Insurance Management System - CS6100 Project

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Data Analytics, Visualization, Model Computation and Predictions

Imports

Importing libraries

In [6]:
```
import pandas as pd
import os
import seaborn as sns
import numpy as np
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
import string
import random
import uuid
from collections import Counter
from imblearn.over_sampling import SMOTE
from imblearn.combine import SMOTETomek
from imblearn.over_sampling import KMeansSMOTE
from imblearn.under_sampling import RandomUnderSampler
```

Importing Data

In [7]:
```
# Get the current working directory
cwd = os.getcwd()

# Print the current working directory
print("Current working directory: {0}".format(cwd))

# Loading the data
df = pd.read_csv (r'telematics_syn-032021.csv')
```

```
Current working directory: C:\Users\Surya\Desktop\Report\code\backend
```

Understanding the data

In [8]:
```
df.columns
```

Out[8]:
```
Index(['Duration', 'Insured.age', 'Insured.sex', 'Car.age', 'Marital',
       'Car.use', 'Credit.score', 'Region', 'Annual.miles.drive',
```

```
       'Years.noclaims', 'Territory', 'Annual.pct.driven',
       'Total.miles.driven', 'Pct.drive.mon', 'Pct.drive.tue', 'Pct.drive.wed',
       'Pct.drive.thr', 'Pct.drive.fri', 'Pct.drive.sat', 'Pct.drive.sun',
       'Pct.drive.2hrs', 'Pct.drive.3hrs', 'Pct.drive.4hrs', 'Pct.drive.wkday',
       'Pct.drive.wkend', 'Pct.drive.rush am', 'Pct.drive.rush pm',
       'Avgdays.week', 'Accel.06miles', 'Accel.08miles', 'Accel.09miles',
       'Accel.11miles', 'Accel.12miles', 'Accel.14miles', 'Brake.06miles',
       'Brake.08miles', 'Brake.09miles', 'Brake.11miles', 'Brake.12miles',
       'Brake.14miles', 'Left.turn.intensity08', 'Left.turn.intensity09',
       'Left.turn.intensity10', 'Left.turn.intensity11',
       'Left.turn.intensity12', 'Right.turn.intensity08',
       'Right.turn.intensity09', 'Right.turn.intensity10',
       'Right.turn.intensity11', 'Right.turn.intensity12', 'NB_Claim',
       'AMT_Claim'],
      dtype='object')
```

Variable names and descriptions.

Traditionally gathered data

Duration - Duration of the insurance coverage of a given policy, in days

Insured.age - Age of insured driver, in years

Insured.sex - Sex of insured driver (Male/Female)

Car.age - Age of vehicle, in years

Marital - Marital status (Single/Married)

Car.use - Use of vehicle: Private, Commute, Farmer, Commercial

Credit.score - Credit score of insured driver

Region - Type of region where driver lives: rural, urban

Annual.miles.drive - Annual miles expected to be driven declared by driver

Years.noclaims - Number of years without any claims

Territory - Territorial location of vehicle

Telematically sensed data

Annual.pct.driven - Annualized percentage of time on the road

Total.miles.driven - Total distance driven in miles

Pct.drive.xxx - Percent of driving day xxx of the week: mon/tue/. . . /sun

Pct.drive.xhrs - Percent vehicle driven within x hrs: 2hrs/3hrs/4hrs

Pct.drive.xxx - Percent vehicle driven during xxx: wkday/wkend

Pct.drive.rushxx - Percent of driving during xx rush hours: am/pm

Avgdays.week - Mean number of days used per week

Accel.xxmiles - Number of sudden acceleration 6/8/9/. . . /14 mph/s per 1000 miles

Brake.xxmiles - Number of sudden brakes 6/8/9/. . . /14 mph/s per 1000 miles

Left.turn.intensityxx - Number of left turn per 1000 miles with intensity 08/09/10/11/12

Right.turn.intensityxx - Number of right turn per 1000 miles with intensity 08/09/10/11/12

Response NB_Claim - Number of claims during observation

AMT_Claim - Aggregated amount of claims during observation

Source of dataset description- Article: Synthetic Dataset Generation of Driver Telematics by Banghee So, Jean-Philippe Boucher and Emiliano A. Valdez

Summary Statistics

In [310]:

```
df.describe().T
```

Out[310]:

	count	mean	std	min	25%	50%	
Duration	100000.0	314.204060	79.746222	2.700000e+01	200.000000	365.000000	366.00
Insured.age	100000.0	51.378950	15.467075	1.600000e+01	39.000000	51.000000	63.00
Car.age	100000.0	5.639720	4.062135	-2.000000e+00	2.000000	5.000000	8.00
Credit.score	100000.0	800.888870	83.382316	4.220000e+02	766.000000	825.000000	856.00
Annual.miles.drive	100000.0	9124.122908	3826.144730	0.000000e+00	6213.710000	7456.452000	12427.42
Years.noclaims	100000.0	28.839960	16.123717	0.000000e+00	15.000000	29.000000	41.00
Territory	100000.0	56.531390	24.036518	1.100000e+01	35.000000	62.000000	78.00
Annual.pct.driven	100000.0	0.502294	0.299189	2.739726e-03	0.249315	0.490411	0.75
Total.miles.driven	100000.0	4833.575303	4545.943016	9.529813e-02	1529.897500	3468.287765	6779.87
Pct.drive.mon	100000.0	0.139365	0.042807	0.000000e+00	0.120894	0.137909	0.15
Pct.drive.tue	100000.0	0.151262	0.047612	0.000000e+00	0.130084	0.147900	0.16
Pct.drive.wed	100000.0	0.148288	0.044609	0.000000e+00	0.129348	0.147083	0.16
Pct.drive.thr	100000.0	0.153009	0.044418	0.000000e+00	0.133619	0.151377	0.17
Pct.drive.fri	100000.0	0.157641	0.043716	0.000000e+00	0.138615	0.155996	0.17
Pct.drive.sat	100000.0	0.137912	0.053069	0.000000e+00	0.109415	0.134668	0.16
Pct.drive.sun	100000.0	0.112524	0.049864	-1.880000e-09	0.085258	0.110706	0.13
Pct.drive.2hrs	100000.0	0.003931	0.008122	0.000000e+00	0.000000	0.001308	0.00
Pct.drive.3hrs	100000.0	0.000868	0.004005	0.000000e+00	0.000000	0.000000	0.00
Pct.drive.4hrs	100000.0	0.000242	0.002592	0.000000e+00	0.000000	0.000000	0.00
Pct.drive.wkday	100000.0	0.749550	0.083039	0.000000e+00	0.710336	0.752464	0.79

	count	mean	std	min	25%	50%	
Pct.drive.wkend	100000.0	0.250450	0.083039	0.000000e+00	0.204727	0.247536	0.28
Pct.drive.rush am	100000.0	0.097823	0.078752	0.000000e+00	0.037389	0.078013	0.14
Pct.drive.rush pm	100000.0	0.137598	0.069939	0.000000e+00	0.090424	0.129842	0.17
Avgdays.week	100000.0	5.533067	1.248339	2.009022e-01	4.911596	5.890227	6.48
Accel.06miles	100000.0	43.097120	62.104937	0.000000e+00	9.000000	24.000000	52.00
Accel.08miles	100000.0	4.532490	19.531385	0.000000e+00	0.000000	1.000000	3.00
Accel.09miles	100000.0	1.753550	14.560158	0.000000e+00	0.000000	0.000000	1.00
Accel.11miles	100000.0	0.929150	11.936031	0.000000e+00	0.000000	0.000000	0.00
Accel.12miles	100000.0	0.525090	9.699139	0.000000e+00	0.000000	0.000000	0.00
Accel.14miles	100000.0	0.357030	8.433604	0.000000e+00	0.000000	0.000000	0.00
Brake.06miles	100000.0	83.652540	80.229374	0.000000e+00	33.000000	60.000000	107.00
Brake.08miles	100000.0	9.594090	18.138818	0.000000e+00	3.000000	6.000000	11.00
Brake.09miles	100000.0	3.102530	12.701017	0.000000e+00	1.000000	2.000000	3.00
Brake.11miles	100000.0	1.349240	10.591411	0.000000e+00	0.000000	1.000000	1.00
Brake.12miles	100000.0	0.589900	9.124862	0.000000e+00	0.000000	0.000000	0.00
Brake.14miles	100000.0	0.354990	8.234056	0.000000e+00	0.000000	0.000000	0.00
Left.turn.intensity08	100000.0	915.676300	16330.899091	0.000000e+00	7.000000	66.000000	361.00
Left.turn.intensity09	100000.0	718.053600	15666.068925	0.000000e+00	2.000000	22.000000	146.00
Left.turn.intensity10	100000.0	551.574010	14687.929802	0.000000e+00	0.000000	3.000000	30.00
Left.turn.intensity11	100000.0	487.340690	14198.331308	0.000000e+00	0.000000	1.000000	9.00
Left.turn.intensity12	100000.0	447.758420	13719.790281	0.000000e+00	0.000000	0.000000	2.00
Right.turn.intensity08	100000.0	843.461830	11630.185503	0.000000e+00	11.000000	122.000000	680.00
Right.turn.intensity09	100000.0	565.056100	10657.402935	0.000000e+00	3.000000	43.000000	321.00
Right.turn.intensity10	100000.0	326.654840	9460.244357	0.000000e+00	0.000000	7.000000	81.00
Right.turn.intensity11	100000.0	246.713120	8977.569994	0.000000e+00	0.000000	2.000000	27.00
Right.turn.intensity12	100000.0	198.753690	8585.177049	0.000000e+00	0.000000	0.000000	9.00
NB_Claim	100000.0	0.044940	0.218130	0.000000e+00	0.000000	0.000000	0.00
AMT_Claim	100000.0	137.602253	1264.320056	0.000000e+00	0.000000	0.000000	0.00

Missing Data

In [20]:

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

Out[20]:

```
Duration                0
Insured_age             0
Insured_sex             0
Car_age                 0
```

```
Marital                   0
Car_use                   0
Credit_score              0
Region                    0
Annual_miles_drive        0
Years_noclaims            0
Territory                 0
Annual_pct_driven         0
Total_miles_driven        0
Pct_drive_mon             0
Pct_drive_tue             0
Pct_drive_wed             0
Pct_drive_thr             0
Pct_drive_fri             0
Pct_drive_sat             0
Pct_drive_sun             0
Pct_drive_2hrs            0
Pct_drive_3hrs            0
Pct_drive_4hrs            0
Pct_drive_wkday           0
Pct_drive_wkend           0
Pct_drive_rusham          0
Pct_drive_rushpm          0
Avgdays_week              0
Accel_06miles             0
Accel_08miles             0
Accel_09miles             0
Accel_11miles             0
Accel_12miles             0
Accel_14miles             0
Brake_06miles             0
Brake_08miles             0
Brake_09miles             0
Brake_11miles             0
Brake_12miles             0
Brake_14miles             0
Left_turn_intensity08     0
Left_turn_intensity09     0
Left_turn_intensity10     0
Left_turn_intensity11     0
Left_turn_intensity12     0
Right_turn_intensity08    0
Right_turn_intensity09    0
Right_turn_intensity10    0
Right_turn_intensity11    0
Right_turn_intensity12    0
NB_Claim                  0
AMT_Claim                 0
licensePlate              0
dtype: int64
```

Dataset customization

Removing "." and spaces from column names

In [9]:

```
# getting a list of column names
col_list=df.columns.values.tolist()
```

```
#Renaming the columns by replacing "." and with underscores
for i in range(0,len(col_list)):
    col_list[i]=col_list[i].replace(".", "_")

#Removing spaces in variable names
for i in range(0,len(col_list)):
    col_list[i]=col_list[i].replace(" ", "")
#reassigning the new list of column names
df.columns = col_list
```

Removing null values

In [10]:

```
# Drop rows with null values (if any)
df.dropna(axis = 1)

#Verify number of null values in each column
df.isnull().sum(axis = 0)
```

Out[10]:

```
Duration                0
Insured_age             0
Insured_sex             0
Car_age                 0
Marital                 0
Car_use                 0
Credit_score            0
Region                  0
Annual_miles_drive      0
Years_noclaims          0
Territory               0
Annual_pct_driven       0
Total_miles_driven      0
Pct_drive_mon           0
Pct_drive_tue           0
Pct_drive_wed           0
Pct_drive_thr           0
Pct_drive_fri           0
Pct_drive_sat           0
Pct_drive_sun           0
Pct_drive_2hrs          0
Pct_drive_3hrs          0
Pct_drive_4hrs          0
Pct_drive_wkday         0
Pct_drive_wkend         0
Pct_drive_rusham        0
Pct_drive_rushpm        0
Avgdays_week            0
Accel_06miles           0
Accel_08miles           0
Accel_09miles           0
Accel_11miles           0
Accel_12miles           0
Accel_14miles           0
Brake_06miles           0
Brake_08miles           0
Brake_09miles           0
Brake_11miles           0
Brake_12miles           0
Brake_14miles           0
```

```
Left_turn_intensity08     0
Left_turn_intensity09     0
Left_turn_intensity10     0
Left_turn_intensity11     0
Left_turn_intensity12     0
Right_turn_intensity08    0
Right_turn_intensity09    0
Right_turn_intensity10    0
Right_turn_intensity11    0
Right_turn_intensity12    0
NB_Claim                  0
AMT_Claim                 0
dtype: int64
```

Assigning unique id to each row

In [11]:

```
df['licensePlate']=df.index+1

original_ids = df['licensePlate'].unique()
DIGITS = 9  # number of hex digits of the UUID to use
new_ids = {cid: int(uuid.uuid4().hex[:DIGITS], base=16) for cid in original_ids}
df['licensePlate'] = df['licensePlate'].map(new_ids)
```

In [12]:

```
df['licensePlate'] = df['licensePlate'].astype(str)

u=list(string.ascii_uppercase)
df['licensePlate']=(df['licensePlate'].str.replace('[1-2]',lambda x: random.choice(u)))
```

```
C:\Users\Surya\AppData\Local\Temp/ipykernel_6424/3019233714.py:4: FutureWarning: The defa
ult value of regex will change from True to False in a future version.
  df['licensePlate']=(df['licensePlate'].str.replace('[1-2]',lambda x: random.choice(u)))
```

In [13]:

```
df['licensePlate'].head()
```

Out[13]:

```
0    68AC404O7V5
1    6579K584X79
2    6W673894A04
3    40P49934X5F
4    C9B500890KQ
Name: licensePlate, dtype: object
```

In [14]:

```
df['licensePlate'].nunique()
```

Out[14]:

```
100000
```

Splitting data

Selecting customer data with a non-zero claim amount.

In [46]:

```
df_claim = df[df['AMT_Claim']!=0]
df_claim
```

Out[46]:

	Duration	Insured_age	Insured_sex	Car_age	Marital	Car_use	Credit_score	Region	Annual_mi
0	366	45	Male	-1	Married	Commute	609.0	Urban	
1	182	44	Female	3	Married	Commute	575.0	Urban	
14	366	77	Male	8	Married	Private	814.0	Urban	
27	365	51	Male	6	Married	Commute	824.0	Urban	
42	365	66	Female	5	Married	Private	842.0	Urban	
...	...	...	...	...	...	...	...	...	
99833	366	45	Male	6	Married	Commute	721.0	Urban	
99842	366	47	Female	4	Single	Commute	682.0	Urban	
99915	328	29	Female	5	Single	Private	593.0	Urban	
99919	366	51	Male	0	Married	Commute	623.0	Urban	
99991	365	46	Male	1	Married	Commute	817.0	Urban	

3864 rows × 53 columns

In [47]:

```
df_claim.describe()
```

Out[47]:

	Duration	Insured_age	Car_age	Credit_score	Annual_miles_drive	Years_noclaims	Territory
count	3864.000000	3864.000000	3864.000000	3864.000000	3864.000000	3864.000000	3864.000000
mean	346.751294	46.668996	4.532867	767.590062	9870.118120	23.427795	56.686594
std	52.047600	14.524704	3.658961	91.600061	3980.113467	14.887444	23.188049
min	181.000000	18.000000	-2.000000	453.000000	683.508100	0.000000	12.000000
25%	365.000000	35.000000	1.000000	712.750000	6213.710000	10.000000	35.000000
50%	366.000000	46.000000	4.000000	788.500000	9320.565000	22.000000	63.000000
75%	366.000000	57.000000	7.000000	836.000000	12427.420000	35.000000	76.000000
max	366.000000	90.000000	18.000000	900.000000	31068.550000	74.000000	91.000000

8 rows × 48 columns

Selecting customer data with a zero claim amount.

In [43]:

```
#getting values with non-zero insurance claim
df_noclaim = df[df['AMT_Claim']==0]
df_noclaim
```

Out[43]:

	Duration	Insured_age	Insured_sex	Car_age	Marital	Car_use	Credit_score	Region	Annual_
2	184	48	Female	6	Married	Commute	847.0	Urban	
3	183	71	Male	6	Married	Private	842.0	Urban	

	Duration	Insured_age	Insured_sex	Car_age	Marital	Car_use	Credit_score	Region	Annual_r
4	183	84	Male	10	Married	Private	856.0	Urban	
5	365	35	Male	8	Single	Commute	857.0	Urban	
6	366	23	Female	8	Single	Private	778.0	Urban	
...	...	...	...	...	...	...	...	...	
99995	182	61	Male	10	Single	Private	824.0	Urban	
99996	192	48	Male	3	Married	Commute	850.0	Urban	
99997	184	50	Male	2	Single	Commute	650.0	Rural	
99998	184	76	Male	2	Married	Private	811.0	Rural	
99999	365	25	Female	2	Single	Commercial	818.0	Rural	

96136 rows × 53 columns

In [44]:

```
df_noclaim.describe()
```

Out[44]:

	Duration	Insured_age	Car_age	Credit_score	Annual_miles_drive	Years_noclaims	Territ
count	96136.000000	96136.000000	96136.000000	96136.000000	96136.000000	96136.000000	96136.000
mean	312.895887	51.568257	5.684208	802.227251	9094.139078	29.057491	56.525
std	80.386103	15.473885	4.071238	82.755924	3816.801263	16.133594	24.070
min	27.000000	16.000000	-2.000000	422.000000	0.000000	0.000000	11.000
25%	195.000000	39.000000	2.000000	769.000000	6213.710000	15.000000	35.000
50%	365.000000	52.000000	5.000000	826.000000	7456.452000	29.000000	62.000
75%	366.000000	64.000000	9.000000	856.000000	12427.420000	42.000000	78.000
max	366.000000	103.000000	20.000000	900.000000	56731.172300	79.000000	91.000

8 rows × 48 columns

Visualization to understand the data

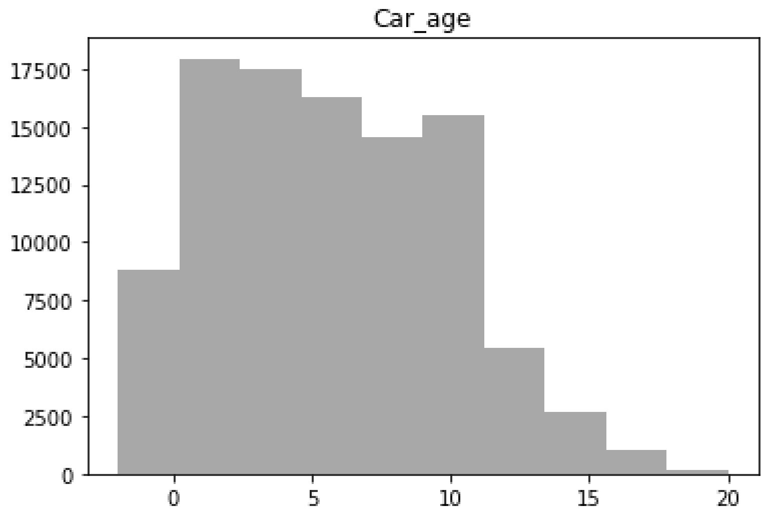
Age Distribution

In [45]:

```
df.hist(column='Car_age', grid=False, color='#A8A8A8')
```

Out[45]:

```
array([[<AxesSubplot:title={'center':'Car_age'}>]], dtype=object)
```

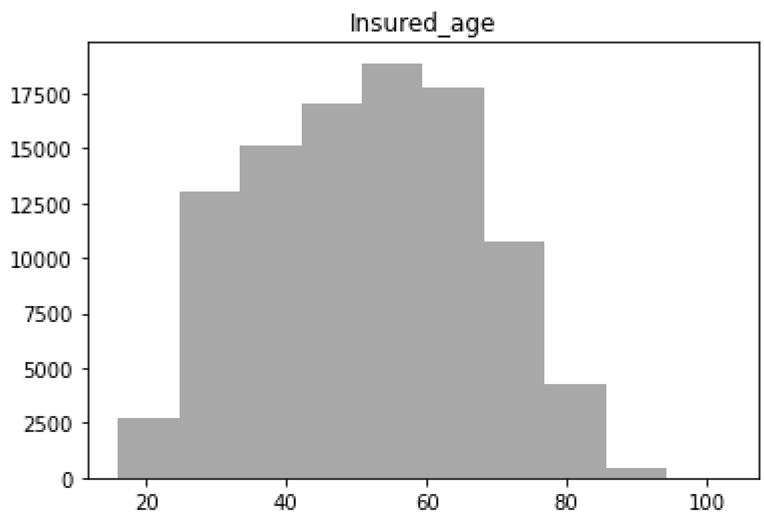


In [323]:

```
df.hist(column='Insured_age', grid=False, color='#A8A8A8')
```

Out[323]:

```
array([[<AxesSubplot:title={'center':'Insured_age'}>]], dtype=object)
```



In [324]:

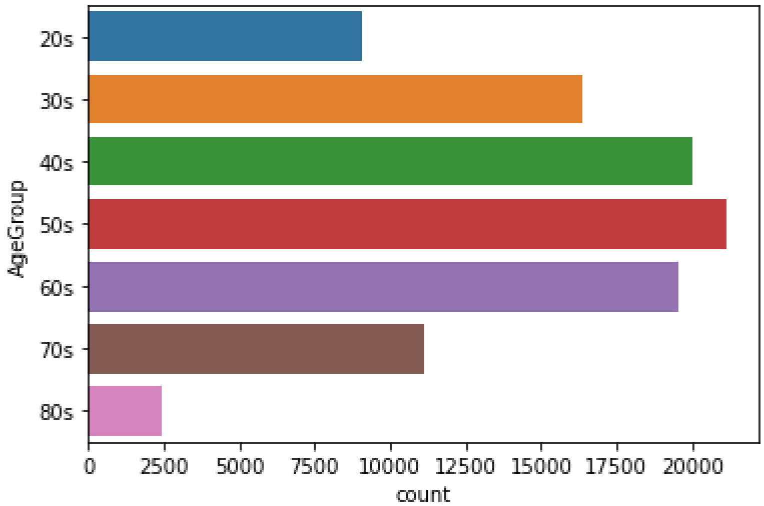
```
bins=np.arange(20, 100, 10).tolist()
labels = ['20s','30s','40s','50s','60s','70s','80s',]
df['AgeGroup'] = pd.cut(df['Insured_age'], bins=bins, labels=labels, right=False)




sns.countplot(data=df,y='AgeGroup')
```

Out[324]:

```
<AxesSubplot:xlabel='count', ylabel='AgeGroup'>
```



In [325]:

```
df[['Insured_age','AgeGroup']]
```

Out[325]:

	Insured_age	AgeGroup
0	45	40s
1	44	40s
2	48	40s
3	71	70s
4	84	80s
...	...	...
99995	61	60s
99996	48	40s
99997	50	50s
99998	76	70s
99999	25	20s

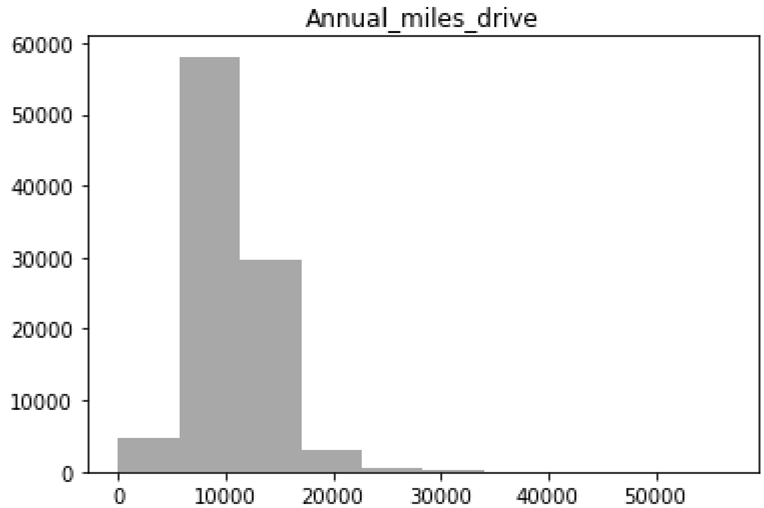
100000 rows × 2 columns

In [21]:

```
#sns.countplot(data=df,y='AMT_Claim')
df_noclaim.hist(column='Annual_miles_drive', bins=10, grid=False, color='#A8A8A8')
```

Out[21]:

```
array([[<AxesSubplot:title={'center':'Annual_miles_drive'}>]],
      dtype=object)
```

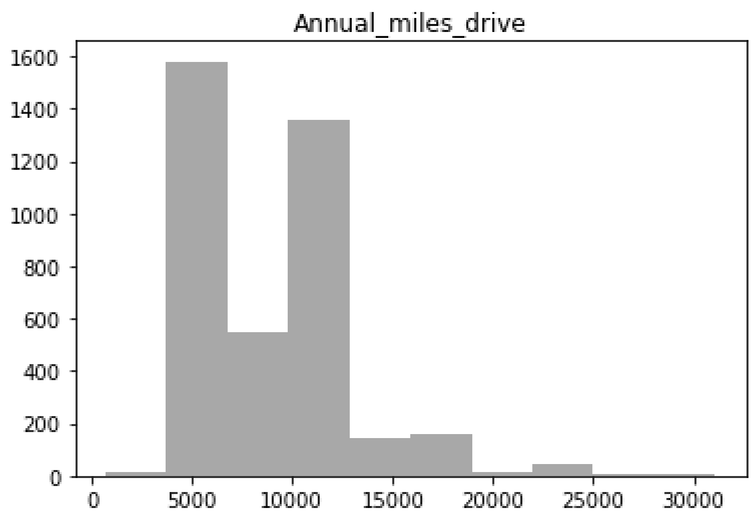


In [327]:

```
df_claim.hist(column='Annual_miles_drive', bins=10, grid=False, color='#A8A8A8')
```

Out[327]:

```
array([[<AxesSubplot:title={'center':'Annual_miles_drive'}>]],
      dtype=object)
```

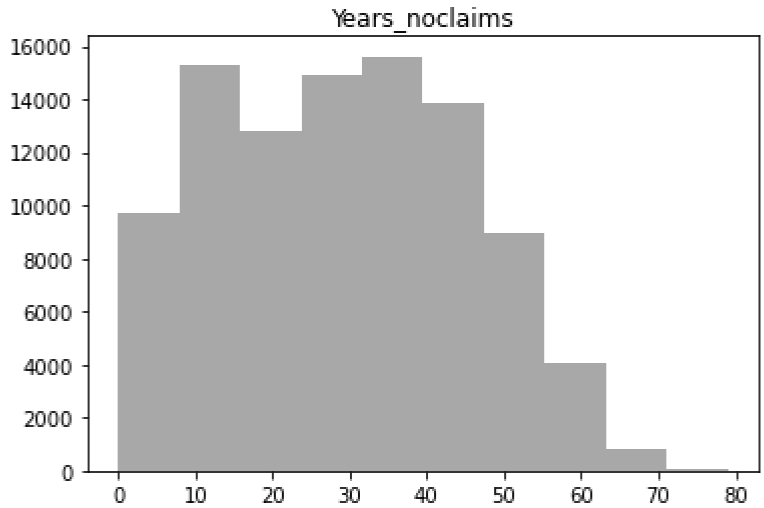


In [328]:

```
df_noclaim.hist(column='Years_noclaims', bins=10, grid=False, color='#A8A8A8')
```

Out[328]:

```
array([[<AxesSubplot:title={'center':'Years_noclaims'}>]], dtype=object)
```



In [329]:
```
bins=np.arange(0, 11000, 1000).tolist()
labels = ['1s','2s','3s','4s','5s','6s','7s','8s','9s','10s']
df['ClaimGroup'] = pd.cut(df['AMT_Claim'], bins=bins, labels=labels, right=False)
```

In [330]:
```
bins=np.arange(400, 1100, 100).tolist()
labels = ['400s','500s','600s','700s','800s','900s']
df['CSgroup'] = pd.cut(df['Credit_score'], bins=bins, labels=labels, right=False)
```

In [331]:
```
df[['Credit_score','CSgroup']]
```

Out[331]:

	Credit_score	CSgroup
0	609.0	600s
1	575.0	500s
2	847.0	800s
3	842.0	800s
4	856.0	800s
...	...	...
99995	824.0	800s
99996	850.0	800s
99997	650.0	600s
99998	811.0	800s
99999	818.0	800s

100000 rows × 2 columns

In [332]:
```
df_noclaim.describe()
```

Out[332]:

	Duration	Insured_age	Car_age	Credit_score	Annual_miles_drive	Years_noclaims	Territ

	Duration	Insured_age	Car_age	Credit_score	Annual_miles_drive	Years_noclaims	Territ
count	96136.000000	96136.000000	96136.000000	96136.000000	96136.000000	96136.000000	96136.00
mean	312.895887	51.568257	5.684208	802.227251	9094.139078	29.057491	56.52
std	80.386103	15.473885	4.071238	82.755924	3816.801263	16.133594	24.07
min	27.000000	16.000000	-2.000000	422.000000	0.000000	0.000000	11.00
25%	195.000000	39.000000	2.000000	769.000000	6213.710000	15.000000	35.00
50%	365.000000	52.000000	5.000000	826.000000	7456.452000	29.000000	62.00
75%	366.000000	64.000000	9.000000	856.000000	12427.420000	42.000000	78.00
max	366.000000	103.000000	20.000000	900.000000	56731.172300	79.000000	91.00

8 rows × 48 columns

Logistic Regression model development for Claim(boolean)

Converting NB_Claim into a binary variable to use for predicting claim or no-claim

In [15]:

```
df['NB_Claim'] = df['NB_Claim'].replace([2,3],1)
```

Feature Engineering for Machine Learning model to predict Claim(boolean)

In [334]:

```
df.columns
```

Out[334]:

```
Index(['Duration', 'Insured_age', 'Insured_sex', 'Car_age', 'Marital',
       'Car_use', 'Credit_score', 'Region', 'Annual_miles_drive',
       'Years_noclaims', 'Territory', 'Annual_pct_driven',
       'Total_miles_driven', 'Pct_drive_mon', 'Pct_drive_tue', 'Pct_drive_wed',
       'Pct_drive_thr', 'Pct_drive_fri', 'Pct_drive_sat', 'Pct_drive_sun',
       'Pct_drive_2hrs', 'Pct_drive_3hrs', 'Pct_drive_4hrs', 'Pct_drive_wkday',
       'Pct_drive_wkend', 'Pct_drive_rusham', 'Pct_drive_rushpm',
       'Avgdays_week', 'Accel_06miles', 'Accel_08miles', 'Accel_09miles',
       'Accel_11miles', 'Accel_12miles', 'Accel_14miles', 'Brake_06miles',
       'Brake_08miles', 'Brake_09miles', 'Brake_11miles', 'Brake_12miles',
       'Brake_14miles', 'Left_turn_intensity08', 'Left_turn_intensity09',
       'Left_turn_intensity10', 'Left_turn_intensity11',
       'Left_turn_intensity12', 'Right_turn_intensity08',
       'Right_turn_intensity09', 'Right_turn_intensity10',
       'Right_turn_intensity11', 'Right_turn_intensity12', 'NB_Claim',
       'AMT_Claim', 'licensePlate', 'AgeGroup', 'ClaimGroup', 'CSgroup'],
      dtype='object')
```

In [23]:

```
##Using correlation to select features for NB_Claim
###Correlation with Outcome- Claim Amount
```

```
cor=df.corr()
cor_outcome = abs(cor["NB_Claim"])
```

In [28]:

```
###Getting list of features with correlation <=0.02 with NB_Claim
low_corr_features = cor_outcome[cor_outcome<=0.02]
low_corr_features
```

Out[28]:

```
Territory                  0.000372
Pct_drive_mon              0.004537
Pct_drive_tue              0.007379
Pct_drive_wed              0.000531
Pct_drive_thr              0.013419
Pct_drive_fri              0.001047
Pct_drive_sat              0.002518
Pct_drive_sun              0.005679
Pct_drive_3hrs             0.011303
Pct_drive_4hrs             0.001521
Pct_drive_wkday            0.004970
Pct_drive_wkend            0.004970
Pct_drive_rusham           0.004490
Accel_08miles              0.006750
Accel_09miles              0.000213
Accel_11miles              0.001120
Accel_12miles              0.001403
Accel_14miles              0.001420
Brake_09miles              0.014620
Brake_11miles              0.004977
Brake_12miles              0.000065
Brake_14miles              0.001468
Left_turn_intensity08      0.014664
Left_turn_intensity09      0.013420
Left_turn_intensity10      0.011179
Left_turn_intensity11      0.010892
Left_turn_intensity12      0.011089
Right_turn_intensity08     0.009481
Right_turn_intensity09     0.009687
Right_turn_intensity10     0.010437
Right_turn_intensity11     0.010195
Right_turn_intensity12     0.008442
Name: NB_Claim, dtype: float64
```

In [29]:

```
###Features with corr value above 0.2 with NB_Claim
abv02_corr_outcome = cor_outcome[cor_outcome>0.02]
abv02_corr_outcome
```

Out[29]:

```
Duration               0.082858
Insured_age            0.062190
Car_age                0.059088
Credit_score           0.078828
Annual_miles_drive     0.043590
Years_noclaims         0.066323
Annual_pct_driven      0.171985
Total_miles_driven     0.181478
Pct_drive_2hrs         0.024174
Pct_drive_rushpm       0.026586
Avgdays_week           0.049732
Accel_06miles          0.026545
Brake_06miles          0.040644
```

```
Brake_08miles          0.034615
NB_Claim               1.000000
AMT_Claim              0.515198
Name: NB_Claim, dtype: float64
```

In [48]:

```
#Selecting features with correlation above 0.2 with the final outcome NB_Claim (boolean)
X_df= df[["Duration","Insured_age","Car_age","Credit_score","Annual_miles_drive","Years_n
y_df=df['NB_Claim']
```

In [49]:

```
#Split the data into training set and test set. Use train test split() with test size = 0
from sklearn.model_selection import train_test_split
X1train, X1test, y1train, y1test = train_test_split(X_df, y_df, test_size = 0.2)
```

In [22]:

```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X1train = sc.fit_transform(X1train)
X1test = sc.transform(X1test)
```

Logistic Regression

In [23]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression


model3 = LogisticRegression(multi_class='ovr', random_state = 0)
model3.fit(X1train, y1train)
y1test = model3.predict(X1test)

# Model Evaluation
m3_train=model3.score(X1train, y1train)
m3_test=model3.score(X1test, y1test)
```

In [342]:

```
print("For the model:", model3, ", the training accuracy is",m3_train,"and the testing ac
```

```
For the model: LogisticRegression(multi_class='ovr', random_state=0) , the training accur
acy is 0.957525 and the testing accuracy is 1.0
```

Random forest classsifier

In [24]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report


model4 = RandomForestClassifier(n_estimators = 50, max_depth = 10,min_samples_leaf=1, min
model4.fit(X1train, y1train)
y1test = model4.predict(X1test)

# Model Evaluation
m4_train=model4.score(X1train, y1train)
m4_test=model4.score(X1test, y1test)
```

In [35]:
```
print("For the model:", model4, ", the training accuracy is",m4_train,"and the testing ac
```

```
For the model: RandomForestClassifier(max_depth=10, n_estimators=50) , the training accur
acy is 0.9610375 and the testing accuracy is 1.0
```

Stochastic Gradient Descent Classifier (SGD-Classifier) - To minimize the cost function of the gradient descent

In [25]:
```
from sklearn.linear_model import SGDClassifier

sgdc = SGDClassifier(max_iter=1000, tol=0.01)
print(sgdc)

xtrain, xtest, ytrain, ytest = train_test_split(X_df, y_df, test_size = 0.15)
sgdc.fit(xtrain, ytrain)

sgdc.fit(xtrain, ytrain)
score = sgdc.score(xtrain, ytrain)
print("Training score: ", score)

ypred = sgdc.predict(xtest)
cm = confusion_matrix(ytest, ypred)
print(cm)

cr = classification_report(ytest, ypred)
print(cr)
```

```
SGDClassifier(tol=0.01)
Training score:  0.9549058823529412
[[14334    40]
 [  626     0]]
              precision    recall  f1-score   support

           0       0.96      1.00      0.98     14374
           1       0.00      0.00      0.00       626

    accuracy                           0.96     15000
   macro avg       0.48      0.50      0.49     15000
weighted avg       0.92      0.96      0.94     15000
```

The Challenge

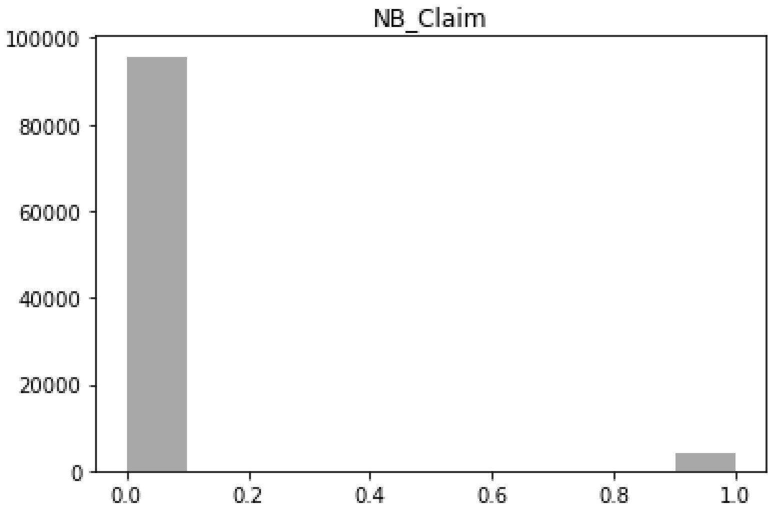
In [50]:
```
Counter(df['NB_Claim'])
```

Out[50]:
```
Counter({1: 4272, 0: 95728})
```

Introduction to the challenge

In [51]:
```
df.hist(column='NB_Claim', grid=False, color='#A8A8A8')
```

Out[51]:
```
array([[<AxesSubplot:title={'center':'NB_Claim'}>]], dtype=object)
```



In [42]:
```
print("The number of rows with no claims is",len(df_noclaim), "and the number of rows wit
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_6424/1692536174.py in <module>
----> 1 print("The number of rows with no claims is",len(df_noclaim), "and the number of
 rows with claim data is",len(df_claim), "and hence the claims data percentage is only",l
en(df_claim)*100/len(df),"percent.")

NameError: name 'df_noclaim' is not defined
```

Some of the companys may experience low claim rate, as fact in support of this statement In 2019, 5.1 percent of insured homes had a claim, according to ISO source: https://www.iii.org/fact-statistic/facts-statistics-homeowners-and-renters-insurance

Solution to the challenge - SMOTE (Synthetic Minority Oversampling Technique)

In [55]:
```
#Selecting features with correlation above 0.2 with the final outcome Claim (boolean)
X_df= df[["Duration","Insured_age","Car_age","Credit_score","Annual_miles_drive","Years_n
y_df=df['NB_Claim']
```

In [56]:
```
Counter(y_df)
```

Out[56]:
```
Counter({1: 4272, 0: 95728})
```

In [53]:
```
sample_technique=SMOTE()
X, y = sample_technique.fit_resample(X_df, y_df)
Counter(y)
```

Out[53]:
```
Counter({1: 95728, 0: 95728})
```

Stochastic Gradient Descent Classifier after generating samples with Synthetic Minority Oversampling Technique

In [54]:
```
from sklearn.linear_model import SGDClassifier

sgdc = SGDClassifier(max_iter=1000, tol=0.01,loss='log')
print(sgdc)

xtrain, xtest, ytrain, ytest = train_test_split(X, y, test_size = 0.15)
sgdc.fit(xtrain, ytrain)

sgdc.fit(xtrain, ytrain)
score = sgdc.score(xtrain, ytrain)
print("The training score for SGDC-SMOTE is ", score)

ypred = sgdc.predict(xtest)
cm = confusion_matrix(ytest, ypred)
print(cm)

cr = classification_report(ytest, ypred)
print(cr)
```

```
SGDClassifier(loss='log', tol=0.01)
The training score for SGDC-SMOTE is  0.7037367040070789
[[ 8264  6173]
 [ 2301 11981]]
              precision    recall  f1-score   support

           0       0.78      0.57      0.66     14437
           1       0.66      0.84      0.74     14282

    accuracy                           0.70     28719
   macro avg       0.72      0.71      0.70     28719
weighted avg       0.72      0.70      0.70     28719
```

In [58]:
```
sample_technique=SMOTETomek()
X, y = sample_technique.fit_resample(X_df, y_df)
Counter(y)
```

Out[58]:
```
Counter({1: 95427, 0: 95427})
```

Stochastic Gradient Descent Classifier after generating samples with SMOTE-TOMEK Links Method

In [59]:
```
from sklearn.linear_model import SGDClassifier

sgdc2 = SGDClassifier(max_iter=1000, tol=0.01)
print(sgdc2)

xtrain, xtest, ytrain, ytest = train_test_split(X, y, test_size = 0.15)
sgdc2.fit(xtrain, ytrain)

sgdc2.fit(xtrain, ytrain)
score = sgdc2.score(xtrain, ytrain)
print("The training score for SGDC-SMOTE-TOMEK is : ", score)

ypred = sgdc2.predict(xtest)
cm = confusion_matrix(ytest, ypred)
print(cm)
```

```
cr = classification_report(ytest, ypred)
print(cr)
```

```
SGDClassifier(tol=0.01)
The training score for SGDC-SMOTE-TOMEK is :  0.5510617968870396
[[ 1546 12776]
 [  110 14197]]
              precision    recall  f1-score   support

           0       0.93      0.11      0.19     14322
           1       0.53      0.99      0.69     14307

    accuracy                           0.55     28629
   macro avg       0.73      0.55      0.44     28629
weighted avg       0.73      0.55      0.44     28629
```

In [58]:

```
from xgboost import XGBClassifier
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score, KFold

xtrain, xtest, ytrain, ytest=train_test_split(X, y, test_size=0.15)

xgbc = XGBClassifier(use_label_encoder=False, eval_metric='logloss')
print(xgbc)

xgbc.fit(xtrain, ytrain)

# - cross validataion
scores = cross_val_score(xgbc, xtrain, ytrain, cv=5)
print("Mean cross-validation score: %.2f" % scores.mean())

kfold = KFold(n_splits=10, shuffle=True)
kf_cv_scores = cross_val_score(xgbc, xtrain, ytrain, cv=kfold )
print("K-fold CV average score: %.2f" % kf_cv_scores.mean())

ypred = xgbc.predict(xtest)
cm = confusion_matrix(ytest,ypred)
print(cm)
```

```
XGBClassifier(base_score=None, booster=None, colsample_bylevel=None,
              colsample_bynode=None, colsample_bytree=None,
              enable_categorical=False, eval_metric='logloss', gamma=None,
              gpu_id=None, importance_type=None, interaction_constraints=None,
              learning_rate=None, max_delta_step=None, max_depth=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              n_estimators=100, n_jobs=None, num_parallel_tree=None,
              predictor=None, random_state=None, reg_alpha=None,
              reg_lambda=None, scale_pos_weight=None, subsample=None,
              tree_method=None, use_label_encoder=False,
              validate_parameters=None, verbosity=None)
Mean cross-validation score: 0.96
K-fold CV average score: 0.96
[[13868   356]
 [  707 13693]]
```

Predicting values for Claim(boolean)

In [64]:
```
df["predictedClaimValue"]= sgdc.predict(X_df)
```

In [65]:
```
df['predictedClaimValue'] = df['predictedClaimValue'].astype(bool)
```

In [66]:
```
df[["predictedClaimValue","NB_Claim"]].tail()
```

Out[66]:

	predictedClaimValue	NB_Claim
99995	False	0
99996	False	0
99997	False	0
99998	False	0
99999	False	0

Importing the final dataset to csv for transfer to front end

In [358]:
```
df.columns
```

Out[358]:
```
Index(['Duration', 'Insured_age', 'Insured_sex', 'Car_age', 'Marital',
       'Car_use', 'Credit_score', 'Region', 'Annual_miles_drive',
       'Years_noclaims', 'Territory', 'Annual_pct_driven',
       'Total_miles_driven', 'Pct_drive_mon', 'Pct_drive_tue', 'Pct_drive_wed',
       'Pct_drive_thr', 'Pct_drive_fri', 'Pct_drive_sat', 'Pct_drive_sun',
       'Pct_drive_2hrs', 'Pct_drive_3hrs', 'Pct_drive_4hrs', 'Pct_drive_wkday',
       'Pct_drive_wkend', 'Pct_drive_rusham', 'Pct_drive_rushpm',
       'Avgdays_week', 'Accel_06miles', 'Accel_08miles', 'Accel_09miles',
       'Accel_11miles', 'Accel_12miles', 'Accel_14miles', 'Brake_06miles',
       'Brake_08miles', 'Brake_09miles', 'Brake_11miles', 'Brake_12miles',
       'Brake_14miles', 'Left_turn_intensity08', 'Left_turn_intensity09',
       'Left_turn_intensity10', 'Left_turn_intensity11',
       'Left_turn_intensity12', 'Right_turn_intensity08',
       'Right_turn_intensity09', 'Right_turn_intensity10',
       'Right_turn_intensity11', 'Right_turn_intensity12', 'NB_Claim',
       'AMT_Claim', 'licensePlate', 'AgeGroup', 'ClaimGroup', 'CSgroup',
       'predictedClaimValue'],
      dtype='object')
```

In [67]:
```
df_ui=df[[
        "licensePlate",
        "Left_turn_intensity08",
        "Left_turn_intensity09",
        "Left_turn_intensity10",
        "Left_turn_intensity11",
        "Left_turn_intensity12",
        "Pct_drive_mon",
        "Pct_drive_tue",
```

```
        "Pct_drive_wed",
        "Pct_drive_thr",
        "Pct_drive_fri",
        "Pct_drive_sat",
        "Pct_drive_sun",
        "Right_turn_intensity08",
        "Right_turn_intensity09",
        "Right_turn_intensity10",
        "Right_turn_intensity11",
        "Right_turn_intensity12",
        "Accel_06miles",
        "Accel_08miles",
        "Accel_09miles",
        "Accel_11miles",
        "Accel_12miles",
        "Accel_14miles",
        "Brake_06miles",
        "Brake_08miles",
        "Brake_09miles",
        "Brake_11miles",
        "Brake_12miles",
        "Brake_14miles",
        "predictedClaimValue"]]
```

In [68]:

```
df_ui.to_csv('telematics_ui.csv')
```

In [69]:

```
selected=df_ui.iloc[5030:5050].to_dict(orient='index')
```

In [70]:

```
to_json=list(selected.values())
```

In [72]:

```
to_json
```

Out[72]:


```
[{'licensePlate': 'N0700990669',
  'Left_turn_intensity08': 0.0,
  'Left_turn_intensity09': 0.0,
  'Left_turn_intensity10': 0.0,
  'Left_turn_intensity11': 0.0,
  'Left_turn_intensity12': 0.0,
  'Pct_drive_mon': 0.133938067,
  'Pct_drive_tue': 0.171810682,
  'Pct_drive_wed': 0.234837918,
  'Pct_drive_thr': 0.193674109,
  'Pct_drive_fri': 0.110159078,
  'Pct_drive_sat': 0.062476984,
  'Pct_drive_sun': 0.093103163,
  'Right_turn_intensity08': 5.0,
  'Right_turn_intensity09': 0.0,
  'Right_turn_intensity10': 0.0,
  'Right_turn_intensity11': 0.0,
  'Right_turn_intensity12': 0.0,
  'Accel_06miles': 39.0,
  'Accel_08miles': 1.0,
  'Accel_09miles': 0.0,
  'Accel_11miles': 0.0,
```

```
 'Accel_12miles': 0.0,
 'Accel_14miles': 0.0,
 'Brake_06miles': 103.0,
 'Brake_08miles': 7.0,
 'Brake_09miles': 1.0,
 'Brake_11miles': 0.0,
 'Brake_12miles': 0.0,
 'Brake_14miles': 0.0,
 'predictedClaimValue': False},
{'licensePlate': '3A08466Z97',
 'Left_turn_intensity08': 1477.0,
 'Left_turn_intensity09': 1018.0,
 'Left_turn_intensity10': 511.0,
 'Left_turn_intensity11': 316.0,
 'Left_turn_intensity12': 199.0,
 'Pct_drive_mon': 0.134974029,
 'Pct_drive_tue': 0.110024968,
 'Pct_drive_wed': 0.279442566,
 'Pct_drive_thr': 0.230480235,
 'Pct_drive_fri': 0.112918664,
 'Pct_drive_sat': 0.088703818,
 'Pct_drive_sun': 0.043455721,
 'Right_turn_intensity08': 1406.0,
 'Right_turn_intensity09': 997.0,
 'Right_turn_intensity10': 606.0,
 'Right_turn_intensity11': 413.0,
 'Right_turn_intensity12': 272.0,
 'Accel_06miles': 54.0,
 'Accel_08miles': 2.0,
 'Accel_09miles': 1.0,
 'Accel_11miles': 0.0,
 'Accel_12miles': 0.0,
 'Accel_14miles': 0.0,
 'Brake_06miles': 78.0,
 'Brake_08miles': 5.0,
 'Brake_09miles': 2.0,
 'Brake_11miles': 1.0,
 'Brake_12miles': 1.0,
 'Brake_14miles': 0.0,
 'predictedClaimValue': False},
{'licensePlate': 'Y7O08U05E45',
 'Left_turn_intensity08': 0.0,
 'Left_turn_intensity09': 0.0,
 'Left_turn_intensity10': 0.0,
 'Left_turn_intensity11': 0.0,
 'Left_turn_intensity12': 0.0,
 'Pct_drive_mon': 0.109097535,
 'Pct_drive_tue': 0.161289058,
 'Pct_drive_wed': 0.142552025,
 'Pct_drive_thr': 0.099442024,
 'Pct_drive_fri': 0.128297845,
 'Pct_drive_sat': 0.16139977,
 'Pct_drive_sun': 0.197921743,
 'Right_turn_intensity08': 2.0,
 'Right_turn_intensity09': 1.0,
 'Right_turn_intensity10': 0.0,
 'Right_turn_intensity11': 0.0,
 'Right_turn_intensity12': 0.0,
 'Accel_06miles': 12.0,
 'Accel_08miles': 0.0,
```

```
 'Accel_09miles': 0.0,
 'Accel_11miles': 0.0,
 'Accel_12miles': 0.0,
 'Accel_14miles': 0.0,
 'Brake_06miles': 80.0,
 'Brake_08miles': 11.0,
 'Brake_09miles': 3.0,
 'Brake_11miles': 1.0,
 'Brake_12miles': 0.0,
 'Brake_14miles': 0.0,
 'predictedClaimValue': False},
{'licensePlate': 'I5089566596',
 'Left_turn_intensity08': 0.0,
 'Left_turn_intensity09': 0.0,
 'Left_turn_intensity10': 0.0,
 'Left_turn_intensity11': 0.0,
 'Left_turn_intensity12': 0.0,
 'Pct_drive_mon': 0.226605452,
 'Pct_drive_tue': 0.193347033,
 'Pct_drive_wed': 0.0784438029999999,
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In [71]:

```
import json
with open('data.json', 'w') as f:
    json.dump(to_json, f)
```

Future Scope with aid of more real world data:

1. More data will lead to increased accuracy of the Machine Learning model in predicting the Claim (True/False) and also computing the potential claim amount.
2. The process of Usage based Auto-insurance quote generation can be made more ML-Centric and highly automated by integrating our system into the existing insurance quote computing mechanisms.
3. Make the usage based insurance system a selling point by generating personalized savings computation based on user data inputs.

References for source of data, description of dataset variables

1. Article: Synthetic Dataset Generation of Driver Telematics by Banghee So, Jean-Philippe Boucher and Emiliano A. Valdez https://arxiv.org/abs/2102.00252

2. Sample projects listed in the class website. https://cs.wmich.edu/gupta/teaching/cs6100/6100BigDataF21web/CS%206100%20Project%20Guid

3. SMOTE-TOMEK Technique https://towardsdatascience.com/imbalanced-classification-in-python-smote-tomek-links-method-6e48dfe69bbc

4.SMOTE Technique https://machinelearningmastery.com/smote-oversampling-for-imbalanced-classification/