

## ▼ Imports and setup

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import OneHotEncoder
from sklearn.model_selection import train_test_split
from sklearn.linear_model import RANSACRegressor
from sklearn.metrics import mean_absolute_error
from sklearn.metrics import r2_score

import scipy as sp
from scipy import stats

from google.colab import drive
drive.mount('/content/gdrive')
```

Drive already mounted at /content/gdrive; to attempt to forcibly remount, call drive.mou



## ▼ Load and proceses data

### ▼ Load data from csv

```
path_after_2010 = '/content/gdrive/My Drive/NIOSH Project/data/violations_processed_undergrou
violation_data = pd.read_csv(path_after_2010)
```

### ▼ Split into features and targets

```
FEATURES = ['MINE_TYPE', 'COAL_METAL_IND', 'SIG_SUB', 'LIKELIHOOD',
            'INJ_ILLNESS', 'NO_AFFECTED', 'NEGLIGENCE', 'VIOLATOR_VIOLATION_CNT',
            'VIOLATOR_INSPECTION_DAY_CNT']
TARGETS = ['PROPOSED_PENALTY']

X = violation_data[FEATURES]
y = violation_data[TARGETS]
```

## ▼ Encode and scale features

```
# Define which columns should be encoded vs scaled
columns_to_encode = ['MINE_TYPE', 'COAL_METAL_IND', 'LIKELIHOOD', 'INJ_ILLNESS', 'SIG_SUB', '
columns_to_scale  = ['VIOLATOR_VIOLATION_CNT', 'NO_AFFECTED', 'VIOLATOR_INSPECTION_DAY_CNT']

# Instantiate encoder/scaler
scaler = StandardScaler()
ohe = OneHotEncoder(sparse=False)

# Scale and Encode Separate Columns
scaled_columns  = scaler.fit_transform(X[columns_to_scale])
encoded_columns = ohe.fit_transform(X[columns_to_encode])

# Concatenate (Column-Bind) Processed Columns Back Together
X_pre = np.concatenate([scaled_columns, encoded_columns], axis=1)
np.nan_to_num(X_pre, copy=False)

print('Features shape:', X_pre.shape)

Features shape: (1106385, 22)
```

## ▼ Split data into training and testing datasets

```
X_train, X_test, y_train, y_test = train_test_split(X_pre, y, test_size = 0.25, random_state

print('X_train shape:', X_train.shape)
print('X_test shape:', X_test.shape)
print('y_train shape:', y_train.shape)
print('y_test shape:', y_test.shape)

X_train shape: (829788, 22)
X_test shape: (276597, 22)
y_train shape: (829788, 1)
y_test shape: (276597, 1)
```

## ▼ Define and Fit Simple Linear Regression Model

```
lin_reg = LinearRegression().fit(X_train, y_train)

lin_reg_y_pred_train = lin_reg.predict(X_train)
lin_reg_y_pred_test = lin_reg.predict(X_test)

lin_reg_r_squared_train = r2_score(y_train, lin_reg_y_pred_train)
lin_reg_r_squared_test = r2_score(y_test, lin_reg_y_pred_test)
```

```
lin_reg_r_squared_test = r2_score(y_test, lin_reg_y_pred_test)
```

```
lin_reg_mae_train = mean_absolute_error(y_train, lin_reg_y_pred_train)
lin_reg_mae_test = mean_absolute_error(y_test, lin_reg_y_pred_test)
```

```
print('Simple Linear Regression Scores:')
print('Training R^2 = %.3f' % lin_reg_r_squared_train)
print('Training MAE = %.3f' % lin_reg_mae_train)

print('\nTesting R^2 = %.3f' % lin_reg_r_squared_test)
print('Testing MAE = %.3f' % lin_reg_mae_test)
```

```
↳ Simple Linear Regression Scores:
```

```
Training R^2 = 0.282
Training MAE = 841.392
```

```
Testing R^2 = 0.273
Testing MAE = 846.103
```

## ▼ Define and Fit RANSAC Regressor

```
ransac_reg = RANSACRegressor().fit(X_train, y_train)

ransac_reg_y_pred_train = ransac_reg.predict(X_train)
ransac_reg_y_pred_test = ransac_reg.predict(X_test)

ransac_reg_r_squared_train = r2_score(y_train, ransac_reg_y_pred_train)
ransac_reg_r_squared_test = r2_score(y_test, ransac_reg_y_pred_test)

ransac_reg_mae_train = mean_absolute_error(y_train, ransac_reg_y_pred_train)
ransac_reg_mae_test = mean_absolute_error(y_test, ransac_reg_y_pred_test)

print('RANSAC Regression Scores:')
print('Training R^2 = %.3f' % ransac_reg_r_squared_train)
print('Training MAE = %.3f' % ransac_reg_mae_train)

print('\nTesting R^2 = %.3f' % ransac_reg_r_squared_test)
print('Testing MAE = %.3f' % ransac_reg_mae_test)
```

```
RANSAC Regression Scores:
Training R^2 = 0.028
Training MAE = 588.800
```

```
Testing R^2 = 0.028
Testing MAE = 594.484
```

## ▼ Removing Outliers in Target Data

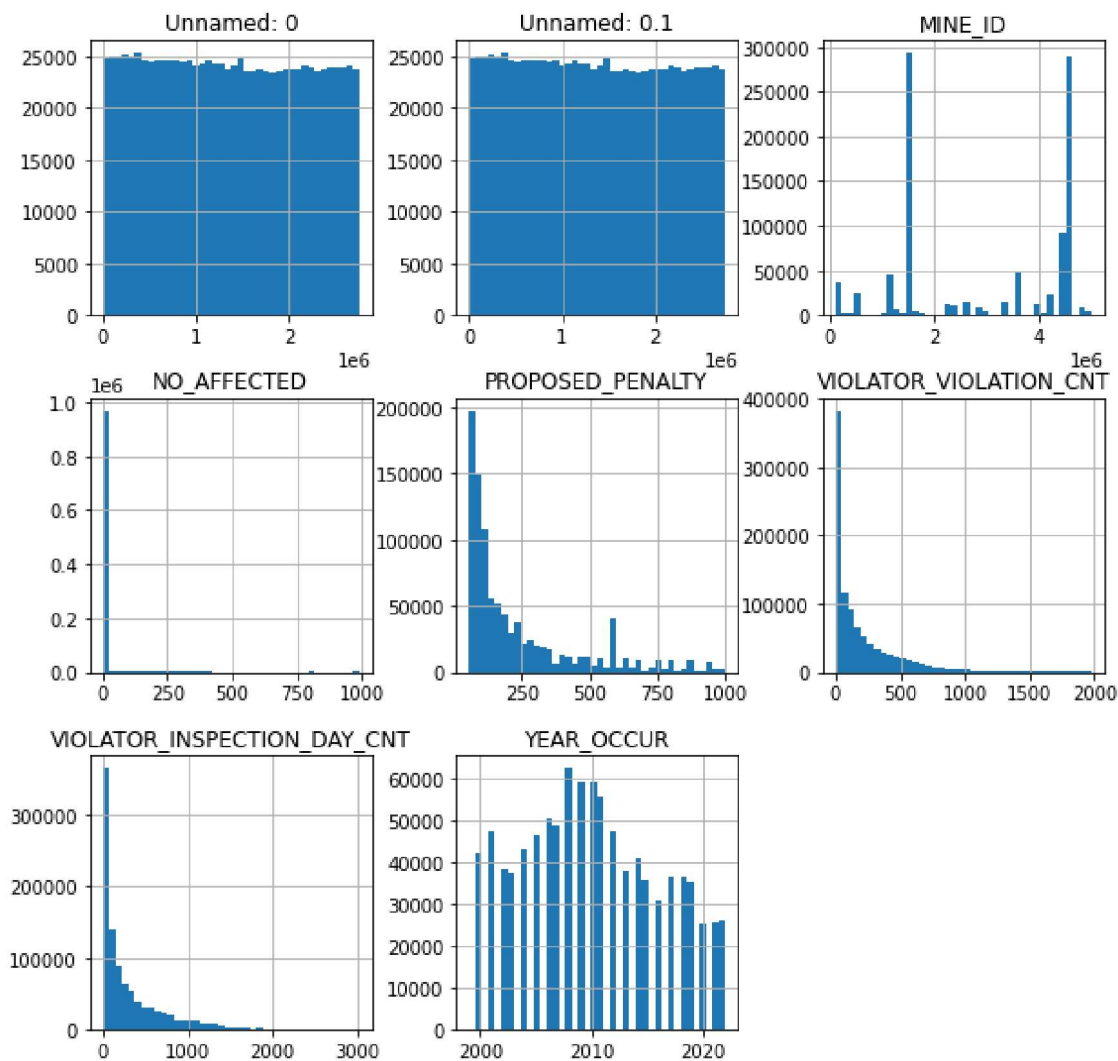
Most of the data in the PROPOSED\_PENALTY column seems to be less than 500. So, let's try removing large values from the dataset.

```
MAX_VALUE = 1000
violations_clipped = violation_data[violation_data['PROPOSED_PENALTY'] <= MAX_VALUE]

print('Total samples = %d' % len(violation_data))
print('Total samples with PROPOSED_PENALTY <= %d: %d' % (MAX_VALUE, len(violations_clipped)))

Total samples = 1106385
Total samples with PROPOSED_PENALTY <= 1000: 969075
```

```
hist = violations_clipped.hist(figsize=(10,10), bins=40)
```



## ▼ Prepare Inlier Data

```

X_inliers = violations_clipped[FEATURES]
y_inliers = violations_clipped[TARGETS]

# Instantiate encoder/scaler
scaler = StandardScaler()
ohe = OneHotEncoder(sparse=False)

# Scale and Encode Separate Columns
scaled_columns_inliers = scaler.fit_transform(X_inliers[columns_to_scale])
encoded_columns_inliers = ohe.fit_transform(X_inliers[columns_to_encode])

# Concatenate (Column-Bind) Processed Columns Back Together
X_pre_inliers = np.concatenate([scaled_columns_inliers, encoded_columns_inliers], axis=1)
np.nan_to_num(X_pre_inliers, copy=False)

X_train_inliers, X_test_inliers, y_train_inliers, y_test_inliers = train_test_split(X_pre_inl

```

## ▼ Inlier Linear Regression

```

lin_reg_inliers = LinearRegression().fit(X_train_inliers, y_train_inliers)

lin_reg_inliers_y_pred_train = lin_reg_inliers.predict(X_train_inliers)
lin_reg_inliers_y_pred_test = lin_reg_inliers.predict(X_test_inliers)

lin_reg_inliers_r_squared_train = r2_score(y_train_inliers, lin_reg_inliers_y_pred_train)
lin_reg_inliers_r_squared_test = r2_score(y_test_inliers, lin_reg_inliers_y_pred_test)

lin_reg_inliers_mae_train = mean_absolute_error(y_train_inliers, lin_reg_inliers_y_pred_train)
lin_reg_inliers_mae_test = mean_absolute_error(y_test_inliers, lin_reg_inliers_y_pred_test)

print('Inlier Simple Linear Regression Scores:')
print('Training R^2 = %.3f' % lin_reg_inliers_r_squared_train)
print('Training MAE = %.3f' % lin_reg_inliers_mae_train)

print('\nTesting R^2 = %.3f' % lin_reg_inliers_r_squared_test)
print('Testing MAE = %.3f' % lin_reg_inliers_mae_test)

```

```

Inlier Simple Linear Regression Scores:
Training R^2 = 0.381
Training MAE = 114.422

```

```

Testing R^2 = 0.385
Testing MAE = 114.914

```

## ▼ Inlier RANSAC Regression

```

ransac_reg_inliers = RANSACRegressor(random_state=35).fit(X_train_inliers, y_train_inliers)

ransac_reg_inliers_y_pred_train = ransac_reg_inliers.predict(X_train_inliers)
ransac_reg_inliers_y_pred_test = ransac_reg_inliers.predict(X_test_inliers)

ransac_reg_inliers_r_squared_train = r2_score(y_train_inliers, ransac_reg_inliers_y_pred_train)
ransac_reg_inliers_r_squared_test = r2_score(y_test_inliers, ransac_reg_inliers_y_pred_test)

ransac_reg_inliers_mae_train = mean_absolute_error(y_train_inliers, ransac_reg_inliers_y_pred_train)
ransac_reg_inliers_mae_test = mean_absolute_error(y_test_inliers, ransac_reg_inliers_y_pred_test)

print('Inlier RANSAC Regression Scores:')
print('Training R^2 = %.3f' % ransac_reg_inliers_r_squared_train)
print('Training MAE = %.3f' % ransac_reg_inliers_mae_train)

print('\nTesting R^2 = %.3f' % ransac_reg_inliers_r_squared_test)
print('Testing MAE = %.3f' % ransac_reg_inliers_mae_test)

Inlier RANSAC Regression Scores:
Training R^2 = 0.108
Training MAE = 120.333

Testing R^2 = 0.115
Testing MAE = 120.713

```

## ▼ Focusing on Outliers

Now lets see if we can fit a model to the larger values.

```

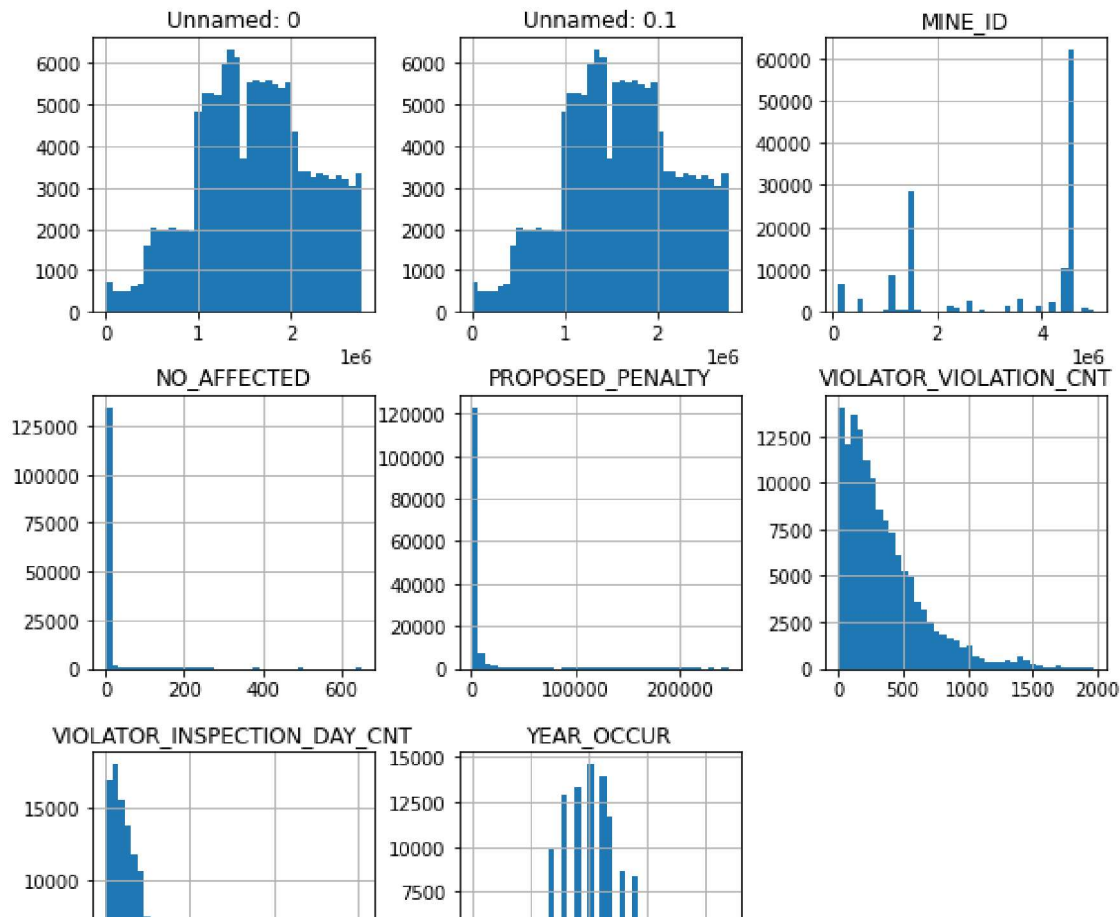
violations_outliers = violation_data[violation_data['PROPOSED_PENALTY'] > MAX_VALUE]

print('Total samples = %d' % len(violation_data))
print('Total samples with PROPOSED_PENALTY > %d: %d' % (MAX_VALUE, len(violations_outliers)))

Total samples = 1106385
Total samples with PROPOSED_PENALTY > 1000: 137310

hist = violations_outliers.hist(figsize=(10,10), bins=40)

```



## ▼ Process outlier data

```

X_outliers = violations_outliers[FEATURES]
y_outliers = violations_outliers[TARGETS]

# Instantiate encoder/scaler
scaler = StandardScaler()
ohe = OneHotEncoder(sparse=False)

# Scale and Encode Separate Columns
scaled_columns_outliers = scaler.fit_transform(X_outliers[columns_to_scale])
encoded_columns_outliers = ohe.fit_transform(X_outliers[columns_to_encode])

# Concatenate (Column-Bind) Processed Columns Back Together
X_pre_outliers = np.concatenate([scaled_columns_outliers, encoded_columns_outliers], axis=1)
np.nan_to_num(X_pre_outliers, copy=False)

X_train_outliers, X_test_outliers, y_train_outliers, y_test_outliers = train_test_split(X_pre_outliers,

```

## ▼ Outlier Linear Regression

```

lin_reg_outliers = LinearRegression().fit(X_train_outliers, y_train_outliers)

lin_reg_outliers_y_pred_train = lin_reg_outliers.predict(X_train_outliers)
lin_reg_outliers_y_pred_test = lin_reg_outliers.predict(X_test_outliers)

lin_reg_outliers_r_squared_train = r2_score(y_train_outliers, lin_reg_outliers_y_pred_train)
lin_reg_outliers_r_squared_test = r2_score(y_test_outliers, lin_reg_outliers_y_pred_test)

lin_reg_outliers_mae_train = mean_absolute_error(y_train_outliers, lin_reg_outliers_y_pred_train)
lin_reg_outliers_mae_test = mean_absolute_error(y_test_outliers, lin_reg_outliers_y_pred_test)

print('Outlier Simple Linear Regression Scores:')
print('Training R^2 = %.3f' % lin_reg_outliers_r_squared_train)
print('Training MAE = %.3f' % lin_reg_outliers_mae_train)

print('\nTesting R^2 = %.3f' % lin_reg_outliers_r_squared_test)
print('Testing MAE = %.3f' % lin_reg_outliers_mae_test)

    Outlier Simple Linear Regression Scores:
    Training R^2 = 0.289
    Training MAE = 3474.002

    Testing R^2 = 0.291
    Testing MAE = 3521.026

```

## ▼ Outlier RANSAC Regression

```

ransac_reg_outliers = RANSACRegressor(random_state=2).fit(X_train_outliers, y_train_outliers)

ransac_reg_outliers_y_pred_train = ransac_reg_outliers.predict(X_train_outliers)
ransac_reg_outliers_y_pred_test = ransac_reg_outliers.predict(X_test_outliers)

ransac_reg_outliers_r_squared_train = r2_score(y_train_outliers, ransac_reg_outliers_y_pred_train)
ransac_reg_outliers_r_squared_test = r2_score(y_test_outliers, ransac_reg_outliers_y_pred_test)

ransac_reg_outliers_mae_train = mean_absolute_error(y_train_outliers, ransac_reg_outliers_y_pred_train)
ransac_reg_outliers_mae_test = mean_absolute_error(y_test_outliers, ransac_reg_outliers_y_pred_test)

print('Outlier RANSAC Regression Scores:')
print('Training R^2 = %.3f' % ransac_reg_outliers_r_squared_train)
print('Training MAE = %.3f' % ransac_reg_outliers_mae_train)

print('\nTesting R^2 = %.3f' % ransac_reg_outliers_r_squared_test)
print('Testing MAE = %.3f' % ransac_reg_outliers_mae_test)

    Outlier RANSAC Regression Scores:
    Training R^2 = -0.094
    Training MAE = 4312.557

```



Testing  $R^2$  = -0.067  
Testing MAE = 4347.706

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