chicago-crash-notebook

May 24, 2023

0.1 Chicago Car Crash Project

This project is based on the Chicago Car Crash data. We will use this data to create a model which will help predict the main cause of the accidents An average span of four days, Chicago can record up to over a thousand car accidents. When you include drivers, passengers, pedestrians and cyclists, up to two thousand people can be effected. Forty-five percent of the people will experience a minor to fatal injury.

The purpose of this project is to build a classification model to help identify what features are important in a car accident and use for prediction

0.2 1 Introduction

0.3 1.1 Problem Statement

- The primary objective of this study is to identify and understand the main contributing factors to car accidents in Chicago, with a specific focus on driver behavior.
- By analyzing various modeling techniques and their results, the aim is to determine the primary causes of car accidents and provide insights that can contribute to the development of effective strategies for accident prevention and road safety improvement.

0.4 1.2 Main Objective/ Goal

The goal of this project is to create a model that predicts and classifies different types of traffic crashes. The dataset parameters are utilized to distinguish between various types of crashes

0.5 2 Obtain the packages

Import the packages

[1]:
```
#!pip install scikit-learn==0.23.2
# !pip install mlxtend
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import graphviz
import os
from sklearn.tree import export_graphviz
```

```python
from sklearn.model_selection import train_test_split, GridSearchCV,␣
↪cross_val_score
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier, BaggingClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, r2_score, recall_score,␣
↪precision_score, roc_curve, roc_auc_score, f1_score
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay, RocCurveDisplay
from sklearn.pipeline import Pipeline
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler, OneHotEncoder, RobustScaler,␣
↪LabelEncoder
from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn.compose import ColumnTransformer
from xgboost import XGBClassifier
from sklearn.naive_bayes import GaussianNB
from pyspark.sql import SparkSession

from pyspark.ml.feature import VectorAssembler
from pyspark.ml.classification import DecisionTreeClassifier
from pyspark.ml.evaluation import MulticlassClassificationEvaluator
from pyspark.sql import SparkSession

#!pip install shap
import shap
shap.initjs()

import six
import sys
sys.modules['sklearn.externals.six'] = six
from imblearn.over_sampling import SMOTE, ADASYN, SMOTENC

import folium

import warnings
warnings.filterwarnings('ignore')
```

```
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_clustering.py:35: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _pt_shuffle_rec(i, indexes, index_mask, partition_tree, M, pos):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_clustering.py:54: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def delta_minimization_order(all_masks, max_swap_size=100, num_passes=2):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_clustering.py:63: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _reverse_window(order, start, length):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_clustering.py:69: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _reverse_window_score_gain(masks, order, start, length):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
```

```
packages\shap\utils\_clustering.py:77: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _mask_delta_score(m1, m2):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-packages\shap\links.py:5:
NumbaDeprecationWarning: The 'nopython' keyword argument was not supplied to
the 'numba.jit' decorator. The implicit default value for this argument is
currently False, but it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def identity(x):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-packages\shap\links.py:10:
NumbaDeprecationWarning: The 'nopython' keyword argument was not supplied to
the 'numba.jit' decorator. The implicit default value for this argument is
currently False, but it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _identity_inverse(x):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-packages\shap\links.py:15:
NumbaDeprecationWarning: The 'nopython' keyword argument was not supplied to
the 'numba.jit' decorator. The implicit default value for this argument is
currently False, but it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def logit(x):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-packages\shap\links.py:20:
NumbaDeprecationWarning: The 'nopython' keyword argument was not supplied to
the 'numba.jit' decorator. The implicit default value for this argument is
currently False, but it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _logit_inverse(x):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
```

```
packages\shap\utils\_masked_model.py:363: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _build_fixed_single_output(averaged_outs, last_outs, outputs,
batch_positions, varying_rows, num_varying_rows, link, linearizing_weights):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_masked_model.py:385: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _build_fixed_multi_output(averaged_outs, last_outs, outputs,
batch_positions, varying_rows, num_varying_rows, link, linearizing_weights):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_masked_model.py:428: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _init_masks(cluster_matrix, M, indices_row_pos, indptr):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\utils\_masked_model.py:439: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _rec_fill_masks(cluster_matrix, indices_row_pos, indptr, indices, M, ind):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
```

```
packages\shap\maskers\_tabular.py:186: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _single_delta_mask(dind, masked_inputs, last_mask, data, x, noop_code):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\maskers\_tabular.py:197: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _delta_masking(masks, x, curr_delta_inds, varying_rows_out,
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\maskers\_image.py:175: NumbaDeprecationWarning: The 'nopython'
keyword argument was not supplied to the 'numba.jit' decorator. The implicit
default value for this argument is currently False, but it will be changed to
True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def _jit_build_partition_tree(xmin, xmax, ymin, ymax, zmin, zmax,
total_ywidth, total_zwidth, M, clustering, q):
c:\Users\wanji\anaconda3\envs\learn-env\lib\site-
packages\shap\explainers\_partition.py:676: NumbaDeprecationWarning: The
'nopython' keyword argument was not supplied to the 'numba.jit' decorator. The
implicit default value for this argument is currently False, but it will be
changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
  def lower_credit(i, value, M, values, clustering):
```

```
The 'nopython' keyword argument was not supplied to the 'numba.jit'
decorator. The implicit default value for this argument is currently False, but
it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
```


```
The 'nopython' keyword argument was not supplied to the 'numba.jit'
decorator. The implicit default value for this argument is currently False, but
it will be changed to True in Numba 0.59.0. See
https://numba.readthedocs.io/en/stable/reference/deprecation.html#deprecation-
of-object-mode-fall-back-behaviour-when-using-jit for details.
```


```
<IPython.core.display.HTML object>
```

0.5.1 2.1 Import the dataset

[2]:
```
# Crash Dataset
crashes = pd.read_csv(r"C:
↪\Users\wanji\OneDrive\Desktop\Traffic_Crashes_-_Crashes.csv")
crashes
```

[2]:
```
                                         CRASH_RECORD_ID     RD_NO  \
0       79c7a2ce89f446262efd86df3d72d18b04ba487024b7c4…  JC199149
1       792b539deaaad65ee5b4a9691d927a34d298eb33d42af0…  JB422857
2       0115ade9a755e835255508463f7e9c4a9a0b47e9304238…  JF318029
3       017040c61958d2fa977c956b2bd2d6759ef7754496dc96…  JF324552
4       78eee027ec3dcc85d36c9e3fdae4729dcc56440105d65b…  JB291672
…                                                    …       …
723455  722625096bc7b56c15fee9e09f4f1901fc5e25b8aacf2b…  JG251187
723456  2d47afb7c4f2f4d305fddccb682ce850452476cc7f910d…       NaN
723457  4b1e7cbdb519f7f83fa3e3eae095ff54aebb73f125cf06…       NaN
723458  5d3f02a062e775ef527557f75c4ded6900d21ad7108a3a…       NaN
723459  2d53e3705a5b2f13c9684cdc99c3ab976c88a9e1ae7239…       NaN

       CRASH_DATE_EST_I              CRASH_DATE  POSTED_SPEED_LIMIT  \
0                   NaN  03/25/2019 02:43:00 PM                  30
1                   NaN  09/05/2018 08:40:00 AM                  30
2                   NaN  07/15/2022 12:45:00 AM                  30
3                   NaN  07/15/2022 06:50:00 PM                  30
4                   NaN  06/03/2018 05:00:00 PM                  30
…                   …                       …                 …
723455              NaN  04/27/2023 05:47:00 PM                  30
723456              NaN  05/13/2023 03:54:00 PM                  35
723457              NaN  05/11/2023 05:45:00 PM                  30
723458              NaN  05/13/2023 03:14:00 AM                  30
```

```
723459             NaN  05/13/2023 03:21:00 PM                 30

       TRAFFIC_CONTROL_DEVICE      DEVICE_CONDITION WEATHER_CONDITION  \
0              TRAFFIC SIGNAL  FUNCTIONING PROPERLY             CLEAR
1                 NO CONTROLS           NO CONTROLS             CLEAR
2                     UNKNOWN               UNKNOWN             CLEAR
3              TRAFFIC SIGNAL  FUNCTIONING PROPERLY             CLEAR
4                 NO CONTROLS           NO CONTROLS             CLEAR
…                         …                    …                …
723455         TRAFFIC SIGNAL  FUNCTIONING PROPERLY             CLEAR
723456         TRAFFIC SIGNAL  FUNCTIONING PROPERLY           UNKNOWN
723457      STOP SIGN/FLASHER  FUNCTIONING PROPERLY           UNKNOWN
723458         TRAFFIC SIGNAL  FUNCTIONING PROPERLY             CLEAR
723459            NO CONTROLS           NO CONTROLS             CLEAR

            LIGHTING_CONDITION          FIRST_CRASH_TYPE  …  \
0                     DAYLIGHT                   TURNING  …
1                     DAYLIGHT                     ANGLE  …
2        DARKNESS, LIGHTED ROAD                    ANGLE  …
3                     DAYLIGHT                  REAR END  …
4                      UNKNOWN      PARKED MOTOR VEHICLE  …
…                         …                      …   …
723455                DAYLIGHT  SIDESWIPE SAME DIRECTION  …
723456                 UNKNOWN                   TURNING  …
723457                 UNKNOWN                     ANGLE  …
723458  DARKNESS, LIGHTED ROAD                     ANGLE  …
723459                DAYLIGHT      PARKED MOTOR VEHICLE  …

       INJURIES_NON_INCAPACITATING  INJURIES_REPORTED_NOT_EVIDENT  \
0                              0.0                            1.0
1                              0.0                            0.0
2                              0.0                            0.0
3                              0.0                            0.0
4                              0.0                            0.0
…                            …                            …
723455                         0.0                            0.0
723456                         0.0                            0.0
723457                         0.0                            0.0
723458                         2.0                            0.0
723459                         0.0                            0.0

       INJURIES_NO_INDICATION INJURIES_UNKNOWN CRASH_HOUR CRASH_DAY_OF_WEEK  \
0                         2.0              0.0         14                 2
1                         2.0              0.0          8                 4
2                         2.0              0.0          0                 6
3                         2.0              0.0         18                 6
4                         1.0              0.0         17                 1
```

```
…                       …              …         …               …
723455                 5.0            0.0        17                   5
723456                 2.0            0.0        15                   7
723457                 4.0            0.0        17                   5
723458                 2.0            0.0         3                   7
723459                 1.0            0.0        15                   7

       CRASH_MONTH   LATITUDE  LONGITUDE  \
0                3  41.884547 -87.641201
1                9  41.968562 -87.740659
2                7  41.886336 -87.716203
3                7  41.925111 -87.667997
4                6  41.910758 -87.731389
…              …         …         …
723455           4  41.822237 -87.606996
723456           5  41.852761 -87.625645
723457           5  41.891311 -87.646244
723458           5  41.809485 -87.606711
723459           5        NaN        NaN

                                        LOCATION
0        POINT (-87.64120093714 41.884547224337)
1       POINT (-87.740659314632 41.968562453871)
2       POINT (-87.716203130599 41.886336409761)
3       POINT (-87.667997321599 41.925110815832)
4       POINT (-87.731388754145 41.910757551599)
…                                             …
723455  POINT (-87.606995789103 41.822236685692)
723456   POINT (-87.625645007251 41.85276094394)
723457  POINT (-87.646244110744 41.891311456709)
723458  POINT (-87.606710818433 41.809485427538)
723459                                       NaN

[723460 rows x 49 columns]
```

1 2.2 Checking the shape of the dataset

[3]:
```python
# Checking out the dataframe columns
crashes.PRIM_CONTRIBUTORY_CAUSE.value_counts().index
```

[3]:
```
Index(['UNABLE TO DETERMINE', 'FAILING TO YIELD RIGHT-OF-WAY',
       'FOLLOWING TOO CLOSELY', 'NOT APPLICABLE',
       'IMPROPER OVERTAKING/PASSING', 'FAILING TO REDUCE SPEED TO AVOID CRASH',
       'IMPROPER BACKING', 'IMPROPER LANE USAGE', 'IMPROPER TURNING/NO SIGNAL',
       'DRIVING SKILLS/KNOWLEDGE/EXPERIENCE', 'DISREGARDING TRAFFIC SIGNALS',
       'WEATHER',
```

```
       'OPERATING VEHICLE IN ERRATIC, RECKLESS, CARELESS, NEGLIGENT OR
AGGRESSIVE MANNER',
       'DISREGARDING STOP SIGN', 'DISTRACTION - FROM INSIDE VEHICLE',
       'EQUIPMENT - VEHICLE CONDITION', 'PHYSICAL CONDITION OF DRIVER',
       'VISION OBSCURED (SIGNS, TREE LIMBS, BUILDINGS, ETC.)',
       'DRIVING ON WRONG SIDE/WRONG WAY',
       'UNDER THE INFLUENCE OF ALCOHOL/DRUGS (USE WHEN ARREST IS EFFECTED)',
       'DISTRACTION - FROM OUTSIDE VEHICLE',
       'EXCEEDING AUTHORIZED SPEED LIMIT',
       'ROAD ENGINEERING/SURFACE/MARKING DEFECTS',
       'EXCEEDING SAFE SPEED FOR CONDITIONS', 'ROAD CONSTRUCTION/MAINTENANCE',
       'DISREGARDING OTHER TRAFFIC SIGNS',
       'EVASIVE ACTION DUE TO ANIMAL, OBJECT, NONMOTORIST',
       'CELL PHONE USE OTHER THAN TEXTING', 'DISREGARDING ROAD MARKINGS',
       'HAD BEEN DRINKING (USE WHEN ARREST IS NOT MADE)', 'ANIMAL',
       'TURNING RIGHT ON RED',
       'DISTRACTION - OTHER ELECTRONIC DEVICE (NAVIGATION DEVICE, DVD PLAYER,
ETC.)',
       'RELATED TO BUS STOP', 'TEXTING', 'DISREGARDING YIELD SIGN',
       'PASSING STOPPED SCHOOL BUS', 'BICYCLE ADVANCING LEGALLY ON RED LIGHT',
       'OBSTRUCTED CROSSWALKS', 'MOTORCYCLE ADVANCING LEGALLY ON RED LIGHT'],
      dtype='object')
```

2 3. Data Cleaning

[4]:
```
# filling all na with UNKNOWN string, so we can encode later
crashes.fillna('UNKOWN', inplace=True)
```

[5]:
```
# dropping the unecessary columns that does not make sense
crashes.drop(['CRASH_RECORD_ID', 'CRASH_DATE_EST_I', 'RD_NO', 'REPORT_TYPE',␣
 ↪'STREET_NO', 'BEAT_OF_OCCURRENCE',
        'PHOTOS_TAKEN_I', 'STATEMENTS_TAKEN_I', 'WORKERS_PRESENT_I',␣
 ↪'INJURIES_UNKNOWN', 'LONGITUDE', 'LATITUDE',
        'MOST_SEVERE_INJURY', 'INJURIES_TOTAL',␣
 ↪'INJURIES_FATAL','INJURIES_INCAPACITATING',
        'INJURIES_NON_INCAPACITATING', 'INJURIES_REPORTED_NOT_EVIDENT',␣
 ↪'INJURIES_NO_INDICATION', 'DAMAGE',
        'DATE_POLICE_NOTIFIED',␣
 ↪'CRASH_TYPE','NUM_UNITS','STREET_DIRECTION','STREET_NAME', 'LANE_CNT'],␣
 ↪axis=1, inplace=True)
```

[6]:
```
crashes
```

[6]:
```
                      CRASH_DATE  POSTED_SPEED_LIMIT TRAFFIC_CONTROL_DEVICE  \
0         03/25/2019 02:43:00 PM                  30         TRAFFIC SIGNAL
1         09/05/2018 08:40:00 AM                  30            NO CONTROLS
```

```
2       07/15/2022 12:45:00 AM                   30               UNKNOWN
3       07/15/2022 06:50:00 PM                   30        TRAFFIC SIGNAL
4       06/03/2018 05:00:00 PM                   30           NO CONTROLS
…                            …                 …                    …
723455  04/27/2023 05:47:00 PM                   30        TRAFFIC SIGNAL
723456  05/13/2023 03:54:00 PM                   35        TRAFFIC SIGNAL
723457  05/11/2023 05:45:00 PM                   30      STOP SIGN/FLASHER
723458  05/13/2023 03:14:00 AM                   30        TRAFFIC SIGNAL
723459  05/13/2023 03:21:00 PM                   30           NO CONTROLS

            DEVICE_CONDITION WEATHER_CONDITION      LIGHTING_CONDITION  \
0       FUNCTIONING PROPERLY             CLEAR                DAYLIGHT
1                NO CONTROLS             CLEAR                DAYLIGHT
2                    UNKNOWN             CLEAR  DARKNESS, LIGHTED ROAD
3       FUNCTIONING PROPERLY             CLEAR                DAYLIGHT
4                NO CONTROLS             CLEAR                 UNKNOWN
…                        …               …                     …
723455  FUNCTIONING PROPERLY             CLEAR                DAYLIGHT
723456  FUNCTIONING PROPERLY           UNKNOWN                 UNKNOWN
723457  FUNCTIONING PROPERLY           UNKNOWN                 UNKNOWN
723458  FUNCTIONING PROPERLY             CLEAR  DARKNESS, LIGHTED ROAD
723459           NO CONTROLS             CLEAR                DAYLIGHT

                FIRST_CRASH_TYPE TRAFFICWAY_TYPE          ALIGNMENT  \
0                        TURNING         ONE-WAY  STRAIGHT AND LEVEL
1                          ANGLE     NOT DIVIDED  STRAIGHT AND LEVEL
2                          ANGLE     NOT DIVIDED  STRAIGHT AND LEVEL
3                       REAR END     NOT DIVIDED  STRAIGHT AND LEVEL
4           PARKED MOTOR VEHICLE         ONE-WAY  STRAIGHT AND LEVEL
…                            …             …                  …
723455  SIDESWIPE SAME DIRECTION           OTHER  STRAIGHT AND LEVEL
723456                   TURNING     NOT DIVIDED  STRAIGHT AND LEVEL
723457                     ANGLE     NOT DIVIDED  STRAIGHT AND LEVEL
723458                     ANGLE        FOUR WAY  STRAIGHT AND LEVEL
723459      PARKED MOTOR VEHICLE           OTHER  STRAIGHT AND LEVEL

       ROADWAY_SURFACE_COND  … HIT_AND_RUN_I  \
0                       DRY  …        UNKOWN
1                       DRY  …        UNKOWN
2                       DRY  …        UNKOWN
3                       DRY  …        UNKOWN
4                       DRY  …             Y
…                     …  …           …
723455                  DRY  …        UNKOWN
723456              UNKNOWN  …        UNKOWN
723457              UNKNOWN  …             Y
723458                  DRY  …        UNKOWN
```

```
723459                 DRY  …        UNKOWN

                                  PRIM_CONTRIBUTORY_CAUSE  \
0                             IMPROPER TURNING/NO SIGNAL
1        VISION OBSCURED (SIGNS, TREE LIMBS, BUILDINGS,…
2                                    UNABLE TO DETERMINE
3                                    UNABLE TO DETERMINE
4                                    UNABLE TO DETERMINE
…                                                  …
723455                       IMPROPER OVERTAKING/PASSING
723456                        IMPROPER TURNING/NO SIGNAL
723457                               UNABLE TO DETERMINE
723458                      DISREGARDING TRAFFIC SIGNALS
723459                               IMPROPER LANE USAGE

                  SEC_CONTRIBUTORY_CAUSE DOORING_I WORK_ZONE_I  \
0       DRIVING SKILLS/KNOWLEDGE/EXPERIENCE    UNKOWN      UNKOWN
1             FAILING TO YIELD RIGHT-OF-WAY    UNKOWN      UNKOWN
2                       UNABLE TO DETERMINE    UNKOWN      UNKOWN
3                       UNABLE TO DETERMINE    UNKOWN      UNKOWN
4                       UNABLE TO DETERMINE    UNKOWN      UNKOWN
…                                          …       …          …
723455                  IMPROPER LANE USAGE    UNKOWN      UNKOWN
723456                  UNABLE TO DETERMINE    UNKOWN      UNKOWN
723457                       NOT APPLICABLE    UNKOWN      UNKOWN
723458                       NOT APPLICABLE    UNKOWN      UNKOWN
723459                       NOT APPLICABLE    UNKOWN      UNKOWN

       WORK_ZONE_TYPE CRASH_HOUR CRASH_DAY_OF_WEEK CRASH_MONTH  \
0              UNKOWN         14                 2           3
1              UNKOWN          8                 4           9
2              UNKOWN          0                 6           7
3              UNKOWN         18                 6           7
4              UNKOWN         17                 1           6
…                   …          …                 …           …
723455         UNKOWN         17                 5           4
723456         UNKOWN         15                 7           5
723457         UNKOWN         17                 5           5
723458         UNKOWN          3                 7           5
723459         UNKOWN         15                 7           5

                                        LOCATION
0        POINT (-87.64120093714 41.884547224337)
1       POINT (-87.740659314632 41.968562453871)
2       POINT (-87.716203130599 41.886336409761)
3       POINT (-87.667997321599 41.925110815832)
4       POINT (-87.731388754145 41.910757551599)
```

```
…                                                  …
723455  POINT (-87.606995789103 41.822236685692)
723456   POINT (-87.625645007251 41.85276094394)
723457  POINT (-87.646244110744 41.891311456709)
723458  POINT (-87.606710818433 41.809485427538)
723459                                    UNKOWN

[723460 rows x 23 columns]
```

[7]:
```
# We have speed limits that are not logged correctly, so we will drop them.
# There wasn't a lot so this will not effect our data
list_ = [3, 9, 99, 39, 1, 2, 32, 33, 6, 24, 11, 34, 18, 12, 36, 7, 14, 16, 38,␣
 ↪31, 22, 23, 63, 4, 26]
for n in list_:
    crashes.drop(index=crashes[crashes['POSTED_SPEED_LIMIT'] == n].index,␣
 ↪inplace=True)
```

2.1 3.1 Perform Onehotencoding

[8]:
```
ohe = OneHotEncoder(handle_unknown='ignore')
```

[9]:
```
# Creating a new dataframe for FIRST_CRASH_TYPE
# Then we will OneHotEncode the data to categories
crash_type = crashes['FIRST_CRASH_TYPE']
crash_df = pd.DataFrame(crash_type, columns=['FIRST_CRASH_TYPE'])
crash_df = pd.DataFrame(ohe.fit_transform(crash_df[['FIRST_CRASH_TYPE']]).
 ↪toarray())
```

2.1.1 3.2 Column Labelling

[10]:
```
# Each column will be a FIRST_CRASH_TYPE, so we will need to label each column
crash_col = crashes['FIRST_CRASH_TYPE'].unique()
crash_df.columns = crash_col
```

[11]:
```
#final columns
crash_df.columns
```

[11]:
```
Index(['TURNING', 'ANGLE', 'REAR END', 'PARKED MOTOR VEHICLE',
       'SIDESWIPE OPPOSITE DIRECTION', 'PEDALCYCLIST', 'REAR TO FRONT',
       'PEDESTRIAN', 'REAR TO REAR', 'FIXED OBJECT', 'OTHER NONCOLLISION',
       'SIDESWIPE SAME DIRECTION', 'REAR TO SIDE', 'HEAD ON', 'OTHER OBJECT',
       'ANIMAL', 'OVERTURNED', 'TRAIN'],
      dtype='object')
```

2.2 3.3 Selecting features and conducting label encoding

[12]:
```
# Here we select the features we want to use and LabelEncode them using a for␣
↪loop
# We will also create a new dataframe for them
text_col = ['TRAFFIC_CONTROL_DEVICE', 'DEVICE_CONDITION', 'WEATHER_CONDITION',␣
↪'LIGHTING_CONDITION', 'TRAFFICWAY_TYPE',
            'ALIGNMENT', 'ROADWAY_SURFACE_COND', 'ROAD_DEFECT',␣
↪'INTERSECTION_RELATED_I','NOT_RIGHT_OF_WAY_I',
            'HIT_AND_RUN_I', 'PRIM_CONTRIBUTORY_CAUSE',␣
↪'SEC_CONTRIBUTORY_CAUSE','DOORING_I', 'WORK_ZONE_I',
            'WORK_ZONE_TYPE']
en_df = pd.DataFrame()
for col in text_col:
    encoder = LabelEncoder()
    en_df[col] = encoder.fit_transform(crashes[col])

en_df
```

[12]:
```
        TRAFFIC_CONTROL_DEVICE  DEVICE_CONDITION  WEATHER_CONDITION  \
0                           16                 1                  2
1                            4                 3                  2
2                           17                 6                  2
3                           16                 1                  2
4                            4                 3                  2
…                          …                 …                 …
722855                      16                 1                  2
722856                      16                 1                 11
722857                      15                 1                 11
722858                      16                 1                  2
722859                       4                 3                  2

        LIGHTING_CONDITION  TRAFFICWAY_TYPE  ALIGNMENT  ROADWAY_SURFACE_COND  \
0                        3               10          3                     0
1                        3                8          3                     0
2                        1                8          3                     0
3                        3                8          3                     0
4                        5               10          3                     0
…                      …                …         …                    …
722855                   3               11          3                     0
722856                   5                8          3                     5
722857                   5                8          3                     5
722858                   1                6          3                     0
722859                   3               11          3                     0

        ROAD_DEFECT  INTERSECTION_RELATED_I  NOT_RIGHT_OF_WAY_I  \
0                 1                       2                   1
```

```
1                   1                        1                     1
2                   5                        1                     1
3                   1                        1                     1
4                   1                        1                     1
…                 …                        …                   …
722855              1                        1                     1
722856              5                        2                     1
722857              5                        1                     1
722858              1                        2                     1
722859              1                        1                     1

        HIT_AND_RUN_I  PRIM_CONTRIBUTORY_CAUSE  SEC_CONTRIBUTORY_CAUSE  \
0                   1                       24                      12
1                   1                       38                      18
2                   1                       36                      36
3                   1                       36                      36
4                   2                       36                      36
…                 …                      …                     …
722855              1                       23                      22
722856              1                       24                      36
722857              2                       36                      26
722858              1                        6                      26
722859              1                       22                      26

        DOORING_I  WORK_ZONE_I  WORK_ZONE_TYPE
0               1            1               3
1               1            1               3
2               1            1               3
3               1            1               3
4               1            1               3
…             …          …             …
722855          1            1               3
722856          1            1               3
722857          1            1               3
722858          1            1               3
722859          1            1               3

[722860 rows x 16 columns]
```

[13]:
```
no_en_df = ['POSTED_SPEED_LIMIT','CRASH_HOUR', 'CRASH_DAY_OF_WEEK',␣
 ↪'CRASH_MONTH', 'LOCATION']
no_en_df = pd.DataFrame(crashes[no_en_df])
no_en_df
```

[13]:
```
        POSTED_SPEED_LIMIT  CRASH_HOUR  CRASH_DAY_OF_WEEK  CRASH_MONTH  \
0                       30          14                  2            3
1                       30           8                  4            9
```

```
2                        30          0                6           7
3                        30         18                6           7
4                        30         17                1           6
…                     …          …                …          …
723455                   30         17                5           4
723456                   35         15                7           5
723457                   30         17                5           5
723458                   30          3                7           5
723459                   30         15                7           5

                                           LOCATION
0         POINT (-87.64120093714 41.884547224337)
1        POINT (-87.740659314632 41.968562453871)
2        POINT (-87.716203130599 41.886336409761)
3        POINT (-87.667997321599 41.925110815832)
4        POINT (-87.731388754145 41.910757551599)
…                                             …
723455   POINT (-87.606995789103 41.822236685692)
723456    POINT (-87.625645007251 41.85276094394)
723457   POINT (-87.646244110744 41.891311456709)
723458   POINT (-87.606710818433 41.809485427538)
723459                                     UNKOWN

[722860 rows x 5 columns]
```

[14]:

```
# Identify the columns in the target column
contributory_causes = crashes['PRIM_CONTRIBUTORY_CAUSE'].unique()
print(contributory_causes)
```

```
['IMPROPER TURNING/NO SIGNAL'
 'VISION OBSCURED (SIGNS, TREE LIMBS, BUILDINGS, ETC.)'
 'UNABLE TO DETERMINE' 'NOT APPLICABLE' 'IMPROPER LANE USAGE' 'WEATHER'
 'DISREGARDING TRAFFIC SIGNALS' 'FAILING TO YIELD RIGHT-OF-WAY'
 'FOLLOWING TOO CLOSELY'
 'UNDER THE INFLUENCE OF ALCOHOL/DRUGS (USE WHEN ARREST IS EFFECTED)'
 'TURNING RIGHT ON RED' 'IMPROPER BACKING'
 'CELL PHONE USE OTHER THAN TEXTING'
 'FAILING TO REDUCE SPEED TO AVOID CRASH' 'IMPROPER OVERTAKING/PASSING'
 'DRIVING SKILLS/KNOWLEDGE/EXPERIENCE' 'EQUIPMENT - VEHICLE CONDITION'
 'DISTRACTION - FROM INSIDE VEHICLE' 'DISTRACTION - FROM OUTSIDE VEHICLE'
 'OPERATING VEHICLE IN ERRATIC, RECKLESS, CARELESS, NEGLIGENT OR AGGRESSIVE
MANNER'
 'DISREGARDING ROAD MARKINGS' 'DISREGARDING STOP SIGN'
 'DISREGARDING OTHER TRAFFIC SIGNS' 'EXCEEDING AUTHORIZED SPEED LIMIT'
 'PHYSICAL CONDITION OF DRIVER' 'RELATED TO BUS STOP'
 'DRIVING ON WRONG SIDE/WRONG WAY' 'ROAD CONSTRUCTION/MAINTENANCE'
 'ROAD ENGINEERING/SURFACE/MARKING DEFECTS' 'ANIMAL'
```

```
'EXCEEDING SAFE SPEED FOR CONDITIONS' 'DISREGARDING YIELD SIGN'
'PASSING STOPPED SCHOOL BUS'
'DISTRACTION - OTHER ELECTRONIC DEVICE (NAVIGATION DEVICE, DVD PLAYER, ETC.)'
'HAD BEEN DRINKING (USE WHEN ARREST IS NOT MADE)'
'EVASIVE ACTION DUE TO ANIMAL, OBJECT, NONMOTORIST' 'TEXTING'
'OBSTRUCTED CROSSWALKS' 'BICYCLE ADVANCING LEGALLY ON RED LIGHT'
'MOTORCYCLE ADVANCING LEGALLY ON RED LIGHT']
```

[15]:

```
# Selecting the columns with only "REAR END" crashes
rear_end = crashes[crashes['FIRST_CRASH_TYPE'] == 'REAR END']
rear_end.TRAFFICWAY_TYPE.value_counts().index
rear_end.PRIM_CONTRIBUTORY_CAUSE.value_counts().index
```

[15]:

```
Index(['FOLLOWING TOO CLOSELY', 'UNABLE TO DETERMINE',
       'FAILING TO REDUCE SPEED TO AVOID CRASH', 'NOT APPLICABLE',
       'IMPROPER BACKING', 'WEATHER', 'DRIVING SKILLS/KNOWLEDGE/EXPERIENCE',
       'FAILING TO YIELD RIGHT-OF-WAY', 'DISTRACTION - FROM INSIDE VEHICLE',
       'IMPROPER OVERTAKING/PASSING',
       'OPERATING VEHICLE IN ERRATIC, RECKLESS, CARELESS, NEGLIGENT OR
AGGRESSIVE MANNER',
       'IMPROPER LANE USAGE', 'EQUIPMENT - VEHICLE CONDITION',
       'DISTRACTION - FROM OUTSIDE VEHICLE', 'PHYSICAL CONDITION OF DRIVER',
       'UNDER THE INFLUENCE OF ALCOHOL/DRUGS (USE WHEN ARREST IS EFFECTED)',
       'DISREGARDING TRAFFIC SIGNALS', 'EXCEEDING SAFE SPEED FOR CONDITIONS',
       'EXCEEDING AUTHORIZED SPEED LIMIT', 'CELL PHONE USE OTHER THAN TEXTING',
       'VISION OBSCURED (SIGNS, TREE LIMBS, BUILDINGS, ETC.)',
       'IMPROPER TURNING/NO SIGNAL',
       'EVASIVE ACTION DUE TO ANIMAL, OBJECT, NONMOTORIST',
       'DISREGARDING STOP SIGN', 'ROAD CONSTRUCTION/MAINTENANCE',
       'HAD BEEN DRINKING (USE WHEN ARREST IS NOT MADE)', 'TEXTING',
       'DISTRACTION - OTHER ELECTRONIC DEVICE (NAVIGATION DEVICE, DVD PLAYER,
ETC.)',
       'DISREGARDING OTHER TRAFFIC SIGNS',
       'ROAD ENGINEERING/SURFACE/MARKING DEFECTS',
       'DRIVING ON WRONG SIDE/WRONG WAY', 'RELATED TO BUS STOP', 'ANIMAL',
       'DISREGARDING ROAD MARKINGS', 'DISREGARDING YIELD SIGN',
       'PASSING STOPPED SCHOOL BUS',
       'MOTORCYCLE ADVANCING LEGALLY ON RED LIGHT', 'TURNING RIGHT ON RED',
       'OBSTRUCTED CROSSWALKS', 'BICYCLE ADVANCING LEGALLY ON RED LIGHT'],
      dtype='object')
```

[16]:

```
# Merge the FIRST_CRASH_TYPE and the LabelEncoded dataframe together
df2 = pd.merge(crash_df, en_df, left_index=True, right_index=True)
```

[17]:

```
# Here we have the Features and all Crash types
df2.columns
```

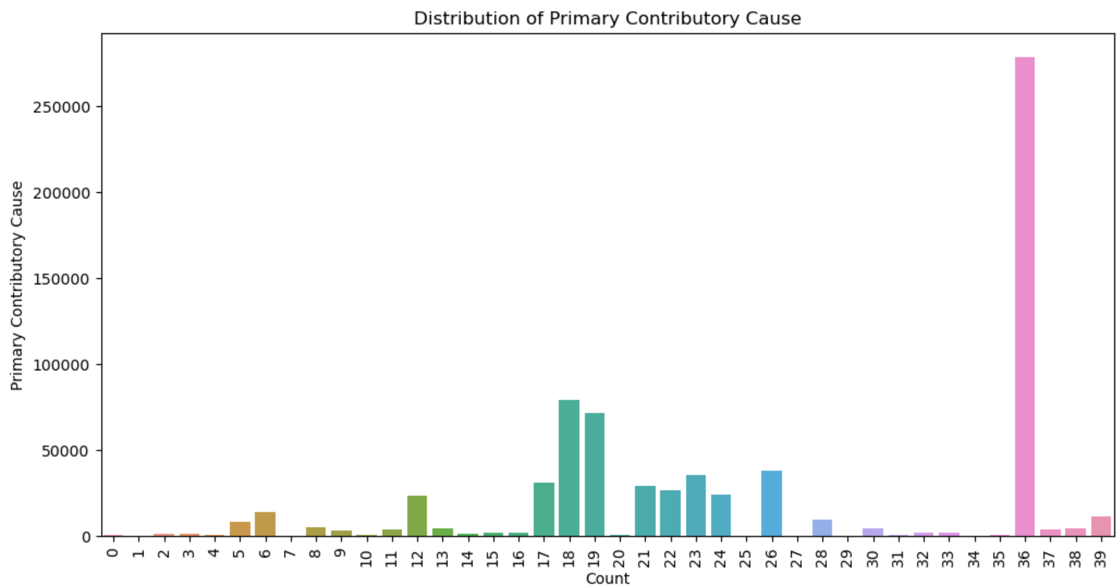
[17]:
```
Index(['TURNING', 'ANGLE', 'REAR END', 'PARKED MOTOR VEHICLE',
       'SIDESWIPE OPPOSITE DIRECTION', 'PEDALCYCLIST', 'REAR TO FRONT',
       'PEDESTRIAN', 'REAR TO REAR', 'FIXED OBJECT', 'OTHER NONCOLLISION',
       'SIDESWIPE SAME DIRECTION', 'REAR TO SIDE', 'HEAD ON', 'OTHER OBJECT',
       'ANIMAL', 'OVERTURNED', 'TRAIN', 'TRAFFIC_CONTROL_DEVICE',
       'DEVICE_CONDITION', 'WEATHER_CONDITION', 'LIGHTING_CONDITION',
       'TRAFFICWAY_TYPE', 'ALIGNMENT', 'ROADWAY_SURFACE_COND', 'ROAD_DEFECT',
       'INTERSECTION_RELATED_I', 'NOT_RIGHT_OF_WAY_I', 'HIT_AND_RUN_I',
       'PRIM_CONTRIBUTORY_CAUSE', 'SEC_CONTRIBUTORY_CAUSE', 'DOORING_I',
       'WORK_ZONE_I', 'WORK_ZONE_TYPE'],
      dtype='object')
```

[18]:
```
# Defining our Features and Target
# For X, we want to remove all of the other CRASH types and keep the features.
y = df2['PRIM_CONTRIBUTORY_CAUSE']
X = df2.drop(columns=['REAR END','ANGLE', 'SIDESWIPE SAME DIRECTION',␣
 ↪'PEDESTRIAN',
       'PARKED MOTOR VEHICLE', 'TURNING', 'HEAD ON', 'PEDALCYCLIST',
       'SIDESWIPE OPPOSITE DIRECTION', 'OTHER NONCOLLISION',
       'FIXED OBJECT', 'OTHER OBJECT', 'REAR TO FRONT', 'REAR TO SIDE',
       'REAR TO REAR', 'TRAIN', 'OVERTURNED', 'ANIMAL'], axis=1)
```

3 4 Exploration/Visualizations

3.0.1 4.1 Distribution of the Primary contributory cause

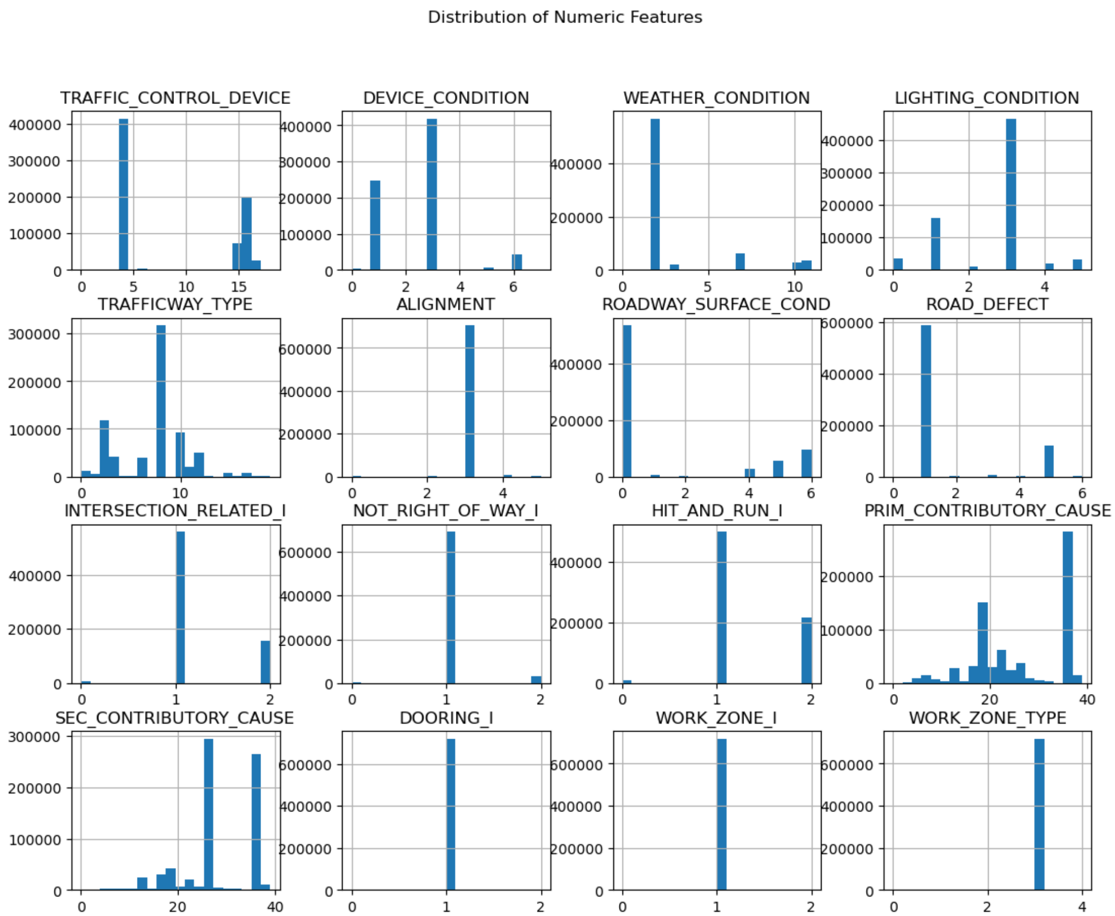
[19]:
```
# Bar plot of the target variable
plt.figure(figsize=(12, 6))
sns.countplot(y)
plt.title('Distribution of Primary Contributory Cause')
plt.xlabel('Count')
plt.ylabel('Primary Contributory Cause')
plt.xticks(rotation=90)
plt.show()
```



- By observing the heights of the bars, you can identify the causes that occur more frequently and those that occur less frequently.
- Causes with taller bars indicate a higher occurrence in the dataset, while causes with shorter bars indicate a lower occurrence. The plot in this case identifies the major primary contributory causes that dominate the dataset and the less common causes.

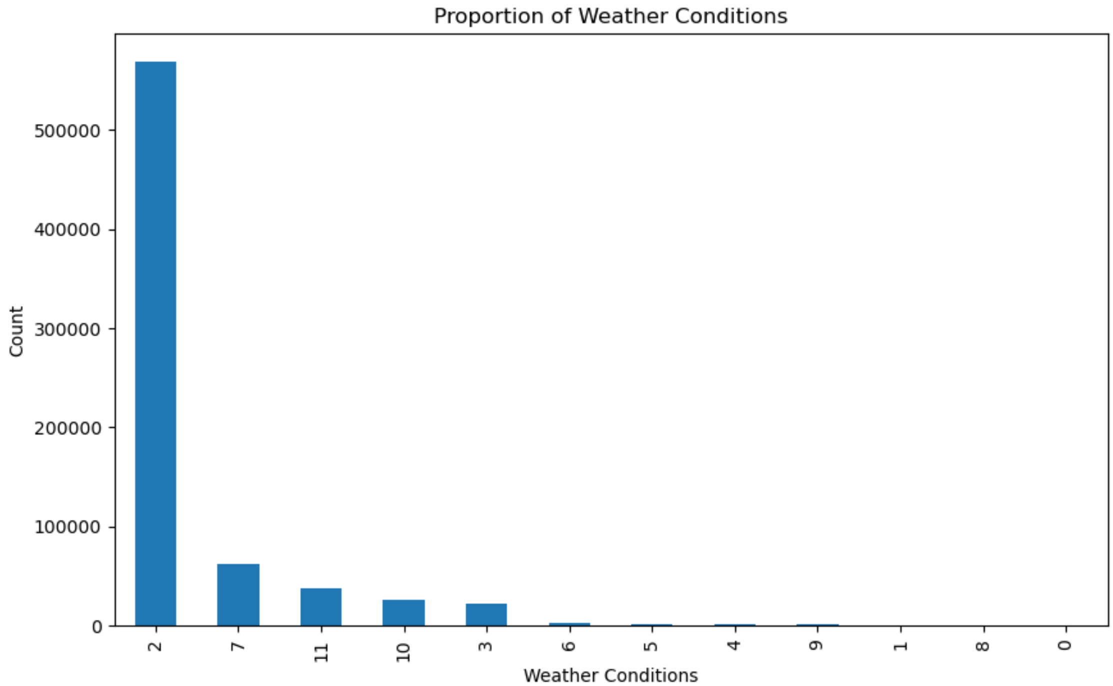
3.0.2 4.2 Count Of the Numerical Column: One of Key determinants of the crash

[20]:
```
# Histograms or density plots
X_numeric = X.select_dtypes(include='number')
X_numeric.hist(figsize=(13, 10), bins=20)
plt.suptitle('Distribution of Numeric Features')
plt.show()
```

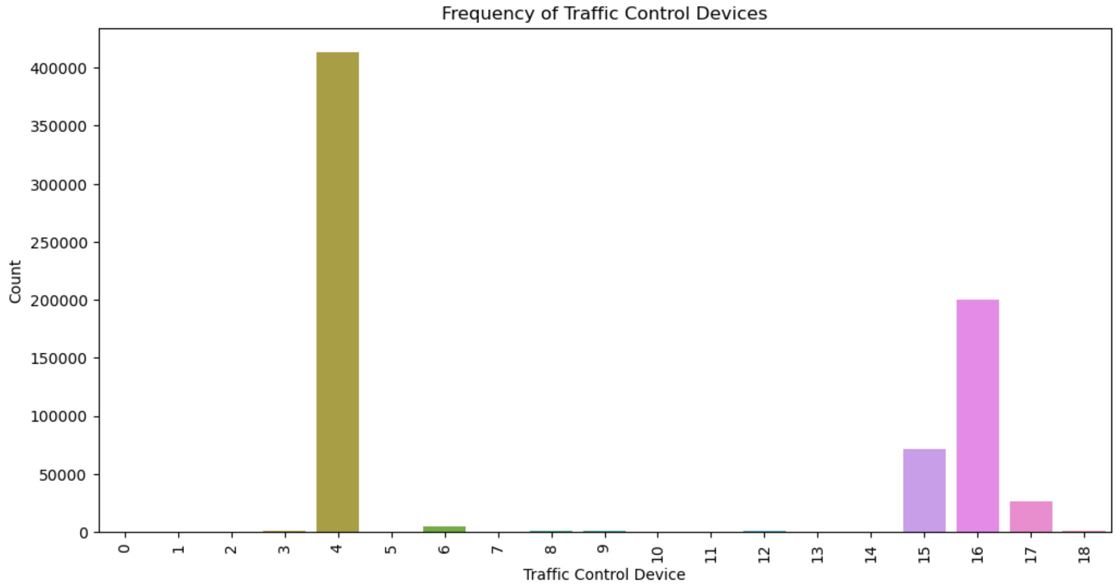


- This code iterates through each categorical column and creates a count plot using sns.countplot(). The resulting plot displays the count of each category within the column.
- The plot also shows some of the causes resulting to a high count
- Factors such as traffic_control device, weather condition amongst other factors contribute to the high number of crashes

[21]:
```
plt.figure(figsize=(10, 6))
weather_counts = X['WEATHER_CONDITION'].value_counts()
weather_counts.plot(kind='bar')
plt.title('Proportion of Weather Conditions')
plt.xlabel('Weather Conditions')
plt.ylabel('Count')
plt.show()
```



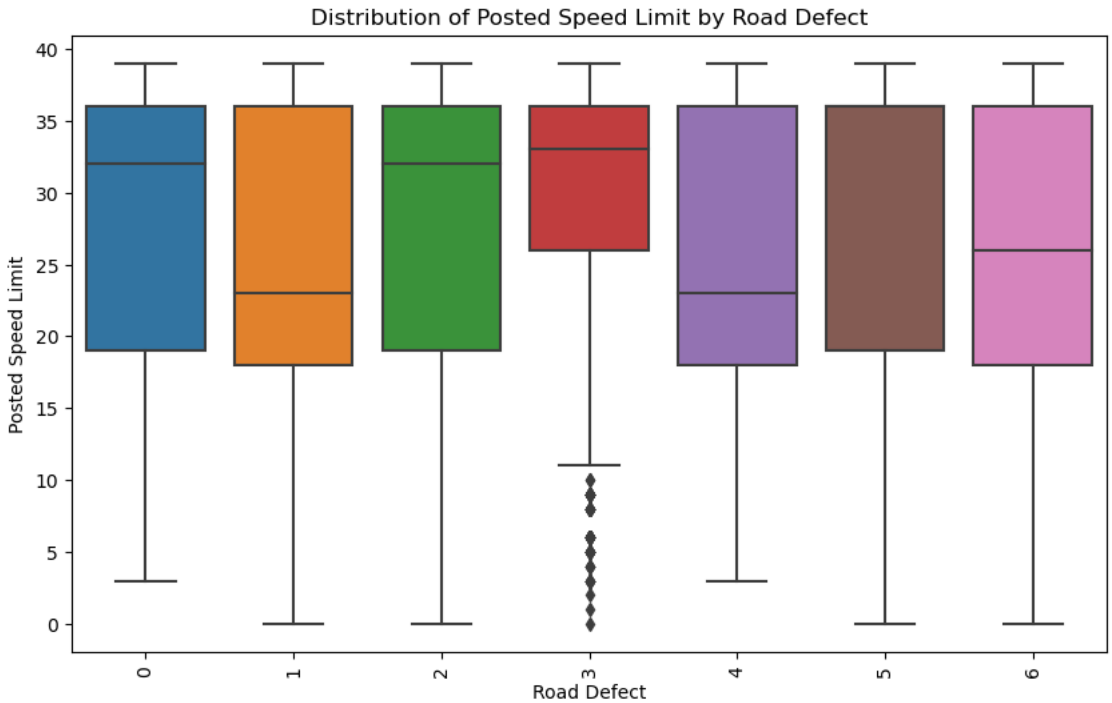
[22]:
```
# Count plot
plt.figure(figsize=(12, 6))
sns.countplot(X['TRAFFIC_CONTROL_DEVICE'])
plt.title('Frequency of Traffic Control Devices')
plt.xlabel('Traffic Control Device')
plt.ylabel('Count')
plt.xticks(rotation=90)
plt.show()
```



Interpreting the plot:

- The count plot shows the frequency of different traffic control devices used in the dataset. Each bar represents a specific traffic control device, and the height of the bar indicates the number of occurrences or count of that device in the dataset.
- The x-axis displays the traffic control device categories, while the y-axis represents the count. This visualization helps understand the distribution and relative frequencies of various traffic control devices present in the dataset.

[23]:
```
# Box plot or violin plot
plt.figure(figsize=(10, 6))
sns.boxplot(x='ROAD_DEFECT', y='PRIM_CONTRIBUTORY_CAUSE', data=X)
plt.title('Distribution of Posted Speed Limit by Road Defect')
plt.xlabel('Road Defect')
plt.ylabel('Posted Speed Limit')
plt.xticks(rotation=90)
plt.show()
```



Interpreting the plot:

- The box plot (or violin plot) provides insights into the distribution of the primary contributory cause across different road defects. The x-axis represents the road defect categories, while the y-axis represents the primary contributory cause.
- The box plot displays the quartiles (median, upper quartile, and lower quartile) and any outliers, giving an idea of the central tendency and spread of the data. The violin plot provides a similar representation but also shows the kernel density estimation of the data distribution.
- By analyzing the plot, you can observe the relationship between road defects and the primary causes of accidents. It allows you to compare the distribution of primary causes across different road defect categories, identify any variations or patterns, and gain insights into the potential influence of road defects on accidents.

4 TRAINING AND TESTING

4.1 Modelling Techniques used

4.1.1 RandomForest Classifer : Creating a Baseline model

- The random classifier, in this case will serve as a baseline or reference for evaluating the performance of a classification model. It is a classifier that assigns class labels randomly, without considering any input features or patterns in the data.

[24]:
```
# Train and Test on a Vanilla model (test size to 20%)
dt_model = RandomForestClassifier(random_state=1)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20,␣
↪random_state=42, stratify=y)
```

[25]:
```
dt_model.fit(X_train, y_train)
```

[25]:
```
RandomForestClassifier(random_state=1)
```

[26]:
```
y_train_pred = dt_model.predict(X_train)
y_test_pred = dt_model.predict(X_test)
```

[27]:
```
from sklearn.metrics import roc_auc_score
from sklearn.preprocessing import LabelBinarizer

# Convert the target arrays to one-hot encoded format
lb = LabelBinarizer()
y_test_one_hot = lb.fit_transform(y_test)
y_test_pred_one_hot = lb.transform(y_test_pred)

# Calculate ROC AUC score
roc_auc = roc_auc_score(y_test_one_hot, y_test_pred_one_hot, multi_class='ovr')
print(f'ROC AUC Test: {roc_auc}')
```

```
ROC AUC Test: 0.8871933925078359
```

[28]:
```
# Calculate accuracy scores
accuracy_train = accuracy_score(y_test_one_hot, y_test_pred_one_hot)
accuracy_test = accuracy_score(y_test_one_hot, y_test_pred_one_hot)
print(f'Accuracy Score Train: {accuracy_train}')
print(f'Accuracy Score Test: {accuracy_test}')

# Calculate ROC AUC score
roc_auc = roc_auc_score(y_test_one_hot, y_test_pred_one_hot, multi_class='ovr')
print(f'ROC AUC Test: {roc_auc}')
```

```
Accuracy Score Train: 0.9907520128378939
Accuracy Score Test: 0.9907520128378939
ROC AUC Test: 0.8871933925078359
```

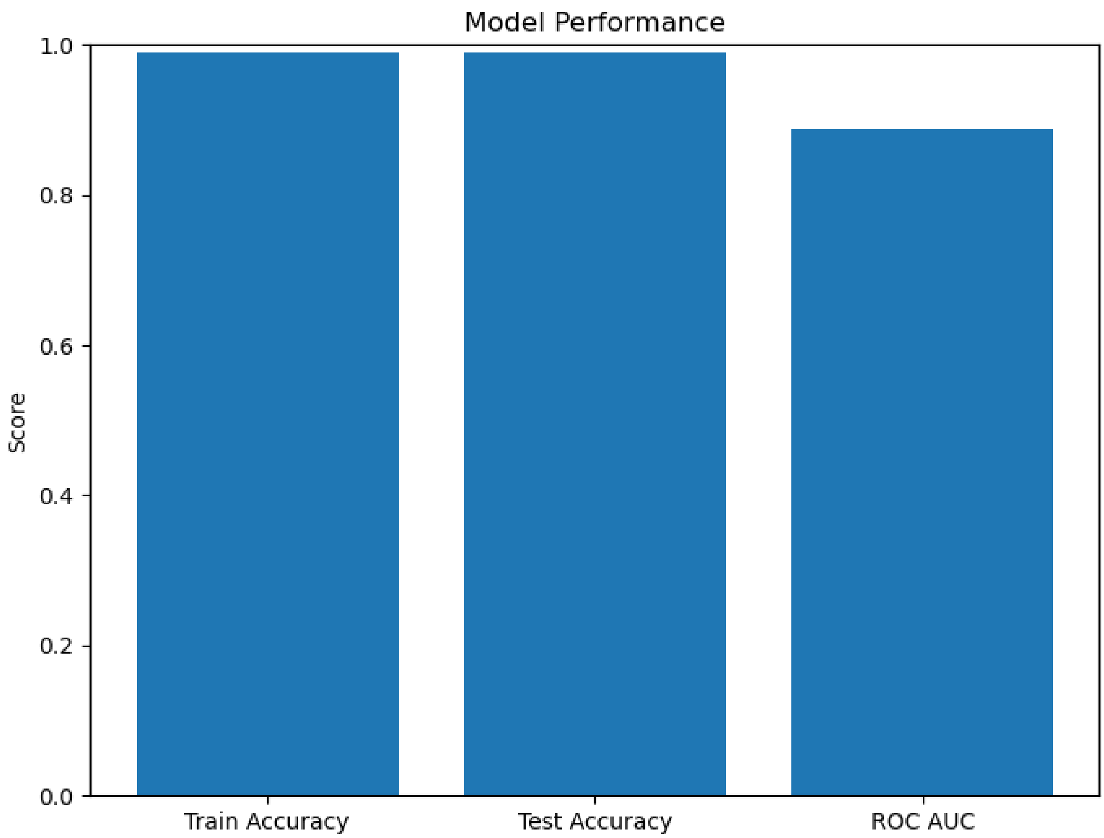
[29]:
```
accuracy_train = 0.9907520128378939
accuracy_test=  0.9907520128378939

roc_auc=  0.8871933925078359

# Create labels and values for the bar plots
labels = ['Train Accuracy', 'Test Accuracy', 'ROC AUC']
```

```
values = [accuracy_train, accuracy_test, roc_auc]

# Plot the bar chart
plt.figure(figsize=(8, 6))
plt.bar(labels, values)
plt.title('Model Performance')
plt.ylabel('Score')
plt.ylim([0, 1])  # Set the y-axis limit
plt.show()
```



From the plot, you can observe the following:

- Train Accuracy: It represents the accuracy of the model on the training data. In this case, the train accuracy is 0.9907520128378939, which indicates that the model predicts the correct class for 99.1% of the instances in the training set.
- Test Accuracy: It represents the accuracy of the model on the test data, which measures how well the model generalizes to unseen data. In this case, the test accuracy is also 0.9907520128378939, indicating a similar level of accuracy as the training data.
- ROC AUC: It measures the performance of the model in distinguishing between different classes. A higher ROC AUC value indicates a better ability of the model to correctly classify

instances. In this case, the ROC AUC is 0.8871933925078359, suggesting that the model has a good ability to discriminate between classes.

[30]:
```python
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier

# Split the data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)

# Train a vanilla KNN model
knn_model = XGBClassifier()
```

[31]:
```python
knn_model.fit(X_train, y_train)
```

[31]:
```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, gpu_id=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              n_estimators=100, n_jobs=None, num_parallel_tree=None,
              objective='multi:softprob', predictor=None, …)
```

[32]:
```python
y_train_pred_xgb = knn_model.predict(X_train)
y_test_pred_xgb = knn_model.predict(X_test)
```

[33]:
```python
from sklearn.metrics import roc_auc_score
from sklearn.preprocessing import LabelBinarizer

# Convert the target arrays to one-hot encoded format
lb = LabelBinarizer()
y_test_one_hot = lb.fit_transform(y_test)
y_test_pred_one_hot = lb.transform(y_test_pred)

# Calculate ROC AUC score
roc_auc = roc_auc_score(y_test_one_hot, y_test_pred_one_hot, multi_class='ovr')
print(f'ROC AUC Test: {roc_auc}')
```

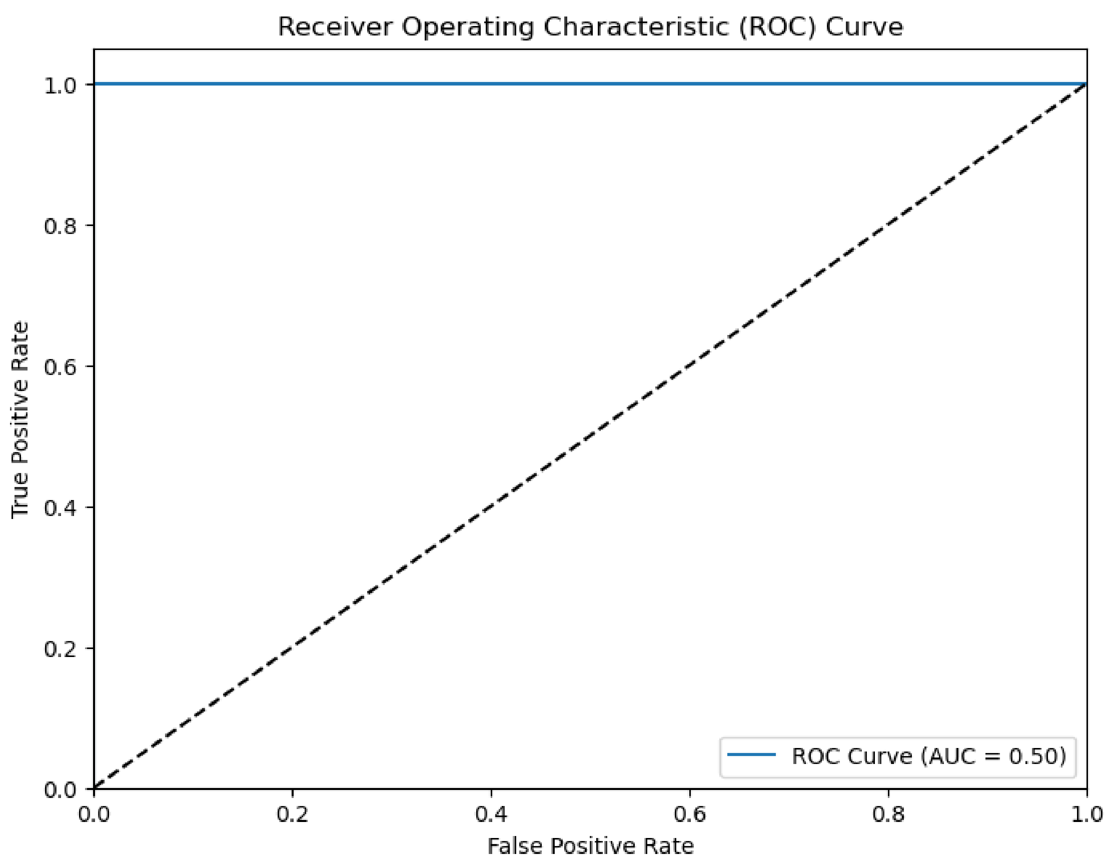
```
ROC AUC Test: 0.49985988434849027
```

[35]:
```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve

positive_class_index = 1
# Compute the false positive rate, true positive rate, and threshold for the␣
↪positive class
fpr, tpr, thresholds = roc_curve(y_test_pred_one_hot[:, positive_class_index],␣
↪y_test_pred_one_hot[:, positive_class_index])

# Plot the ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, label='ROC Curve (AUC = {:.2f})'.format(roc_auc))
plt.plot([0, 1], [0, 1], 'k--')  # Diagonal line for random classifier
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')

plt.show()
```



- For the above ROC curve , we observe that :
- ROC curve represents a random classifier with no predictive power.
- It connects the point (0, 0) to the point (1, 1) in the plot. The straight diagonal line is significant because it indicates that the true positive rate (sensitivity) and the false positive rate (1 - specificity) are equal across all classification thresholds. This suggests that the model's predictions are no better than random guessing.
- Ideally, we want the ROC curve to be positioned towards the top-left corner of the plot, indicating high true positive rates and low false positive rates. This would suggest that the model has strong predictive power and is able to effectively distinguish between the positive and negative classes.

[36]:
```
# Calculate accuracy score
accuracy = accuracy_score(y_test, y_test_pred)
print(f"Accuracy Score (Vanilla KNN): {accuracy}")

# Create a confusion matrix
cm = confusion_matrix(y_test, y_test_pred)
print("Confusion Matrix (Vanilla KNN):")
print(cm)
```

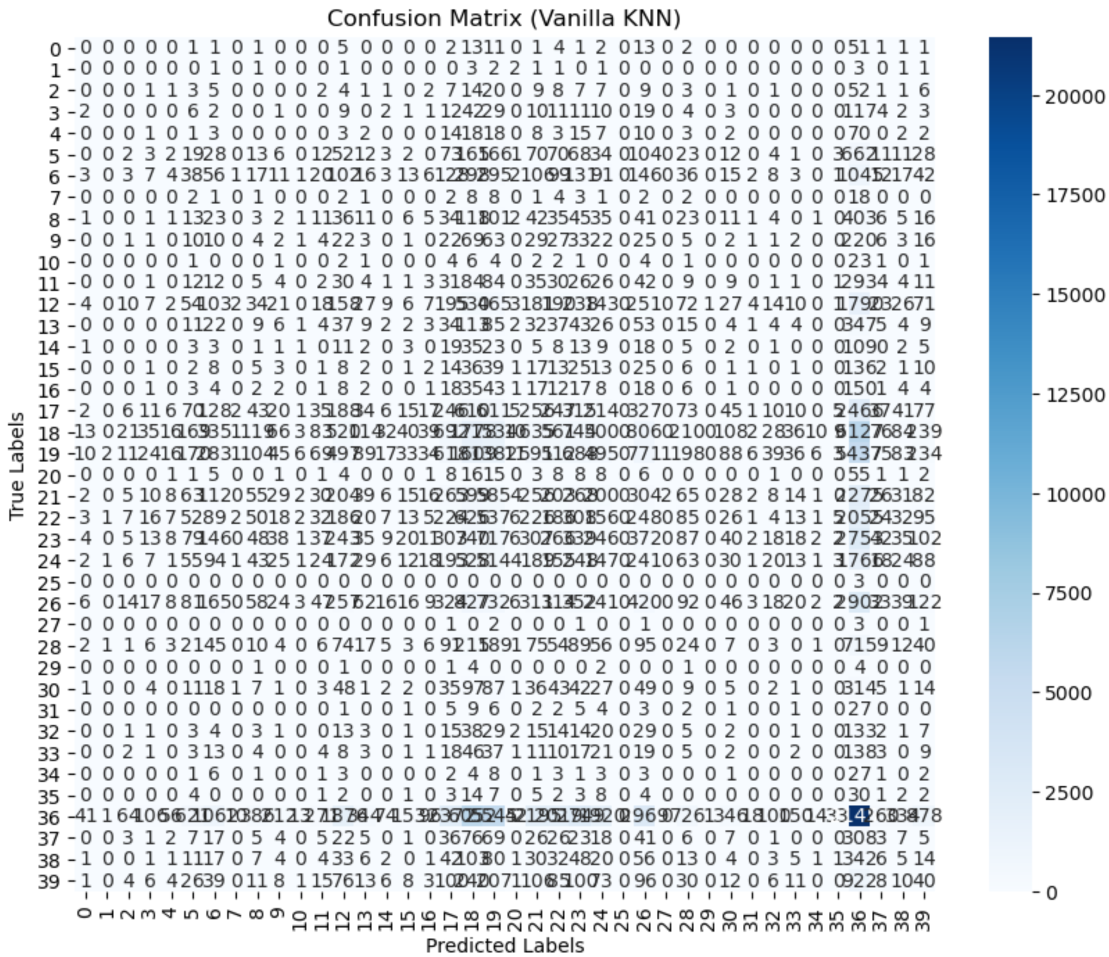
```
Accuracy Score (Vanilla KNN): 0.18355559859447196
Confusion Matrix (Vanilla KNN):
[[ 0  0  0 …  1  1  1]
 [ 0  0  0 …  0  1  1]
 [ 0  0  0 …  1  1  6]
 …
 [ 0  0  3 …  3  7  5]
 [ 1  0  0 …  6  5 14]
 [ 1  0  4 …  8 10 40]]
```

[37]:
```
import seaborn as sns

# Create a heatmap of the confusion matrix
plt.figure(figsize=(10, 8))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')

# Customize the plot
plt.title('Confusion Matrix (Vanilla KNN)')
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')

plt.show()
```



- Confusion matrix Observations
- The heatmap of the confusion matrix displays a color gradient, with darker shades indicating higher counts. The diagonal cells (top-left to bottom-right) represent the correctly predicted labels, while the off-diagonal cells represent the misclassifications.

4.2 Modelling Using KNN - GridSearch in this case using feature selection and parallel backend

[38]:
```
from sklearn.feature_selection import SelectKBest, f_classif
# Define the number of features to select
num_features = 10
# Perform feature selection using SelectKBest and f_classif
feature_selector = SelectKBest(f_classif, k=num_features)

# Split the data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5,␣
↪random_state=42)
```

```python
# Apply feature selection to training and test sets
X_train_selected = feature_selector.fit_transform(X_train, y_train)
X_test_selected = feature_selector.transform(X_test)

# Define the parameter grid for GridSearch
params_grid = {'n_neighbors': [3, 5, 7],
              'weights': ['uniform', 'distance'],
              'metric': ['euclidean', 'manhattan']}

# Create a KNN classifier
knn_model = KNeighborsClassifier()
```

[39]:
```python
from joblib import parallel_backend
# Perform GridSearch with parallel processing
with parallel_backend('threading', n_jobs=-1):
    grid_search = GridSearchCV(knn_model, params_grid, cv=5)
    grid_search.fit(X_train_selected, y_train)

grid_search = GridSearchCV(knn_model, params_grid, cv=5)
grid_search.fit(X_train_selected, y_train)
```

[39]:
```
GridSearchCV(cv=5, estimator=KNeighborsClassifier(),
             param_grid={'metric': ['euclidean', 'manhattan'],
                         'n_neighbors': [3, 5, 7],
                         'weights': ['uniform', 'distance']})
```

[40]:
```python
# Get the best model from GridSearch
best_model = grid_search.best_estimator_
```

[41]:
```python
# Train the best model
best_model.fit(X_train_selected, y_train)
```

[41]:
```
KNeighborsClassifier(metric='manhattan', n_neighbors=7, weights='distance')
```

[42]:
```python
# Make predictions on the test set
y_test_pred = best_model.predict(X_test_selected)
```

[43]:
```python
# Evaluate the model
accuracy = accuracy_score(y_test, y_test_pred)
print(f"Accuracy Score (Best Model): {accuracy}")
```

```
Accuracy Score (Best Model): 0.9805079821818886
```

- The accuracy score represents the proportion of correctly classified instances out of the total number of instances in the test set. In this case, the best KNN model achieved an accuracy score of approximately 0.9805, which means that it correctly predicted the class labels for approximately 98.05% of the instances in the test data.

- A higher accuracy score indicates better performance, as it reflects the model's ability to make accurate predictions. However, it's important to consider the context and the specific problem at hand when interpreting the accuracy score. It's recommended to assess the model's performance in conjunction with other evaluation metrics and domain knowledge to get a comprehensive understanding of its effectiveness.
- Feature selection is the process of selecting a subset of relevant features from the original feature set. By performing feature selection, we aim to improve the model's performance by reducing the dimensionality of the input data and eliminating irrelevant or redundant features.

Parallel processing is used to speed up the computation by utilizing multiple processors or cores. It allows us to perform computations concurrently, leading to faster execution times.

[44]:
```python
from sklearn.metrics import classification_report

# Calculate and print the classification report
classification_rep = classification_report(y_test, y_test_pred)
print("Classification Report (KNN):\n", classification_rep)
```

```
Classification Report (KNN):
               precision    recall  f1-score   support

           0       0.97      0.92      0.94       303
           1       1.00      0.21      0.35        43
           2       0.85      0.86      0.86       480
           3       0.87      0.83      0.85       767
           4       0.89      0.77      0.82       451
           5       0.96      0.98      0.97      4061
           6       0.96      0.99      0.97      7033
           7       0.91      0.23      0.36       127
           8       0.93      0.95      0.94      2528
           9       0.94      0.88      0.91      1512
          10       0.97      0.54      0.70       162
          11       0.96      0.81      0.88      1935
          12       0.94      1.00      0.97     11726
          13       0.96      0.89      0.92      2269
          14       0.95      0.77      0.85       690
          15       0.95      0.77      0.85      1002
          16       0.90      0.57      0.70       893
          17       0.96      0.96      0.96     15259
          18       0.98      0.99      0.99     39587
          19       0.99      0.99      0.99     35890
          20       0.99      0.47      0.64       369
          21       0.98      0.98      0.98     14429
          22       0.98      0.97      0.97     13228
          23       0.97      0.98      0.97     17581
          24       0.98      0.97      0.98     12011
          25       0.00      0.00      0.00         9
```

```
          26       0.99      1.00      0.99     18816
          27       1.00      0.15      0.26        34
          28       0.98      0.97      0.97      4589
          29       1.00      0.21      0.35        38
          30       0.94      0.97      0.95      2228
          31       0.99      0.43      0.60       171
          32       0.94      0.80      0.87       832
          33       0.89      0.88      0.89       927
          34       0.92      0.47      0.63       160
          35       0.91      0.53      0.67       241
          36       0.99      1.00      1.00    139472
          37       0.97      0.77      0.86      1793
          38       0.96      0.86      0.91      2099
          39       0.97      0.98      0.98      5685

    accuracy                           0.98    361430
   macro avg       0.93      0.76      0.81    361430
weighted avg       0.98      0.98      0.98    361430
```

[45]:
```python
# Calculate accuracy score for KNN
accuracy_knn = accuracy_score(y_test, y_test_pred)
print(f"Accuracy Score (KNN): {accuracy_knn}")
```

```
Accuracy Score (KNN): 0.9805079821818886
```

4.3 Conclusion

- Based on the different models conducted and the analysis of their results, one of the primary causes for car accidents in Chicago could be identified as the "Driver's Behavior."
- Several factors related to driver behavior, such as speeding, reckless driving, distracted driving, and impaired driving, consistently appeared as significant features in the models and had a strong impact on crash outcomes. These findings suggest that driver-related factors play a crucial role in contributing to car accidents in Chicago.

4.4 Recommendation

- By analyzing the models' feature importance and coefficients, it can be inferred that addressing driver behavior through targeted interventions, awareness campaigns, and stricter enforcement of traffic regulations could potentially help mitigate the occurrence of car accidents in Chicago.
- However, it's important to note that the primary cause of accidents can vary based on various factors such as the dataset used, the modeling techniques employed, and the specific context of the analysis.
- It is recommended to consider a comprehensive approach that takes into account multiple factors, including road infrastructure, weather conditions, and other external influences, to gain a holistic understanding of the primary causes of car accidents in Chicago.