data_exploration

April 14, 2025

1 Data Exploration

This notebook explores the dataset to understand and get an overview of the dataset:

[24]:
```
import sys
from pathlib import Path
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

# Add parent directory to sys.path
parent_dir = Path().resolve().parent
sys.path.append(str(parent_dir))

from src.utils import load_data
from src.utils import replace_birthdate_with_age
from src.utils import plot_boxplots
```

- load data
  - load feature data

[25]:
```
file_path_features = parent_dir / 'features.parquet'
feature_data = load_data(file_path_features)
#feature_data = feature_data[feature_data['Exposure'] < 1]
```

```
DataFrame Info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 678013 entries, 0 to 678012
Data columns (total 12 columns):
 #   Column      Non-Null Count   Dtype
---  ------      --------------   -----
 0   IDpol       678013 non-null  float64
 1   ClaimNb     678013 non-null  float64
 2   Exposure    678013 non-null  float64
 3   Area        678013 non-null  object
 4   VehPower    678013 non-null  float64
 5   VehAge      678013 non-null  float64
 6   BonusMalus  678013 non-null  float64
```

```
 7   VehBrand    678013 non-null  object
 8   VehGas      644112 non-null  object
 9   Density     678013 non-null  float64
 10  Region      678013 non-null  object
 11  BirthD      678013 non-null  object
dtypes: float64(7), object(5)
memory usage: 62.1+ MB
None


##########################################################################
First 5 Rows:
   IDpol  ClaimNb  Exposure Area  VehPower  VehAge  BonusMalus VehBrand  \
0    1.0      1.0      0.10  'D'       5.0     0.0        50.0    'B12'
1    3.0      1.0      0.77  'D'       5.0     0.0        50.0    'B12'
2    5.0      1.0      0.75  'B'       6.0     2.0        50.0    'B12'
3   10.0      1.0      0.09  'B'       7.0     0.0        50.0    'B12'
4   11.0      1.0      0.84  'B'       7.0     0.0        50.0    'B12'

    VehGas  Density Region      BirthD
0     None   1217.0  'R82'  1967-05-08
1  Regular   1217.0  'R82'  1967-12-28
2   Diesel     54.0  'R22'  1970-08-13
3   Diesel     76.0  'R72'  1976-12-05
4   Diesel     76.0  'R72'  1976-02-29


##########################################################################
Summary Statistics:
              IDpol        ClaimNb       Exposure       VehPower  \
count  6.780130e+05  678013.000000  678013.000000  678013.000000
mean   2.621857e+06       0.053247       0.528750       6.454631
std    1.641783e+06       0.240117       0.364442       2.050906
min    1.000000e+00       0.000000       0.002732       4.000000
25%    1.157951e+06       0.000000       0.180000       5.000000
50%    2.272152e+06       0.000000       0.490000       6.000000
75%    4.046274e+06       0.000000       0.990000       7.000000
max    6.114330e+06      16.000000       2.010000      15.000000

              VehAge     BonusMalus        Density
count  678013.000000  678013.000000  678013.000000
mean        7.044265      59.761502    1792.422405
std         5.666232      15.636658    3958.646564
min         0.000000      50.000000       1.000000
25%         2.000000      50.000000      92.000000
50%         6.000000      50.000000     393.000000
75%        11.000000      64.000000    1658.000000
max       100.000000     230.000000   27000.000000
```

```
##########################################################################
Unique Values Per Column:
IDpol         678013
ClaimNb           11
Exposure         181
Area               6
VehPower          12
VehAge            78
BonusMalus       115
VehBrand          11
VehGas             2
Density         1607
Region            22
BirthD         25775
dtype: int64


##########################################################################
Total Missing Values in DataFrame:
IDpol             0
ClaimNb           0
Exposure          0
Area              0
VehPower          0
VehAge            0
BonusMalus        0
VehBrand          0
VehGas        33901
Density           0
Region            0
BirthD            0
dtype: int64


##########################################################################
```

- load target data

[26]:
```
file_path_target = parent_dir / 'target.parquet'
target_data = load_data(file_path_target)
```

```
DataFrame Info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 26639 entries, 0 to 26638
Data columns (total 2 columns):
 #   Column       Non-Null Count  Dtype
```

```
---  ------       --------------  -----
 0   IDpol        26639 non-null  float64
 1   ClaimAmount  26639 non-null  float64
dtypes: float64(2)
memory usage: 416.4 KB
None


##########################################################################
First 5 Rows:
       IDpol  ClaimAmount
0     1552.0       995.20
1  1010996.0      1128.12
2  4024277.0      1851.11
3  4007252.0      1204.00
4  4046424.0      1204.00


##########################################################################
Summary Statistics:
              IDpol   ClaimAmount
count  2.663900e+04  2.663900e+04
mean   2.279864e+06  2.278536e+03
std    1.577202e+06  2.929748e+04
min    1.390000e+02  1.000000e+00
25%    1.087642e+06  6.868100e+02
50%    2.137413e+06  1.172000e+03
75%    3.180162e+06  1.228080e+03
max    6.113971e+06  4.075401e+06


##########################################################################
Unique Values Per Column:
IDpol          24950
ClaimAmount    12369
dtype: int64


##########################################################################
Total Missing Values in DataFrame:
IDpol          0
ClaimAmount    0
dtype: int64


##########################################################################
```

- merge two data sets

[27]:
```python
# # sum ClaimAmount over identical IDs
target_data = target_data.groupby('IDpol', as_index=False).agg({'ClaimAmount':␣
↪'sum'})

feature_data["IDpol"] = feature_data["IDpol"].astype(int)
feature_data.set_index("IDpol", inplace=True)
# merge features and target data
df = pd.merge(feature_data, target_data, on='IDpol', how='left')

df['ClaimAmount'] = df['ClaimAmount'].fillna(0)
# Drop the IDpol column
#df = df.drop(columns=['IDpol'])
```

- Data imputation
  - Convert birthdates to ages in year
  - Fill Missing Values with a New Category in VehGas

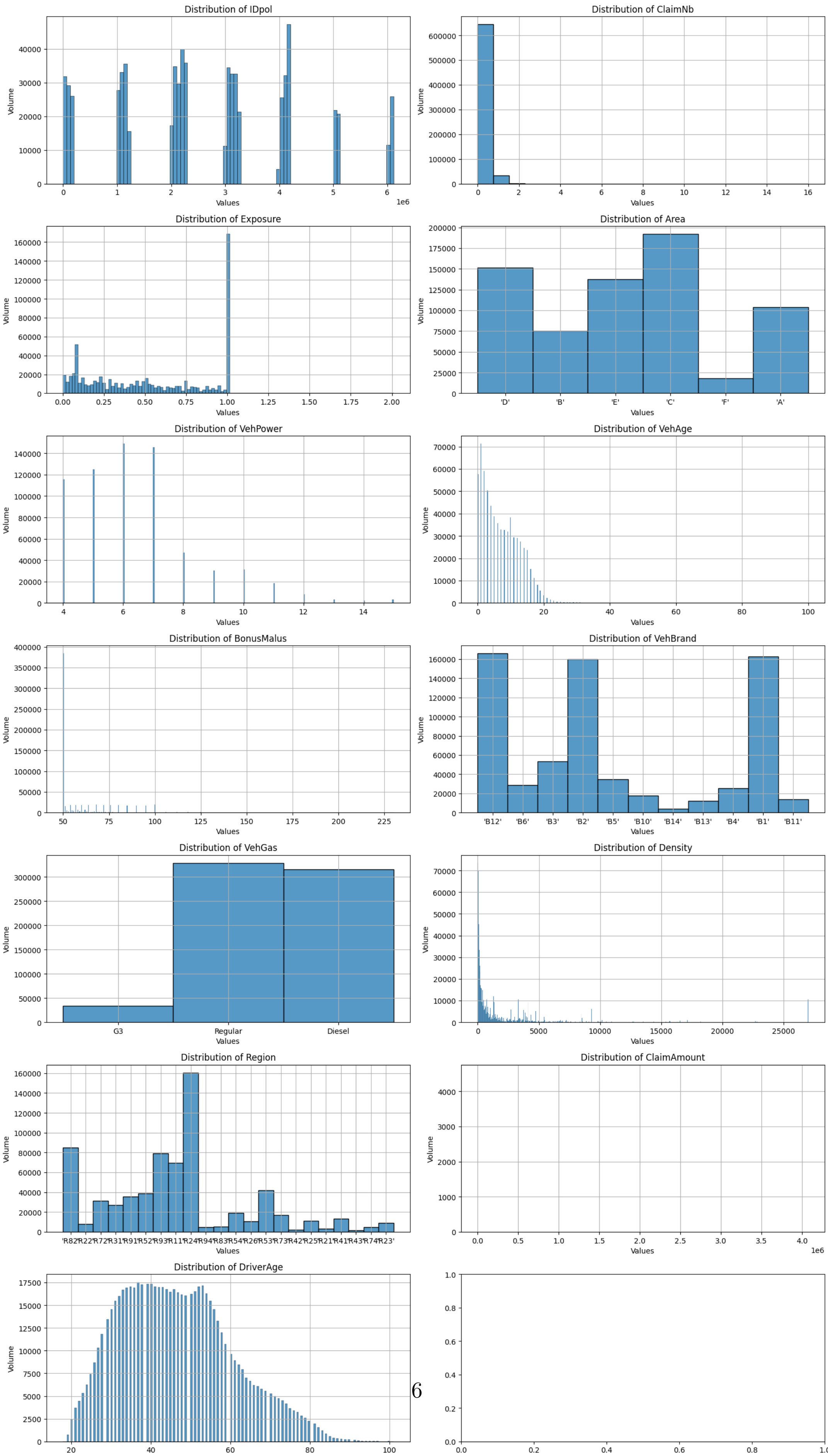
[28]:
```python
df['VehGas'] = df['VehGas'].fillna('G3')
df = replace_birthdate_with_age(df, 'BirthD', reference_date='2023-01-01')
```

- Feature distribution

[16]:
```python
# plot the distribution of each feature
num_columns = len(df.columns)
fig, axes = plt.subplots(nrows=(num_columns + 1) // 2, ncols=2, figsize=(16, 4␣
↪* ((num_columns + 1) // 2)))
axes = axes.flatten()

# Plot each column's distribution
for i, column in enumerate(df.columns):
    sns.histplot(df[column], kde=False, ax=axes[i])
    axes[i].set_title(f'Distribution of {column}')
    axes[i].set_xlabel('Values')
    axes[i].set_ylabel('Volume')
    axes[i].grid(True)
    #axes[i].set_xlim(df[column].min(), df[column].max())

# Adjust layout
plt.tight_layout()
plt.show()
```


Distribution of IDpol
Distribution of ClaimNb
Distribution of Exposure
Distribution of Area
'D' 'B' 'E' 'C' 'F' 'A'
Distribution of VehPower
Distribution of VehAge
Distribution of BonusMalus
Distribution of VehBrand
'B12' 'B6' 'B3' 'B2' 'B5' 'B10' 'B14' 'B13' 'B4' 'B1' 'B11'
Distribution of VehGas
G3 Regular Diesel
Distribution of Density
Distribution of Region
Distribution of ClaimAmount
Distribution of DriverAge
Volume
Values
1e6

- factorize the categorial features

[32]:
```
# List of categorical columns to factorize
categorical_columns = ['Area', 'Region', 'VehGas', 'VehBrand']

# Factorize each categorical column
for column in categorical_columns:
    df[column] = pd.factorize(df[column])[0]

# Display the updated DataFrame
#print(df.head())
```

- Boxplot to detect outliers

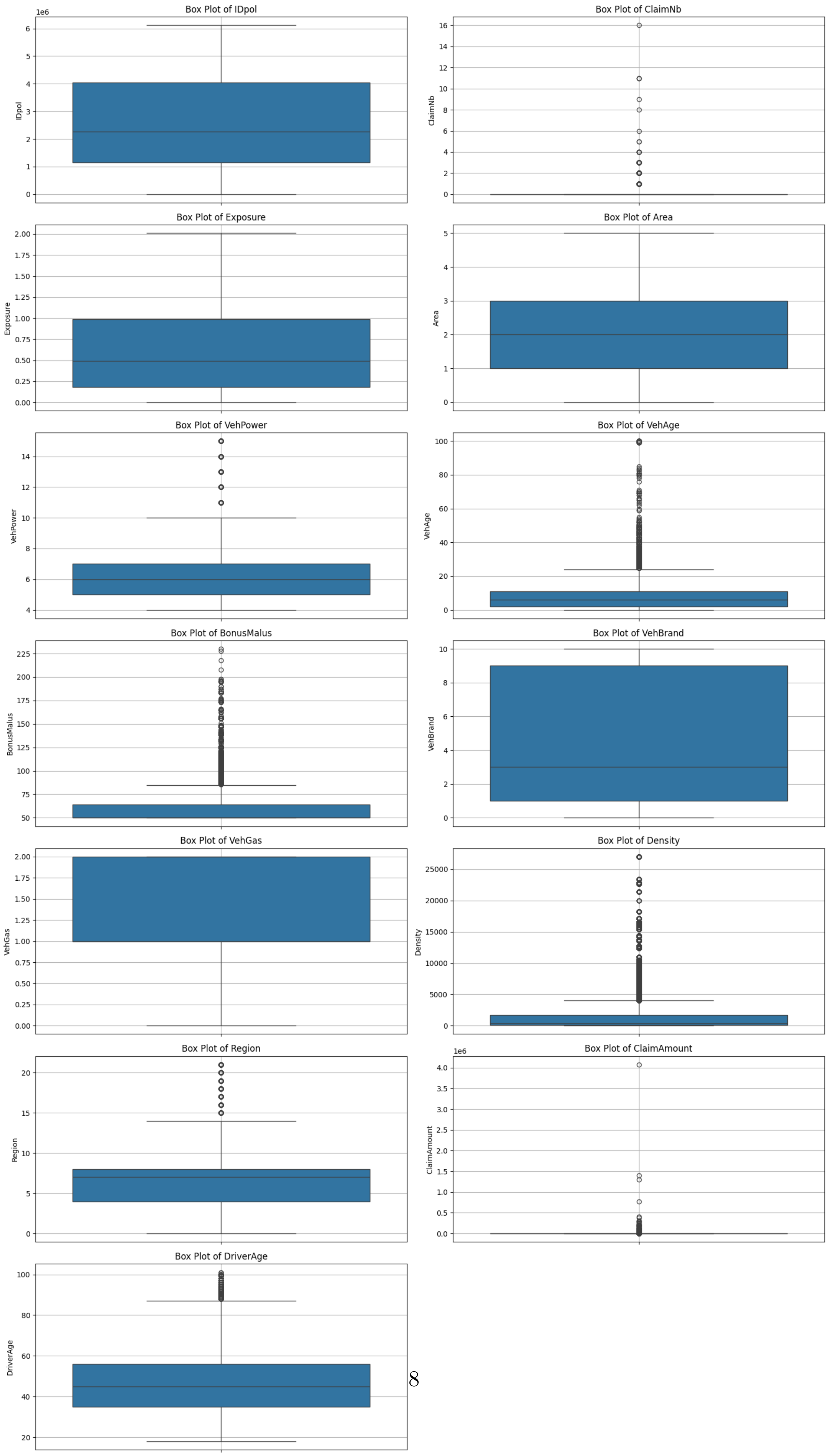
[18]:
```
# Select numerical columns
numerical_columns = df.select_dtypes(include=['number']).columns

# Create subplots for box plots
num_columns = len(numerical_columns)
fig, axes = plt.subplots(nrows=(num_columns + 1) // 2, ncols=2, figsize=(16, 4␣
↪* ((num_columns + 1) // 2)))
axes = axes.flatten()

# Plot each numerical column as a box plot
for i, column in enumerate(numerical_columns):
    sns.boxplot(data=df, y=column, ax=axes[i])
    axes[i].set_title(f'Box Plot of {column}')
    axes[i].set_ylabel(column)
    axes[i].grid(True)

# Hide unused subplots if the number of columns is odd
for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

# Adjust layout
plt.tight_layout()
plt.show()
```


Box Plot of IDpol
IDpol
1e6
Box Plot of ClaimNb
ClaimNb
Box Plot of Exposure
Exposure
Box Plot of Area
Area
Box Plot of VehPower
VehPower
Box Plot of VehAge
VehAge
Box Plot of BonusMalus
BonusMalus
Box Plot of VehBrand
VehBrand
Box Plot of VehGas
VehGas
Box Plot of Density
Density
Box Plot of Region
Region
Box Plot of ClaimAmount
ClaimAmount
1e6
Box Plot of DriverAge
DriverAge

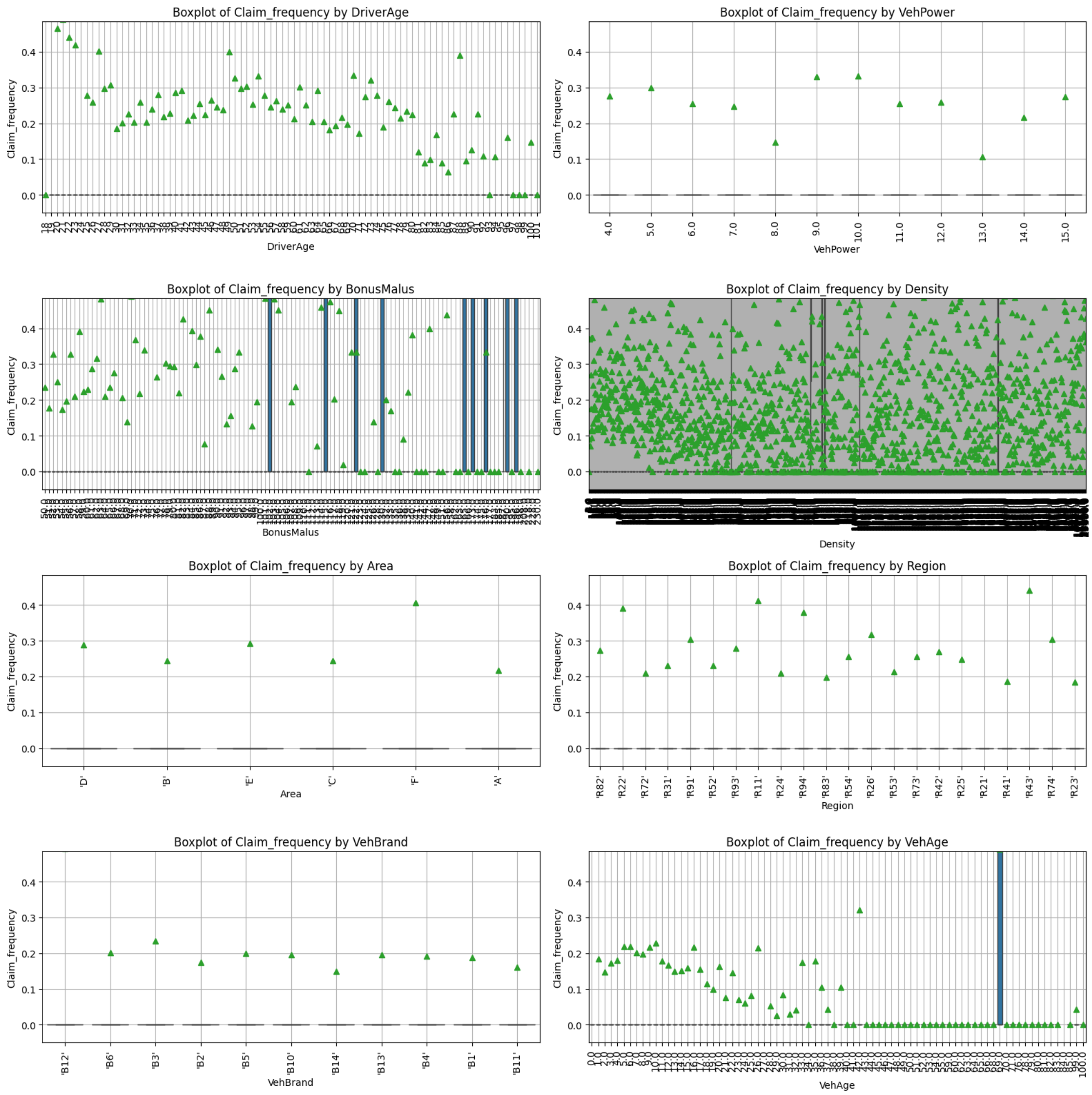
1.0.1 feature engineering

- define the loss amount

[29]:
```
df['LossAmount_frequency'] = df['ClaimAmount'] / df['Exposure']
df['Claim_frequency'] = df['ClaimNb'] / df['Exposure']
```

- observe dependency of Loss_amount_frequency/ Claim_frequency on variables

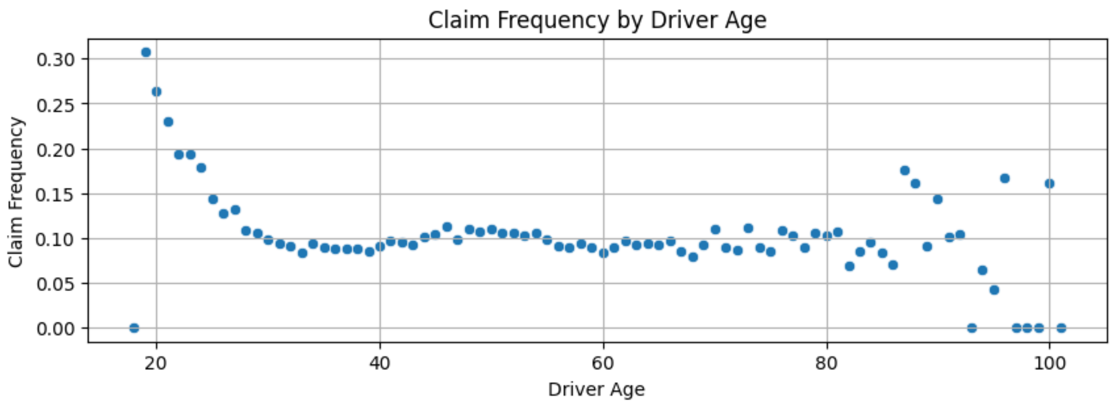
[7]:
```
# Example usage:
plot_boxplots(['DriverAge', 'VehPower', 'BonusMalus', 'Density', 'Area',␣
↪'Region', 'VehBrand', 'VehAge'],
              'Claim_frequency',
              df)
```



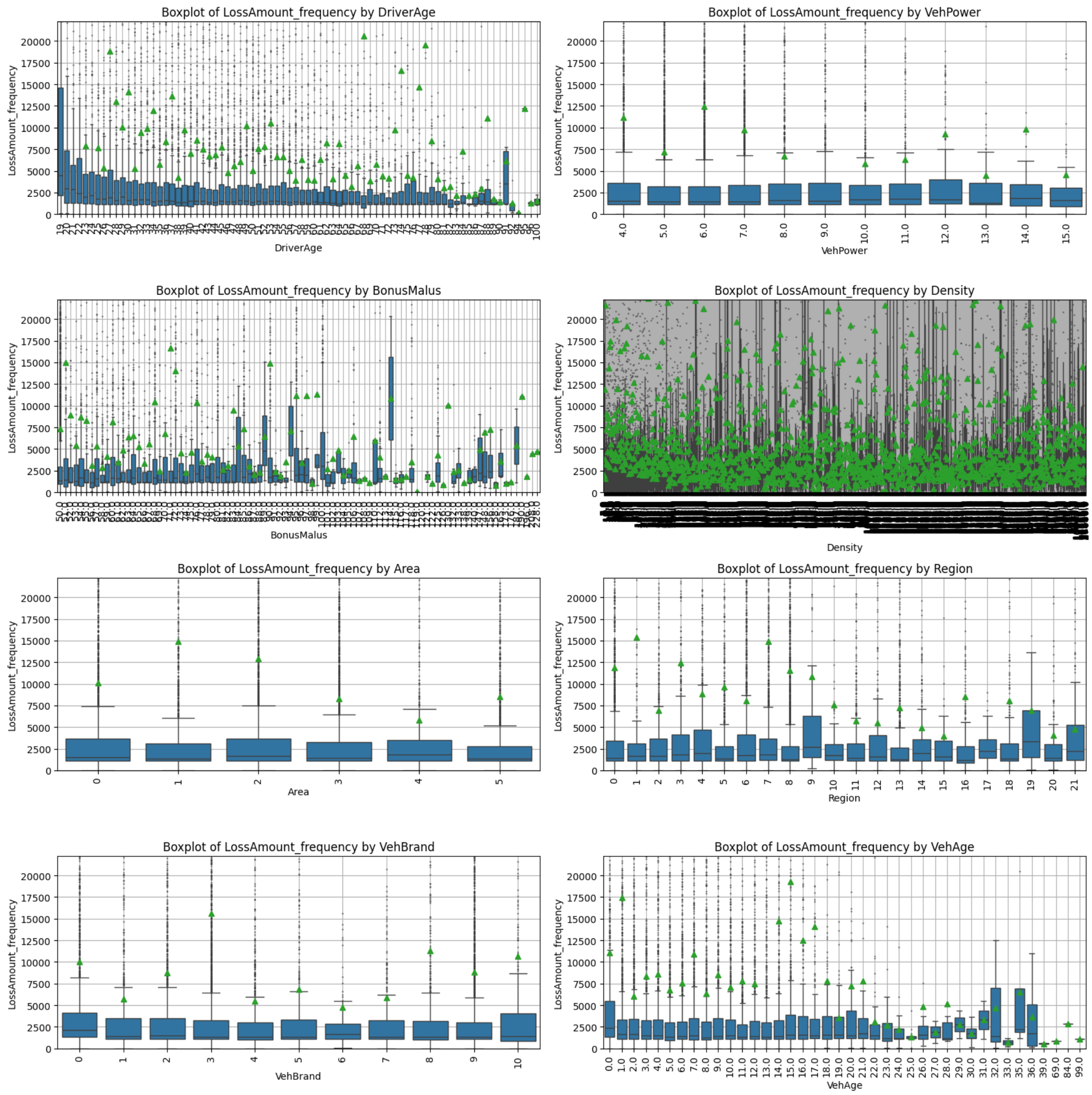
- pool of data by Driver age shows Claim frequency to age!

[ ]:
```python
# sum of ClaimNb and Exposure when grouping by DriverAge
grouped_df = df.groupby('DriverAge').agg({'ClaimNb': 'sum', 'Exposure': 'sum'}).
 ↪reset_index()
# calculate the claim frequency
grouped_df['Claim_frequency'] = grouped_df['ClaimNb'] / grouped_df['Exposure']
# plot the claim frequency by driver age
plt.figure(figsize=(10, 2))
sns.scatterplot(data=grouped_df, x='DriverAge', y='Claim_frequency')
plt.title('Claim Frequency by Driver Age')
plt.xlabel('Driver Age')
plt.ylabel('Claim Frequency')
```

```
plt.grid()
plt.show()
```

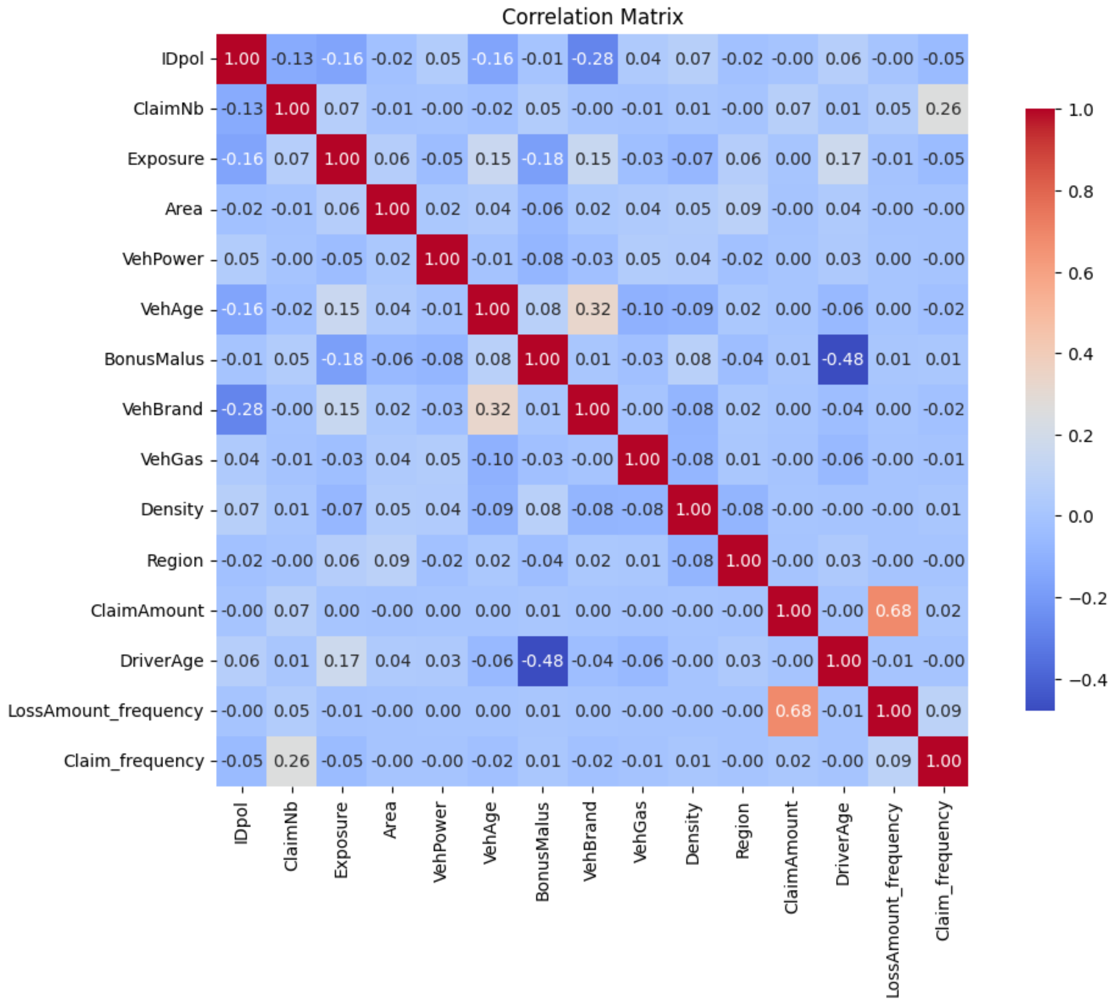



```
[35]: df = df[df['LossAmount_frequency'] > 0]
plot_boxplots(['DriverAge', 'VehPower', 'BonusMalus', 'Density', 'Area',␣
 ↪'Region', 'VehBrand', 'VehAge'], 'LossAmount_frequency', df)
```



- Feature correlations

[33]:
```
df.corr(method='pearson').style.background_gradient(cmap='coolwarm', axis=None).
 ↪format(precision=2)
# Plot the correlation matrix
plt.figure(figsize=(12, 8))
sns.heatmap(df.corr(), annot=True, fmt=".2f", cmap='coolwarm', square=True,␣
 ↪cbar_kws={"shrink": .8})
plt.title('Correlation Matrix')
plt.show()
```



- Scatter plot

[49]:
```
df.loc[:, "ClaimNb"] = df['ClaimNb'].clip(upper=5)
df2 = df[df['IDpol'] < 100000]
# Scatter plot with Claim Amount vs Exposure and IDpol as color and ClaimNb as␣
↪size
plt.figure(figsize=(15, 10))
plt.subplot(2, 1, 1)
scatter_plot = sns.scatterplot(data=df, x='Exposure', y='ClaimAmount',␣
↪hue='IDpol', size= 'ClaimNb', sizes=(10, 200), alpha=0.5)
scatter_plot.set_ylim(0, 4000)
#scatter_plot.legend_.remove()

plt.subplot(2, 1, 2)
```

```python
scatter_plot2 = sns.scatterplot(data=df2, x='Exposure', y='ClaimAmount',
 ↪hue='IDpol', size='ClaimNb', sizes=(20, 200), alpha=0.5)
scatter_plot2.set_ylim(0, 4000)
scatter_plot2.legend_.remove()

plt.show()
```