or the distance of the flight. AIRLINE_ID is redundant with CARRIER_NAME. DISTANCE is redundant with the DISTANCE_GROUP binned feature. Since CRS_ELAPSED_TIME would be a function of the distance traveled, it was also dropped. OP_UNIQUE_CARRIER is redundant with CARRIER_NAME, which is also easier to interpret in subsequent sections, therefore OP_UNIQUE_CARRIER will be dropped. Since all cancelled flights were removed, the CANCELLED feature is irrelevant. This left 17 features in our dataset. Some features, such as CARRIER_NAME, ORIGIN, and DEST will not be used in modeling but are retained for later use.

[7]:
```
dropped = ['TAIL_NUM','ORIGIN_AIRPORT_ID',␣
 ↪'ARR_TIME_BLK','CANCELLED','AIRLINE_ID','DISTANCE', 'CRS_ELAPSED_TIME',␣
 ↪'OP_UNIQUE_CARRIER']
dec_red = dec_merged.drop(dropped, axis=1)
dec_red.head()
```

[7]:
```
   DAY_OF_MONTH  DAY_OF_WEEK ORIGIN DEST  DEP_DEL15 DEP_TIME_BLK  \
0             8            7    STL  SAN        0.0    1100-1159
1             8            7    STL  SAT        0.0    1200-1259
2             8            7    STL  SAT        0.0    2100-2159
3             8            7    STL  SEA        0.0    0900-0959
4             8            7    STL  SFO        1.0    1800-1859

   DISTANCE_GROUP           CARRIER_NAME  PILOTS_COPILOTS  \
0               7  Southwest Airlines Co.            8989
1               4  Southwest Airlines Co.            8989
2               4  Southwest Airlines Co.            8989
3               7  Southwest Airlines Co.            8989
4               7  Southwest Airlines Co.            8989
```

```
   PASSENGER_HANDLING  PASS_GEN_SVC_ADMIN  MAINTENANCE  PRCP  SNOW  SNWD  \
0                9668               15475         2482  0.02   0.0   0.0
1                9668               15475         2482  0.02   0.0   0.0
2                9668               15475         2482  0.02   0.0   0.0
3                9668               15475         2482  0.02   0.0   0.0
4                9668               15475         2482  0.02   0.0   0.0

   TMAX  AWND
0  58.0  9.84
1  58.0  9.84
2  58.0  9.84
3  58.0  9.84
4  58.0  9.84
```

[8]:

```
dec_red.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 558026 entries, 0 to 558025
Data columns (total 17 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   DAY_OF_MONTH        558026 non-null  int64
 1   DAY_OF_WEEK         558026 non-null  int64
 2   ORIGIN              558026 non-null  object
 3   DEST                558026 non-null  object
 4   DEP_DEL15           558026 non-null  float64
 5   DEP_TIME_BLK        558026 non-null  object
 6   DISTANCE_GROUP      558026 non-null  int64
 7   CARRIER_NAME        558026 non-null  object
 8   PILOTS_COPILOTS     558026 non-null  int64
 9   PASSENGER_HANDLING  558026 non-null  int64
 10  PASS_GEN_SVC_ADMIN  558026 non-null  int64
 11  MAINTENANCE         558026 non-null  int64
 12  PRCP                558026 non-null  float64
 13  SNOW                558026 non-null  float64
 14  SNWD                558026 non-null  float64
 15  TMAX                558026 non-null  float64
 16  AWND                558026 non-null  float64
dtypes: float64(6), int64(7), object(4)
memory usage: 72.4+ MB
```

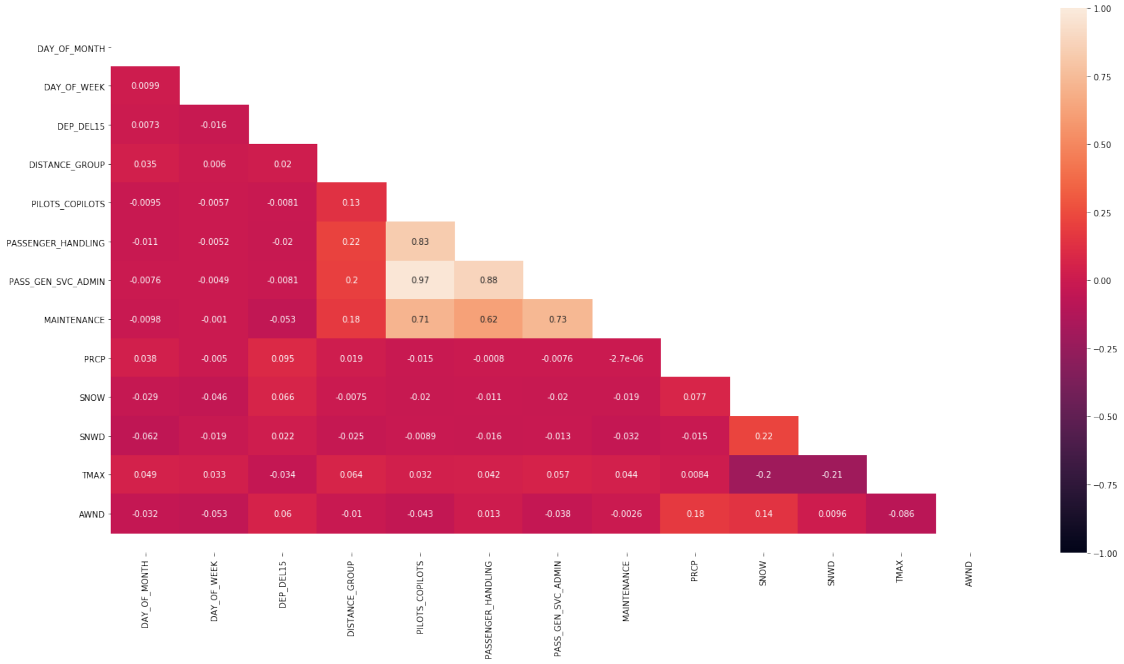
[9]:

```
# Correlation Matrix for multicollinearity
plt.figure(figsize=(24, 12))
mask = np.triu(np.ones_like(dec_red.corr(), dtype=np.bool))
heatmap = sns.heatmap(dec_red.corr(), mask=mask, vmin=-1, vmax=1, annot=True)

# Make the full heat map visible
```

```
b, t = plt.ylim() # discover the values for bottom and top
b += 0.5 # Add 0.5 to the bottom
t -= 0.5 # Subtract 0.5 from the top
plt.ylim(b, t) # update the ylim(bottom, top) values
plt.show() # ta-da!
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:3:
DeprecationWarning: `np.bool` is a deprecated alias for the builtin `bool`. To
silence this warning, use `bool` by itself. Doing this will not modify any
behavior and is safe. If you specifically wanted the numpy scalar type, use
`np.bool_` here.
Deprecated in NumPy 1.20; for more details and guidance:
https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  This is separate from the ipykernel package so we can avoid doing imports
until
```



1.2 2. Feature Creation

Since the day of the month did not show an easily identifiable pattern for departure delays, a new feature WEEK_OF_MONTH was created. This feature consists of 4 full (7-day) weeks and 1 partial (3-day) week. WEEK_OF_MONTH distributions for departure delay were evaluated to determine the optimal feature to use.

```
WEEK_OF_MONTH

  1-7 = Week 1 = 1
  8-14 = Week 2 = 2
```

```
15-21 = Week 3 = 3
22-28 = week 4 = 4
29-31 = partial week 5 = 5
```

While DEP_TIME_BLK showed- REDUCE CARDINALITY OF DEPARTURE TIME BLOCKS (PREVIOUSLY 19 levels with inconsistent bucket size to 4 bins)

```
Redeye/Early Departure = 12:01 a.m. - 5:59 a.m  = 1
Morning Departure = 6:00 a.m - 11:59 a.m.  = 2
Daytime Departure = 12:00 p.m. - 5:59 p.m = 3
Late Departure = 6:00 p.m. - 11:59 p.m. = 4
```

1.2.1 Create WEEK_OF_MONTH

[10]:

```python
def month_weeks_range(x):
    if x <= 7:
        return 1
    elif x <= 14:
        return 2
    elif x <= 21:
        return 3
    elif x <= 28:
        return 4
    else:
        return 5

dec_red['WEEK_OF_MONTH'] = dec_red['DAY_OF_MONTH'].apply(lambda x: month_weeks_range(x))
dec_red['WEEK_OF_MONTH'].value_counts()
```

[10]:

```
3    129144
1    128108
2    125664
4    122390
5     52720
Name: WEEK_OF_MONTH, dtype: int64
```

[11]:

```python
# Explore DAY OF MONTH with DEP_DEL15
Week = pd.crosstab(dec_red['WEEK_OF_MONTH'], dec_red['DEP_DEL15'])
Week['Total'] = Week.sum(axis=1)
Week.loc['Total'] = Week.sum()
Week['Percent_Delayed'] = ((Week.iloc[:,1])/((Week.iloc[:,0])+(Week.iloc[:,1])))
Week = Week.sort_values('Percent_Delayed')
Week
```

[11]:

```
DEP_DEL15         0.0     1.0   Total  Percent_Delayed
WEEK_OF_MONTH
2              102803   22861  125664         0.181922
```

```
Total          441734  116292  558026         0.208399
3              101636   27508  129144         0.213003
1              100715   27393  128108         0.213827
4               95691   26699  122390         0.218147
5               40889   11831   52720         0.224412
```

[12]:

```
# Drop DAY_OF_MONTH in place of WEEK_OF_MONTH
dec_red.drop(columns=['DAY_OF_MONTH'], inplace = True)
```

1.2.2 Transform DEP_TIME_BLK

[13]:

```
dep_blk = {'0600-0659':2, '0700-0759':2, '0800-0859':2,
           '0900-0959':2,'1000-1059':2, '1100-1159':2,
           '1200-1259':3, '1300-1359':3, '1400-1459':3,
           '1500-1559':3, '1600-1659':3, '1700-1759':3,
           '1800-1859':4, '1900-1959':4,'2000-2059':4,
           '2100-2159':4, '2200-2259':4,
           '2200-2259':4, '2300-2359':4, '0001-0559':1}

dec_red['DEP_TIME_BLK'] = dec_red['DEP_TIME_BLK'].replace(dep_blk)
dec_red['DEP_TIME_BLK'].value_counts()
```

[13]:

```
2    213792
3    197393
4    131938
1     14903
Name: DEP_TIME_BLK, dtype: int64
```

[14]:

```
# Explore DEP_TIME_BLK with DEP_DEL15
DEP = pd.crosstab(dec_red['DEP_TIME_BLK'], dec_red['DEP_DEL15'])
DEP['Total'] = DEP.sum(axis=1)
DEP.loc['Total'] = DEP.sum()
DEP['Percent_Delayed'] = ((DEP.iloc[:,1])/((DEP.iloc[:,0])+(DEP.iloc[:,1])))
DEP = DEP.sort_values('Percent_Delayed')
DEP
```

[14]:

```
DEP_DEL15        0.0     1.0   Total  Percent_Delayed
DEP_TIME_BLK
1              13563    1340   14903         0.089915
2             183722   30070  213792         0.140651
Total         441734  116292  558026         0.208399
3             150278   47115  197393         0.238686
4              94171   37767  131938         0.286248
```

1.3 3. Feature Transformation

Since the non-numeric features remaining in our dataset will not be ingested in the model, but used later to enhance findings, interpretations and recommendations, and we are using the XGBoost Classification algorithm for modeling purposes, further transformations are unnecessary. XGBoost is not sensitive to transformations or scaling of features in the same way that decision trees and random forest are not. By not scaling our features, we remove the need to scale subsequent data ingested by the model and facilitate easier interpretability of our model with real-world data.

[15]:
```
# List remaining features and types
dec_red.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 558026 entries, 0 to 558025
Data columns (total 17 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   DAY_OF_WEEK         558026 non-null  int64
 1   ORIGIN              558026 non-null  object
 2   DEST                558026 non-null  object
 3   DEP_DEL15           558026 non-null  float64
 4   DEP_TIME_BLK        558026 non-null  int64
 5   DISTANCE_GROUP      558026 non-null  int64
 6   CARRIER_NAME        558026 non-null  object
 7   PILOTS_COPILOTS     558026 non-null  int64
 8   PASSENGER_HANDLING  558026 non-null  int64
 9   PASS_GEN_SVC_ADMIN  558026 non-null  int64
 10  MAINTENANCE         558026 non-null  int64
 11  PRCP                558026 non-null  float64
 12  SNOW                558026 non-null  float64
 13  SNWD                558026 non-null  float64
 14  TMAX                558026 non-null  float64
 15  AWND                558026 non-null  float64
 16  WEEK_OF_MONTH       558026 non-null  int64
dtypes: float64(6), int64(8), object(3)
memory usage: 72.4+ MB
```

1.4 4. Balance the data set

[16]:
```
# Identify the imbalanced class
dec_red['DEP_DEL15'].value_counts()
```

[16]:
```
0.0    441734
1.0    116292
Name: DEP_DEL15, dtype: int64
```

[17]:
```
df_grouped_by =  dec_red.groupby(["DEP_DEL15"])
```

```
df_balanced = df_grouped_by.apply(lambda x: x.sample(df_grouped_by.size().
  ↪min()))
df_balanced.reset_index(drop=True, inplace =True)
df_balanced
```

```
[17]:
        DAY_OF_WEEK ORIGIN DEST  DEP_DEL15  DEP_TIME_BLK  DISTANCE_GROUP  \
0                 2    ATL  DEN        0.0             4               5
1                 6    MSP  FLL        0.0             2               6
2                 5    OGG  SFO        0.0             4              10
3                 5    IAD  SEA        0.0             3              10
4                 3    SEA  BOI        0.0             3               2
…             …    …  …        …           …             …
232579            2    SEA  BUR        1.0             2               4
232580            1    PHX  TUS        1.0             4               1
232581            4    SAN  SEA        1.0             3               5
232582            6    TPA  ATL        1.0             3               2
232583            6    DEN  IND        1.0             4               4

                  CARRIER_NAME  PILOTS_COPILOTS  PASSENGER_HANDLING  \
0       Southwest Airlines Co.             8989                9668
1         Delta Air Lines Inc.             9293               15331
2        United Air Lines Inc.             7637               16888
3         Delta Air Lines Inc.             9293               15331
4         Alaska Airlines Inc.             2893                1062
…                        …              …                  …
232579    Alaska Airlines Inc.             2893                1062
232580      Mesa Airlines Inc.             1312                   0
232581    Delta Air Lines Inc.             9293               15331
232582    Delta Air Lines Inc.             9293               15331
232583  Southwest Airlines Co.             8989                9668

        PASS_GEN_SVC_ADMIN  MAINTENANCE  PRCP  SNOW  SNWD  TMAX   AWND  \
0                    15475         2482  0.00   0.0   0.0  56.0  11.86
1                    15809         6122  0.00   0.0   0.0  72.0   7.83
2                    15237         4991  0.39   0.0   0.0  81.0   7.38
3                    15809         6122  0.25   0.0   0.0  38.0   5.82
4                     5737          898  0.54   0.0   0.0  49.0   8.05
…                    …          …   …   …   …   …   …
232579                5737          898  0.00   0.0   0.0  40.0   4.70
232580                1205           34  0.00   0.0   0.0  62.0   6.49
232581               15809         6122  0.00   0.0   0.0  69.0   2.91
232582               15809         6122  0.32   0.0   0.0  80.0  10.07
232583               15475         2482  0.18   2.8   1.2  29.0  19.24

        WEEK_OF_MONTH
0                   5
1                   1
```

```
2                      1
3                      2
4                      2
…                   …
232579                 4
232580                 3
232581                 1
232582                 4
232583                 4

[232584 rows x 17 columns]
```

[18]:
```
# Confirm the majority class was undersampled
df_balanced['DEP_DEL15'].value_counts()
```

[18]:
```
0.0    116292
1.0    116292
Name: DEP_DEL15, dtype: int64
```

1.5 5. Split the data set

[19]:
```
# partition model used features
model = df_balanced.drop(['ORIGIN','DEST', 'CARRIER_NAME'], axis = 1)

# Move DEP_DEL15 to first position for modeling
Dep = model['DEP_DEL15']
model.drop(labels=['DEP_DEL15'], axis=1,inplace = True)
model.insert(0, 'DEP_DEL15', Dep)
model
```

[19]:
```
        DEP_DEL15  DAY_OF_WEEK  DEP_TIME_BLK  DISTANCE_GROUP  PILOTS_COPILOTS  \
0             0.0            2             4               5             8989
1             0.0            6             2               6             9293
2             0.0            5             4              10             7637
3             0.0            5             3              10             9293
4             0.0            3             3               2             2893
…             …          …           …             …               …
232579        1.0            2             2               4             2893
232580        1.0            1             4               1             1312
232581        1.0            4             3               5             9293
232582        1.0            6             3               2             9293
232583        1.0            6             4               4             8989

        PASSENGER_HANDLING  PASS_GEN_SVC_ADMIN  MAINTENANCE  PRCP  SNOW  SNWD  \
0                     9668               15475         2482  0.00   0.0   0.0
1                    15331               15809         6122  0.00   0.0   0.0
2                    16888               15237         4991  0.39   0.0   0.0
```

```
3                    15331               15809         6122  0.25   0.0    0.0
4                     1062                5737          898  0.54   0.0    0.0
…                    …                   …          …    …    …    …
232579                1062                5737          898  0.00   0.0    0.0
232580                   0                1205           34  0.00   0.0    0.0
232581               15331               15809         6122  0.00   0.0    0.0
232582               15331               15809         6122  0.32   0.0    0.0
232583                9668               15475         2482  0.18   2.8    1.2

        TMAX   AWND  WEEK_OF_MONTH
0       56.0  11.86              5
1       72.0   7.83              1
2       81.0   7.38              1
3       38.0   5.82              2
4       49.0   8.05              2
…       …    …             …
232579  40.0   4.70              4
232580  62.0   6.49              3
232581  69.0   2.91              1
232582  80.0  10.07              4
232583  29.0  19.24              4

[232584 rows x 14 columns]
```

[20]:

```
# Split all data into 90% train and 10% holdout
df_train, df_holdout = train_test_split(model, test_size=0.10,␣
 ↪stratify=model['DEP_DEL15'])

# Split holdout to 50% validation and 50% test
df_val, df_test = train_test_split(df_holdout, test_size=0.50,␣
 ↪stratify=df_holdout['DEP_DEL15'])
```

add code to upload to bucket

[21]:

```
df_train.shape
```

[21]:

```
(209325, 14)
```

[22]:

```
df_val.shape
```

[22]:

```
(11629, 14)
```

[23]:

```
df_test.shape
```

[23]:

```
(11630, 14)
```

[30]:

```
# Save train data set for modeling to model_data folder in bucket
csv_buffer=StringIO()
df_train.to_csv(csv_buffer, index=False)

BUCKET_NAME = 'ads-508-airline'
FileName= 'model_data/df_train.csv'

s3csv = boto3.client('s3')

response=s3csv.put_object(Body=csv_buffer.getvalue(),
                           Bucket=BUCKET_NAME,
                           Key=FileName)
```

[31]:

```
# Save validation data set for modeling to model_data folder in bucket
csv_buffer=StringIO()
df_val.to_csv(csv_buffer, index=False)

BUCKET_NAME = 'ads-508-airline'
FileName= 'model_data/df_val.csv'

s3csv = boto3.client('s3')

response=s3csv.put_object(Body=csv_buffer.getvalue(),
                           Bucket=BUCKET_NAME,
                           Key=FileName)
```

[32]:

```
# Save test data set for modeling to model_data folder in bucket
csv_buffer=StringIO()
df_test.to_csv(csv_buffer, index=False)

BUCKET_NAME = 'ads-508-airline'
FileName= 'model_data/df_test.csv'

s3csv = boto3.client('s3')

response=s3csv.put_object(Body=csv_buffer.getvalue(),
                           Bucket=BUCKET_NAME,
                           Key=FileName)
```

[ ]:

```

```