CIND820_initial_analysis

June 25, 2023

[ ]:

```
import pandas as pd

df = pd.read_csv("../../data/raw/Crash_Reporting_Drivers_Data.csv")
df.head()
```

```
C:\Users\Zhaokai\AppData\Local\Temp\ipykernel_19140\4144606215.py:3:
DtypeWarning: Columns (1) have mixed types. Specify dtype option on import or
set low_memory=False.
  df = pd.read_csv("../../data/raw/Crash_Reporting_Drivers_Data.csv")
```

[ ]:

```
  Report Number Local Case Number                 Agency Name  \
0    DD5620004G         190046109   Rockville Police Departme
1   MCP29620057         200023865    Montgomery County Police
2   MCP2651004P         210035267    Montgomery County Police
3   MCP3050004K         200016465    Montgomery County Police
4   MCP2641001J         200016526    Montgomery County Police

        ACRS Report Type          Crash Date/Time Route Type     Road Name  \
0  Property Damage Crash   09/26/2019 07:20:00 AM        NaN           NaN
1  Property Damage Crash   06/18/2020 02:00:00 AM     County  DAIRYMAID DR
2  Property Damage Crash   09/08/2021 12:30:00 PM        NaN           NaN
3  Property Damage Crash   04/19/2020 03:39:00 PM     County    RUSSETT RD
4           Injury Crash   04/20/2020 09:15:00 AM     County   ARCHDALE RD

  Cross-Street Type  Cross-Street Name                Off-Road Description  \
0               NaN                NaN                         PARKING LOT
1            County            METZ DR                                 NaN
2               NaN                NaN  PARKING LOT OF 10109 COLESVILLE RD
3            County         ARCTIC AVE                                 NaN
4            County  GUNNERS BRANCH RD                                 NaN

    … Speed Limit Driverless Vehicle Parked Vehicle Vehicle Year  \
0   …          15                 No             No         2017
1   …          35                 No             No         2020
2   …           0                 No             No         2010
3   …          25                 No             No         2004
4   …          25                 No             No         2006
```

```
  Vehicle Make  Vehicle Model Equipment Problems   Latitude  Longitude  \
0       THOMAS            BUS         NO MISUSE  39.103518 -77.157669
1          UNK            UNK           UNKNOWN  39.154847 -77.271245
2       TOYOTA            SUV           UNKNOWN  39.020303 -77.011436
3        DODGE  GRAND CARAVAN         NO MISUSE  39.080062 -77.097845
4        HONDA           CR-V           UNKNOWN  39.175230 -77.241090

                   Location
0  (39.10351817, -77.15766933)
1    (39.15484667, -77.271245)
2  (39.02030267, -77.01143583)
3    (39.08006167, -77.097845)
4        (39.17523, -77.24109)

[5 rows x 43 columns]
```

[ ]:

```
# number of rows, number of columns for dataset
nrow,ncol=df.shape
nrow,ncol
```

[ ]:

```
(159357, 43)
```

[ ]:

```
# We have following data types of variables float64(2), int64(2), object(39).
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 159357 entries, 0 to 159356
Data columns (total 43 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   Report Number                   159357 non-null  object
 1   Local Case Number               159357 non-null  object
 2   Agency Name                     159357 non-null  object
 3   ACRS Report Type                159357 non-null  object
 4   Crash Date/Time                 159357 non-null  object
 5   Route Type                      143710 non-null  object
 6   Road Name                       144586 non-null  object
 7   Cross-Street Type               143684 non-null  object
 8   Cross-Street Name               144577 non-null  object
 9   Off-Road Description            14769 non-null   object
 10  Municipality                    17700 non-null   object
 11  Related Non-Motorist            5019 non-null    object
 12  Collision Type                  158820 non-null  object
 13  Weather                         146879 non-null  object
 14  Surface Condition               140664 non-null  object
 15  Light                           158035 non-null  object
 16  Traffic Control                 135447 non-null  object
 17  Driver Substance Abuse          130386 non-null  object
 18  Non-Motorist Substance Abuse    3976 non-null    object
 19  Person ID                       159357 non-null  object
 20  Driver At Fault                 159357 non-null  object
 21  Injury Severity                 159357 non-null  object
 22  Circumstance                    29401 non-null   object
 23  Driver Distracted By            159357 non-null  object
 24  Drivers License State           150465 non-null  object
 25  Vehicle ID                      159357 non-null  object
 26  Vehicle Damage Extent           159077 non-null  object
 27  Vehicle First Impact Location   159201 non-null  object
 28  Vehicle Second Impact Location  159101 non-null  object
 29  Vehicle Body Type               156923 non-null  object
 30  Vehicle Movement                159018 non-null  object
 31  Vehicle Continuing Dir          156880 non-null  object
 32  Vehicle Going Dir               156880 non-null  object
 33  Speed Limit                     159357 non-null  int64
 34  Driverless Vehicle              159357 non-null  object
 35  Parked Vehicle                  159357 non-null  object
 36  Vehicle Year                    159357 non-null  int64
 37  Vehicle Make                    159335 non-null  object
 38  Vehicle Model                   159295 non-null  object
 39  Equipment Problems              127136 non-null  object
 40  Latitude                        159357 non-null  float64
 41  Longitude                       159357 non-null  float64
 42  Location                        159357 non-null  object
dtypes: float64(2), int64(2), object(39)
memory usage: 52.3+ MB
```

```
[ ]: # according to the output of last code section df.info(), we will remove␣
      ↪columns with small amount of non-null count values
     new_df=df.drop(["Off-Road Description","Municipality","Related␣
      ↪Non-Motorist","Non-Motorist Substance Abuse","Circumstance"],axis=1)

     # we will also remove "Driverless Vehicle", according to its values␣
      ↪distribution below, we can tell this column is meaningless.
     # df["Driverless Vehicle"].value_counts()
     # No          158668
     # Unknown        689
     # Name: Driverless Vehicle, dtype: int64
     new_df=new_df.drop(["Driverless Vehicle"],axis=1)

     # we also remove columns that are not related to this study.
     new_df=new_df.drop(["Road Name","Cross-Street Type","Cross-Street Name","Report␣
      ↪Number","Local Case Number","Agency Name",
             "Person ID", "Drivers License State","Vehicle␣
      ↪ID","Latitude","Longitude"],axis=1)
```

```
# During the data cleaning stage, the researcher found out most values from the␣
 ↪columns related to the vehicle category are
# corrupted and contaminated. As a consequence, the researcher had to give up␣
 ↪the factors under the vehicle categories.
new_df=new_df.drop(["Vehicle Year","Vehicle Make","Vehicle Model","Vehicle␣
 ↪Going Dir","Vehicle Continuing Dir",
                    "Vehicle Movement","Vehicle Body Type","Vehicle Second␣
 ↪Impact Location","Vehicle First Impact Location",
                    "Parked Vehicle","Vehicle Damage Extent","Equipment␣
 ↪Problems","Location"],axis=1)

# Considering the ACRS Report Type is more similar to another target attribute,␣
 ↪this study"s class attribute is injury severity.
# As a result, this column needs to be removed.
print(new_df["ACRS Report Type"].value_counts())
new_df=new_df.drop(["ACRS Report Type"],axis=1)
new_df.info()
```

```
Property Damage Crash    101048
Injury Crash              57913
Fatal Crash                 396
Name: ACRS Report Type, dtype: int64
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 159357 entries, 0 to 159356
Data columns (total 12 columns):
 #   Column                  Non-Null Count   Dtype
---  ------                  --------------   -----
 0   Crash Date/Time         159357 non-null  object
 1   Route Type              143710 non-null  object
 2   Collision Type          158820 non-null  object
 3   Weather                 146879 non-null  object
 4   Surface Condition       140664 non-null  object
 5   Light                   158035 non-null  object
 6   Traffic Control         135447 non-null  object
 7   Driver Substance Abuse  130386 non-null  object
 8   Driver At Fault         159357 non-null  object
 9   Injury Severity         159357 non-null  object
 10  Driver Distracted By    159357 non-null  object
 11  Speed Limit             159357 non-null  int64
dtypes: int64(1), object(11)
memory usage: 14.6+ MB
```

[ ]:
```
new_df["Crash Date/Time"].value_counts()
# There is no missing value for this field.
# However, the Crash Date/Time can not be used directly for study,
# because the length is too big to manage
# So, it is a more reasonable way to convert this column into two new columns
# 1. day of the week
# 2. time of the day
```

[ ]:

```
12/10/2018 06:10:00 PM    11
06/09/2020 06:53:00 PM    10
03/03/2017 06:00:00 AM    10
03/28/2019 09:30:00 AM    10
05/17/2017 03:36:00 PM     9
                          ..
09/10/2015 10:30:00 PM     1
06/30/2018 02:02:00 AM     1
08/23/2018 08:32:00 PM     1
02/20/2023 02:05:00 PM     1
05/09/2023 02:56:00 AM     1
Name: Crash Date/Time, Length: 87470, dtype: int64
```

[ ]:

```
# Adding column Day of Week
from datetime import datetime
def convert_to_day_of_week(date_format:str,date_string:str):
    date_object = datetime.strptime(date_string,date_format)
    day_of_week = date_object.weekday()
    day_name_list = ["Monday", "Tuesday", "Wednesday", "Thursday", "Friday",␣
 ↪"Saturday", "Sunday"]
    day_name = day_name_list[day_of_week]
    return day_name

def apply_conversion(datetime):
    return convert_to_day_of_week("%m/%d/%Y %I:%M:%S %p", datetime)

new_df["Day of Week"]=new_df["Crash Date/Time"].apply(apply_conversion)
new_df["Day of Week"].value_counts()
```

[ ]:

```
Friday       25701
Tuesday      24992
Thursday     24831
Wednesday    24554
Monday       23034
Saturday     19790
Sunday       16455
Name: Day of Week, dtype: int64
```

[ ]:

```
# Adding column Time of Day
from datetime import datetime
def convert_to_time_of_day(date_format:str,date_string:str):
    date_object = datetime.strptime(date_string,date_format)
    hour = date_object.hour
    if 0<= hour <6:
        return "dawn"
    elif 6 <= hour < 12:
        return "morning"
    elif 12<= hour <18:
        return "afternoon"
    else:
        return "evening"

def apply_conversion(datetime):
    return convert_to_time_of_day("%m/%d/%Y %I:%M:%S %p", datetime)

new_df["Time of Day"]=new_df["Crash Date/Time"].apply(apply_conversion)
new_df["Time of Day"].value_counts()
```

```
[ ]: afternoon    65690
     morning      45568
     evening      37233
     dawn         10866
     Name: Time of Day, dtype: int64
```

[ ]:

```
# Now the Time of Day and Day of Week Columns are generated.
# Therefore, the Crash Date/Time can be removed.
new_df = new_df.drop(["Crash Date/Time"],axis=1)
new_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 159357 entries, 0 to 159356
Data columns (total 13 columns):
 #   Column                  Non-Null Count   Dtype
---  ------                  --------------   -----
 0   Route Type              143710 non-null  object
 1   Collision Type          158820 non-null  object
 2   Weather                 146879 non-null  object
 3   Surface Condition       140664 non-null  object
 4   Light                   158035 non-null  object
 5   Traffic Control         135447 non-null  object
 6   Driver Substance Abuse  130386 non-null  object
 7   Driver At Fault         159357 non-null  object
 8   Injury Severity         159357 non-null  object
 9   Driver Distracted By    159357 non-null  object
 10  Speed Limit             159357 non-null  int64
 11  Day of Week             159357 non-null  object
 12  Time of Day             159357 non-null  object
dtypes: int64(1), object(12)
memory usage: 15.8+ MB
```

[ ]:

```
print(new_df["Route Type"].value_counts())
# Based on the output of the value counts,
# There are three types of rows that needed to be removed
# Due to the ambiguous meaning of the value
# 1. other public roadway
# 2. government
# 3. unknown

new_df=new_df.loc[(new_df["Route Type"]!="Government")
           &(new_df["Route Type"]!="Other Public Roadway")
           &(new_df["Route Type"]!="Unknown")]
print("---------------After removal---------------")
print(new_df["Route Type"].value_counts())
```

```
Maryland (State)        71500
County                  51339
Municipality             8713
US (State)               6926
Interstate (State)       2985
Other Public Roadway     1053
Government                612
Ramp                      523
Service Road               40
Unknown                    19
Name: Route Type, dtype: int64
---------------After removal---------------
Maryland (State)      71500
County                51339
Municipality           8713
US (State)             6926
Interstate (State)     2985
Ramp                    523
Service Road             40
Name: Route Type, dtype: int64
```

[ ]:

```
print(new_df["Collision Type"].value_counts())
# Based on the output of the value counts,
# The rows contains unknown in collision type column will be removed
new_df=new_df.loc[(new_df["Collision Type"]!="UNKNOWN")]
# The reason why we did not impute the "OTHER" value
# It could be a type different from all these types of accidents
# Other here is meaningful
print("---------------After removal---------------")
print(new_df["Collision Type"].value_counts())
```

```
SAME DIR REAR END               51626
STRAIGHT MOVEMENT ANGLE         27621
OTHER                           17384
```

```
SAME DIRECTION SIDESWIPE        14813
SINGLE VEHICLE                  14437
HEAD ON LEFT TURN               11723
SAME DIRECTION RIGHT TURN        3479
SAME DIRECTION LEFT TURN         3425
HEAD ON                          3417
OPPOSITE DIRECTION SIDESWIPE     2618
ANGLE MEETS LEFT TURN            1870
ANGLE MEETS RIGHT TURN           1114
SAME DIR REND LEFT TURN           685
SAME DIR REND RIGHT TURN          683
UNKNOWN                           667
SAME DIR BOTH LEFT TURN           648
ANGLE MEETS LEFT HEAD ON          639
OPPOSITE DIR BOTH LEFT TURN       294
Name: Collision Type, dtype: int64
---------------After removal---------------
SAME DIR REAR END               51626
STRAIGHT MOVEMENT ANGLE         27621
OTHER                           17384
SAME DIRECTION SIDESWIPE        14813
SINGLE VEHICLE                  14437
HEAD ON LEFT TURN               11723
SAME DIRECTION RIGHT TURN        3479
SAME DIRECTION LEFT TURN         3425
HEAD ON                          3417
OPPOSITE DIRECTION SIDESWIPE     2618
ANGLE MEETS LEFT TURN            1870
ANGLE MEETS RIGHT TURN           1114
SAME DIR REND LEFT TURN           685
SAME DIR REND RIGHT TURN          683
SAME DIR BOTH LEFT TURN           648
ANGLE MEETS LEFT HEAD ON          639
OPPOSITE DIR BOTH LEFT TURN       294
Name: Collision Type, dtype: int64
```

[ ]:

```
print(new_df["Weather"].value_counts())
new_df=new_df.loc[(new_df["Weather"]!="UNKNOWN")&
                  (new_df["Weather"]!="OTHER")]
print("---------------After removal---------------")
print(new_df["Weather"].value_counts())
```

```
CLEAR                       106110
RAINING                      18884
CLOUDY                       15991
SNOW                          1401
FOGGY                          624
UNKNOWN                        517
```

```
WINTRY MIX                     381
OTHER                          337
SLEET                          209
SEVERE WINDS                   153
BLOWING SNOW                   111
BLOWING SAND, SOIL, DIRT        13
Name: Weather, dtype: int64
---------------After removal---------------
CLEAR                       106110
RAINING                      18884
CLOUDY                       15991
SNOW                          1401
FOGGY                          624
WINTRY MIX                     381
SLEET                          209
SEVERE WINDS                   153
BLOWING SNOW                   111
BLOWING SAND, SOIL, DIRT        13
Name: Weather, dtype: int64
```

[ ]:

```
print(new_df["Surface Condition"].value_counts())
new_df=new_df.loc[(new_df["Surface Condition"]!="UNKNOWN")&
                  (new_df["Surface Condition"]!="OTHER")]
print("---------------After removal---------------")
print(new_df["Surface Condition"].value_counts())
```

```
DRY                       109664
WET                        25982
ICE                          936
SNOW                         917
UNKNOWN                      211
SLUSH                        192
OTHER                        155
MUD, DIRT, GRAVEL             45
WATER(STANDING/MOVING)        37
OIL                           24
SAND                           4
Name: Surface Condition, dtype: int64
---------------After removal---------------
DRY                       109664
WET                        25982
ICE                          936
SNOW                         917
SLUSH                        192
MUD, DIRT, GRAVEL             45
WATER(STANDING/MOVING)        37
OIL                           24
SAND                           4
```

```
Name: Surface Condition, dtype: int64
```

[ ]:

```
print(new_df["Light"].value_counts())
new_df=new_df.loc[(new_df["Light"]!="UNKNOWN")&
                  (new_df["Light"]!="OTHER")&
                  (new_df["Light"]!="DARK -- UNKNOWN LIGHTING")]
print("---------------After removal---------------")
new_df["Light"].value_counts()
```

```
DAYLIGHT          105499
DARK LIGHTS ON     35966
DARK NO LIGHTS      4486
DUSK                3604
DAWN                3090
Name: Light, dtype: int64
---------------After removal---------------
```

[ ]:

```
DAYLIGHT          105499
DARK LIGHTS ON     35966
DARK NO LIGHTS      4486
DUSK                3604
DAWN                3090
Name: Light, dtype: int64
```

[ ]:

```
print(new_df["Traffic Control"].value_counts())
new_df=new_df.loc[(new_df["Traffic Control"]!="UNKNOWN")&
                  (new_df["Traffic Control"]!="OTHER")
                 ]
print("---------------After removal---------------")
new_df["Traffic Control"].value_counts()
```

```
NO CONTROLS                 60897
TRAFFIC SIGNAL              53135
STOP SIGN                   11159
FLASHING TRAFFIC SIGNAL      1890
OTHER                        1793
YIELD SIGN                   1620
PERSON                        256
WARNING SIGN                  146
UNKNOWN                       120
RAILWAY CROSSING DEVICE        42
SCHOOL ZONE SIGN DEVICE        14
Name: Traffic Control, dtype: int64
---------------After removal---------------
```

[ ]:

```
NO CONTROLS                 60897
TRAFFIC SIGNAL              53135
STOP SIGN                   11159
```

```
FLASHING TRAFFIC SIGNAL     1890
YIELD SIGN                  1620
PERSON                       256
WARNING SIGN                 146
RAILWAY CROSSING DEVICE       42
SCHOOL ZONE SIGN DEVICE       14
Name: Traffic Control, dtype: int64
```

[ ]:

```
print(new_df["Driver Substance Abuse"].value_counts())
new_df=new_df.loc[(new_df["Driver Substance Abuse"]!="OTHER")]
print("---------------After removal---------------")
print(new_df["Driver Substance Abuse"].value_counts())

# if it is not non detected, unknown, or null value
# the value will be converted to detected.
def convert_substance_abuse_levels(src):
    if(src == "NONE DETECTED" or src =="UNKNOWN" or src == None):
        return src
    else:
        return"DETECTED"

new_df["Driver Substance Abuse"]=new_df["Driver Substance Abuse"].
 ↪map(convert_substance_abuse_levels)
print("---------------After Converting---------------")
print(new_df["Driver Substance Abuse"].value_counts())
# replace unknown with null values and then, forward fill imputation for null␣
 ↪values.
new_df["Driver Substance Abuse"] = new_df["Driver Substance Abuse"].
 ↪replace("UNKNOWN",None)
new_df["Driver Substance Abuse"] = new_df["Driver Substance Abuse"].
 ↪fillna(method="ffill")
print("---------------After imputation---------------")
print(new_df["Driver Substance Abuse"] .value_counts())
```

```
NONE DETECTED                 109687
UNKNOWN                         9467
ALCOHOL PRESENT                 3609
ALCOHOL CONTRIBUTED             1269
ILLEGAL DRUG PRESENT             238
MEDICATION PRESENT               108
ILLEGAL DRUG CONTRIBUTED          89
COMBINED SUBSTANCE PRESENT        82
MEDICATION CONTRIBUTED            57
OTHER                             57
COMBINATION CONTRIBUTED           43
Name: Driver Substance Abuse, dtype: int64
---------------After removal---------------
```

```
NONE DETECTED                  109687
UNKNOWN                          9467
ALCOHOL PRESENT                  3609
ALCOHOL CONTRIBUTED              1269
ILLEGAL DRUG PRESENT              238
MEDICATION PRESENT                108
ILLEGAL DRUG CONTRIBUTED           89
COMBINED SUBSTANCE PRESENT         82
MEDICATION CONTRIBUTED             57
COMBINATION CONTRIBUTED            43
Name: Driver Substance Abuse, dtype: int64
---------------After Converting---------------
NONE DETECTED    109687
DETECTED          32796
UNKNOWN            9467
Name: Driver Substance Abuse, dtype: int64
---------------After imputation---------------
NONE DETECTED    116894
DETECTED          35056
Name: Driver Substance Abuse, dtype: int64
```

[ ]:

```python
print(new_df["Driver At Fault"].value_counts())
new_df=new_df.loc[(new_df["Driver At Fault"]!="Unknown")]
print("---------------After removal---------------")
new_df["Driver At Fault"].value_counts()
```

```
Yes        81064
No         67055
Unknown     3831
Name: Driver At Fault, dtype: int64
---------------After removal---------------
```

[ ]:

```
Yes    81064
No     67055
Name: Driver At Fault, dtype: int64
```

[ ]:

```python
# same process as handling "Driver Substance Abuse" is performed here.
print(new_df["Driver Distracted By"].value_counts())

def convert_distracted_levels(src):
    if(src == "NOT DISTRACTED" or src =="UNKNOWN" or src == None):
        return src
    else:
        return"DISTRACTED"

new_df["Driver Distracted By"]=new_df["Driver Distracted By"].
  ↪map(convert_distracted_levels)
```

```
print("---------------After removal---------------")
print(new_df["Driver Distracted By"].value_counts())

# Imputes unknown field. Using forward imputation.
print("---------------After imputation---------------")
new_df["Driver Distracted By"] = new_df["Driver Distracted By"].
 ↪replace("UNKNOWN",None)
new_df["Driver Distracted By"] = new_df["Driver Distracted By"].
 ↪fillna(method="ffill")
new_df["Driver Distracted By"] .value_counts()
```

```
NOT DISTRACTED                                          93773
UNKNOWN                                                 25964
LOOKED BUT DID NOT SEE                                  18661
INATTENTIVE OR LOST IN THOUGHT                           3790
OTHER DISTRACTION                                        2825
DISTRACTED BY OUTSIDE PERSON OBJECT OR EVENT              855
BY OTHER OCCUPANTS                                        381
OTHER CELLULAR PHONE RELATED                              332
OTHER ELECTRONIC DEVICE (NAVIGATIONAL PALM PILOT)         301
TALKING OR LISTENING TO CELLULAR PHONE                    261
NO DRIVER PRESENT                                         221
BY MOVING OBJECT IN VEHICLE                               191
EATING OR DRINKING                                        177
ADJUSTING AUDIO AND OR CLIMATE CONTROLS                   123
USING OTHER DEVICE CONTROLS INTEGRAL TO VEHICLE            80
TEXTING FROM A CELLULAR PHONE                              59
USING DEVICE OBJECT BROUGHT INTO VEHICLE                   56
DIALING CELLULAR PHONE                                     44
SMOKING RELATED                                            25
Name: Driver Distracted By, dtype: int64
---------------After removal---------------
NOT DISTRACTED    93773
DISTRACTED        28382
UNKNOWN           25964
Name: Driver Distracted By, dtype: int64
---------------After imputation---------------
```

```
[ ]: NOT DISTRACTED    113632
     DISTRACTED         34487
     Name: Driver Distracted By, dtype: int64
```

```
[ ]: # summary statistics for numeric attributes
     new_df.describe()
     # Although "Speed Limit" attribute is a numeric attribute
     # The data is organized as categorical.
     # We will reduce levels from 15 to 5.
```

```
print(new_df["Speed Limit"].value_counts())
levels = ["0-10","15-25","30-40","45-55","60-70"]
bins = [0, 10, 25, 40, 55, 70]
new_df["Speed Limit"] = pd.cut(new_df["Speed Limit"], bins= bins,labels=levels)
new_df["Speed Limit"] = new_df["Speed Limit"].astype("category")
print("---------------After convert---------------")
print(new_df["Speed Limit"].value_counts())
```

```
35    43337
40    29880
30    20084
25    19985
45    11162
15     5056
50     4184
0      3930
55     3534
5      3424
10     2499
20      925
60       62
65       52
70        5
Name: Speed Limit, dtype: int64
---------------After convert---------------
30-40    93301
15-25    25966
45-55    18880
0-10      5923
60-70      119
Name: Speed Limit, dtype: int64
```

```
[ ]: # hint: use this before you print large amount of data
     pd.set_option("display.max_rows", 500)
     pd.set_option("display.max_columns", 500)
     pd.set_option("display.width", 1000)
```

```
[ ]: # remove all rows that contain null values.
     new_df = new_df.dropna(how="any")
     new_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 105379 entries, 3 to 159356
Data columns (total 13 columns):
 #   Column                  Non-Null Count   Dtype
---  ------                  --------------   -----
 0   Route Type              105379 non-null  object
 1   Collision Type          105379 non-null  object
 2   Weather                 105379 non-null  object
 3   Surface Condition       105379 non-null  object
 4   Light                   105379 non-null  object
 5   Traffic Control         105379 non-null  object
 6   Driver Substance Abuse  105379 non-null  object
 7   Driver At Fault         105379 non-null  object
 8   Injury Severity         105379 non-null  object
 9   Driver Distracted By    105379 non-null  object
 10  Speed Limit             105379 non-null  category
 11  Day of Week             105379 non-null  object
 12  Time of Day             105379 non-null  object
dtypes: category(1), object(12)
memory usage: 10.6+ MB
```

[ ]:

```
# Count the occurrences of each unique value in the class attribute "Injury␣
 ↪Severity"
new_df["Injury Severity"].value_counts()
```

[ ]:

```
NO APPARENT INJURY          84376
POSSIBLE INJURY             11873
SUSPECTED MINOR INJURY       8108
SUSPECTED SERIOUS INJURY      956
FATAL INJURY                   66
Name: Injury Severity, dtype: int64
```

[ ]:

```
# according to the output of last code section, 130578(NO APPARENT INJURY)/
 ↪159357(total rows) = 81.9%
# we can tell that the multi-class problem has imbalanced class distributions.␣
 ↪reducing number of classes could help address the issue. we will deal with
# imbalanced class distributions later.
# A large number of classes can increase the complexity of the classification␣
 ↪problem, by reducing the number of classes, we can simplify the problem
# and make it more manageable for the model to learn the distinguishing␣
 ↪features, which may lead to better performance.

# for target variable "Injury Severity", convert 5 classes to 3 classes
new_df["Injury Severity"]=new_df["Injury Severity"].map({"NO APPARENT INJURY":
 ↪"No Injury","POSSIBLE INJURY":"Minor Injury","SUSPECTED MINOR INJURY":"Minor␣
 ↪Injury","SUSPECTED SERIOUS INJURY":"Serious Injury",
                                             "FATAL INJURY":"Serious Injury"})
new_df["Injury Severity"].value_counts()
```

[ ]:

```
No Injury         84376
Minor Injury      19981
Serious Injury     1022
Name: Injury Severity, dtype: int64
```

[ ]:

```
# convert each column data type from object to category, to improve efficiency␣
 ↪during data modeling stage.
new_df = new_df.apply(lambda x:x.astype('category'))
new_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 105379 entries, 3 to 159356
Data columns (total 13 columns):
 #   Column                  Non-Null Count   Dtype   
---  ------                  --------------   -----   
 0   Route Type              105379 non-null  category
 1   Collision Type          105379 non-null  category
 2   Weather                 105379 non-null  category
 3   Surface Condition       105379 non-null  category
 4   Light                   105379 non-null  category
 5   Traffic Control         105379 non-null  category
 6   Driver Substance Abuse  105379 non-null  category
 7   Driver At Fault         105379 non-null  category
 8   Injury Severity         105379 non-null  category
 9   Driver Distracted By    105379 non-null  category
 10  Speed Limit             105379 non-null  category
 11  Day of Week             105379 non-null  category
 12  Time of Day             105379 non-null  category
dtypes: category(13)
memory usage: 2.1 MB
```

[ ]:

```
# summary statistics for all columns
new_df.describe()
```

[ ]:

```
              Route Type     Collision Type Weather Surface Condition  \
count             105379             105379  105379            105379   
unique                 7                 17      10                 9   
top     Maryland (State)  SAME DIR REAR END   CLEAR               DRY   
freq               54209              38119   76845             83103   

           Light Traffic Control Driver Substance Abuse Driver At Fault  \
count     105379          105379                 105379          105379   
unique         5               9                      2               2   
top     DAYLIGHT  TRAFFIC SIGNAL          NONE DETECTED             Yes   
freq       73360           46384                  84640           55157   

       Injury Severity Driver Distracted By Speed Limit Day of Week  \
count           105379               105379      105379      105379   
unique               3                    2           5           7   
top          No Injury       NOT DISTRACTED       30-40      Friday   
freq             84376                81402       73969       17081   
```

```
       Time of Day
count       105379
unique           4
top      afternoon
freq         43517
```

[ ]:

```
new_df.to_csv("cleaned_data.csv",index=False)
```

[ ]:

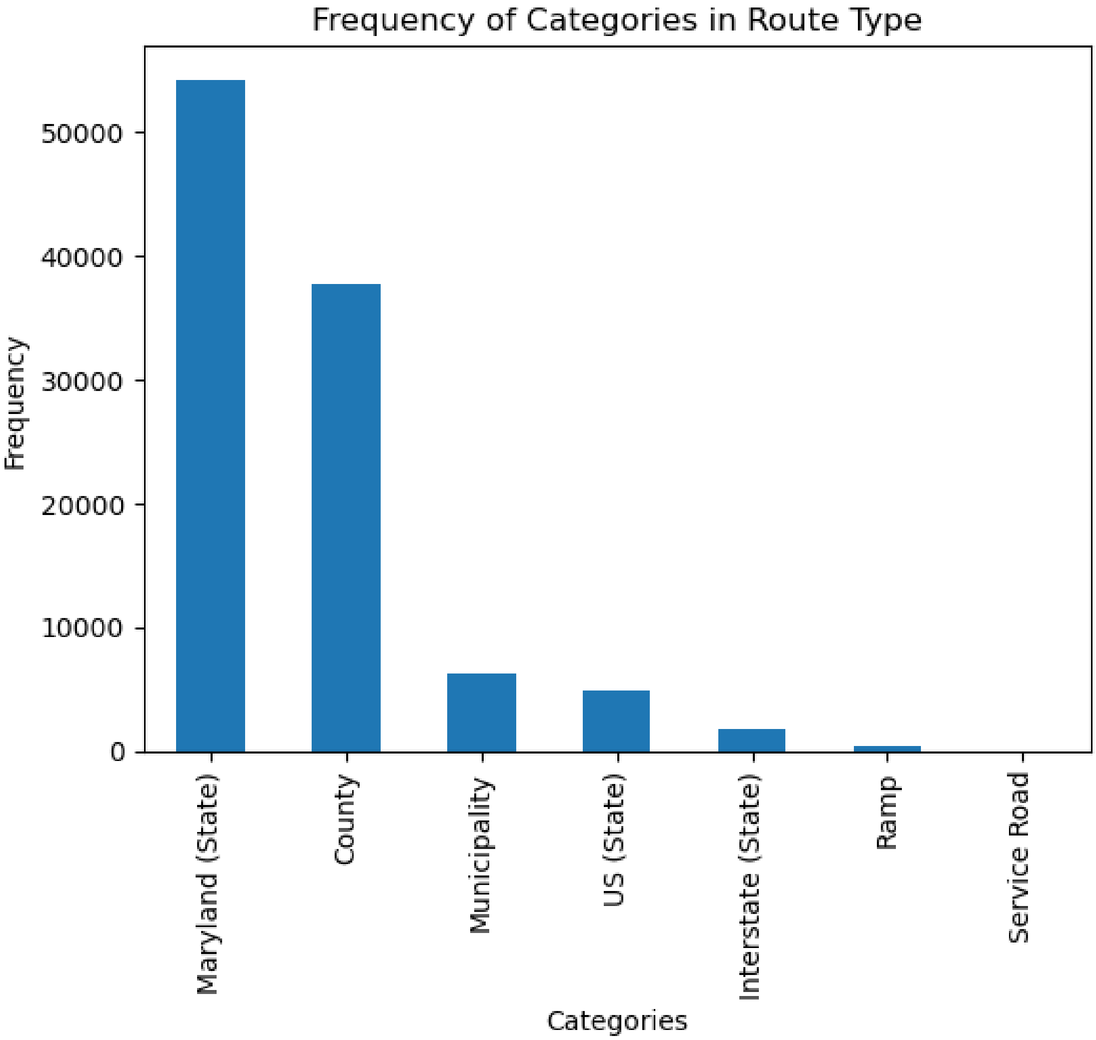
```
# Univariate visualization for all attributes

import matplotlib.pyplot as plt

col_summary = {}
for column in new_df.columns:
    col_summary[column] = new_df[column].value_counts()

# Print the summary statistics
for column, summary in col_summary.items():
    print(f"Summary statistics for {column}:")
    print(summary)
    print()

# Visualize the summary statistics using a bar plot
for column, summary in col_summary.items():
    summary.plot(kind='bar')
    plt.title(f"Frequency of Categories in {column}")
    plt.xlabel("Categories")
    plt.ylabel("Frequency")
    plt.show()
```

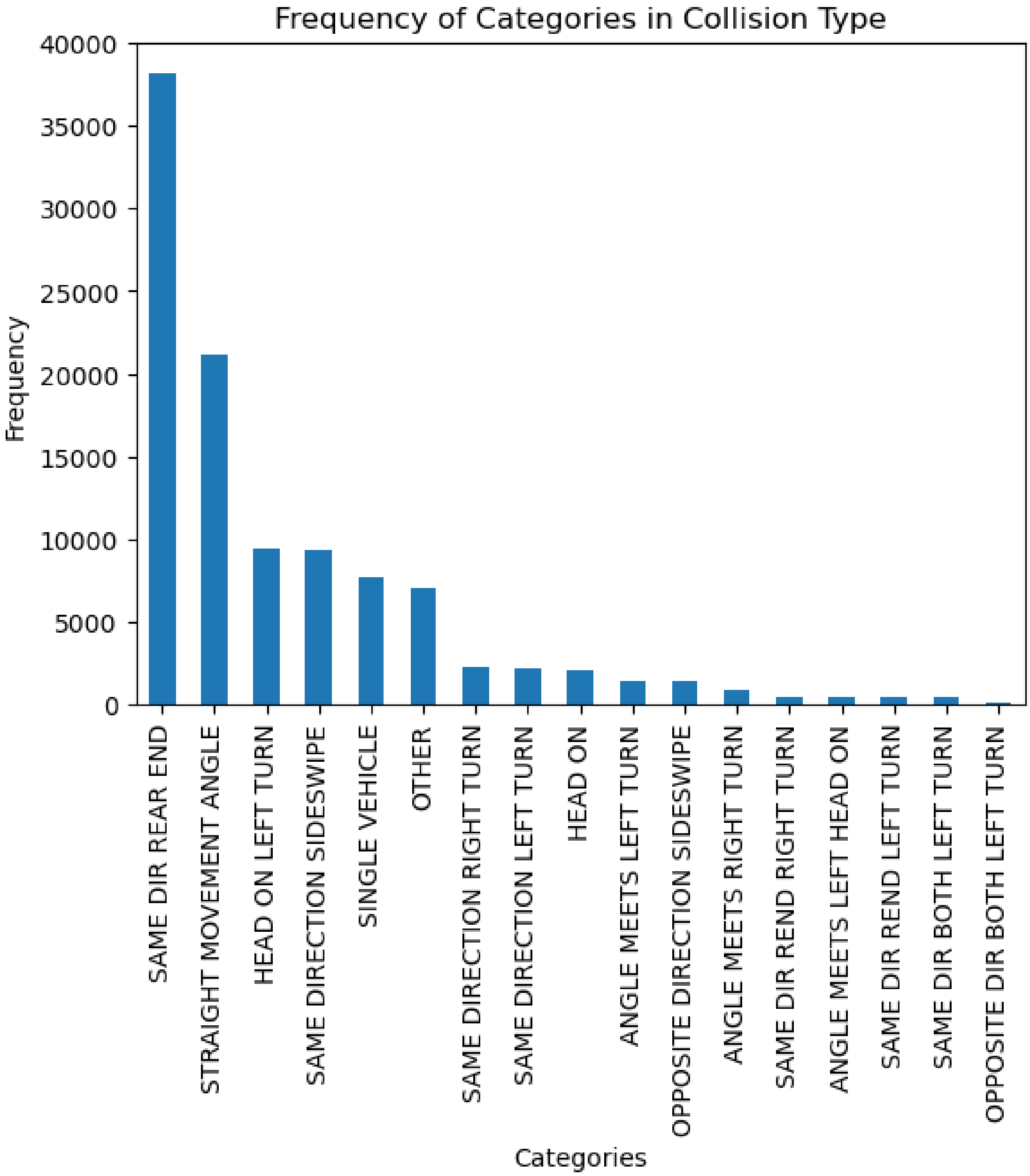
```
Summary statistics for Route Type:
Maryland (State)      54209
County                37754
Municipality           6272
US (State)             4846
Interstate (State)     1883
Ramp                    391
Service Road             24
Name: Route Type, dtype: int64

Summary statistics for Collision Type:
SAME DIR REAR END                 38119
STRAIGHT MOVEMENT ANGLE           21153
HEAD ON LEFT TURN                  9488
SAME DIRECTION SIDESWIPE           9378
SINGLE VEHICLE                     7760
OTHER                              7093
```

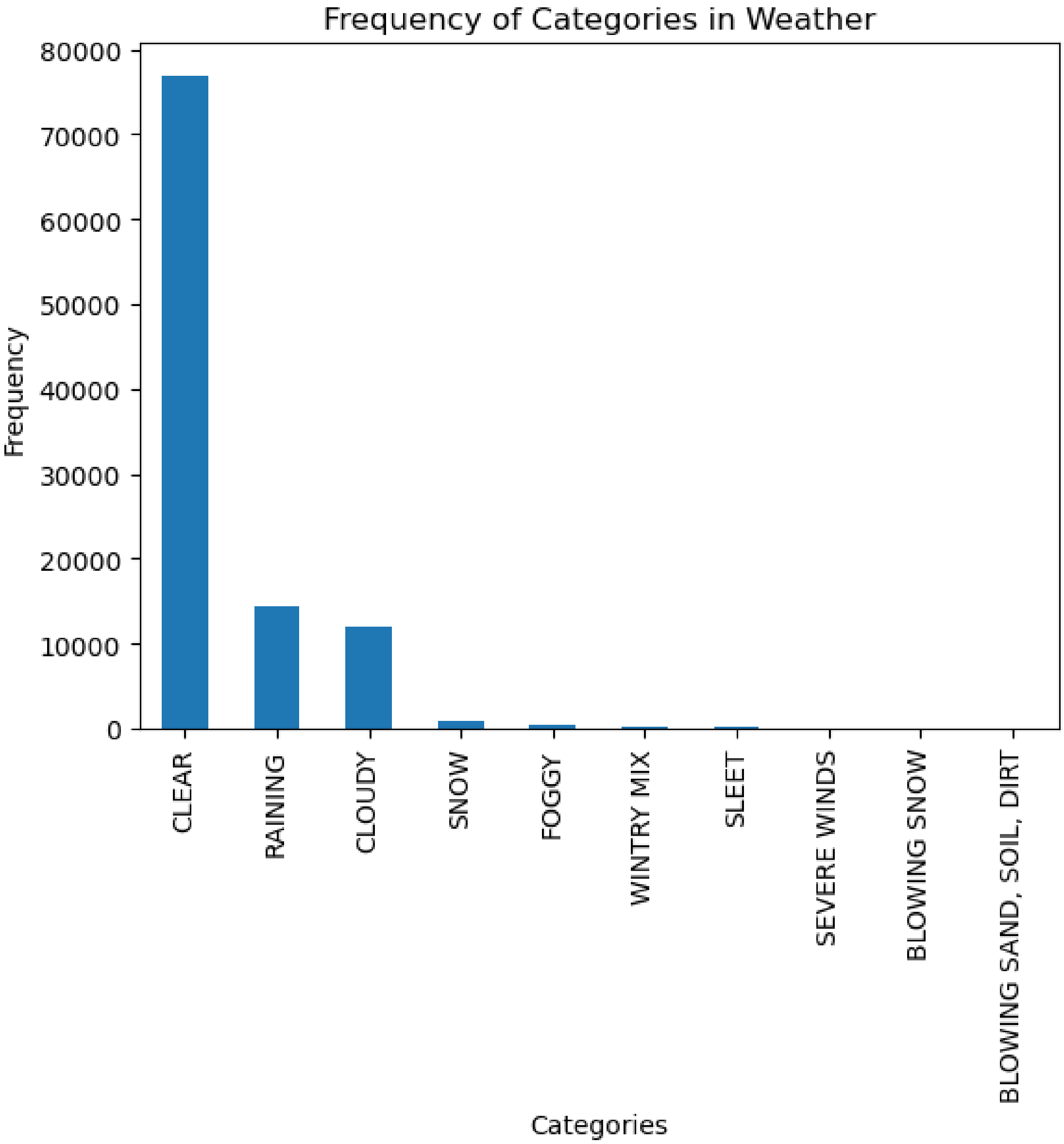
```
SAME DIRECTION RIGHT TURN        2320
SAME DIRECTION LEFT TURN         2189
HEAD ON                          2095
ANGLE MEETS LEFT TURN            1461
OPPOSITE DIRECTION SIDESWIPE     1394
ANGLE MEETS RIGHT TURN            852
SAME DIR REND RIGHT TURN          509
ANGLE MEETS LEFT HEAD ON          478
SAME DIR REND LEFT TURN           472
SAME DIR BOTH LEFT TURN           445
OPPOSITE DIR BOTH LEFT TURN       173
Name: Collision Type, dtype: int64

Summary statistics for Weather:
CLEAR                       76845
RAINING                     14512
CLOUDY                      11951
SNOW                          992
FOGGY                         475
WINTRY MIX                    270
SLEET                         137
SEVERE WINDS                  112
BLOWING SNOW                   78
BLOWING SAND, SOIL, DIRT        7
Name: Weather, dtype: int64

Summary statistics for Surface Condition:
DRY                       83103
WET                       20743
SNOW                        681
ICE                         643
SLUSH                       134
WATER(STANDING/MOVING)       29
MUD, DIRT, GRAVEL            27
OIL                          18
SAND                          1
Name: Surface Condition, dtype: int64

Summary statistics for Light:
DAYLIGHT          73360
DARK LIGHTS ON    24422
DARK NO LIGHTS     3001
DUSK               2381
DAWN               2215
Name: Light, dtype: int64

Summary statistics for Traffic Control:
TRAFFIC SIGNAL             46384
```

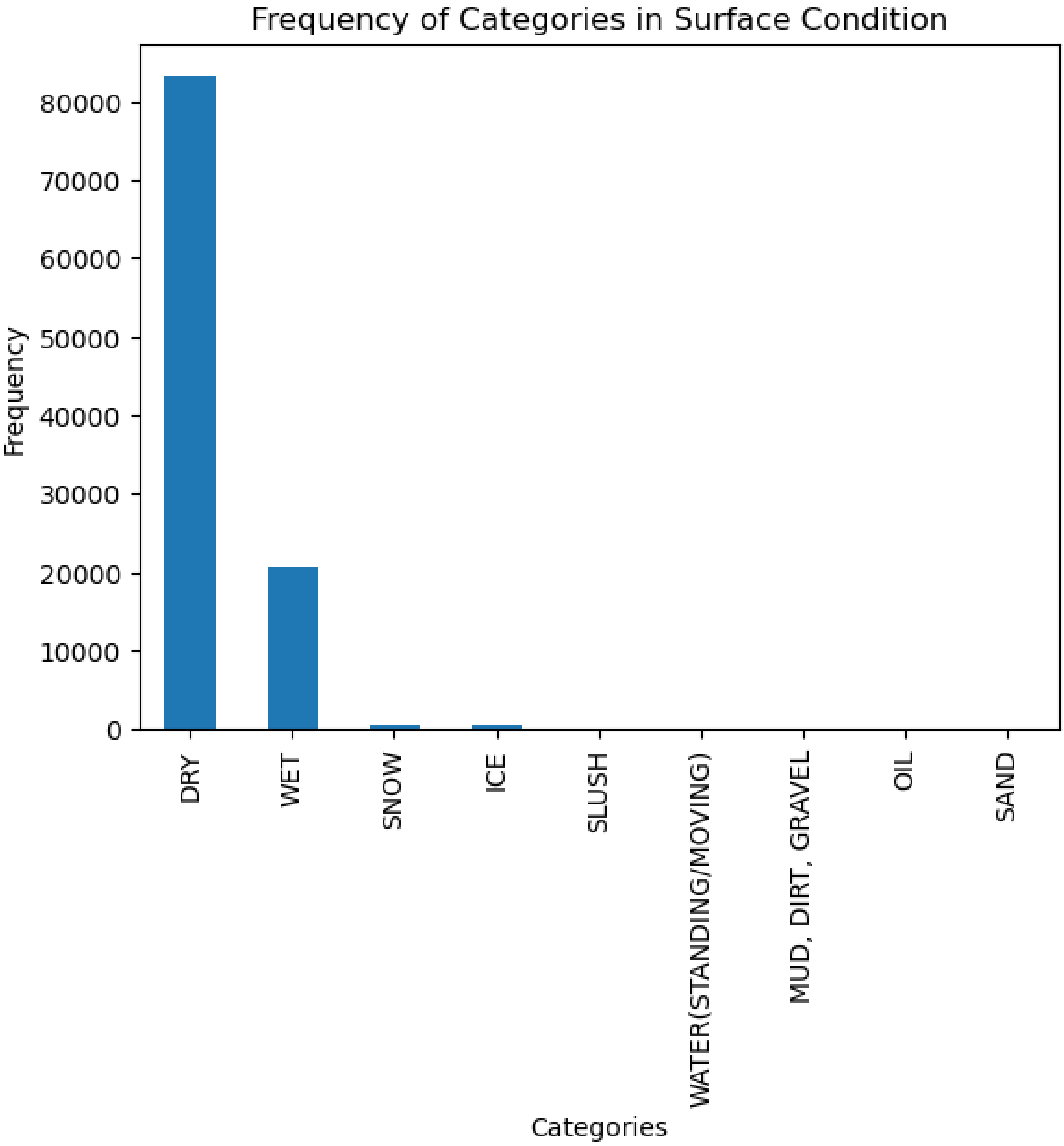
```
NO CONTROLS                46235
STOP SIGN                   9346
FLASHING TRAFFIC SIGNAL     1623
YIELD SIGN                  1419
PERSON                       200
WARNING SIGN                 126
RAILWAY CROSSING DEVICE       35
SCHOOL ZONE SIGN DEVICE       11
Name: Traffic Control, dtype: int64

Summary statistics for Driver Substance Abuse:
NONE DETECTED    84640
DETECTED         20739
Name: Driver Substance Abuse, dtype: int64

Summary statistics for Driver At Fault:
Yes    55157
No     50222
Name: Driver At Fault, dtype: int64

Summary statistics for Injury Severity:
No Injury         84376
Minor Injury      19981
Serious Injury     1022
Name: Injury Severity, dtype: int64

Summary statistics for Driver Distracted By:
NOT DISTRACTED    81402
DISTRACTED        23977
Name: Driver Distracted By, dtype: int64

Summary statistics for Speed Limit:
30-40    73969
15-25    16063
45-55    14587
0-10       688
60-70       72
Name: Speed Limit, dtype: int64

Summary statistics for Location:
(38.953, -77.338)              26
(39.11342767, -77.23648183)    18
(39.11061, -76.98979833)       18
(39.07997592, -77.13826298)    15
(39.045425, -76.99073667)      12
                               ..
(39.08948038, -77.09106495)     1
(39.089465, -77.13933833)       1
```

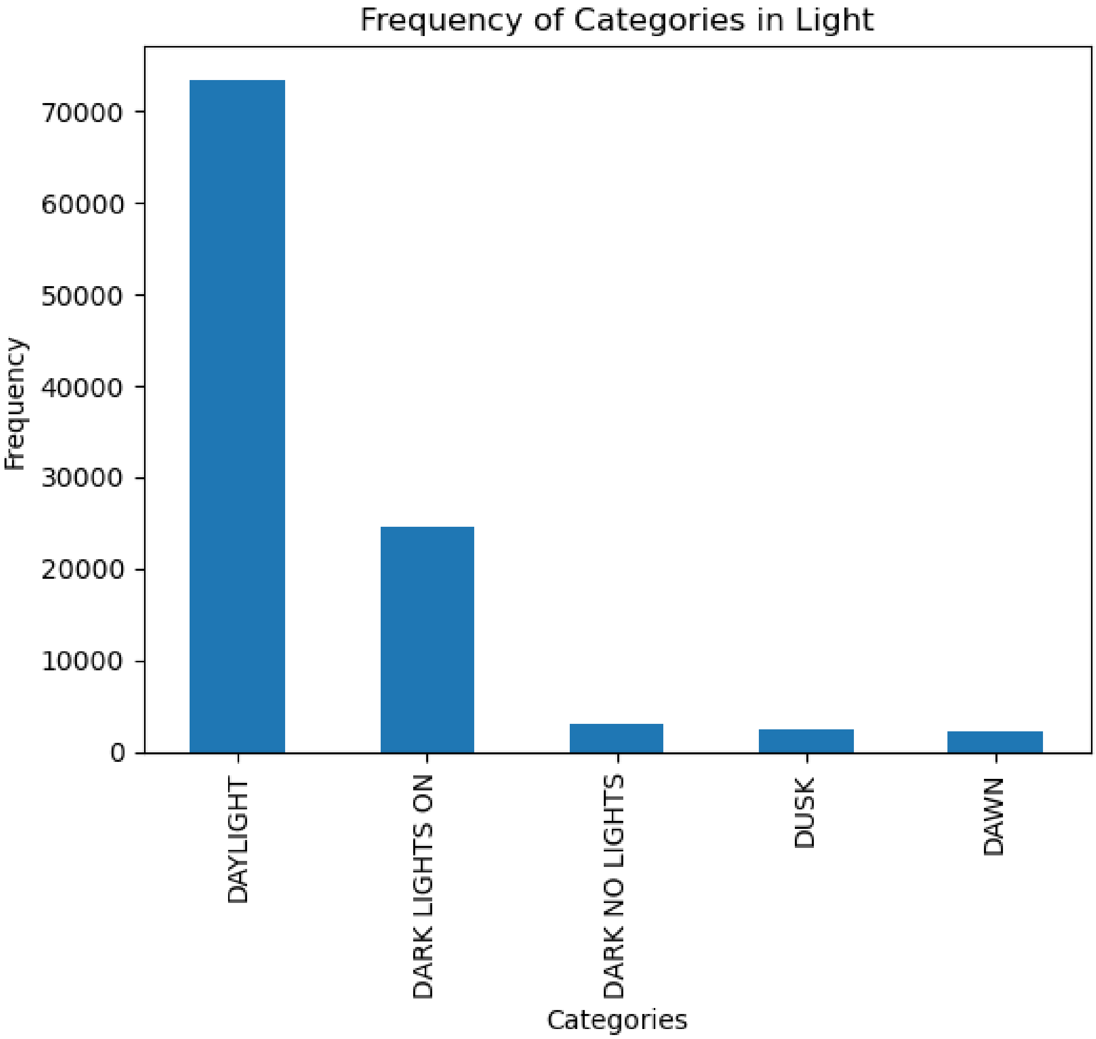
```
(39.15043833, -77.06744833)     1
(39.05174667, -77.06638167)     1
(39.06682667, -77.11454667)     1
Name: Location, Length: 55772, dtype: int64

Summary statistics for Day of Week:
Friday       17081
Tuesday      16683
Thursday     16517
Wednesday    16425
Monday       15385
Saturday     12657
Sunday       10631
Name: Day of Week, dtype: int64

Summary statistics for Time of Day:
afternoon    43517
morning      31297
evening      23983
dawn          6582
Name: Time of Day, dtype: int64
```

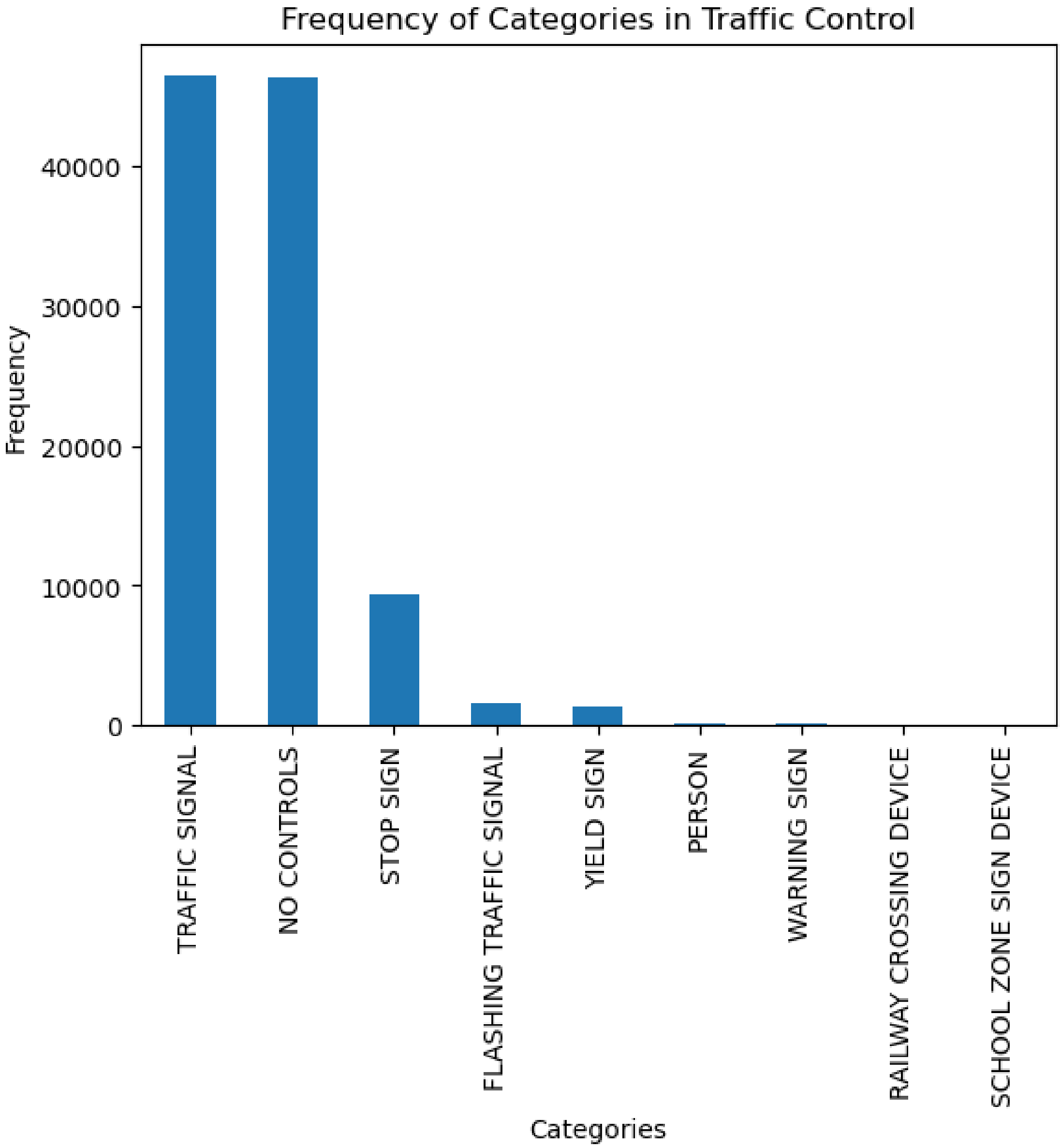

Frequency of Categories in Route Type
Frequency
50000
40000
30000
20000
10000
0
Maryland (State)
County
Municipality
US (State)
Interstate (State)
Ramp
Service Road
Categories

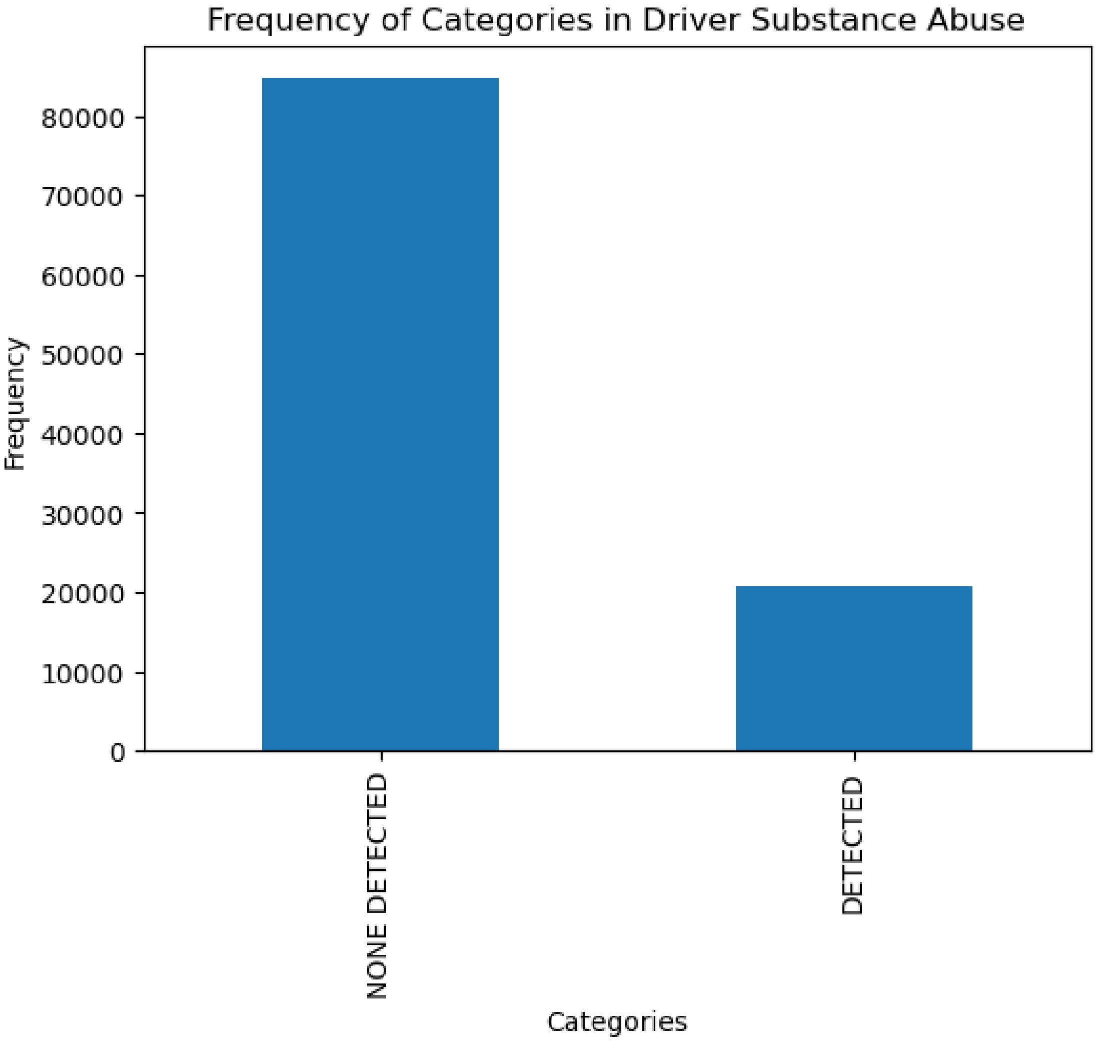

Frequency of Categories in Collision Type
Frequency
40000
35000
30000
25000
20000
15000
10000
5000
0
SAME DIR REAR END
STRAIGHT MOVEMENT ANGLE
HEAD ON LEFT TURN
SAME DIRECTION SIDESWIPE
SINGLE VEHICLE
OTHER
SAME DIRECTION RIGHT TURN
SAME DIRECTION LEFT TURN
HEAD ON
ANGLE MEETS LEFT TURN
OPPOSITE DIRECTION SIDESWIPE
ANGLE MEETS RIGHT TURN
SAME DIR REND RIGHT TURN
ANGLE MEETS LEFT HEAD ON
SAME DIR REND LEFT TURN
SAME DIR BOTH LEFT TURN
OPPOSITE DIR BOTH LEFT TURN
Categories

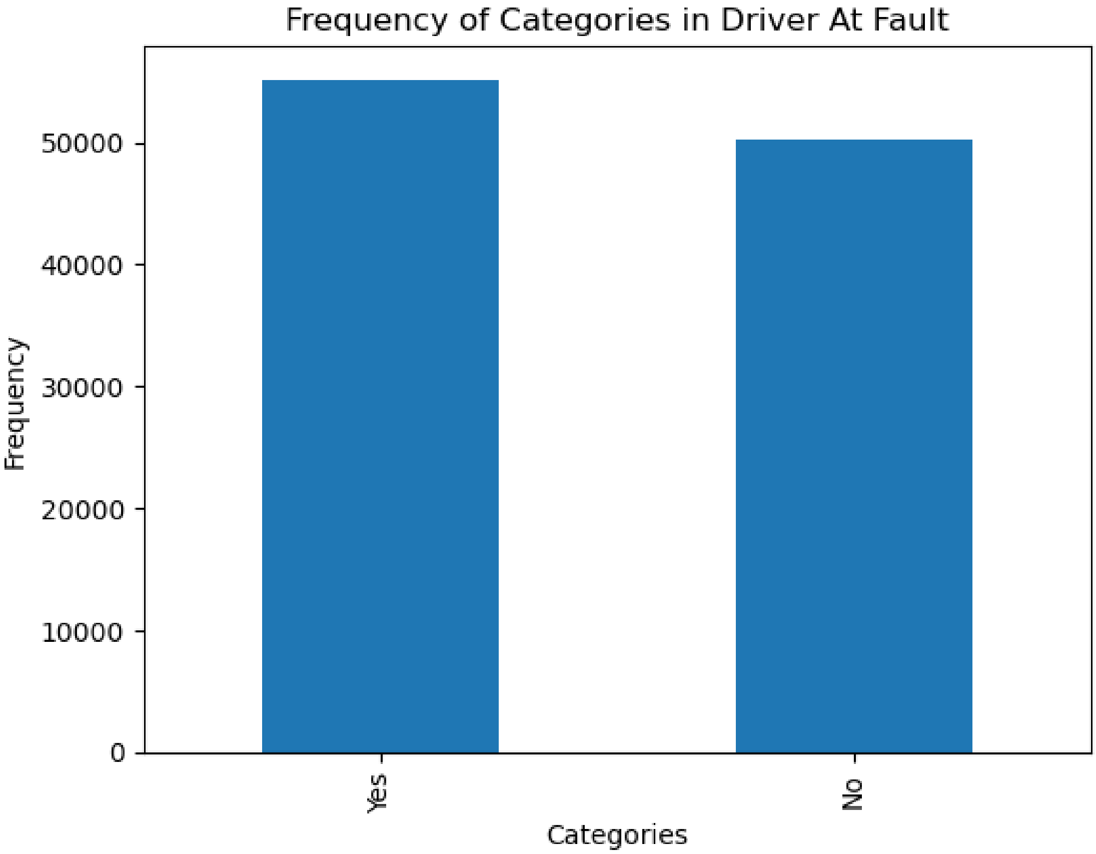

Frequency of Categories in Weather
Frequency
80000
70000
60000
50000
40000
30000
20000
10000
0
CLEAR
RAINING
CLOUDY
SNOW
FOGGY
WINTRY MIX
SLEET
SEVERE WINDS
BLOWING SNOW
BLOWING SAND, SOIL, DIRT
Categories

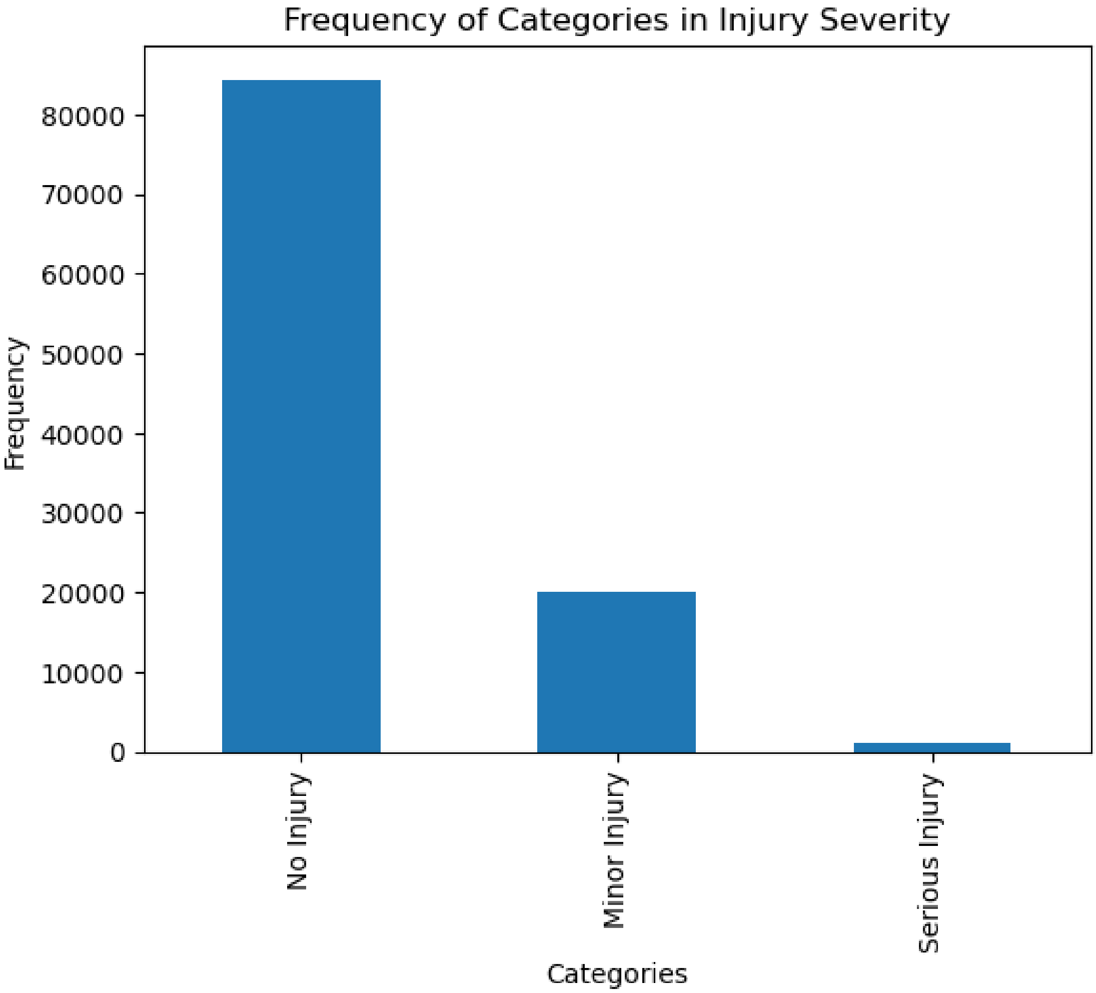

Frequency of Categories in Surface Condition
Frequency
80000
70000
60000
50000
40000
30000
20000
10000
0
DRY
WET
SNOW
ICE
SLUSH
WATER(STANDING/MOVING)
MUD, DIRT, GRAVEL
OIL
SAND
Categories

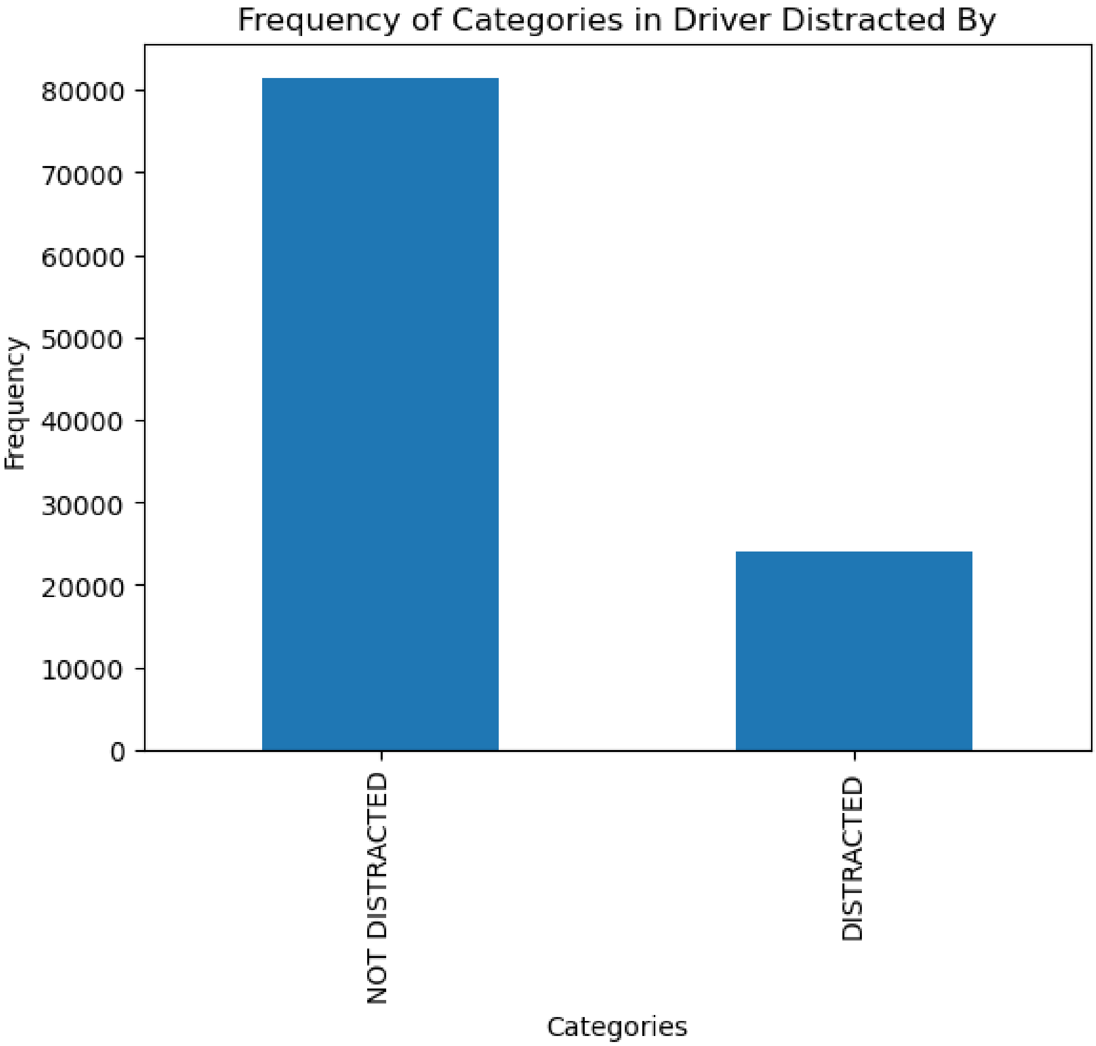

Frequency of Categories in Light
Frequency
70000
60000
50000
40000
30000
20000
10000
0
DAYLIGHT
DARK LIGHTS ON
DARK NO LIGHTS
DUSK
DAWN
Categories

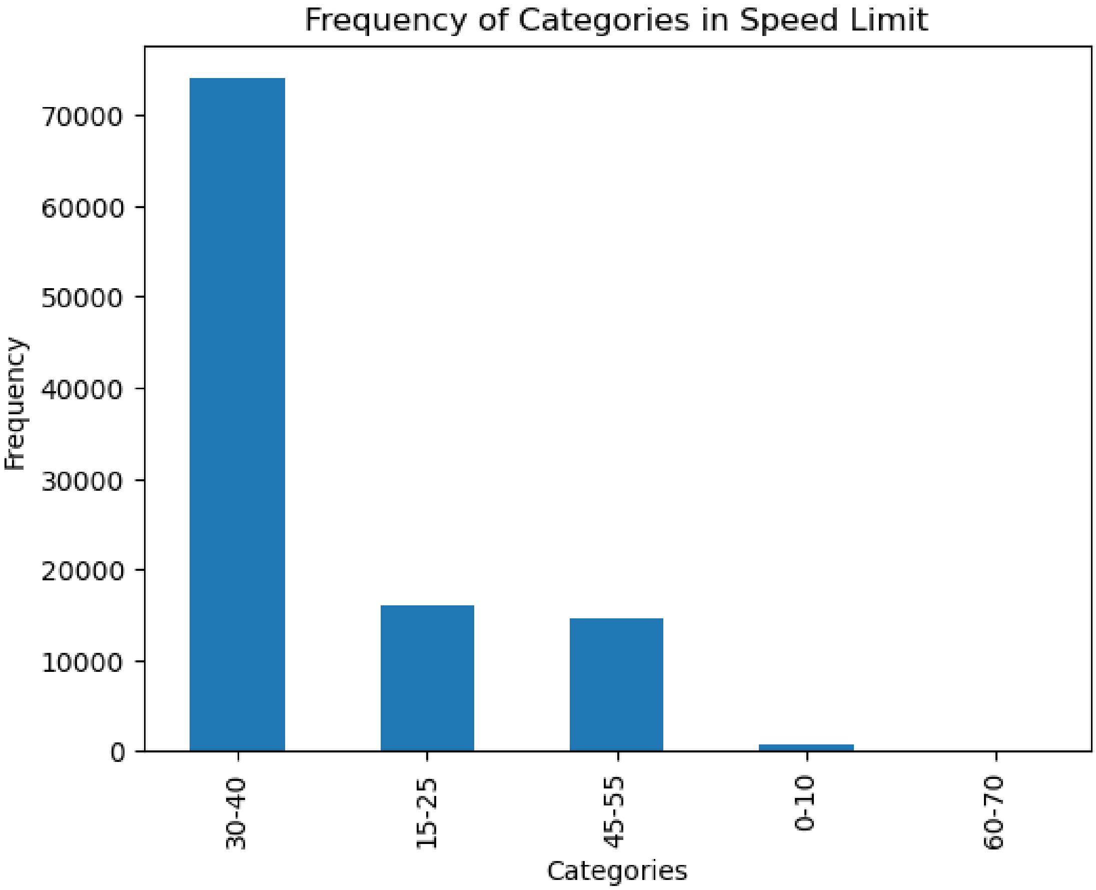

Frequency of Categories in Traffic Control
Frequency
0
10000
20000
30000
40000
TRAFFIC SIGNAL
NO CONTROLS
STOP SIGN
FLASHING TRAFFIC SIGNAL
YIELD SIGN
PERSON
WARNING SIGN
RAILWAY CROSSING DEVICE
SCHOOL ZONE SIGN DEVICE
Categories

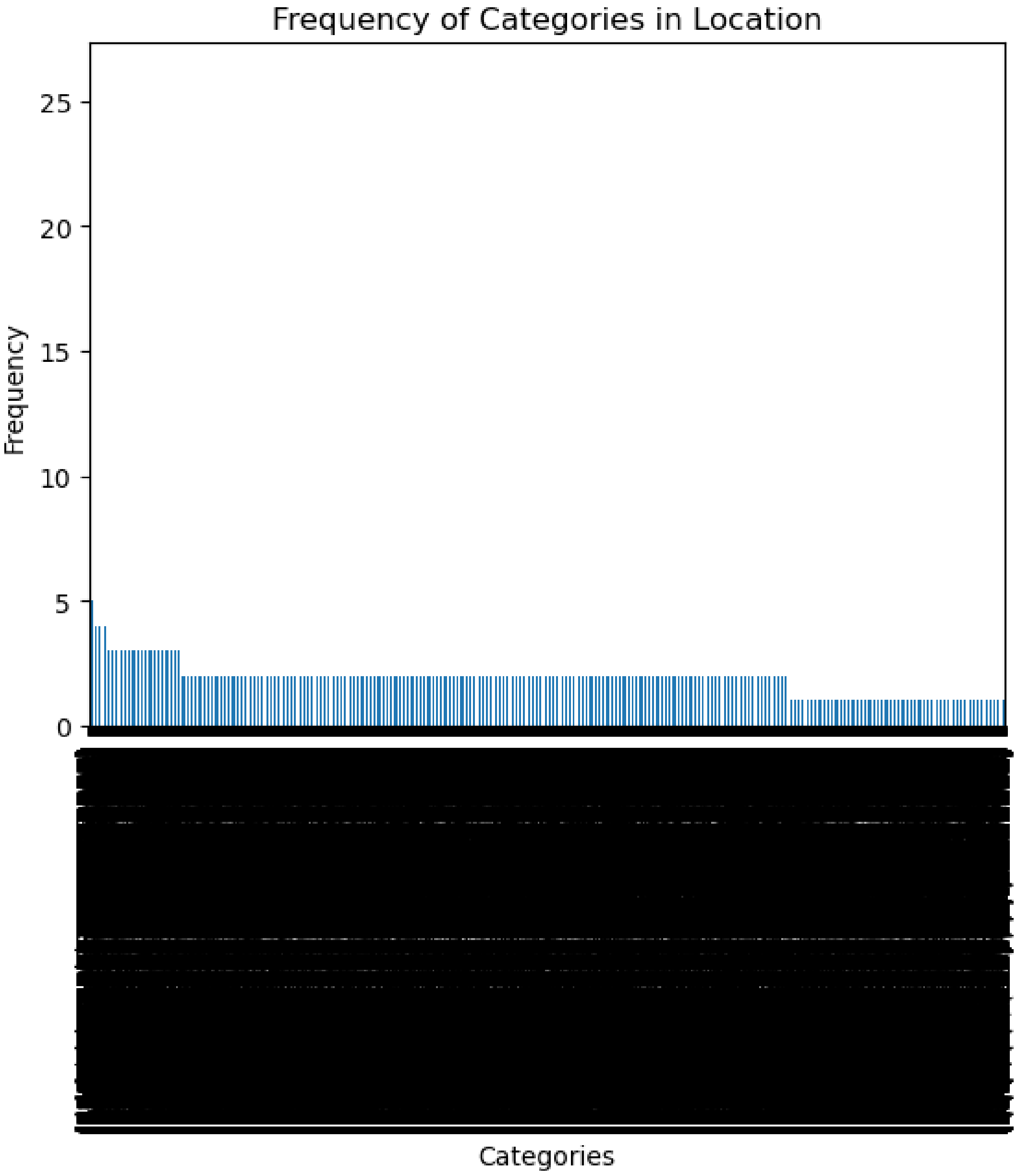

Frequency of Categories in Driver Substance Abuse
Frequency
0
10000
20000
30000
40000
50000
60000
70000
80000
NONE DETECTED
DETECTED
Categories

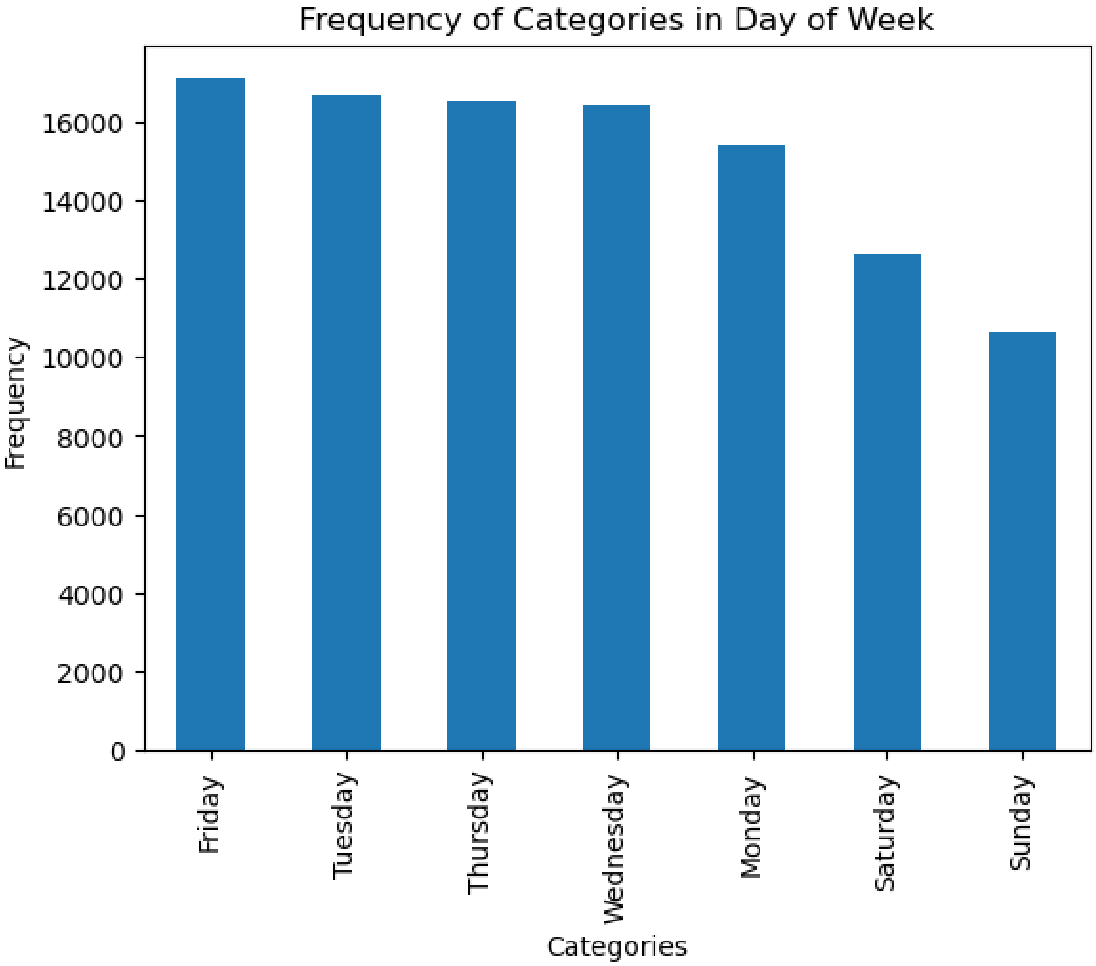

Frequency of Categories in Driver At Fault
Frequency
50000
40000
30000
20000
10000
0
Yes
No
Categories

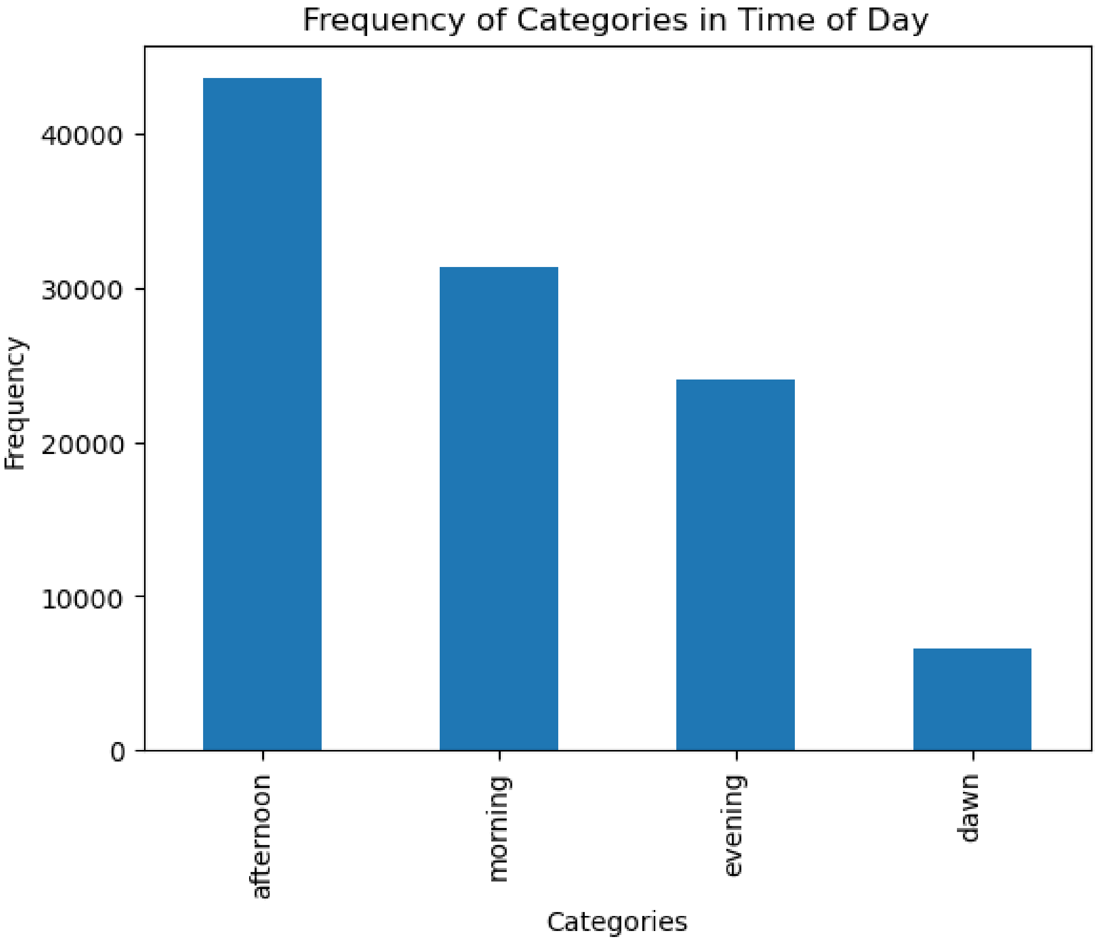

Frequency of Categories in Injury Severity
Frequency
80000
70000
60000
50000
40000
30000
20000
10000
0
No Injury
Minor Injury
Serious Injury
Categories


Frequency of Categories in Driver Distracted By
Frequency
80000
70000
60000
50000
40000
30000
20000
10000
0
NOT DISTRACTED
DISTRACTED
Categories


Frequency of Categories in Speed Limit
Frequency
70000
60000
50000
40000
30000
20000
10000
0
30-40
15-25
45-55
0-10
60-70
Categories


Frequency of Categories in Location
Frequency
25
20
15
10
5
0
Categories


Frequency of Categories in Day of Week
Frequency
0
2000
4000
6000
8000
10000
12000
14000
16000
Friday
Tuesday
Thursday
Wednesday
Monday
Saturday
Sunday
Categories

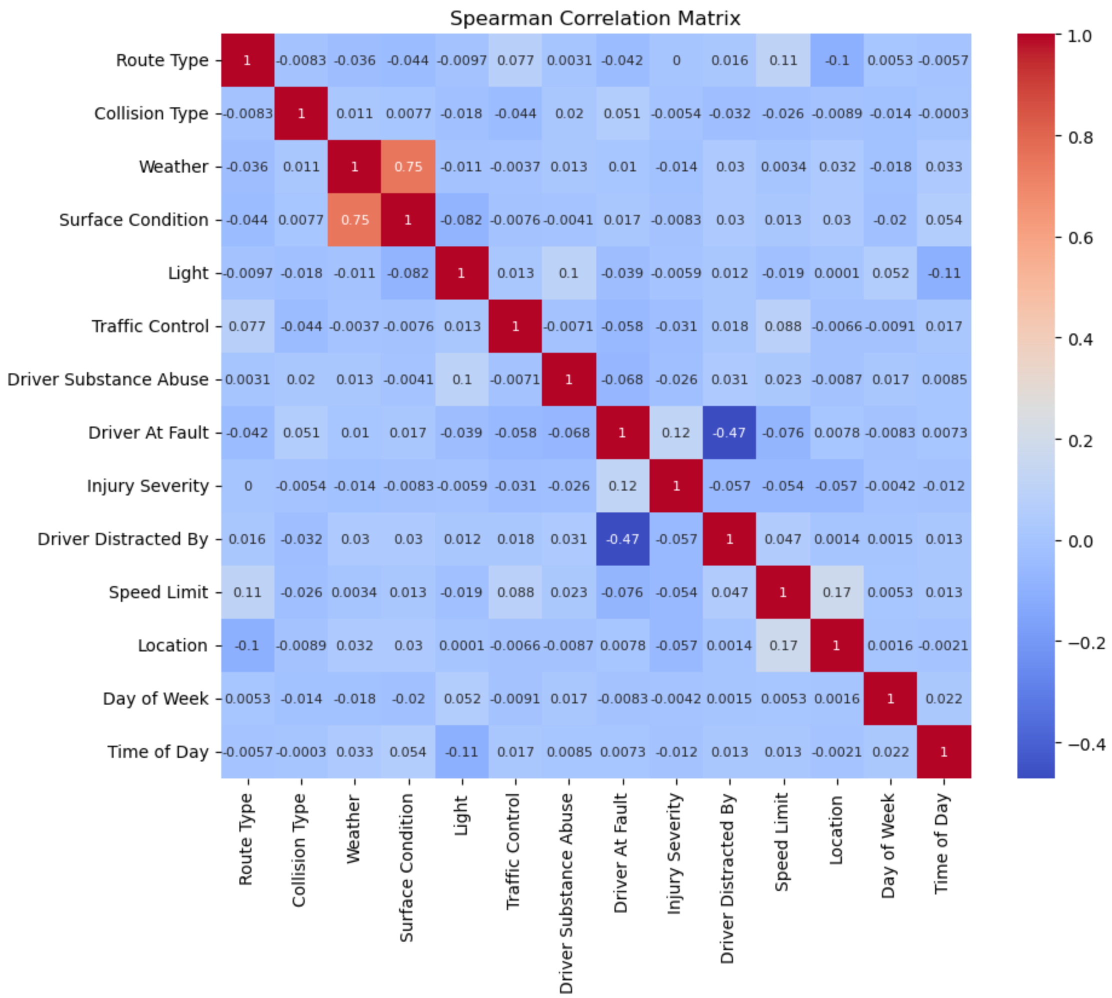


[ ]:

```python
# spearman correlation matrix and heatmap

import seaborn as sb
import matplotlib.pyplot as plt
import numpy as np

new_df_numeric = new_df.apply(lambda x: x.cat.codes)
correlation_matrix = new_df_numeric.corr(method="spearman",numeric_only=False)
rounded_matrix = np.round(correlation_matrix,decimals=4)
print(rounded_matrix)
plt.figure(figsize=(10,8))
sb.heatmap(rounded_matrix, annot=True, annot_kws={"size": 8}, cmap="coolwarm")
plt.title("Spearman Correlation Matrix")
plt.show()
```

```
                        Route Type  Collision Type  Weather  Surface Condition
Light  Traffic Control  Driver Substance Abuse  Driver At Fault  Injury Severity
Driver Distracted By  Speed Limit  Location  Day of Week  Time of Day
```

```
Route Type                  1.0000         -0.0083  -0.0361            -0.0440
-0.0097           0.0769                  0.0031          -0.0416
0.0000                0.0159       0.1060   -0.1024       0.0053      -0.0057
Collision Type             -0.0083          1.0000   0.0110             0.0077
-0.0181          -0.0439                  0.0201           0.0513
-0.0054               -0.0316      -0.0258   -0.0089      -0.0136      -0.0003
Weather                    -0.0361          0.0110   1.0000             0.7511
-0.0111          -0.0037                  0.0133           0.0103
-0.0141                0.0305       0.0034    0.0323      -0.0176       0.0325
Surface Condition          -0.0440          0.0077   0.7511             1.0000
-0.0817          -0.0076                 -0.0041           0.0174
-0.0083                0.0302       0.0125    0.0303      -0.0202       0.0537
Light                      -0.0097         -0.0181  -0.0111            -0.0817
1.0000           0.0130                  0.1006          -0.0394
-0.0059                0.0120      -0.0186    0.0001       0.0517      -0.1083
Traffic Control             0.0769         -0.0439  -0.0037            -0.0076
0.0130           1.0000                 -0.0071          -0.0583
-0.0310                0.0185       0.0885   -0.0066      -0.0091       0.0167
Driver Substance Abuse      0.0031          0.0201   0.0133            -0.0041
0.1006          -0.0071                  1.0000          -0.0682
-0.0265                0.0306       0.0227   -0.0087       0.0172       0.0085
Driver At Fault            -0.0416          0.0513   0.0103             0.0174
-0.0394          -0.0583                 -0.0682           1.0000
0.1174               -0.4725      -0.0763    0.0078      -0.0083       0.0073
Injury Severity             0.0000         -0.0054  -0.0141            -0.0083
-0.0059          -0.0310                 -0.0265           0.1174
1.0000               -0.0566      -0.0544   -0.0573      -0.0042      -0.0116
Driver Distracted By        0.0159         -0.0316   0.0305             0.0302
0.0120           0.0185                  0.0306          -0.4725
-0.0566                1.0000       0.0472    0.0014       0.0015       0.0131
Speed Limit                 0.1060         -0.0258   0.0034             0.0125
-0.0186           0.0885                  0.0227          -0.0763
-0.0544                0.0472       1.0000    0.1731       0.0053       0.0125
Location                   -0.1024         -0.0089   0.0323             0.0303
0.0001          -0.0066                 -0.0087           0.0078
-0.0573                0.0014       0.1731    1.0000       0.0016      -0.0021
Day of Week                 0.0053         -0.0136  -0.0176            -0.0202
0.0517          -0.0091                  0.0172          -0.0083
-0.0042                0.0015       0.0053    0.0016       1.0000       0.0222
Time of Day                -0.0057         -0.0003   0.0325             0.0537
-0.1083           0.0167                  0.0085           0.0073
-0.0116                0.0131       0.0125   -0.0021       0.0222       1.0000
```



[ ]:

```
# very powerful package, however, it is very complicated to use.
# need to spend more time to understand Cramér's V and dython.

# import dython as dy
# from dython.nominal import associations
# from dython.nominal import identify_nominal_columns

# associations(new_df)
```

[ ]:

```
new_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 105379 entries, 3 to 159356
Data columns (total 14 columns):
 #   Column                    Non-Null Count   Dtype
---  ------                    --------------   -----
```

```
 0   Route Type              105379 non-null  category
 1   Collision Type          105379 non-null  category
 2   Weather                 105379 non-null  category
 3   Surface Condition       105379 non-null  category
 4   Light                   105379 non-null  category
 5   Traffic Control         105379 non-null  category
 6   Driver Substance Abuse  105379 non-null  category
 7   Driver At Fault         105379 non-null  category
 8   Injury Severity         105379 non-null  category
 9   Driver Distracted By    105379 non-null  category
 10  Speed Limit             105379 non-null  category
 11  Location                105379 non-null  category
 12  Day of Week             105379 non-null  category
 13  Time of Day             105379 non-null  category
dtypes: category(14)
memory usage: 5.0 MB
```