Importing Libraries

In [3]:
```
!pip install plotly
```

```
Requirement already satisfied: plotly in c:\programdata\anaconda3\lib\site-packages (5.13.1)
Requirement already satisfied: tenacity>=6.2.0 in c:\programdata\anaconda3\lib\site-packages (from plotly) (8.2.2)
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```

In [4]:

```
pip install scikit-plot
```

```
Requirement already satisfied: scikit-plot in c:\programdata\anaconda3\lib\site-packages (0.3.7)
Requirement already satisfied: scipy>=0.9 in c:\programdata\anaconda3\lib\site-packages (from scikit-plot) (1.7.1)
Requirement already satisfied: joblib>=0.10 in c:\programdata\anaconda3\lib\site-packages (from scikit-plot) (1.2.0)
Requirement already satisfied: scikit-learn>=0.18 in c:\programdata\anaconda3\lib\site-packages (from scikit-plot) (1.2.2)
Requirement already satisfied: matplotlib>=1.4.0 in c:\programdata\anaconda3\lib\site-packages (from scikit-plot) (3.4.3)
Requirement already satisfied: pillow>=6.2.0 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-plot)
(8.4.0)
Requirement already satisfied: numpy>=1.16 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-plot) (1.
24.2)
Requirement already satisfied: python-dateutil>=2.7 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-
plot) (2.8.2)
Requirement already satisfied: pyparsing>=2.2.1 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-plo
t) (3.0.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-plo
t) (1.3.1)
Requirement already satisfied: cycler>=0.10 in c:\programdata\anaconda3\lib\site-packages (from matplotlib>=1.4.0->scikit-plot)
(0.10.0)
Requirement already satisfied: six in c:\programdata\anaconda3\lib\site-packages (from cycler>=0.10->matplotlib>=1.4.0->scikit-plo
t) (1.16.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from scikit-learn>=0.18->scikit
-plot) (2.2.0)
Collecting numpy>=1.16
  Downloading numpy-1.22.4-cp39-cp39-win_amd64.whl (14.7 MB)
Installing collected packages: numpy
  Attempting uninstall: numpy
    Found existing installation: numpy 1.24.2
    Uninstalling numpy-1.24.2:
```

```
      Successfully uninstalled numpy-1.24.2
Note: you may need to restart the kernel to use updated packages.
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    WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
ERROR: Could not install packages due to an OSError: [WinError 5] Access is denied: 'C:\\ProgramData\\Anaconda3\\Lib\\site-package
s\\~umpy\\.libs\\libopenblas64__v0.3.21-gcc_10_3_0.dll'
Consider using the `--user` option or check the permissions.

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```

In [5]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from collections import defaultdict
import seaborn as sns  # viz
from IPython.display import HTML, display
pd.set_option("display.max_columns",None)
import plotly.express as px
import os
import urllib
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from sklearn.model_selection import cross_val_predict
import numpy as np
import pandas as pd
import seaborn as sns
import plotly.express as px
import matplotlib.pyplot as plt
import seaborn as sb
```

```
from sklearn.preprocessing import LabelEncoder
import seaborn as sns
from sklearn.model_selection import train_test_split
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', None)
from sklearn.impute import SimpleImputer, MissingIndicator
from sklearn.compose import ColumnTransformer
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import  mean_absolute_error,r2_score
from sklearn.preprocessing import OneHotEncoder
from sklearn.ensemble import RandomForestRegressor
from sklearn.preprocessing import StandardScaler
import pandas as pd
import matplotlib.pyplot as plt
import scikitplot as skplt
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split, RandomizedSearchCV, TimeSeriesSplit
from sklearn.metrics import classification_report
#for model-building
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import SGDClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import classification_report, f1_score, accuracy_score, confusion_matrix
from sklearn.metrics import roc_curve, auc, roc_auc_score

# Setting environment to ignore future warnings
import warnings
warnings.simplefilter('ignore')
from sklearn.preprocessing import StandardScaler # standardize characteristic data
from sklearn.model_selection import train_test_split # split the data into training and testing
from collections import Counter
```

In [6]:

```
from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = 'all'
```

Importing Dataset

The data is extracted from the website data.gov.uk website from the road-accidents-safety-data files available on Importing url from the website and creating folder for using it, so that it can be retrieved directly from the folder.

In [7]:
```
import pandas as pd
import csv

data = pd.read_csv(r'D:\uk_road_accident_2019.csv')
data.head(10)
```

Out[7]:

	accident_index	speed_limit	light_conditions	weather_conditions	road_surface_conditions	vehicle_type	junction_location	skidding_and_overturning	vehi
0	2019010225080	30	darkness	other	wet or damp	at least one van	at or within 20 metres of junction	no skidding or overturning	
1	2019200908684	30	darkness	fine	dry	only cars	at or within 20 metres of junction	no skidding or overturning	a
2	2019040860897	40	daylight	fine	dry	only cars	at or within 20 metres of junction	no skidding or overturning	
3	2019460847205	40	daylight	fine	dry	only cars	not at or within 20 metres of junction	no skidding or overturning	
4	2019051911581	30	daylight	fine	dry	only cars	not at or within 20 metres of junction	no skidding or overturning	
5	2019400862270	60	daylight	fine	dry	at least one biped	not at or within 20 metres of junction	no skidding or overturning	
6	2019420894599	30	darkness	fine	wet or damp	only cars	not at or within 20 metres of junction	no skidding or overturning	
7	2019010162791	50	daylight	fine	dry	only cars	at or within 20 metres of junction	no skidding or overturning	
8	2019360909153	60	daylight	fine	dry	at least one van	at or within 20 metres of junction	no skidding or overturning	
9	2019500856761	60	daylight	fine	dry	only cars	not at or within 20 metres of	no skidding or overturning	a

accident_index	speed_limit	light_conditions	weather_conditions	road_surface_conditions	vehicle_type	junction_location	skidding_and_overturning	vehi
						junction		

Data Pre-processing

In [8]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 31647 entries, 0 to 31646
Data columns (total 14 columns):
 #   Column                       Non-Null Count  Dtype  
---  ------                       --------------  -----  
 0   accident_index               31647 non-null  object 
 1   speed_limit                  31647 non-null  int64  
 2   light_conditions             31647 non-null  object 
 3   weather_conditions           31647 non-null  object 
 4   road_surface_conditions      31647 non-null  object 
 5   vehicle_type                 31647 non-null  object 
 6   junction_location            31647 non-null  object 
 7   skidding_and_overturning     31647 non-null  object 
 8   vehicle_leaving_carriageway  31647 non-null  object 
 9   hit_object_off_carriageway   31647 non-null  object 
 10  first_point_of_impact        31647 non-null  object 
 11  sex_of_driver                31647 non-null  object 
 12  age_of_oldest_driver         25197 non-null  float64
 13  accident_severity            30475 non-null  object 
dtypes: float64(1), int64(1), object(12)
memory usage: 3.4+ MB
```

Checking null values present in the dataframe

In [9]:
```
categorical_columns = ['accident_index','speed_limit', 'light_conditions', 'weather_conditions', 'road_surface_conditions','vehicl
       'junction_location','skidding_and_overturning','vehicle_leaving_carriageway','hit_object_off_carriageway',
       'first_point_of_impact','sex_of_driver','age_of_oldest_driver','accident_severity']
data = data[categorical_columns]

data.isnull().sum()
```

Out[9]:
```
accident_index                  0
speed_limit                     0
light_conditions                0
weather_conditions              0
road_surface_conditions         0
vehicle_type                    0
junction_location               0
skidding_and_overturning        0
vehicle_leaving_carriageway     0
hit_object_off_carriageway      0
first_point_of_impact           0
sex_of_driver                   0
age_of_oldest_driver         6450
accident_severity            1172
dtype: int64
```

get a detailed view about the columns with null values

In [10]:
```
null_columns=data.columns[data.isnull().any()]
data[null_columns].isnull().sum()
```

Out[10]:
```
age_of_oldest_driver    6450
accident_severity       1172
dtype: int64
```

Dropping null values present in dataframe

In [11]:
```
data = data.dropna()

data.isnull().sum()
```

Out[11]:
```
accident_index                  0
speed_limit                     0
light_conditions                0
weather_conditions              0
road_surface_conditions         0
vehicle_type                    0
junction_location               0
skidding_and_overturning        0
vehicle_leaving_carriageway     0
hit_object_off_carriageway      0
first_point_of_impact           0
sex_of_driver                   0
```

```
age_of_oldest_driver          0
accident_severity             0
dtype: int64
```

Checking for negative values in dataframe

In [12]:
```
data = data[data.select_dtypes(include=[np.number]).ge(0).all(1)]
```

Getting unique values in the dataframe

In [13]:
```
data["accident_index"].unique()
data["speed_limit"].unique()
data["light_conditions"].unique()
data["weather_conditions"].unique()
data["road_surface_conditions"].unique()
data["vehicle_type"].unique()
data["junction_location"].unique()
data["skidding_and_overturning"].unique()
data["vehicle_leaving_carriageway"].unique()
data["hit_object_off_carriageway"].unique()
data["sex_of_driver"].unique()
data["age_of_oldest_driver"].unique()
data["accident_severity"].unique()
data["first_point_of_impact"].unique()
```

Out[13]:
```
array(['2019010225080', '2019200908684', '2019051911581', ...,
       '20191369p0654', '2019470903814', '2019010214285'], dtype=object)
```

Out[13]:
```
array([30, 50, 60, 20, 40, 70], dtype=int64)
```

Out[13]:
```
array(['darkness', 'daylight'], dtype=object)
```

Out[13]:
```
array(['other', 'fine', 'data missing or out of range', 'fog or mist'],
      dtype=object)
```

Out[13]:
```
array(['wet or damp', 'dry', 'other', 'data missing or out of range',
       'flood over 3cm. deep'], dtype=object)
```

Out[13]:
```
array(['at least one van', 'only cars', 'at least one biped', 'other',
       'biped and van', 'data missing or out of range'], dtype=object)
```

Out[13]:
```
array(['at or within 20 metres of junction',
       'not at or within 20 metres of junction',
       'data missing or out of range'], dtype=object)
```

Out[13]:
```
array(['no skidding or overturning',
       'at least one vehicle skidded or overturned',
       'data missing or out of range'], dtype=object)
```

Out[13]:
```
array(['none leaving carriageway',
       'at least one vehicle leaving carriageway',
       'data missing or out of range'], dtype=object)
```

Out[13]:
```
array(['none hit an object', 'at least one vehicle hit an object',
       'data missing or out of range'], dtype=object)
```

Out[13]:
```
array(['all males', 'all females', 'male and female',
       'data missing or out of range'], dtype=object)
```

Out[13]:
```
array([ 63.,  82.,  39.,  40.,  57.,  60.,  46.,  47.,  45.,  30.,  41.,
        53.,  26.,  34.,  28.,  18.,  56.,  50.,  22.,  61.,  44.,  36.,
        42.,  68.,  88.,  54.,  51.,  35.,  19.,  17.,  69.,  33.,  21.,
        31.,  24.,  32.,  62.,  49.,  65.,  38.,  27.,  64.,  48.,  67.,
        83.,  58.,  55.,  23.,  59.,  74.,  72.,  29.,  80.,  43.,  20.,
        66.,  75.,   6.,  11.,  52.,  37.,  76.,  25.,  71.,  78.,  70.,
        84.,  15.,  90.,  73.,  79.,  85.,  77.,  81.,  86.,  89.,  87.,
        94.,  93.,  91.,  13.,  92.,  16.,  95.,  99.,  98.,  12.,  14.,
        96., 101.,  97.,  10.])
```

Out[13]:
```
array(['serious', 'fatal', 'slight', 'Serious', 'Slight', 'Fatal'],
      dtype=object)
```

Out[13]:
```
array(['other points of impact',
       'at least one vehicle with frontal impact', 'no impact',
       'data missing or out of range'], dtype=object)
```

Although null values were removed, most of the categorical columns still contain values irrelevant values for prediction.

In [14]:
```
print("weather_conditions",":", (data["weather_conditions"].isin(['data missing or out of range','other'])).sum())
print("road_surface_conditions",":", (data["road_surface_conditions"].isin(['data missing or out of range','other'])).sum())
print("vehicle_type",":", (data["vehicle_type"].isin(['data missing or out of range','other'])).sum())
print("skidding_and_overturning",":", (data["skidding_and_overturning"].isin(['data missing or out of range'])).sum())
print("vehicle_leaving_carriageway",":", (data["vehicle_leaving_carriageway"].isin(['data missing or out of range'])).sum())
print("hit_object_off_carriageway",":", (data["hit_object_off_carriageway"].isin(['data missing or out of range'])).sum())
print("sex_of_driver",":", (data["sex_of_driver"].isin(['data missing or out of range'])).sum())
```

```
weather_conditions : 4686
road_surface_conditions : 432
vehicle_type : 287
skidding_and_overturning : 557
vehicle_leaving_carriageway : 537
hit_object_off_carriageway : 497
sex_of_driver : 600
```

dropping the coloumn records with meaningless data

In [15]:
```
#drop records with meaningless data
data=data[data["weather_conditions"]!='data missing or out of range']
data=data[data["weather_conditions"]!='other']
data=data[data["road_surface_conditions"]!='data missing or out of range']
data=data[data["road_surface_conditions"]!='other']
data=data[data["road_surface_conditions"]!='flood over 3cm. deep']
data=data[data["vehicle_type"]!='data missing or out of range']
data=data[data["vehicle_type"]!='other']
data=data[data["skidding_and_overturning"]!='data missing or out of range']
data=data[data["skidding_and_overturning"]!='other']
data=data[data["vehicle_leaving_carriageway"]!='data missing or out of range']
data=data[data["vehicle_leaving_carriageway"]!='other']
data=data[data["junction_location"]!='data missing or out of range']
data=data[data["hit_object_off_carriageway"]!='data missing or out of range']
data=data[data["hit_object_off_carriageway"]!='other']
data=data[data["sex_of_driver"]!='data missing or out of range']
data=data[data["sex_of_driver"]!='other']
data=data[data["first_point_of_impact"]!='data missing or out of range']
```

Matching differences in the capital letters

In [16]:
```
data['accident_severity'] = data['accident_severity'].replace('serious','Serious')
data['accident_severity'] = data['accident_severity'].replace('slight','Slight')
data['accident_severity'] = data['accident_severity'].replace('fatal','Fatal')
```

In [17]:
```
data["accident_index"].unique()
data["speed_limit"].unique()
data["light_conditions"].unique()
data["weather_conditions"].unique()
data["road_surface_conditions"].unique()
data["vehicle_type"].unique()
data["junction_location"].unique()
data["skidding_and_overturning"].unique()
data["vehicle_leaving_carriageway"].unique()
data["hit_object_off_carriageway"].unique()
data["sex_of_driver"].unique()
data["age_of_oldest_driver"].unique()
```

```
data["accident_severity"].unique()
data["first_point_of_impact"].unique()
```

Out[17]:
```
array(['2019200908684', '2019051911581', '2019420894599', ...,
       '2019070317173', '20191369p0654', '2019470903814'], dtype=object)
```

Out[17]:
```
array([30, 50, 60, 20, 40, 70], dtype=int64)
```

Out[17]:
```
array(['darkness', 'daylight'], dtype=object)
```

Out[17]:
```
array(['fine', 'fog or mist'], dtype=object)
```

Out[17]:
```
array(['dry', 'wet or damp'], dtype=object)
```

Out[17]:
```
array(['only cars', 'at least one van', 'at least one biped',
       'biped and van'], dtype=object)
```

Out[17]:
```
array(['at or within 20 metres of junction',
       'not at or within 20 metres of junction'], dtype=object)
```

Out[17]:
```
array(['no skidding or overturning',
       'at least one vehicle skidded or overturned'], dtype=object)
```

Out[17]:
```
array(['at least one vehicle leaving carriageway',
       'none leaving carriageway'], dtype=object)
```

Out[17]:
```
array(['at least one vehicle hit an object', 'none hit an object'],
      dtype=object)
```

Out[17]:
```
array(['all males', 'all females', 'male and female'], dtype=object)
```

Out[17]:
```
array([ 82.,  39.,  40.,  57.,  60.,  47.,  45.,  46.,  30.,  41.,  53.,
        26.,  34.,  28.,  56.,  50.,  22.,  44.,  42.,  18.,  68.,  54.,
        51.,  19.,  17.,  35.,  69.,  33.,  61.,  21.,  31.,  24.,  32.,
        65.,  38.,  49.,  27.,  64.,  48.,  83.,  58.,  55.,  23.,  36.,
        59.,  72.,  29.,  80.,  20.,  66.,  75.,  11.,  52.,  37.,  25.,
        43.,  71.,  74.,  67.,  62.,  78.,  63.,  84.,  76.,  70.,  15.,
        90.,  73.,  79.,  77.,  88.,  86.,  81.,  89.,  85.,  87.,  94.,
        93.,  91.,  13.,  92.,  16.,  98.,  12.,  95.,  96.,  14., 101.,
        97.,  10.])
```

Out[17]:
```
array(['Fatal', 'Slight', 'Serious'], dtype=object)
```

Out[17]:
```
array(['at least one vehicle with frontal impact',
       'other points of impact', 'no impact'], dtype=object)
```

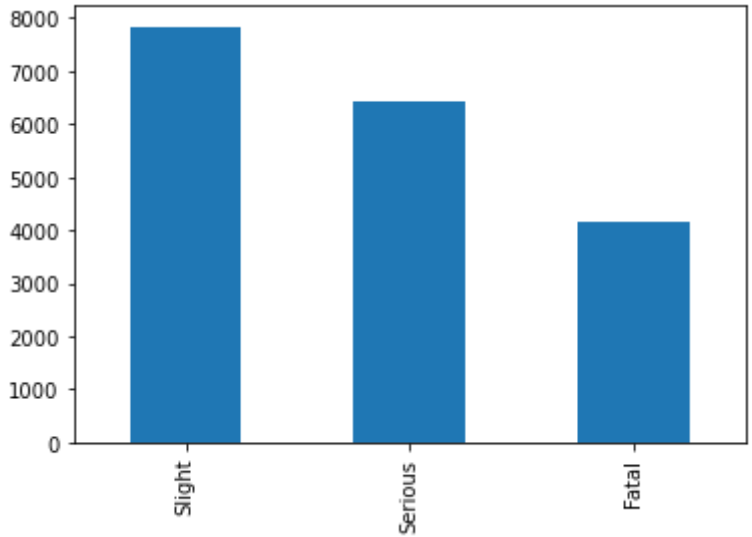
Target variable classes distribution and visualization

In [18]:
```
#target variable classes counts and bar plot
print(data['accident_severity'].value_counts())
data['accident_severity'].value_counts().plot(kind='bar')
```

```
Slight     7839
Serious    6413
Fatal      4151
Name: accident_severity, dtype: int64
```

Out[18]:

```
<AxesSubplot:>
```

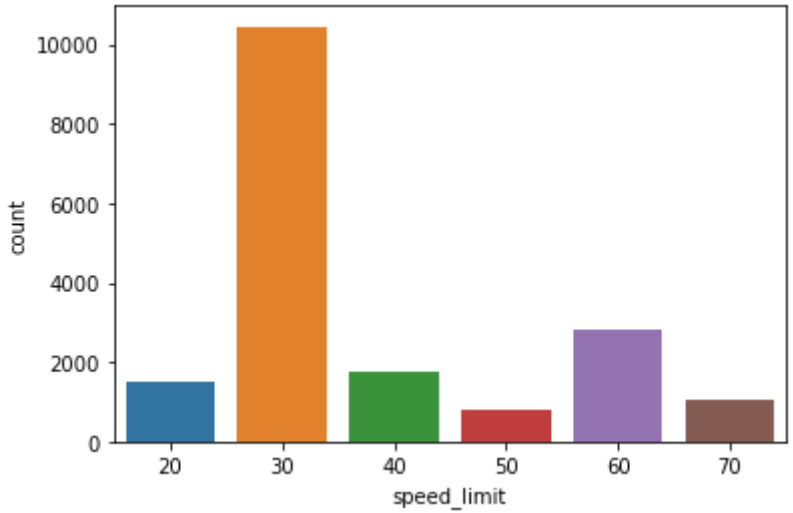


In [19]:

```
sb.countplot(x='speed_limit',data=data)
plt.show()
```

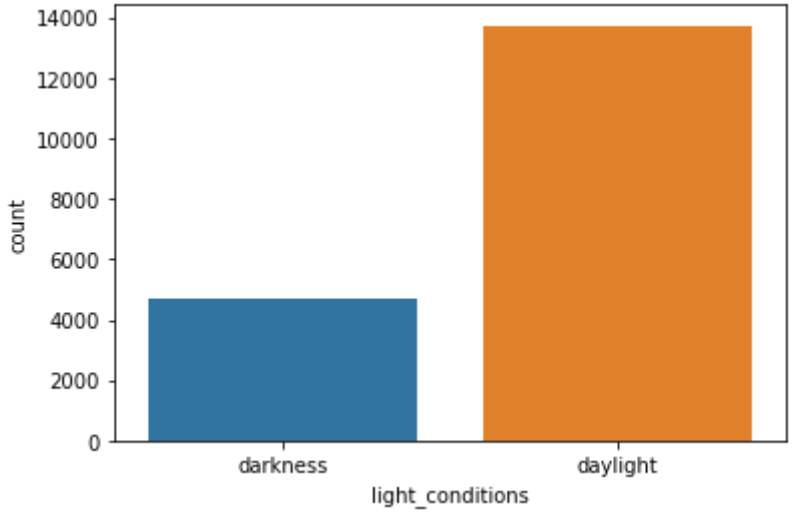
Out[19]:

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



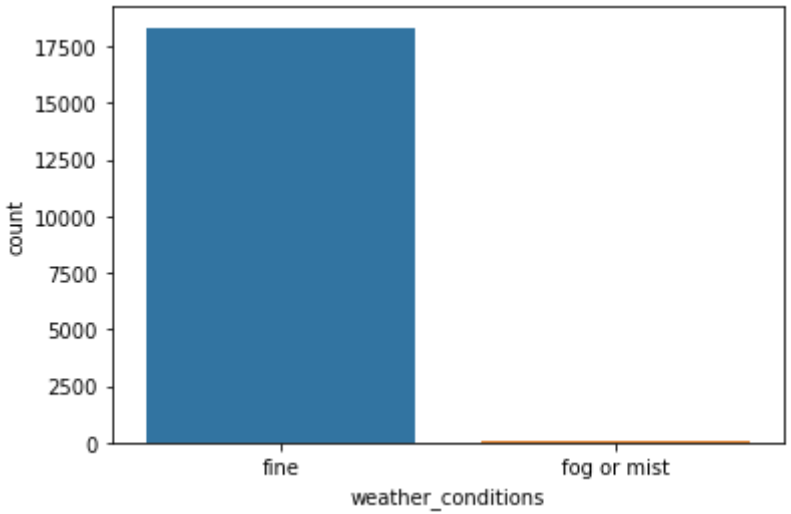
In [20]:
```
sb.countplot(x='light_conditions',data=data)
plt.show()
```

Out[20]:
```
<AxesSubplot:xlabel='light_conditions', ylabel='count'>
```



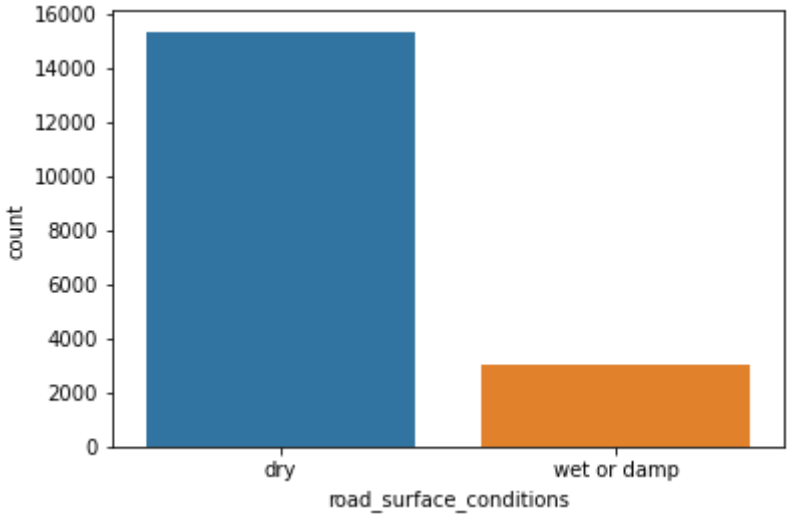
In [21]:
```
sb.countplot(x='weather_conditions',data=data)
plt.show()
```

Out[21]: <AxesSubplot:xlabel='weather_conditions', ylabel='count'>



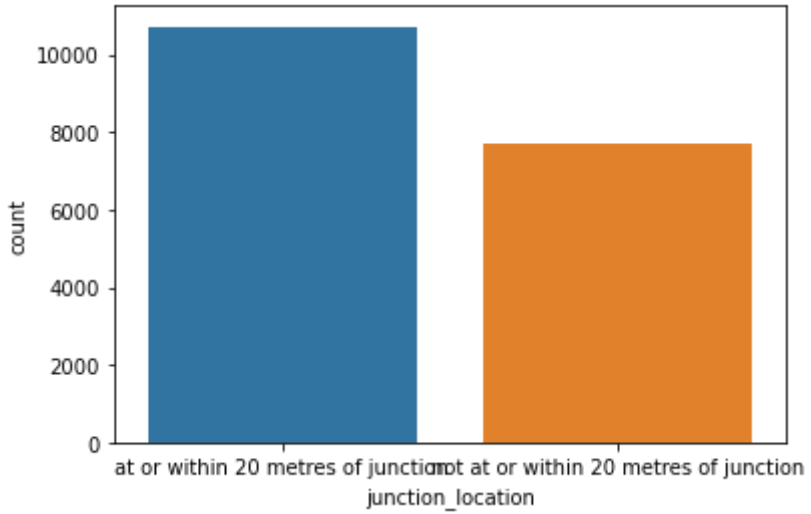
In [22]:
```
sb.countplot(x='road_surface_conditions',data=data)
plt.show()
```

Out[22]: <AxesSubplot:xlabel='road_surface_conditions', ylabel='count'>



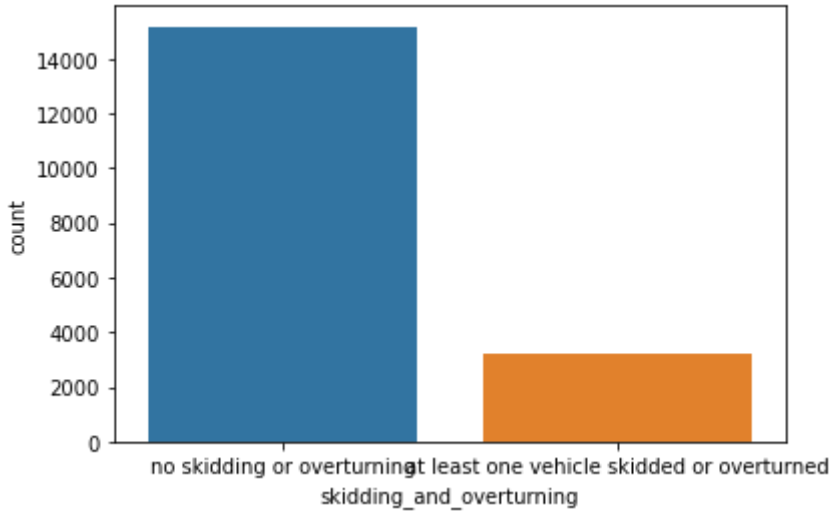
In [23]:
```
sb.countplot(x='junction_location',data=data)
plt.show()
```

Out[23]:
```
<AxesSubplot:xlabel='junction_location', ylabel='count'>
```



In [24]:
```
sb.countplot(x='skidding_and_overturning',data=data)
plt.show()
```

Out[24]:
```
<AxesSubplot:xlabel='skidding_and_overturning', ylabel='count'>
```

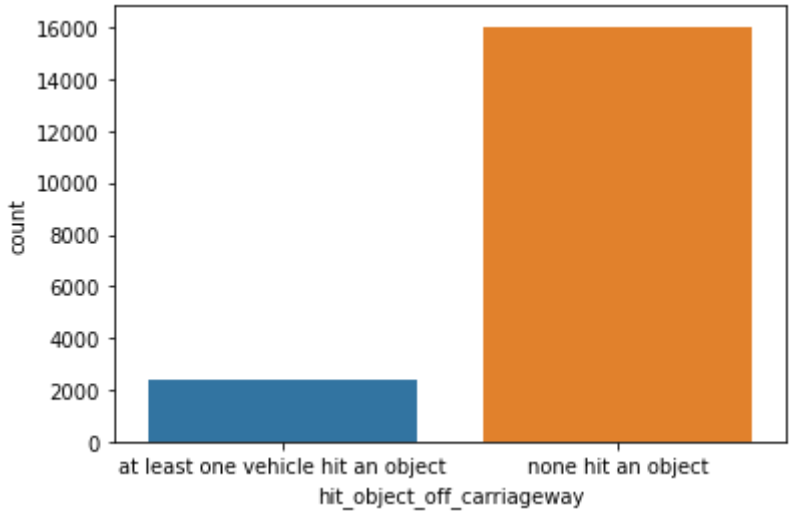


sb.countplot(x='vehicle_leaving_carriageway',data=data)

plt.show()

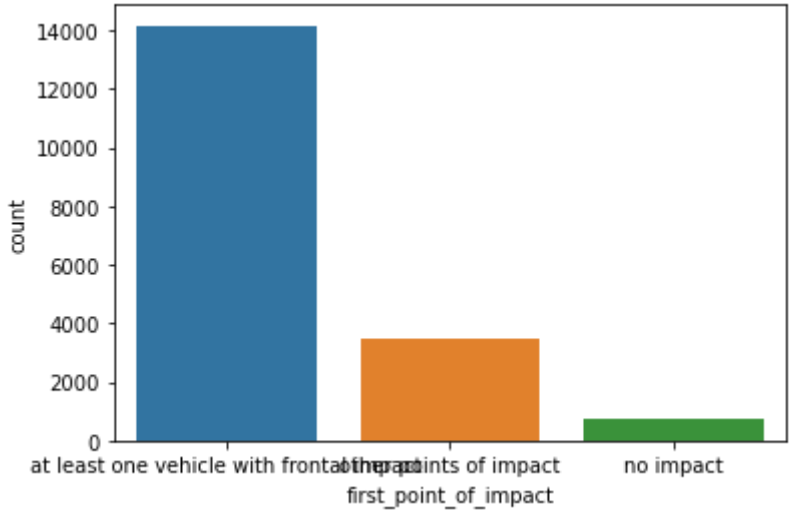
In [25]:
```
sb.countplot(x='hit_object_off_carriageway',data=data)
plt.show()
```

Out[25]:
```
<AxesSubplot:xlabel='hit_object_off_carriageway', ylabel='count'>
```



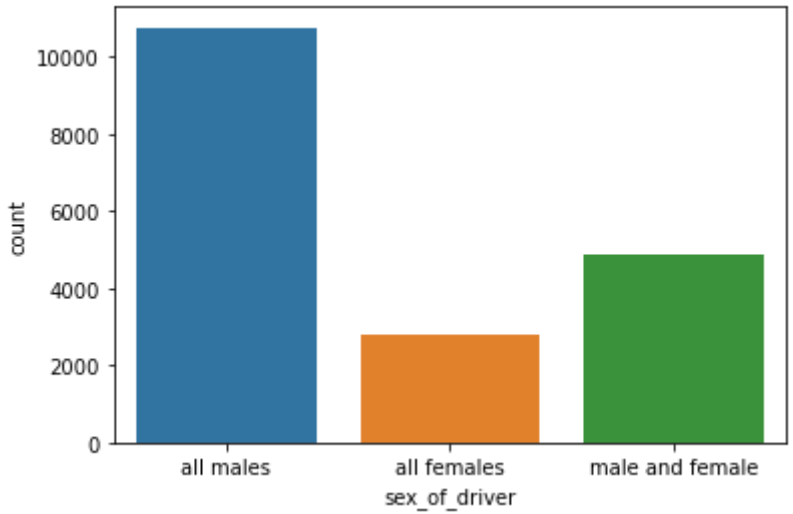
In [26]:
```
sb.countplot(x='first_point_of_impact',data=data)
plt.show()
```

Out[26]: <AxesSubplot:xlabel='first_point_of_impact', ylabel='count'>



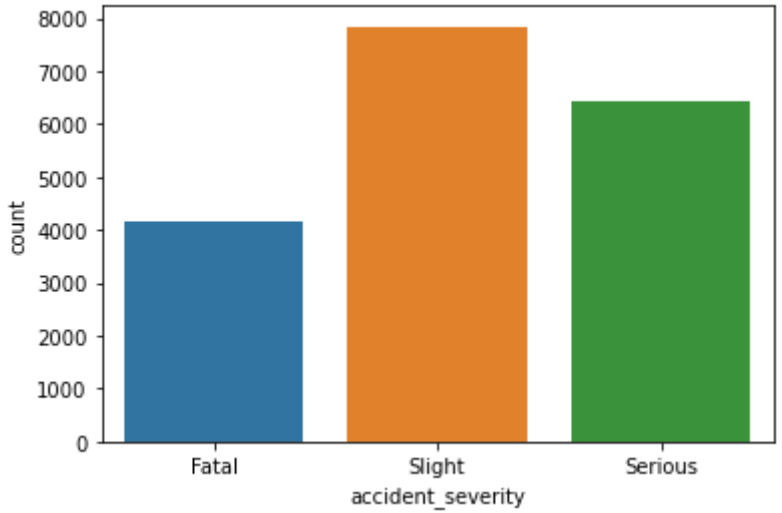
In [27]:
```
sb.countplot(x='sex_of_driver',data=data)
plt.show()
```

Out[27]: <AxesSubplot:xlabel='sex_of_driver', ylabel='count'>



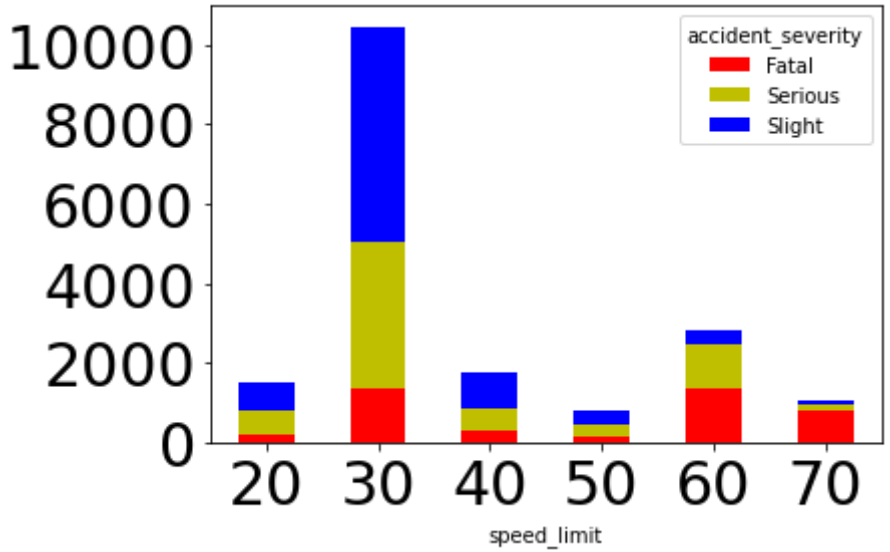
In [28]:
```
sb.countplot(x='accident_severity',data=data)
plt.show()
```

Out[28]: <AxesSubplot:xlabel='accident_severity', ylabel='count'>



In [29]:
```
severity = pd.crosstab(data['speed_limit'], data['accident_severity'])
severity.plot(kind="bar", stacked=True, rot=0,color='r''y''b', fontsize=30)
```

Out[29]:
```
<AxesSubplot:xlabel='speed_limit'>
```



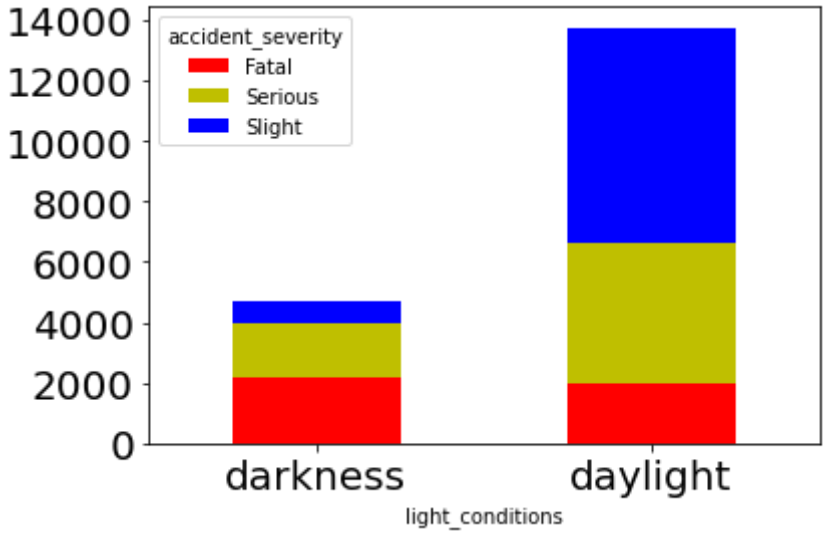
In [30]:
```
severity1 = pd.DataFrame(data.groupby(['light_conditions','accident_severity']).size().reset_index())
severity1
```

Out[30]:

	light_conditions	accident_severity	0
0	darkness	Fatal	2193
1	darkness	Serious	1748
2	darkness	Slight	732
3	daylight	Fatal	1958
4	daylight	Serious	4665
5	daylight	Slight	7107

In [31]:
```
severity1_plot = pd.crosstab(data['light_conditions'], data['accident_severity'])
severity1_plot.plot(kind="bar", stacked=True, rot=0,color='r''y''b', fontsize=20)
```

Out[31]:
```
<AxesSubplot:xlabel='light_conditions'>
```



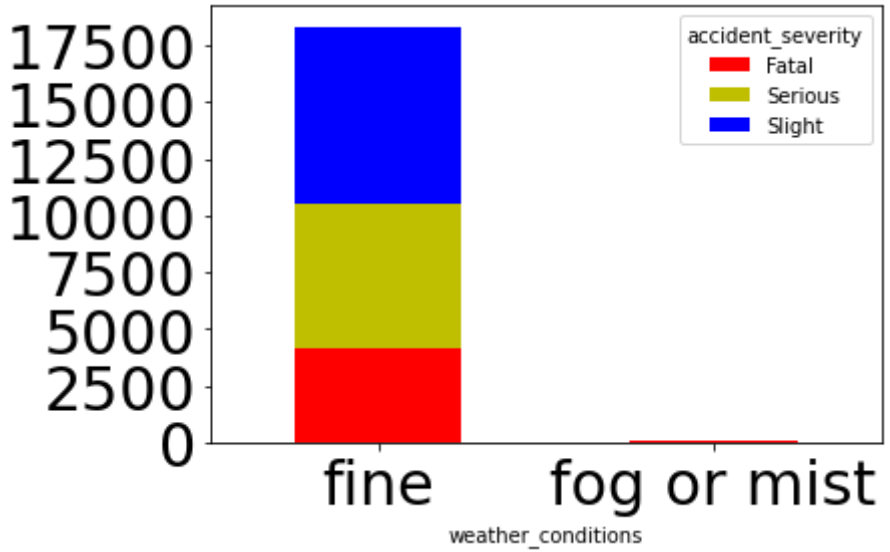
In [32]:
```
severity2 = pd.DataFrame(data.groupby(['weather_conditions','accident_severity']).size().reset_index())
severity2
```

Out[32]:

	weather_conditions	accident_severity	0
0	fine	Fatal	4104
1	fine	Serious	6389
2	fine	Slight	7823
3	fog or mist	Fatal	47
4	fog or mist	Serious	24
5	fog or mist	Slight	16

In [33]:
```
severity2_plot = pd.crosstab(data['weather_conditions'], data['accident_severity'])
severity2_plot.plot(kind="bar", stacked=True, rot=0,color='r''y''b', fontsize=30)
```

Out[33]:
```
<AxesSubplot:xlabel='weather_conditions'>
```



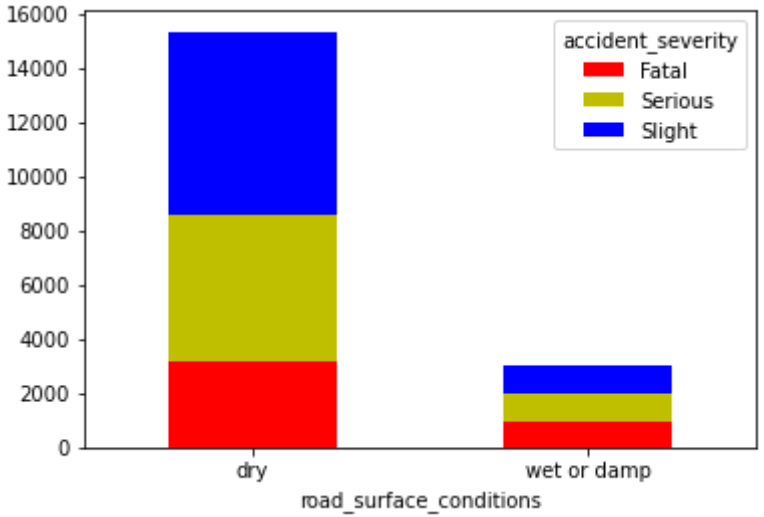
In [34]:
```
severity3 = pd.DataFrame(data.groupby(['road_surface_conditions','accident_severity']).size().reset_index())
severity3
```

Out[34]:

	road_surface_conditions	accident_severity	0
0	dry	Fatal	3181
1	dry	Serious	5406
2	dry	Slight	6752
3	wet or damp	Fatal	970
4	wet or damp	Serious	1007
5	wet or damp	Slight	1087

In [35]:
```
severity3_plot = pd.crosstab(data['road_surface_conditions'], data['accident_severity'])
severity3_plot.plot(kind="bar", stacked=True, rot=0,color='r''y''b')
```

Out[35]:
```
<AxesSubplot:xlabel='road_surface_conditions'>
```



In [36]:
```
severity4 = pd.DataFrame(data.groupby(['vehicle_type','accident_severity']).size().reset_index())
severity4
```

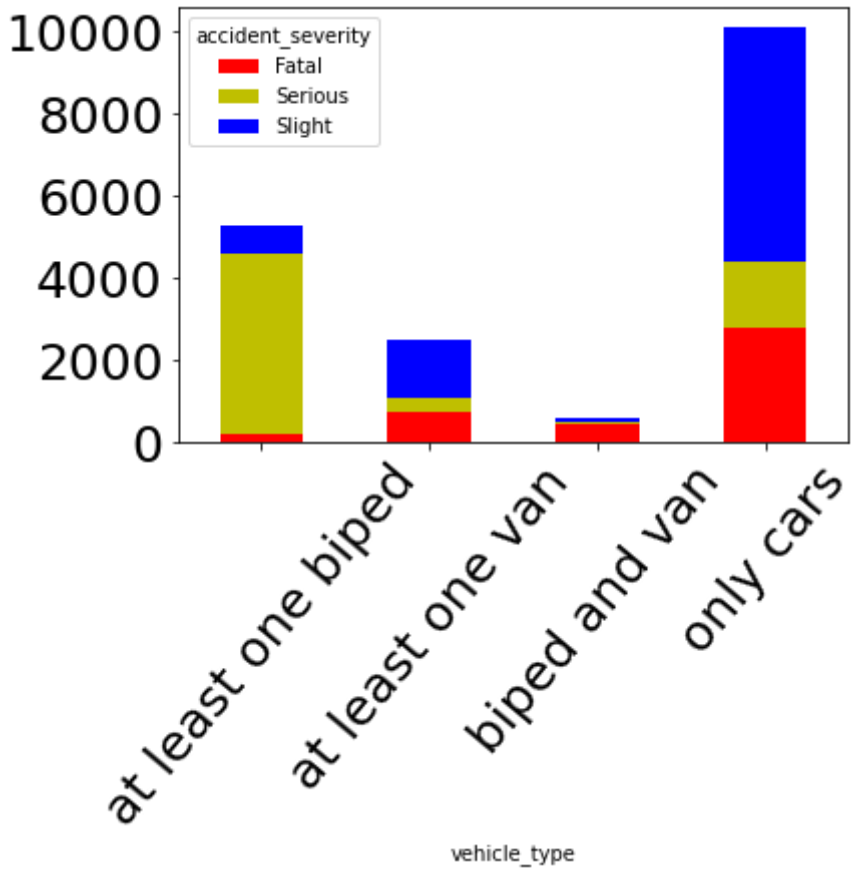
Out[36]:

	vehicle_type	accident_severity	0
0	at least one biped	Fatal	185
1	at least one biped	Serious	4404
2	at least one biped	Slight	664
3	at least one van	Fatal	733
4	at least one van	Serious	356
5	at least one van	Slight	1379
6	biped and van	Fatal	433
7	biped and van	Serious	80

	vehicle_type	accident_severity	0
8	biped and van	Slight	91
9	only cars	Fatal	2800
10	only cars	Serious	1573
11	only cars	Slight	5705

In [37]:
```
severity4_plot = pd.crosstab(data['vehicle_type'], data['accident_severity'])
severity4_plot.plot(kind="bar", stacked=True, rot=50,color='r''y''b', fontsize = 25)
```

Out[37]: <AxesSubplot:xlabel='vehicle_type'>



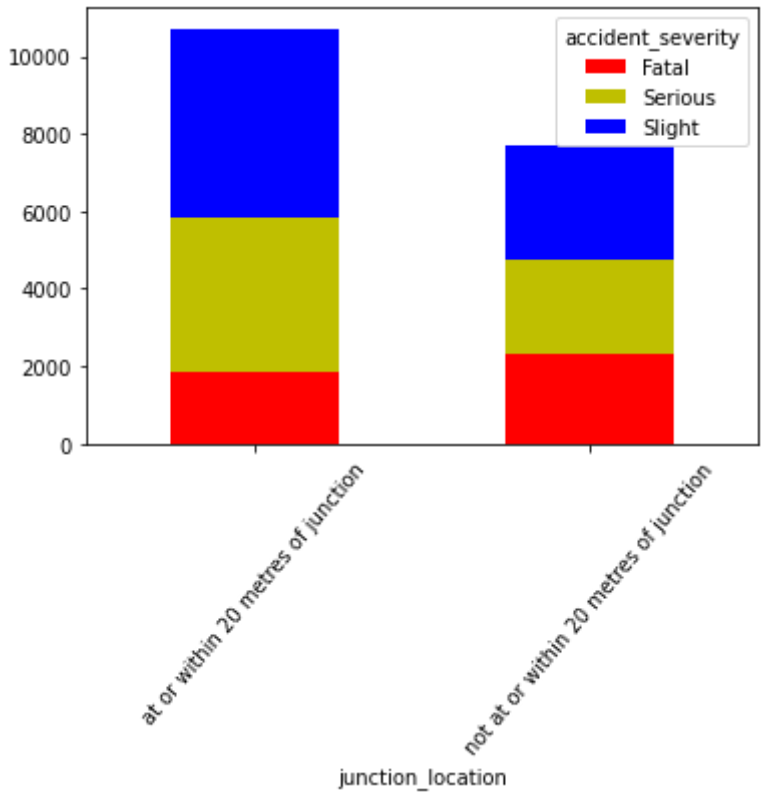
In [38]:
```
severity5 = pd.DataFrame(data.groupby(['junction_location','accident_severity']).size().reset_index())
severity5
```

Out[38]:

	junction_location	accident_severity	0
0	at or within 20 metres of junction	Fatal	1851
1	at or within 20 metres of junction	Serious	3980
2	at or within 20 metres of junction	Slight	4885
3	not at or within 20 metres of junction	Fatal	2300
4	not at or within 20 metres of junction	Serious	2433
5	not at or within 20 metres of junction	Slight	2954

In [39]:
```
severity5_plot = pd.crosstab(data['junction_location'], data['accident_severity'])
severity5_plot.plot(kind="bar", stacked=True, rot=50,color='r''y''b')
```

Out[39]:
```
<AxesSubplot:xlabel='junction_location'>
```



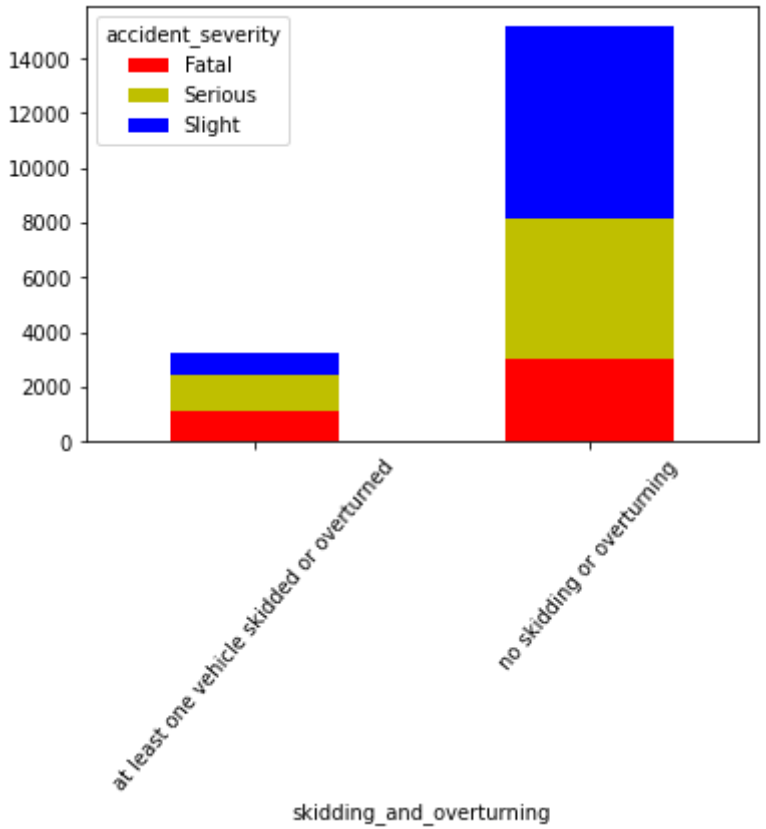
In [40]:
```
severity6 = pd.DataFrame(data.groupby(['skidding_and_overturning','accident_severity']).size().reset_index())
severity6
```

Out[40]:

	skidding_and_overturning	accident_severity	0
0	at least one vehicle skidded or overturned	Fatal	1114
1	at least one vehicle skidded or overturned	Serious	1331
2	at least one vehicle skidded or overturned	Slight	783
3	no skidding or overturning	Fatal	3037
4	no skidding or overturning	Serious	5082
5	no skidding or overturning	Slight	7056

In [41]:
```
severity6_plot = pd.crosstab(data['skidding_and_overturning'], data['accident_severity'])
severity6_plot.plot(kind="bar", stacked=True, rot=50,color='r''y''b')
```

Out[41]:
```
<AxesSubplot:xlabel='skidding_and_overturning'>
```



In [42]:
```
severity7 = pd.DataFrame(data.groupby(['vehicle_leaving_carriageway','accident_severity']).size().reset_index())
severity7
```

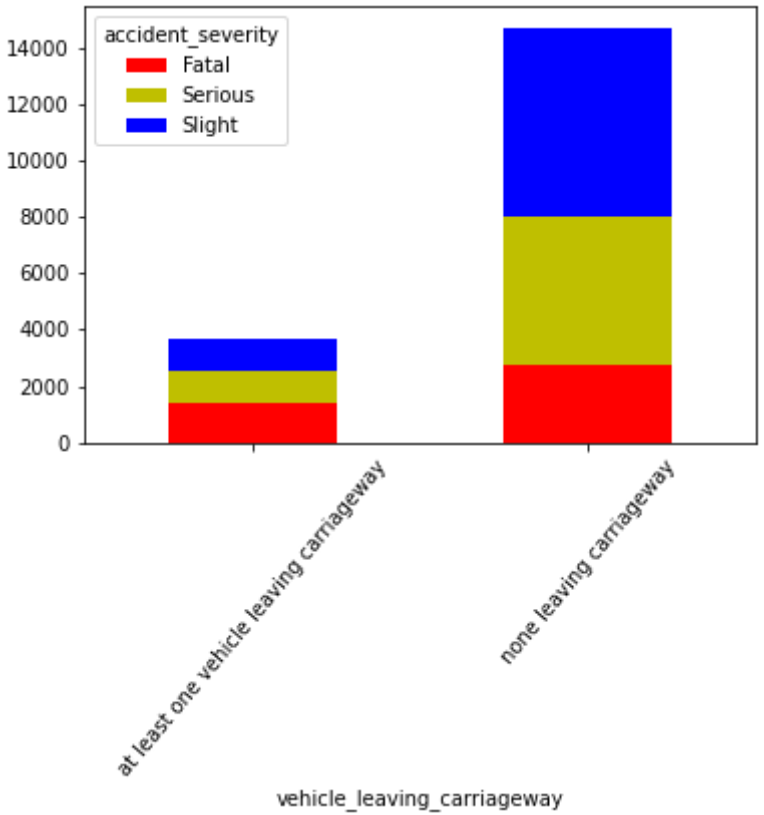
Out[42]:

	vehicle_leaving_carriageway	accident_severity	0
0	at least one vehicle leaving carriageway	Fatal	1427
1	at least one vehicle leaving carriageway	Serious	1121
2	at least one vehicle leaving carriageway	Slight	1117

	vehicle_leaving_carriageway	accident_severity	0
3	none leaving carriageway	Fatal	2724
4	none leaving carriageway	Serious	5292
5	none leaving carriageway	Slight	6722

In [43]:
```
severity7_plot = pd.crosstab(data['vehicle_leaving_carriageway'], data['accident_severity'])
severity7_plot.plot(kind="bar", stacked=True, rot=50,color='r''y''b')
```

Out[43]:
```
<AxesSubplot:xlabel='vehicle_leaving_carriageway'>
```



In [44]:
```
severity8 = pd.DataFrame(data.groupby(['hit_object_off_carriageway','accident_severity']).size().reset_index())
severity8
```

Out[44]:

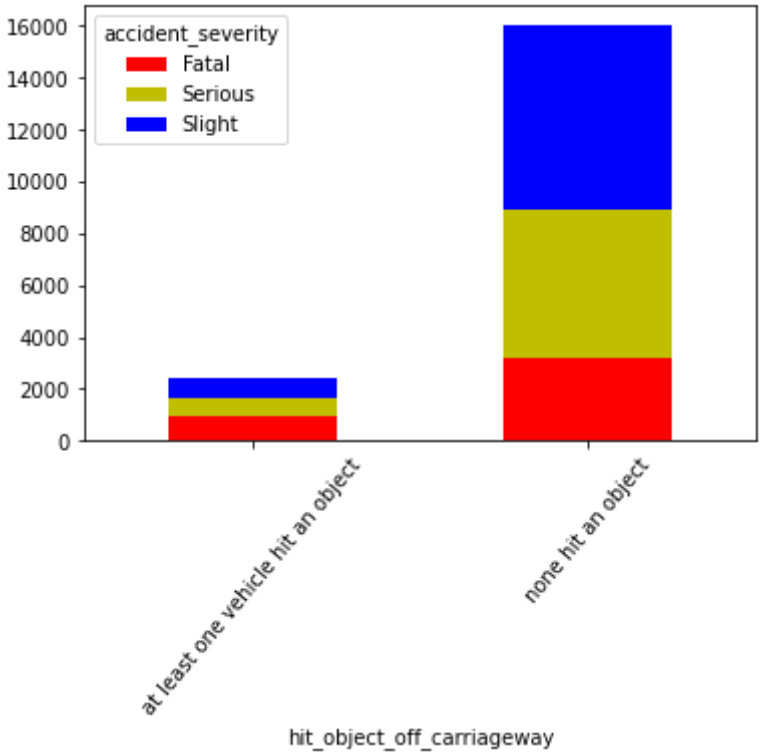
	hit_object_off_carriageway	accident_severity	0
0	at least one vehicle hit an object	Fatal	975
1	at least one vehicle hit an object	Serious	673
2	at least one vehicle hit an object	Slight	731
3	none hit an object	Fatal	3176
4	none hit an object	Serious	5740
5	none hit an object	Slight	7108

In [45]:

```
severity8_plot = pd.crosstab(data['hit_object_off_carriageway'], data['accident_severity'])
severity8_plot.plot(kind="bar", stacked=True, rot=50,color='r''y''b')
```

Out[45]:

```
<AxesSubplot:xlabel='hit_object_off_carriageway'>
```



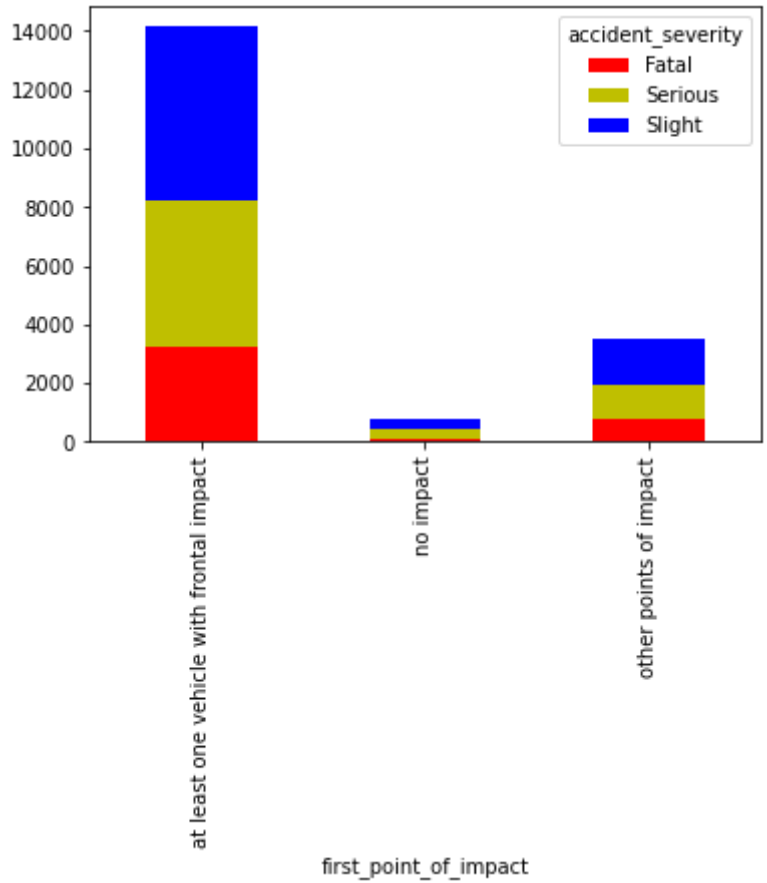
In [46]:
```
severity9 = pd.DataFrame(data.groupby(['first_point_of_impact','accident_severity']).size().reset_index())
severity9
```

Out[46]:

	first_point_of_impact	accident_severity	0
0	at least one vehicle with frontal impact	Fatal	3234
1	at least one vehicle with frontal impact	Serious	4981
2	at least one vehicle with frontal impact	Slight	5934
3	no impact	Fatal	123
4	no impact	Serious	284
5	no impact	Slight	348
6	other points of impact	Fatal	794
7	other points of impact	Serious	1148
8	other points of impact	Slight	1557

In [47]:
```
severity9_plot = pd.crosstab(data['first_point_of_impact'], data['accident_severity'])
severity9_plot.plot(kind="bar", stacked=True, rot=90,color='r''y''b')
```

Out[47]:
```
<AxesSubplot:xlabel='first_point_of_impact'>
```



In [48]:
```
severity10 = pd.DataFrame(data.groupby(['sex_of_driver','accident_severity']).size().reset_index())
severity10
```

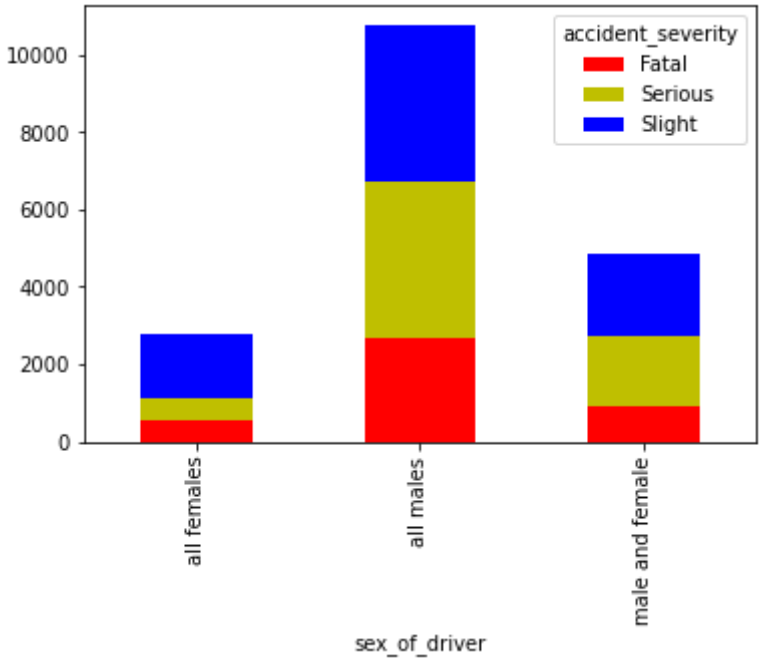
Out[48]:

	sex_of_driver	accident_severity	0
0	all females	Fatal	551
1	all females	Serious	585
2	all females	Slight	1655
3	all males	Fatal	2668
4	all males	Serious	4045

	sex_of_driver	accident_severity	0
5	all males	Slight	4037
6	male and female	Fatal	932
7	male and female	Serious	1783
8	male and female	Slight	2147

In [49]:
```
severity10_plot = pd.crosstab(data['sex_of_driver'], data['accident_severity'])
severity10_plot.plot(kind="bar", stacked=True, rot=90,color='r''y''b')
```

Out[49]:
```
<AxesSubplot:xlabel='sex_of_driver'>
```



In [50]:
```
severity11 = pd.DataFrame(data.groupby(['age_of_oldest_driver','accident_severity']).size().reset_index())
severity11
```

Out[50]:

	age_of_oldest_driver	accident_severity	0
0	10.0	Serious	1
1	11.0	Serious	1
2	11.0	Slight	1
3	12.0	Serious	2
4	12.0	Slight	1
5	13.0	Serious	3
6	14.0	Slight	1
7	15.0	Serious	4
8	15.0	Slight	2
9	16.0	Serious	19
10	16.0	Slight	4
11	17.0	Fatal	29
12	17.0	Serious	45
13	17.0	Slight	34
14	18.0	Fatal	68
15	18.0	Serious	64
16	18.0	Slight	52
17	19.0	Fatal	64
18	19.0	Serious	63
19	19.0	Slight	45
20	20.0	Fatal	55
21	20.0	Serious	57
22	20.0	Slight	71
23	21.0	Fatal	61

	age_of_oldest_driver	accident_severity	0
24	21.0	Serious	60
25	21.0	Slight	62
26	22.0	Fatal	61
27	22.0	Serious	75
28	22.0	Slight	55
29	23.0	Fatal	57
30	23.0	Serious	74
31	23.0	Slight	80
32	24.0	Fatal	71
33	24.0	Serious	62
34	24.0	Slight	93
35	25.0	Fatal	70
36	25.0	Serious	94
37	25.0	Slight	107
38	26.0	Fatal	43
39	26.0	Serious	84
40	26.0	Slight	109
41	27.0	Fatal	67
42	27.0	Serious	104
43	27.0	Slight	107
44	28.0	Fatal	84
45	28.0	Serious	89
46	28.0	Slight	111
47	29.0	Fatal	71

	age_of_oldest_driver	accident_severity	0
48	29.0	Serious	92
49	29.0	Slight	127
50	30.0	Fatal	83
51	30.0	Serious	149
52	30.0	Slight	216
53	31.0	Fatal	66
54	31.0	Serious	119
55	31.0	Slight	118
56	32.0	Fatal	87
57	32.0	Serious	146
58	32.0	Slight	148
59	33.0	Fatal	59
60	33.0	Serious	104
61	33.0	Slight	132
62	34.0	Fatal	71
63	34.0	Serious	123
64	34.0	Slight	135
65	35.0	Fatal	76
66	35.0	Serious	121
67	35.0	Slight	162
68	36.0	Fatal	71
69	36.0	Serious	88
70	36.0	Slight	148
71	37.0	Fatal	87

	age_of_oldest_driver	accident_severity	0
72	37.0	Serious	133
73	37.0	Slight	125
74	38.0	Fatal	73
75	38.0	Serious	125
76	38.0	Slight	139
77	39.0	Fatal	67
78	39.0	Serious	123
79	39.0	Slight	173
80	40.0	Fatal	104
81	40.0	Serious	127
82	40.0	Slight	166
83	41.0	Fatal	86
84	41.0	Serious	94
85	41.0	Slight	163
86	42.0	Fatal	68
87	42.0	Serious	113
88	42.0	Slight	159
89	43.0	Fatal	68
90	43.0	Serious	111
91	43.0	Slight	144
92	44.0	Fatal	74
93	44.0	Serious	101
94	44.0	Slight	159
95	45.0	Fatal	57

	age_of_oldest_driver	accident_severity	0
96	45.0	Serious	114
97	45.0	Slight	177
98	46.0	Fatal	73
99	46.0	Serious	136
100	46.0	Slight	137
101	47.0	Fatal	76
102	47.0	Serious	143
103	47.0	Slight	172
104	48.0	Fatal	85
105	48.0	Serious	175
106	48.0	Slight	190
107	49.0	Fatal	68
108	49.0	Serious	156
109	49.0	Slight	164
110	50.0	Fatal	98
111	50.0	Serious	170
112	50.0	Slight	203
113	51.0	Fatal	102
114	51.0	Serious	138
115	51.0	Slight	163
116	52.0	Fatal	83
117	52.0	Serious	136
118	52.0	Slight	166
119	53.0	Fatal	99

	age_of_oldest_driver	accident_severity	0
120	53.0	Serious	153
121	53.0	Slight	173
122	54.0	Fatal	108
123	54.0	Serious	138
124	54.0	Slight	182
125	55.0	Fatal	64
126	55.0	Serious	135
127	55.0	Slight	162
128	56.0	Fatal	95
129	56.0	Serious	142
130	56.0	Slight	169
131	57.0	Fatal	97
132	57.0	Serious	122
133	57.0	Slight	152
134	58.0	Fatal	74
135	58.0	Serious	128
136	58.0	Slight	150
137	59.0	Fatal	82
138	59.0	Serious	121
139	59.0	Slight	114
140	60.0	Fatal	63
141	60.0	Serious	115
142	60.0	Slight	159
143	61.0	Fatal	73

	age_of_oldest_driver	accident_severity	0
144	61.0	Serious	108
145	61.0	Slight	125
146	62.0	Fatal	53
147	62.0	Serious	114
148	62.0	Slight	115
149	63.0	Fatal	52
150	63.0	Serious	81
151	63.0	Slight	108
152	64.0	Fatal	40
153	64.0	Serious	86
154	64.0	Slight	78
155	65.0	Fatal	66
156	65.0	Serious	86
157	65.0	Slight	100
158	66.0	Fatal	44
159	66.0	Serious	66
160	66.0	Slight	92
161	67.0	Fatal	34
162	67.0	Serious	55
163	67.0	Slight	64
164	68.0	Fatal	39
165	68.0	Serious	52
166	68.0	Slight	83
167	69.0	Fatal	29

	age_of_oldest_driver	accident_severity	0
168	69.0	Serious	54
169	69.0	Slight	68
170	70.0	Fatal	38
171	70.0	Serious	63
172	70.0	Slight	75
173	71.0	Fatal	33
174	71.0	Serious	71
175	71.0	Slight	77
176	72.0	Fatal	34
177	72.0	Serious	71
178	72.0	Slight	82
179	73.0	Fatal	27
180	73.0	Serious	47
181	73.0	Slight	77
182	74.0	Fatal	29
183	74.0	Serious	55
184	74.0	Slight	78
185	75.0	Fatal	31
186	75.0	Serious	42
187	75.0	Slight	71
188	76.0	Fatal	28
189	76.0	Serious	39
190	76.0	Slight	45
191	77.0	Fatal	28

	age_of_oldest_driver	accident_severity	0
192	77.0	Serious	38
193	77.0	Slight	46
194	78.0	Fatal	20
195	78.0	Serious	32
196	78.0	Slight	48
197	79.0	Fatal	23
198	79.0	Serious	41
199	79.0	Slight	54
200	80.0	Fatal	24
201	80.0	Serious	33
202	80.0	Slight	50
203	81.0	Fatal	24
204	81.0	Serious	26
205	81.0	Slight	32
206	82.0	Fatal	27
207	82.0	Serious	23
208	82.0	Slight	45
209	83.0	Fatal	17
210	83.0	Serious	23
211	83.0	Slight	38
212	84.0	Fatal	12
213	84.0	Serious	24
214	84.0	Slight	43
215	85.0	Fatal	12

	age_of_oldest_driver	accident_severity	0
216	85.0	Serious	19
217	85.0	Slight	27
218	86.0	Fatal	10
219	86.0	Serious	13
220	86.0	Slight	27
221	87.0	Fatal	12
222	87.0	Serious	15
223	87.0	Slight	34
224	88.0	Fatal	6
225	88.0	Serious	13
226	88.0	Slight	20
227	89.0	Fatal	5
228	89.0	Serious	7
229	89.0	Slight	16
230	90.0	Fatal	6
231	90.0	Serious	10
232	90.0	Slight	10
233	91.0	Fatal	1
234	91.0	Serious	5
235	91.0	Slight	9
236	92.0	Fatal	1
237	92.0	Serious	4
238	92.0	Slight	5
239	93.0	Fatal	3

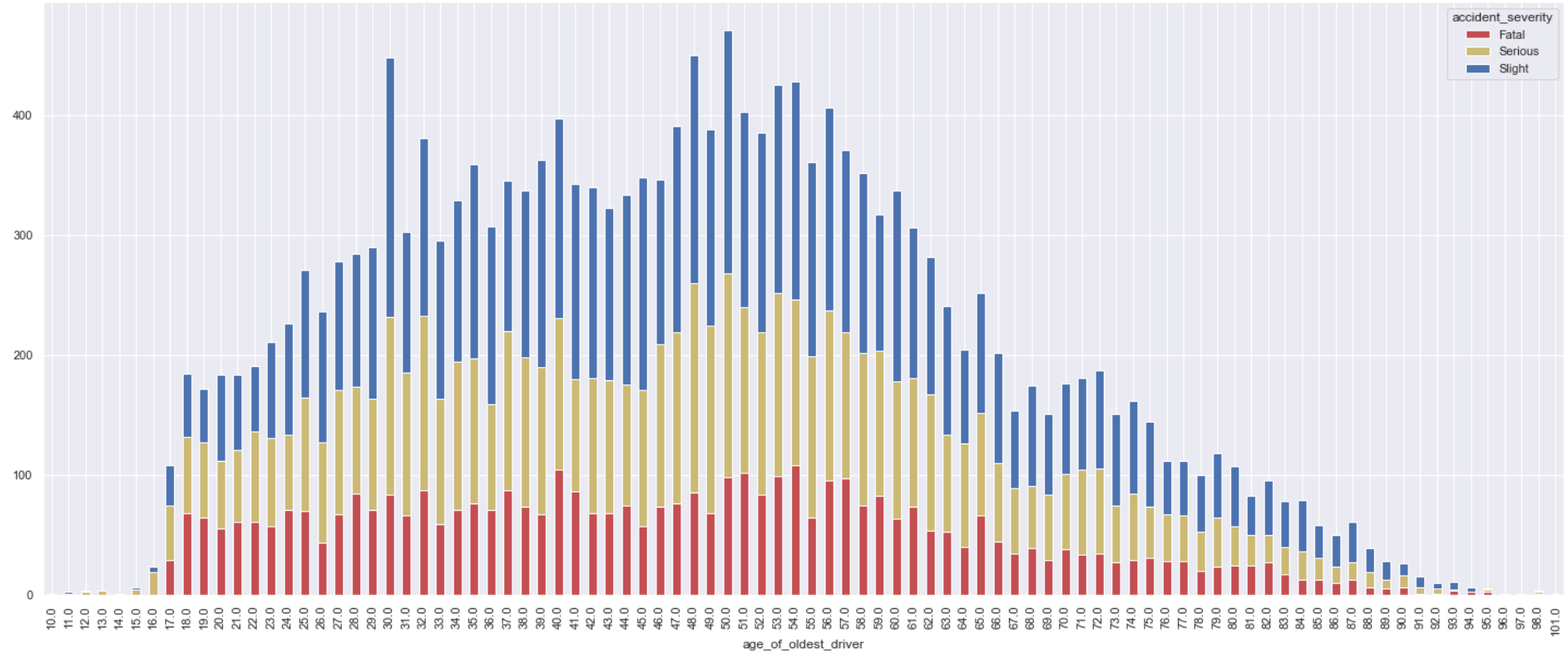
	age_of_oldest_driver	accident_severity	0
240	93.0	Serious	1
241	93.0	Slight	7
242	94.0	Fatal	2
243	94.0	Slight	4
244	95.0	Fatal	2
245	95.0	Serious	2
246	95.0	Slight	1
247	96.0	Slight	1
248	97.0	Serious	1
249	98.0	Fatal	1
250	98.0	Serious	1
251	98.0	Slight	1
252	101.0	Slight	1

In [51]:

```
sns.set(rc={'figure.figsize':(25,10)})
severity10_plot = pd.crosstab(data['age_of_oldest_driver'], data['accident_severity'])
severity10_plot.plot(kind="bar", stacked=True, rot=90,color='r''y''b')
```

Out[51]:

```
<AxesSubplot:xlabel='age_of_oldest_driver'>
```



In [52]:
```
data.groupby(['speed_limit', 'road_surface_conditions'])[[
    'accident_severity'
]].count().reset_index().sort_values(by='speed_limit')
```

Out[52]:

	speed_limit	road_surface_conditions	accident_severity
0	20	dry	1340
1	20	wet or damp	187
2	30	dry	8869
3	30	wet or damp	1572
4	40	dry	1448
5	40	wet or damp	322

	speed_limit	road_surface_conditions	accident_severity
6	50	dry	662
7	50	wet or damp	155
8	60	dry	2155
9	60	wet or damp	648
10	70	dry	865
11	70	wet or damp	180

In [53]:
```
data.groupby(['speed_limit', 'vehicle_type'])[[
    'accident_severity'
]].count().reset_index().sort_values(by='speed_limit')
```

Out[53]:

	speed_limit	vehicle_type	accident_severity
0	20	at least one biped	592
1	20	at least one van	215
2	20	biped and van	90
3	20	only cars	630
4	30	at least one biped	3268
5	30	at least one van	1194
6	30	biped and van	343
7	30	only cars	5636
10	40	biped and van	57
11	40	only cars	1017
8	40	at least one biped	449
9	40	at least one van	247
12	50	at least one biped	188

	speed_limit	vehicle_type	accident_severity
13	50	at least one van	141
14	50	biped and van	25
15	50	only cars	463
16	60	at least one biped	628
17	60	at least one van	366
18	60	biped and van	70
19	60	only cars	1739
22	70	biped and van	19
20	70	at least one biped	128
21	70	at least one van	305
23	70	only cars	593

Converting 'Object' to 'category' dtype - Saves memory

In [54]:
```
for col in set(data.columns) - set(data.describe().columns):
    data[col] = data[col].astype('category')
```

In [55]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 18403 entries, 1 to 31645
Data columns (total 14 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   accident_index              18403 non-null  category
 1   speed_limit                 18403 non-null  int64
 2   light_conditions            18403 non-null  category
 3   weather_conditions          18403 non-null  category
 4   road_surface_conditions     18403 non-null  category
 5   vehicle_type                18403 non-null  category
 6   junction_location           18403 non-null  category
 7   skidding_and_overturning    18403 non-null  category
```

```
 8   vehicle_leaving_carriageway  18403 non-null  category
 9   hit_object_off_carriageway   18403 non-null  category
 10  first_point_of_impact        18403 non-null  category
 11  sex_of_driver                18403 non-null  category
 12  age_of_oldest_driver         18403 non-null  float64
 13  accident_severity            18403 non-null  category
dtypes: category(12), float64(1), int64(1)
memory usage: 1.8 MB
```

4.2 Look into the data pattern first we will check the 'label'

Dimensionality Reduction

In [56]:
```
data_new= data.drop(["accident_index","junction_location","weather_conditions"],axis=1, inplace= False)
data_new.head(3)
```

Out[56]:

	speed_limit	light_conditions	road_surface_conditions	vehicle_type	skidding_and_overturning	vehicle_leaving_carriageway	hit_object_off_carriageway	firs
1	30	darkness	dry	only cars	no skidding or overturning	at least one vehicle leaving carriageway	at least one vehicle hit an object	
4	30	daylight	dry	only cars	no skidding or overturning	none leaving carriageway	none hit an object	
6	30	darkness	wet or damp	only cars	no skidding or overturning	none leaving carriageway	none hit an object	

In [57]:
```
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
data_en=data_new.apply(le.fit_transform)
data_en.head()
```

Out[57]:

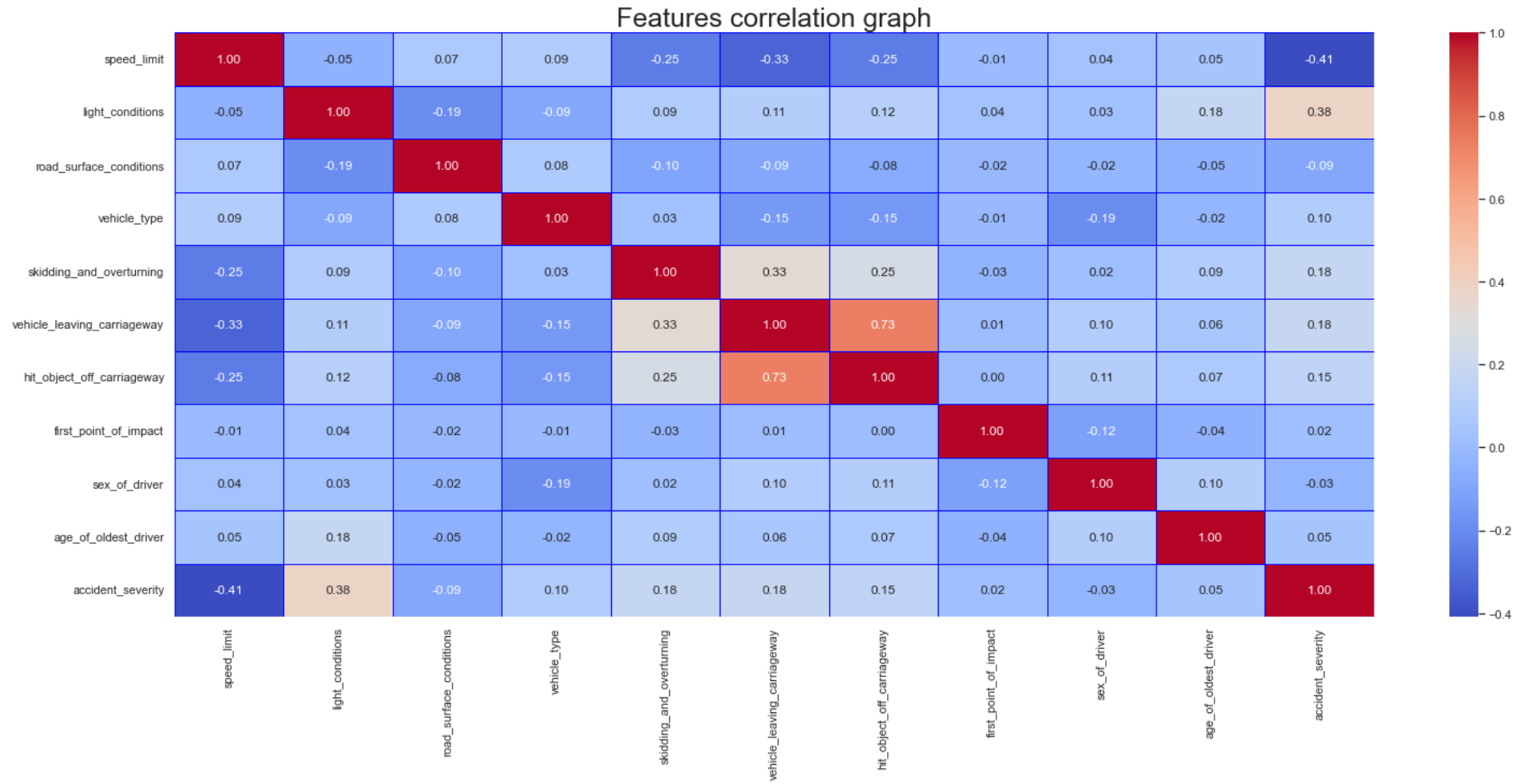
	speed_limit	light_conditions	road_surface_conditions	vehicle_type	skidding_and_overturning	vehicle_leaving_carriageway	hit_object_off_carriageway	firs
1	1	0	0	3	1	0	0	
4	1	1	0	3	1	1	1	
6	1	0	1	3	1	1	1	

	speed_limit	light_conditions	road_surface_conditions	vehicle_type	skidding_and_overturning	vehicle_leaving_carriageway	hit_object_off_carriageway	firs
7	3	1	0	3	1	1	1	
8	4	1	0	1	1	1	1	

In [58]:
```
sns.heatmap(data_en.corr(), annot=True, linewidth=0.5, linecolor="blue", fmt= '.2f',cmap="coolwarm")
plt.title("Features correlation graph", fontsize= 25)
plt.show()
```

Out[58]:
```
<AxesSubplot:>
```

Out[58]:
```
Text(0.5, 1.0, 'Features correlation graph')
```



In [59]:
```
data_x = data_en.drop('accident_severity', axis=1)
data_y = data_en['accident_severity']
print(data_x.shape)
```

```
(18403, 10)
```

In [60]:
```
data_x.head(5)
```

Out[60]:

	speed_limit	light_conditions	road_surface_conditions	vehicle_type	skidding_and_overturning	vehicle_leaving_carriageway	hit_object_off_carriageway	firs
1	1	0	0	3	1	0	0	
4	1	1	0	3	1	1	1	
6	1	0	1	3	1	1	1	
7	3	1	0	3	1	1	1	
8	4	1	0	1	1	1	1	

In [61]:
```
# standardize data
sc = StandardScaler()
data_X = sc.fit_transform(data_x)
print(data_X.shape,data_y.shape)
```

```
(18403, 10) (18403,)
```

In [62]:
```
# split into training and testing
x_train,x_test, y_train,y_test = train_test_split(data_X, data_y, test_size=0.2, random_state=42)
print(x_train.shape,x_test.shape, y_train.shape,y_test.shape)
```

```
(14722, 10) (3681, 10) (14722,) (3681,)
```

In [63]:
```
data_en.accident_severity.value_counts()
```

Out[63]:
```
2    7839
1    6413
0    4151
Name: accident_severity, dtype: int64
```

In [64]:
```
!pip install imblearn
```

```
Requirement already satisfied: imblearn in c:\programdata\anaconda3\lib\site-packages (0.0)
Requirement already satisfied: imbalanced-learn in c:\programdata\anaconda3\lib\site-packages (from imblearn) (0.10.1)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from imbalanced-learn->imblear
n) (2.2.0)
Requirement already satisfied: numpy>=1.17.3 in c:\programdata\anaconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.2
2.4)
```

```
Requirement already satisfied: joblib>=1.1.1 in c:\programdata\anaconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.2.
0)
Requirement already satisfied: scipy>=1.3.2 in c:\programdata\anaconda3\lib\site-packages (from imbalanced-learn->imblearn) (1.7.
1)
Requirement already satisfied: scikit-learn>=1.0.2 in c:\programdata\anaconda3\lib\site-packages (from imbalanced-learn->imblearn)
(1.2.2)
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```

Performing Oversampling

In [65]:

```
from imblearn.over_sampling import RandomOverSampler

data_X = data_en.drop('accident_severity', axis=1)
data_y = data_en['accident_severity']

ros = RandomOverSampler(random_state=42)
X_resampled, y_resampled = ros.fit_resample(data_X, data_y)

# check the class distribution after oversampling
pd.Series(y_resampled).value_counts()
```

Out[65]:

```
0    7839
2    7839
1    7839
Name: accident_severity, dtype: int64
```

In [66]:

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score

# Split data into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X_resampled, y_resampled, test_size=0.2, random_state=42)

# Initialize models
```

```
models = {
    'Decision Tree': DecisionTreeClassifier(random_state=42),
    'Random Forest': RandomForestClassifier(random_state=42),
    'Logistic Regression': LogisticRegression(random_state=42),
    'K-Nearest Neighbors': KNeighborsClassifier(),
    'Gaussian Naive Bayes': GaussianNB(),
    'Support Vector Machine': SVC(random_state=42),
}

# Train and evaluate models
for name, model in models.items():
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)
    print(f'{name}: {accuracy}')
```

Out[66]:
```
DecisionTreeClassifier
DecisionTreeClassifier(random_state=42)
```

```
Decision Tree: 0.7876275510204082
```

Out[66]:
```
RandomForestClassifier
RandomForestClassifier(random_state=42)
```

```
Random Forest: 0.7980442176870748
```

Out[66]:
```
LogisticRegression
LogisticRegression(random_state=42)
```

```
Logistic Regression: 0.7070578231292517
```

Out[66]:
```
KNeighborsClassifier
KNeighborsClassifier()
```

```
K-Nearest Neighbors: 0.7527636054421769
```

Out[66]:
```
GaussianNB
GaussianNB()
```

```
Gaussian Naive Bayes: 0.6977040816326531
```

Out[66]:
```
SVC
SVC(random_state=42)
```

```
Support Vector Machine: 0.6645408163265306
```

In [67]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score, precision_score, recall_score, confusion_matrix
from sklearn.model_selection import train_test_split

# Load data and split into training and testing sets
X = data_en.drop('accident_severity', axis=1)
y = data_en['accident_severity']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Define models
dt_model = DecisionTreeClassifier(random_state=42)
rf_model = RandomForestClassifier(n_estimators=100, random_state=42)
nb_model = MultinomialNB()
svm_model = SVC(kernel='linear', random_state=42)
gb_model = GradientBoostingClassifier(random_state=42)

# Fit models
dt_model.fit(X_train, y_train)
rf_model.fit(X_train, y_train)
nb_model.fit(X_train, y_train)
svm_model.fit(X_train, y_train)
gb_model.fit(X_train, y_train)

# Make predictions
dt_preds = dt_model.predict(X_test)
rf_preds = rf_model.predict(X_test)
nb_preds = nb_model.predict(X_test)
svm_preds = svm_model.predict(X_test)
gb_preds = gb_model.predict(X_test)

# Evaluate models
print("Decision Tree Accuracy:", accuracy_score(y_test, dt_preds))
print("Random Forest Accuracy:", accuracy_score(y_test, rf_preds))
print("Naive Bayes Accuracy:", accuracy_score(y_test, nb_preds))
```

```
print("SVM Accuracy:", accuracy_score(y_test, svm_preds))
print("Gradient Boosting Accuracy:", accuracy_score(y_test, gb_preds))

print("Decision Tree Precision:", precision_score(y_test, dt_preds, average='weighted'))
print("Random Forest Precision:", precision_score(y_test, rf_preds, average='weighted'))
print("Naive Bayes Precision:", precision_score(y_test, nb_preds, average='weighted'))
print("SVM Precision:", precision_score(y_test, svm_preds, average='weighted'))
print("Gradient Boosting Precision:", precision_score(y_test, gb_preds, average='weighted'))

print("Decision Tree Recall:", recall_score(y_test, dt_preds, average='weighted'))
print("Random Forest Recall:", recall_score(y_test, rf_preds, average='weighted'))
print("Naive Bayes Recall:", recall_score(y_test, nb_preds, average='weighted'))
print("SVM Recall:", recall_score(y_test, svm_preds, average='weighted'))
print("Gradient Boosting Recall:", recall_score(y_test, gb_preds, average='weighted'))

print("Decision Tree Confusion Matrix:\n", confusion_matrix(y_test, dt_preds))
print("Random Forest Confusion Matrix:\n", confusion_matrix(y_test, rf_preds))
print("Naive Bayes Confusion Matrix:\n", confusion_matrix(y_test, nb_preds))
print("SVM Confusion Matrix:\n", confusion_matrix(y_test, svm_preds))
print("Gradient Boosting Confusion Matrix:\n", confusion_matrix(y_test, gb_preds))
```

Out[67]:
```
▾ DecisionTreeClassifier
DecisionTreeClassifier(random_state=42)
```

Out[67]:
```
▾ RandomForestClassifier
RandomForestClassifier(random_state=42)
```

Out[67]:
```
▾ MultinomialNB
MultinomialNB()
```

Out[67]:
```
▾ SVC
SVC(kernel='linear', random_state=42)
```

Out[67]:
```
▾ GradientBoostingClassifier
GradientBoostingClassifier(random_state=42)
```

```
Decision Tree Accuracy: 0.7150230915512089
Random Forest Accuracy: 0.7400162999185004
Naive Bayes Accuracy: 0.675903287150231
SVM Accuracy: 0.689214887258897
Gradient Boosting Accuracy: 0.7845694104862809
Decision Tree Precision: 0.7178686443544975
Random Forest Precision: 0.7426649374185417
Naive Bayes Precision: 0.6722582394112191
SVM Precision: 0.711823897140308
Gradient Boosting Precision: 0.8106164787378416
Decision Tree Recall: 0.7150230915512089
Random Forest Recall: 0.7400162999185004
Naive Bayes Recall: 0.675903287150231
SVM Recall: 0.689214887258897
Gradient Boosting Recall: 0.7845694104862809
Decision Tree Confusion Matrix:
 [[ 560  160  100]
 [ 184  883  218]
 [ 140  247 1189]]
Random Forest Confusion Matrix:
 [[ 581  140   99]
 [ 185  907  193]
 [ 130  210 1236]]
Naive Bayes Confusion Matrix:
 [[ 404  126  290]
 [ 159  914  212]
 [ 105  301 1170]]
SVM Confusion Matrix:
 [[ 591  156   73]
 [ 219  944  122]
 [ 167  407 1002]]
Gradient Boosting Confusion Matrix:
 [[ 764   28   28]
 [ 262  878  145]
 [ 200  130 1246]]
```

In [68]:

```
!pip install xgboost
```

```
Requirement already satisfied: xgboost in c:\programdata\anaconda3\lib\site-packages (1.7.5)
Requirement already satisfied: numpy in c:\programdata\anaconda3\lib\site-packages (from xgboost) (1.22.4)
Requirement already satisfied: scipy in c:\programdata\anaconda3\lib\site-packages (from xgboost) (1.7.1)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
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```

In [69]:

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier, AdaBoostClassifier
from sklearn.naive_bayes import MultinomialNB, GaussianNB
from sklearn.svm import SVC, LinearSVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, precision_score, recall_score, confusion_matrix
from sklearn.model_selection import train_test_split
import xgboost as XGBClassifier
from xgboost import XGBClassifier
import pandas as pd


# Split data into training and testing sets
X = data_en.drop('accident_severity', axis=1)
y = data_en['accident_severity']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Define models
dt_model = DecisionTreeClassifier(random_state=42)
rf_model = RandomForestClassifier(n_estimators=100, random_state=42)
nb_model = MultinomialNB()
gnb_model = GaussianNB()
svm_model = SVC(kernel='linear', random_state=42)
lsvm_model = LinearSVC(random_state=42)
knn_model = KNeighborsClassifier(n_neighbors=5)
lr_model = LogisticRegression(random_state=42)
gb_model = GradientBoostingClassifier(random_state=42)
ada_model = AdaBoostClassifier(random_state=42)
xgb_model = XGBClassifier(random_state=42)


# Fit models
dt_model.fit(X_train, y_train)
rf_model.fit(X_train, y_train)
nb_model.fit(X_train, y_train)
gnb_model.fit(X_train, y_train)
svm_model.fit(X_train, y_train)
lsvm_model.fit(X_train, y_train)
knn_model.fit(X_train, y_train)
lr_model.fit(X_train, y_train)
gb_model.fit(X_train, y_train)
```

```
ada_model.fit(X_train, y_train)
xgb_model.fit(X_train, y_train)

# Make predictions
dt_preds = dt_model.predict(X_test)
rf_preds = rf_model.predict(X_test)
nb_preds = nb_model.predict(X_test)
gnb_preds = gnb_model.predict(X_test)
svm_preds = svm_model.predict(X_test)
lsvm_preds = lsvm_model.predict(X_test)
knn_preds = knn_model.predict(X_test)
lr_preds = lr_model.predict(X_test)
gb_preds = gb_model.predict(X_test)
ada_preds = ada_model.predict(X_test)
xgb_preds = xgb_model.predict(X_test)

# Evaluate models
print("Decision Tree Accuracy:", accuracy_score(y_test, dt_preds))
print("Random Forest Accuracy:", accuracy_score(y_test, rf_preds))
print("Naive Bayes Accuracy:", accuracy_score(y_test, nb_preds))
print("Gaussian Naive Bayes Accuracy:", accuracy_score(y_test, gnb_preds))
print("SVM Accuracy:", accuracy_score(y_test, svm_preds))
print("Linear SVM Accuracy:", accuracy_score(y_test, lsvm_preds))
print("KNN Accuracy:", accuracy_score(y_test, knn_preds))
print("Logistic Regression Accuracy:", accuracy_score(y_test, lr_preds))
print("Gradient Boosting Accuracy:", accuracy_score(y_test, gb_preds))
print("AdaBoost Accuracy:", accuracy_score(y_test, ada_preds))
print("xgboost Accuracy:", accuracy_score(y_test, xgb_preds))

print("Decision Tree Precision:", precision_score(y_test, dt_preds, average='weighted'))
print("Random Forest Precision:", precision_score(y_test, rf_preds, average='weighted'))
print("Naive Bayes Precision:", precision_score(y_test, nb_preds, average='weighted'))
print("Gaussian Naive Bayes Precision:", precision_score(y_test, gnb_preds, average='weighted'))
print("SVM Precision:", precision_score(y_test, svm_preds, average='weighted'))
print("Linear SVM Precision:", precision_score(y_test,lsvm_preds, average='weighted'))
print("KNN Precision:", precision_score(y_test, knn_preds, average='weighted'))
print("Logistic Regression Precision:", precision_score(y_test, lr_preds, average='weighted'))
print("Gradient Boosting Precision:", precision_score(y_test, gb_preds, average='weighted'))
print("AdaBoost Precision:", precision_score(y_test, ada_preds, average='weighted'))
print("Decision Tree Precision:", precision_score(y_test, dt_preds, average='weighted'))
print("Random Forest Precision:", precision_score(y_test, rf_preds, average='weighted'))

print("Decision Tree recall:", recall_score(y_test, dt_preds, average='weighted'))
print("Random Forest recall:", recall_score(y_test, rf_preds, average='weighted'))
```

```
print("Naive Bayes recall:", recall_score(y_test, nb_preds, average='weighted'))
print("Gaussian Naive Bayes recall:", recall_score(y_test, gnb_preds, average='weighted'))
print("SVM recall:", recall_score(y_test, svm_preds, average='weighted'))
print("Linear SVM recall:", recall_score(y_test,lsvm_preds, average='weighted'))
print("KNN recall:", recall_score(y_test, knn_preds, average='weighted'))
print("Logistic Regression recall:", recall_score(y_test, lr_preds, average='weighted'))
print("Gradient Boosting recall:", recall_score(y_test, gb_preds, average='weighted'))
print("AdaBoost recall:", recall_score(y_test, ada_preds, average='weighted'))
print("Decision Tree recall:", recall_score(y_test, dt_preds, average='weighted'))
print("Random Forest recall:", recall_score(y_test, rf_preds, average='weighted'))

print("Decision Tree confusion_matrix:", confusion_matrix(y_test, dt_preds))
print("Random Forest confusion_matrix:", confusion_matrix(y_test, rf_preds))
print("Naive Bayes confusion_matrix:", confusion_matrix(y_test, nb_preds))
print("Gaussian Naive Bayes confusion_matrix:", confusion_matrix(y_test, gnb_preds))
print("SVM confusion_matrix:", confusion_matrix(y_test, svm_preds))
print("Linear SVM confusion_matrix:", confusion_matrix(y_test,lsvm_preds))
print("KNN confusion_matrix:", confusion_matrix(y_test, knn_preds))
print("Logistic Regression confusion_matrix:", confusion_matrix(y_test, lr_preds))
print("Gradient Boosting confusion_matrix:", confusion_matrix(y_test, gb_preds))
print("AdaBoost confusion_matrix:", confusion_matrix(y_test, ada_preds))
print("Decision Tree confusion_matrix:", confusion_matrix(y_test, dt_preds))
print("Random Forest confusion_matrix:", confusion_matrix(y_test, rf_preds))
```

Out[69]:
```
DecisionTreeClassifier
DecisionTreeClassifier(random_state=42)
```

Out[69]:
```
RandomForestClassifier
RandomForestClassifier(random_state=42)
```

Out[69]:
```
MultinomialNB
MultinomialNB()
```

Out[69]:
```
GaussianNB
GaussianNB()
```

Out[69]:
```
SVC
SVC(kernel='linear', random_state=42)
```

Out[69]:
```
LinearSVC
LinearSVC(random_state=42)
```

Out[69]:
```
KNeighborsClassifier
KNeighborsClassifier()
```

Out[69]:
```
LogisticRegression
LogisticRegression(random_state=42)
```

Out[69]:
```
GradientBoostingClassifier
GradientBoostingClassifier(random_state=42)
```

Out[69]:
```
AdaBoostClassifier
AdaBoostClassifier(random_state=42)
```

Out[69]:
```
XGBClassifier
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, ...)
```

```
Decision Tree Accuracy: 0.7150230915512089
Random Forest Accuracy: 0.7400162999185004
```

```
Naive Bayes Accuracy: 0.675903287150231
Gaussian Naive Bayes Accuracy: 0.6938331975006792
SVM Accuracy: 0.689214887258897
Linear SVM Accuracy: 0.6916598750339582
KNN Accuracy: 0.7166530834012497
Logistic Regression Accuracy: 0.7307796794349362
Gradient Boosting Accuracy: 0.7845694104862809
AdaBoost Accuracy: 0.7582178755772888
xgboost Accuracy: 0.7775061124694377
Decision Tree Precision: 0.7178686443544975
Random Forest Precision: 0.7426649374185417
Naive Bayes Precision: 0.6722582394112191
Gaussian Naive Bayes Precision: 0.710599139240503
SVM Precision: 0.711823897140308
Linear SVM Precision: 0.7082598053171862
KNN Precision: 0.7202027830136705
Logistic Regression Precision: 0.7366194177963731
Gradient Boosting Precision: 0.8106164787378416
AdaBoost Precision: 0.7667530419967499
Decision Tree Precision: 0.7178686443544975
Random Forest Precision: 0.7426649374185417
Decision Tree recall: 0.7150230915512089
Random Forest recall: 0.7400162999185004
Naive Bayes recall: 0.675903287150231
Gaussian Naive Bayes recall: 0.6938331975006792
SVM recall: 0.689214887258897
Linear SVM recall: 0.6916598750339582
KNN recall: 0.7166530834012497
Logistic Regression recall: 0.7307796794349362
Gradient Boosting recall: 0.7845694104862809
AdaBoost recall: 0.7582178755772888
Decision Tree recall: 0.7150230915512089
Random Forest recall: 0.7400162999185004
Decision Tree confusion_matrix: [[ 560  160  100]
 [ 184  883  218]
 [ 140  247 1189]]
Random Forest confusion_matrix: [[ 581  140   99]
 [ 185  907  193]
 [ 130  210 1236]]
Naive Bayes confusion_matrix: [[ 404  126  290]
 [ 159  914  212]
 [ 105  301 1170]]
Gaussian Naive Bayes confusion_matrix: [[ 549  160  111]
 [ 250  872  163]
```

```
 [ 258  185 1133]]
SVM confusion_matrix: [[ 591  156   73]
 [ 219  944  122]
 [ 167  407 1002]]
Linear SVM confusion_matrix: [[ 571  155   94]
 [ 208  943  134]
 [ 160  384 1032]]
KNN confusion_matrix: [[ 545  141  134]
 [ 192  898  195]
 [ 167  214 1195]]
Logistic Regression confusion_matrix: [[ 573  133  114]
 [ 205  921  159]
 [ 152  228 1196]]
Gradient Boosting confusion_matrix: [[ 764   28   28]
 [ 262  878  145]
 [ 200  130 1246]]
AdaBoost confusion_matrix: [[ 601   44  175]
 [ 196  888  201]
 [ 147  127 1302]]
Decision Tree confusion_matrix: [[ 560  160  100]
 [ 184  883  218]
 [ 140  247 1189]]
Random Forest confusion_matrix: [[ 581  140   99]
 [ 185  907  193]
 [ 130  210 1236]]
```

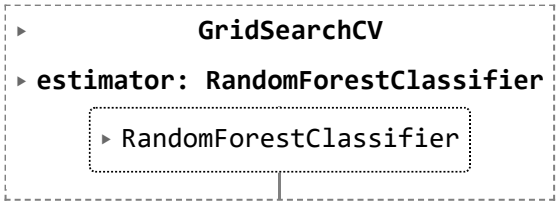
Hyper Parameter Tuning Random Forest

In [70]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

# Define the parameter grid
param_grid = {
    'n_estimators': [100, 300, 500],
    'max_depth': [5, 10, 15],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

# Create a Random Forest classifier
rfc = RandomForestClassifier()
```

```
# Perform grid search cross-validation to find the best hyperparameters
grid_search = GridSearchCV(estimator=rfc, param_grid=param_grid, cv=5, n_jobs=-1)
grid_search.fit(X_resampled, y_resampled)

# Print the best hyperparameters and corresponding mean cross-validation score
print("Best parameters:", grid_search.best_params_)
print("Best score:", grid_search.best_score_)
```

Out[70]:




```
Best parameters: {'max_depth': 15, 'min_samples_leaf': 1, 'min_samples_split': 2, 'n_estimators': 100}
Best score: 0.8187274894010337
```

Neural Network- Tensor Flow

In [71]:

```
pip install tensorflow==1.2.0 --ignore-installed
```

```
Note: you may need to restart the kernel to use updated packages.
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -6blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
ERROR: Could not find a version that satisfies the requirement tensorflow==1.2.0 (from versions: 2.5.0, 2.5.1, 2.5.2, 2.5.3, 2.6.0
rc0, 2.6.0rc1, 2.6.0rc2, 2.6.0, 2.6.1, 2.6.2, 2.6.3, 2.6.4, 2.6.5, 2.7.0rc0, 2.7.0rc1, 2.7.0, 2.7.1, 2.7.2, 2.7.3, 2.7.4, 2.8.0rc
0, 2.8.0rc1, 2.8.0, 2.8.1, 2.8.2, 2.8.3, 2.8.4, 2.9.0rc0, 2.9.0rc1, 2.9.0rc2, 2.9.0, 2.9.1, 2.9.2, 2.9.3, 2.10.0rc0, 2.10.0rc1, 2.
```

```
10.0rc2, 2.10.0rc3, 2.10.0, 2.10.1, 2.11.0rc0, 2.11.0rc1, 2.11.0rc2, 2.11.0, 2.11.1, 2.12.0rc0, 2.12.0rc1, 2.12.0)
ERROR: No matching distribution found for tensorflow==1.2.0
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -6blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
```

```
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
```

In [72]:

```
pip install numpy --upgrade
```

```
Note: you may need to restart the kernel to use updated packages.
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -6blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
Requirement already satisfied: numpy in c:\programdata\anaconda3\lib\site-packages (1.22.4)
Collecting numpy
  Using cached numpy-1.24.2-cp39-cp39-win_amd64.whl (14.9 MB)
Installing collected packages: numpy
  Attempting uninstall: numpy
    Found existing installation: numpy 1.22.4
    Uninstalling numpy-1.22.4:
      Successfully uninstalled numpy-1.22.4
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -6blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
```

```
WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -6blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -5blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -4blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -3blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -2blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -1blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -oblib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -ilelock (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution - (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
    WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
ERROR: Could not install packages due to an OSError: [WinError 5] Access is denied: 'C:\\ProgramData\\Anaconda3\\Lib\\site-package
s\\~-mpy\\.libs\\libopenblas.EL2C6PLE4ZYW3ECEVIV3OXXGRN2NRFM2.gfortran-win_amd64.dll'
Consider using the `--user` option or check the permissions.

WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -7blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
```

In [73]:

```
pip install tensorflow
```

```
Requirement already satisfied: tensorflow in c:\programdata\anaconda3\lib\site-packages (2.11.0)
Requirement already satisfied: tensorflow-intel==2.11.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow) (2.11.0)
```

```
Requirement already satisfied: packaging in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflow)
(21.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensor
flow) (1.4.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tens
orflow) (2.2.0)
Requirement already satisfied: six>=1.12.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflo
w) (1.16.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->t
ensorflow) (1.51.3)
Requirement already satisfied: flatbuffers>=2.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tens
orflow) (23.3.3)
Requirement already satisfied: google-pasta>=0.1.1 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->t
ensorflow) (0.2.0)
Requirement already satisfied: protobuf<3.20,>=3.9.2 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0-
>tensorflow) (3.19.6)
Requirement already satisfied: h5py>=2.9.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflo
w) (3.2.1)
Requirement already satisfied: numpy>=1.20 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflo
w) (1.24.2)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\programdata\anaconda3\lib\site-packages (from tensorflow
-intel==2.11.0->tensorflow) (0.31.0)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->ten
sorflow) (3.3.0)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorflo
w) (58.0.4)
Requirement already satisfied: libclang>=13.0.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tens
orflow) (15.0.6.1)
Requirement already satisfied: astunparse>=1.6.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->ten
sorflow) (1.6.3)
Requirement already satisfied: tensorflow-estimator<2.12,>=2.11.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-i
ntel==2.11.0->tensorflow) (2.11.0)
Requirement already satisfied: keras<2.12,>=2.11.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->t
ensorflow) (2.11.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.1
1.0->tensorflow) (4.5.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->t
ensorflow) (0.4.0)
Requirement already satisfied: tensorboard<2.12,>=2.11 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.
0->tensorflow) (2.11.2)
Requirement already satisfied: wrapt>=1.11.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.11.0->tensorf
low) (1.12.1)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\programdata\anaconda3\lib\site-packages (from astunparse>=1.6.0->tensorflo
w-intel==2.11.0->tensorflow) (0.37.0)
```

```
Requirement already satisfied: werkzeug>=1.0.1 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->tensor
flow-intel==2.11.0->tensorflow) (2.0.2)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.12,
>=2.11->tensorflow-intel==2.11.0->tensorflow) (1.8.1)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->
tensorflow-intel==2.11.0->tensorflow) (2.16.2)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.
12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (0.4.6)
Requirement already satisfied: requests<3,>=2.21.0 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->te
nsorflow-intel==2.11.0->tensorflow) (2.26.0)
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in c:\programdata\anaconda3\lib\site-packages (from tensorboa
rd<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (0.6.1)
Requirement already satisfied: markdown>=2.6.8 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.12,>=2.11->tensor
flow-intel==2.11.0->tensorflow) (3.3.6)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\programdata\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboar
d<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (4.9)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\programdata\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->te
nsorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (0.2.8)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->t
ensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (5.3.0)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\programdata\anaconda3\lib\site-packages (from google-auth-oauthlib<
0.5,>=0.4.1->tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (1.3.1)
Requirement already satisfied: importlib-metadata>=4.4 in c:\programdata\anaconda3\lib\site-packages (from markdown>=2.6.8->tensor
board<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (4.8.1)
Requirement already satisfied: zipp>=0.5 in c:\programdata\anaconda3\lib\site-packages (from importlib-metadata>=4.4->markdown>=2.
6.8->tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (3.6.0)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\programdata\anaconda3\lib\site-packages (from pyasn1-modules>=0.2.1->goo
gle-auth<3,>=1.6.3->tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (0.4.8)
Requirement already satisfied: idna<4,>=2.5 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<
2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (3.2)
Requirement already satisfied: certifi>=2017.4.17 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorb
oard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (2021.10.8)
Requirement already satisfied: charset-normalizer~=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->
tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (2.0.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tens
orboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (1.26.7)
Requirement already satisfied: oauthlib>=3.0.0 in c:\programdata\anaconda3\lib\site-packages (from requests-oauthlib>=0.7.0->googl
e-auth-oauthlib<0.5,>=0.4.1->tensorboard<2.12,>=2.11->tensorflow-intel==2.11.0->tensorflow) (3.2.2)
Requirement already satisfied: pyparsing>=2.0.2 in c:\programdata\anaconda3\lib\site-packages (from packaging->tensorflow-intel==
2.11.0->tensorflow) (3.0.4)
Note: you may need to restart the kernel to use updated packages.
WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -9blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -8blib (c:\programdata\anaconda3\lib\site-packages)
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WARNING: Ignoring invalid distribution -blib (c:\programdata\anaconda3\lib\site-packages)
WARNING: Ignoring invalid distribution -0blib (c:\programdata\anaconda3\lib\site-packages)
```

In [74]:

```
import tensorflow as tf
from tensorflow import keras
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.metrics import accuracy_score


# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(data_x, data_y, test_size=0.2, random_state=42)

# Build the model
model = keras.Sequential([
    keras.layers.Dense(64, activation='relu', input_shape=(X_train.shape[1],)),
    keras.layers.Dense(32, activation='relu'),
    keras.layers.Dense(3, activation='softmax')
])

# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

# Fit the model to the training data
history = model.fit(X_train, y_train, epochs=150, validation_split=0.2)

# Evaluate the model on the testing data
_, acc = model.evaluate(X_test, y_test)
print("Accuracy:", acc)

# Make predictions on the testing data
y_pred = model.predict(X_test)
y_pred = [np.argmax(pred) for pred in y_pred]

acc = accuracy_score(y_test, y_pred)
print("Accuracy:", acc)
# Classify target variables prediction
print("Classification Report:\n", classification_report(y_test, y_pred))
```

```
Epoch 1/150
369/369 [==============================] - 1s 2ms/step - loss: 0.8619 - accuracy: 0.6327 - val_loss: 0.7864 - val_accuracy: 0.6567
Epoch 2/150
369/369 [==============================] - 0s 1ms/step - loss: 0.7604 - accuracy: 0.6954 - val_loss: 0.9118 - val_accuracy: 0.5997
```

```
Epoch 3/150
369/369 [==============================] - 0s 1ms/step - loss: 0.7371 - accuracy: 0.7135 - val_loss: 0.7073 - val_accuracy: 0.7134
Epoch 4/150
369/369 [==============================] - 0s 1ms/step - loss: 0.7119 - accuracy: 0.7335 - val_loss: 0.7035 - val_accuracy: 0.7688
Epoch 5/150
369/369 [==============================] - 0s 1ms/step - loss: 0.7014 - accuracy: 0.7398 - val_loss: 0.8640 - val_accuracy: 0.6085
Epoch 6/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6992 - accuracy: 0.7396 - val_loss: 0.6631 - val_accuracy: 0.7677
Epoch 7/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6829 - accuracy: 0.7485 - val_loss: 0.6701 - val_accuracy: 0.7732
Epoch 8/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6848 - accuracy: 0.7484 - val_loss: 0.6657 - val_accuracy: 0.7603
Epoch 9/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6659 - accuracy: 0.7532 - val_loss: 0.6632 - val_accuracy: 0.7728
Epoch 10/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6683 - accuracy: 0.7543 - val_loss: 0.6505 - val_accuracy: 0.7593
Epoch 11/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6685 - accuracy: 0.7542 - val_loss: 0.6570 - val_accuracy: 0.7732
Epoch 12/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6648 - accuracy: 0.7577 - val_loss: 0.6801 - val_accuracy: 0.7209
Epoch 13/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6590 - accuracy: 0.7589 - val_loss: 0.6719 - val_accuracy: 0.7664
Epoch 14/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6643 - accuracy: 0.7558 - val_loss: 0.7054 - val_accuracy: 0.7579
Epoch 15/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6556 - accuracy: 0.7597 - val_loss: 0.6708 - val_accuracy: 0.7698
Epoch 16/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6556 - accuracy: 0.7580 - val_loss: 0.6715 - val_accuracy: 0.7701
Epoch 17/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6541 - accuracy: 0.7588 - val_loss: 0.6745 - val_accuracy: 0.7317
Epoch 18/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6577 - accuracy: 0.7565 - val_loss: 0.6323 - val_accuracy: 0.7749
Epoch 19/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6525 - accuracy: 0.7584 - val_loss: 0.6313 - val_accuracy: 0.7718
Epoch 20/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6492 - accuracy: 0.7583 - val_loss: 0.6585 - val_accuracy: 0.7470
Epoch 21/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6448 - accuracy: 0.7621 - val_loss: 0.6296 - val_accuracy: 0.7732
Epoch 22/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6461 - accuracy: 0.7622 - val_loss: 0.6326 - val_accuracy: 0.7749
Epoch 23/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6384 - accuracy: 0.7629 - val_loss: 0.6739 - val_accuracy: 0.7406
Epoch 24/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6390 - accuracy: 0.7597 - val_loss: 0.6302 - val_accuracy: 0.7725
```

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Epoch 25/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6390 - accuracy: 0.7599 - val_loss: 0.6317 - val_accuracy: 0.7722
Epoch 26/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6379 - accuracy: 0.7622 - val_loss: 0.6351 - val_accuracy: 0.7756
Epoch 27/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6329 - accuracy: 0.7617 - val_loss: 0.6386 - val_accuracy: 0.7711
Epoch 28/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6292 - accuracy: 0.7639 - val_loss: 0.6432 - val_accuracy: 0.7701
Epoch 29/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6262 - accuracy: 0.7637 - val_loss: 0.6144 - val_accuracy: 0.7745
Epoch 30/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6232 - accuracy: 0.7653 - val_loss: 0.6395 - val_accuracy: 0.7789
Epoch 31/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6180 - accuracy: 0.7684 - val_loss: 0.6134 - val_accuracy: 0.7762
Epoch 32/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6161 - accuracy: 0.7691 - val_loss: 0.6093 - val_accuracy: 0.7735
Epoch 33/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6153 - accuracy: 0.7707 - val_loss: 0.6132 - val_accuracy: 0.7769
Epoch 34/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6102 - accuracy: 0.7729 - val_loss: 0.6055 - val_accuracy: 0.7803
Epoch 35/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6089 - accuracy: 0.7744 - val_loss: 0.6168 - val_accuracy: 0.7762
Epoch 36/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6090 - accuracy: 0.7727 - val_loss: 0.6081 - val_accuracy: 0.7840
Epoch 37/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6083 - accuracy: 0.7752 - val_loss: 0.6148 - val_accuracy: 0.7844
Epoch 38/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6062 - accuracy: 0.7755 - val_loss: 0.6120 - val_accuracy: 0.7711
Epoch 39/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6037 - accuracy: 0.7768 - val_loss: 0.6031 - val_accuracy: 0.7830
Epoch 40/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6055 - accuracy: 0.7759 - val_loss: 0.6105 - val_accuracy: 0.7840
Epoch 41/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6031 - accuracy: 0.7774 - val_loss: 0.6030 - val_accuracy: 0.7868
Epoch 42/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6008 - accuracy: 0.7781 - val_loss: 0.6174 - val_accuracy: 0.7603
Epoch 43/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6034 - accuracy: 0.7761 - val_loss: 0.6117 - val_accuracy: 0.7817
Epoch 44/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6017 - accuracy: 0.7783 - val_loss: 0.6096 - val_accuracy: 0.7803
Epoch 45/150
369/369 [==============================] - 0s 1ms/step - loss: 0.6014 - accuracy: 0.7774 - val_loss: 0.6036 - val_accuracy: 0.7857
Epoch 46/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5994 - accuracy: 0.7780 - val_loss: 0.6188 - val_accuracy: 0.7813
```

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Epoch 47/150
369/369 [==============================] - 1s 2ms/step - loss: 0.6056 - accuracy: 0.7729 - val_loss: 0.6002 - val_accuracy: 0.7881
Epoch 48/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5966 - accuracy: 0.7787 - val_loss: 0.6042 - val_accuracy: 0.7857
Epoch 49/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5988 - accuracy: 0.7773 - val_loss: 0.6043 - val_accuracy: 0.7874
Epoch 50/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5958 - accuracy: 0.7791 - val_loss: 0.6143 - val_accuracy: 0.7874
Epoch 51/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5953 - accuracy: 0.7802 - val_loss: 0.6152 - val_accuracy: 0.7851
Epoch 52/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5959 - accuracy: 0.7794 - val_loss: 0.6111 - val_accuracy: 0.7762
Epoch 53/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5966 - accuracy: 0.7781 - val_loss: 0.6040 - val_accuracy: 0.7851
Epoch 54/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5943 - accuracy: 0.7814 - val_loss: 0.5981 - val_accuracy: 0.7871
Epoch 55/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5934 - accuracy: 0.7803 - val_loss: 0.6018 - val_accuracy: 0.7830
Epoch 56/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5913 - accuracy: 0.7793 - val_loss: 0.6067 - val_accuracy: 0.7834
Epoch 57/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5929 - accuracy: 0.7809 - val_loss: 0.6054 - val_accuracy: 0.7874
Epoch 58/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5918 - accuracy: 0.7803 - val_loss: 0.6036 - val_accuracy: 0.7864
Epoch 59/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5907 - accuracy: 0.7804 - val_loss: 0.5992 - val_accuracy: 0.7881
Epoch 60/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5916 - accuracy: 0.7789 - val_loss: 0.6039 - val_accuracy: 0.7895
Epoch 61/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5889 - accuracy: 0.7813 - val_loss: 0.6124 - val_accuracy: 0.7800
Epoch 62/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5900 - accuracy: 0.7811 - val_loss: 0.6044 - val_accuracy: 0.7878
Epoch 63/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5894 - accuracy: 0.7818 - val_loss: 0.6351 - val_accuracy: 0.7715
Epoch 64/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5896 - accuracy: 0.7798 - val_loss: 0.6000 - val_accuracy: 0.7871
Epoch 65/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5872 - accuracy: 0.7819 - val_loss: 0.6218 - val_accuracy: 0.7810
Epoch 66/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5884 - accuracy: 0.7815 - val_loss: 0.6004 - val_accuracy: 0.7878
Epoch 67/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5886 - accuracy: 0.7818 - val_loss: 0.6017 - val_accuracy: 0.7874
Epoch 68/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5876 - accuracy: 0.7812 - val_loss: 0.6093 - val_accuracy: 0.7861
```

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Epoch 69/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5859 - accuracy: 0.7818 - val_loss: 0.6192 - val_accuracy: 0.7837
Epoch 70/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5869 - accuracy: 0.7825 - val_loss: 0.6120 - val_accuracy: 0.7837
Epoch 71/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5849 - accuracy: 0.7823 - val_loss: 0.6036 - val_accuracy: 0.7857
Epoch 72/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5858 - accuracy: 0.7825 - val_loss: 0.6019 - val_accuracy: 0.7891
Epoch 73/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5838 - accuracy: 0.7827 - val_loss: 0.6042 - val_accuracy: 0.7834
Epoch 74/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5838 - accuracy: 0.7830 - val_loss: 0.6027 - val_accuracy: 0.7881
Epoch 75/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5862 - accuracy: 0.7814 - val_loss: 0.6005 - val_accuracy: 0.7868
Epoch 76/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5834 - accuracy: 0.7838 - val_loss: 0.6184 - val_accuracy: 0.7837
Epoch 77/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5863 - accuracy: 0.7814 - val_loss: 0.6109 - val_accuracy: 0.7861
Epoch 78/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5826 - accuracy: 0.7829 - val_loss: 0.6043 - val_accuracy: 0.7881
Epoch 79/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5811 - accuracy: 0.7830 - val_loss: 0.6040 - val_accuracy: 0.7868
Epoch 80/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5801 - accuracy: 0.7835 - val_loss: 0.6059 - val_accuracy: 0.7891
Epoch 81/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5821 - accuracy: 0.7824 - val_loss: 0.6053 - val_accuracy: 0.7857
Epoch 82/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5791 - accuracy: 0.7830 - val_loss: 0.6093 - val_accuracy: 0.7837
Epoch 83/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5816 - accuracy: 0.7832 - val_loss: 0.5997 - val_accuracy: 0.7868
Epoch 84/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5818 - accuracy: 0.7825 - val_loss: 0.6043 - val_accuracy: 0.7885
Epoch 85/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5798 - accuracy: 0.7837 - val_loss: 0.6070 - val_accuracy: 0.7837
Epoch 86/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5796 - accuracy: 0.7841 - val_loss: 0.6078 - val_accuracy: 0.7844
Epoch 87/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5787 - accuracy: 0.7826 - val_loss: 0.6092 - val_accuracy: 0.7915
Epoch 88/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5806 - accuracy: 0.7829 - val_loss: 0.6097 - val_accuracy: 0.7878
Epoch 89/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5778 - accuracy: 0.7841 - val_loss: 0.6038 - val_accuracy: 0.7885
Epoch 90/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5780 - accuracy: 0.7839 - val_loss: 0.6135 - val_accuracy: 0.7834
```

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Epoch 91/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5768 - accuracy: 0.7845 - val_loss: 0.6060 - val_accuracy: 0.7861
Epoch 92/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5780 - accuracy: 0.7821 - val_loss: 0.6105 - val_accuracy: 0.7820
Epoch 93/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5752 - accuracy: 0.7842 - val_loss: 0.6224 - val_accuracy: 0.7840
Epoch 94/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5765 - accuracy: 0.7840 - val_loss: 0.6088 - val_accuracy: 0.7878
Epoch 95/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5752 - accuracy: 0.7849 - val_loss: 0.6056 - val_accuracy: 0.7871
Epoch 96/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5749 - accuracy: 0.7845 - val_loss: 0.6146 - val_accuracy: 0.7830
Epoch 97/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5744 - accuracy: 0.7849 - val_loss: 0.6058 - val_accuracy: 0.7868
Epoch 98/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5798 - accuracy: 0.7810 - val_loss: 0.6137 - val_accuracy: 0.7881
Epoch 99/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5744 - accuracy: 0.7846 - val_loss: 0.6087 - val_accuracy: 0.7864
Epoch 100/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5741 - accuracy: 0.7863 - val_loss: 0.6109 - val_accuracy: 0.7871
Epoch 101/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5721 - accuracy: 0.7860 - val_loss: 0.6126 - val_accuracy: 0.7810
Epoch 102/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5725 - accuracy: 0.7873 - val_loss: 0.6147 - val_accuracy: 0.7868
Epoch 103/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5735 - accuracy: 0.7849 - val_loss: 0.6089 - val_accuracy: 0.7871
Epoch 104/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5736 - accuracy: 0.7842 - val_loss: 0.6087 - val_accuracy: 0.7885
Epoch 105/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5716 - accuracy: 0.7853 - val_loss: 0.6114 - val_accuracy: 0.7868
Epoch 106/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5725 - accuracy: 0.7845 - val_loss: 0.6133 - val_accuracy: 0.7851
Epoch 107/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5720 - accuracy: 0.7851 - val_loss: 0.6181 - val_accuracy: 0.7861
Epoch 108/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5710 - accuracy: 0.7855 - val_loss: 0.6104 - val_accuracy: 0.7837
Epoch 109/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5720 - accuracy: 0.7867 - val_loss: 0.6188 - val_accuracy: 0.7840
Epoch 110/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5713 - accuracy: 0.7856 - val_loss: 0.6078 - val_accuracy: 0.7874
Epoch 111/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5713 - accuracy: 0.7837 - val_loss: 0.6127 - val_accuracy: 0.7830
Epoch 112/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5679 - accuracy: 0.7878 - val_loss: 0.6188 - val_accuracy: 0.7847
```

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Epoch 113/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5697 - accuracy: 0.7856 - val_loss: 0.6136 - val_accuracy: 0.7844
Epoch 114/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5689 - accuracy: 0.7869 - val_loss: 0.6138 - val_accuracy: 0.7864
Epoch 115/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5710 - accuracy: 0.7858 - val_loss: 0.6126 - val_accuracy: 0.7851
Epoch 116/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5683 - accuracy: 0.7860 - val_loss: 0.6165 - val_accuracy: 0.7830
Epoch 117/150
369/369 [==============================] - 1s 2ms/step - loss: 0.5668 - accuracy: 0.7864 - val_loss: 0.6125 - val_accuracy: 0.7834
Epoch 118/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5679 - accuracy: 0.7867 - val_loss: 0.6186 - val_accuracy: 0.7844
Epoch 119/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5675 - accuracy: 0.7870 - val_loss: 0.6114 - val_accuracy: 0.7844
Epoch 120/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5671 - accuracy: 0.7865 - val_loss: 0.6194 - val_accuracy: 0.7803
Epoch 121/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5676 - accuracy: 0.7885 - val_loss: 0.6144 - val_accuracy: 0.7783
Epoch 122/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5671 - accuracy: 0.7868 - val_loss: 0.6250 - val_accuracy: 0.7851
Epoch 123/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5672 - accuracy: 0.7872 - val_loss: 0.6214 - val_accuracy: 0.7827
Epoch 124/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5653 - accuracy: 0.7864 - val_loss: 0.6205 - val_accuracy: 0.7732
Epoch 125/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5663 - accuracy: 0.7859 - val_loss: 0.6144 - val_accuracy: 0.7847
Epoch 126/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5658 - accuracy: 0.7831 - val_loss: 0.6225 - val_accuracy: 0.7803
Epoch 127/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5645 - accuracy: 0.7870 - val_loss: 0.6131 - val_accuracy: 0.7827
Epoch 128/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5632 - accuracy: 0.7881 - val_loss: 0.6184 - val_accuracy: 0.7800
Epoch 129/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5643 - accuracy: 0.7870 - val_loss: 0.6177 - val_accuracy: 0.7871
Epoch 130/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5637 - accuracy: 0.7861 - val_loss: 0.6214 - val_accuracy: 0.7857
Epoch 131/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5647 - accuracy: 0.7870 - val_loss: 0.6164 - val_accuracy: 0.7806
Epoch 132/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5623 - accuracy: 0.7895 - val_loss: 0.6196 - val_accuracy: 0.7851
Epoch 133/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5634 - accuracy: 0.7872 - val_loss: 0.6197 - val_accuracy: 0.7817
Epoch 134/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5678 - accuracy: 0.7860 - val_loss: 0.6205 - val_accuracy: 0.7830
```

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Epoch 135/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5613 - accuracy: 0.7876 - val_loss: 0.6319 - val_accuracy: 0.7820
Epoch 136/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5624 - accuracy: 0.7859 - val_loss: 0.6191 - val_accuracy: 0.7861
Epoch 137/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5625 - accuracy: 0.7876 - val_loss: 0.6226 - val_accuracy: 0.7820
Epoch 138/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5607 - accuracy: 0.7898 - val_loss: 0.6230 - val_accuracy: 0.7776
Epoch 139/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5605 - accuracy: 0.7889 - val_loss: 0.6235 - val_accuracy: 0.7840
Epoch 140/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5589 - accuracy: 0.7891 - val_loss: 0.6247 - val_accuracy: 0.7789
Epoch 141/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5625 - accuracy: 0.7873 - val_loss: 0.6294 - val_accuracy: 0.7789
Epoch 142/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5603 - accuracy: 0.7882 - val_loss: 0.6273 - val_accuracy: 0.7851
Epoch 143/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5637 - accuracy: 0.7862 - val_loss: 0.6328 - val_accuracy: 0.7779
Epoch 144/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5593 - accuracy: 0.7889 - val_loss: 0.6316 - val_accuracy: 0.7789
Epoch 145/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5587 - accuracy: 0.7883 - val_loss: 0.6209 - val_accuracy: 0.7840
Epoch 146/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5587 - accuracy: 0.7893 - val_loss: 0.6218 - val_accuracy: 0.7817
Epoch 147/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5580 - accuracy: 0.7887 - val_loss: 0.6234 - val_accuracy: 0.7823
Epoch 148/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5568 - accuracy: 0.7882 - val_loss: 0.6452 - val_accuracy: 0.7582
Epoch 149/150
369/369 [==============================] - 0s 1ms/step - loss: 0.5641 - accuracy: 0.7859 - val_loss: 0.6177 - val_accuracy: 0.7847
Epoch 150/150
369/369 [==============================] - 1s 1ms/step - loss: 0.5594 - accuracy: 0.7886 - val_loss: 0.6320 - val_accuracy: 0.7817
116/116 [==============================] - 0s 870us/step - loss: 0.6234 - accuracy: 0.7761
Accuracy: 0.7761477828025818
116/116 [==============================] - 0s 748us/step
Accuracy: 0.776147785927737
Classification Report:
              precision    recall  f1-score   support

           0       0.62      0.89      0.73       820
           1       0.82      0.69      0.75      1285
           2       0.87      0.79      0.83      1576

    accuracy                           0.78      3681
```

```
   macro avg       0.77      0.79      0.77      3681
weighted avg       0.80      0.78      0.78      3681
```

ROC Curve

In [75]:

```
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier, AdaBoostClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from xgboost import XGBClassifier
import matplotlib.pyplot as plt

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(data_x, data_y, test_size=0.2, random_state=42)

models = [
    ('Decision Tree', DecisionTreeClassifier(random_state=42)),
    ('Random Forest', RandomForestClassifier(random_state=42)),
    ('SVM', SVC(kernel='rbf', random_state=42, probability=True)),
    ('Linear SVM', SVC(kernel='linear', random_state=42, probability=True)),
    ('KNN', KNeighborsClassifier()),
    ('Logistic Regression', LogisticRegression(random_state=42)),
    ('Gradient Boosting', GradientBoostingClassifier(random_state=42)),
    ('AdaBoost', AdaBoostClassifier(random_state=42)),
    ('xgboost', XGBClassifier(random_state=42)),
    ('Neural Network', MLPClassifier(random_state=42, max_iter=500)),
]

# Train and predict on each model, and get the predicted probabilities of the positive class
for name, model in models:
    model.fit(X_train, y_train)
    if hasattr(model, "predict_proba"):
        y_pred_proba = model.predict_proba(X_test)[:, 1]
    else:
        y_pred_proba = model.decision_function(X_test)

    # Compute the FPR and TPR at different thresholds, and compute the AUC score
    fpr, tpr, thresholds = roc_curve(y_test, y_pred_proba, pos_label=1)
```

```
    auc_score = auc(fpr, tpr)

    # Plot the ROC curve for each model
    plt.plot(fpr, tpr, label=f'{name} (AUC = {auc_score:.3f})',linewidth=3)

# Set the title and axis labels
plt.title('Receiver Operating Characteristic (ROC) Curve',fontsize=16)
plt.xlabel('False Positive Rate (FPR)',fontsize=16)
plt.ylabel('True Positive Rate (TPR)',fontsize=16)

# Show the legend and plot
plt.legend()
plt.show()
```

Out[75]:
```
DecisionTreeClassifier(random_state=42)
```

Out[75]:
```
[<matplotlib.lines.Line2D at 0x1b5c24e4c10>]
```

Out[75]:
```
RandomForestClassifier(random_state=42)
```

Out[75]:
```
[<matplotlib.lines.Line2D at 0x1b5c31443d0>]
```

Out[75]:
```
SVC(probability=True, random_state=42)
```

Out[75]:
```
[<matplotlib.lines.Line2D at 0x1b5c3389be0>]
```

Out[75]:
```
SVC(kernel='linear', probability=True, random_state=42)
```

Out[75]:
```
[<matplotlib.lines.Line2D at 0x1b5c3389d00>]
```

Out[75]:
```
KNeighborsClassifier()
```

Out[75]: [<matplotlib.lines.Line2D at 0x1b5c3672910>]

Out[75]:
```
LogisticRegression
LogisticRegression(random_state=42)
```

Out[75]: [<matplotlib.lines.Line2D at 0x1b5c36720a0>]

Out[75]:
```
GradientBoostingClassifier
GradientBoostingClassifier(random_state=42)
```

Out[75]: [<matplotlib.lines.Line2D at 0x1b5c364ff10>]

Out[75]:
```
AdaBoostClassifier
AdaBoostClassifier(random_state=42)
```

Out[75]: [<matplotlib.lines.Line2D at 0x1b5c364d4f0>]

Out[75]:
```
XGBClassifier
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, ...)
```

Out[75]: [<matplotlib.lines.Line2D at 0x1b5c39d0d30>]

Out[75]:
```
MLPClassifier
MLPClassifier(max_iter=500, random_state=42)
```

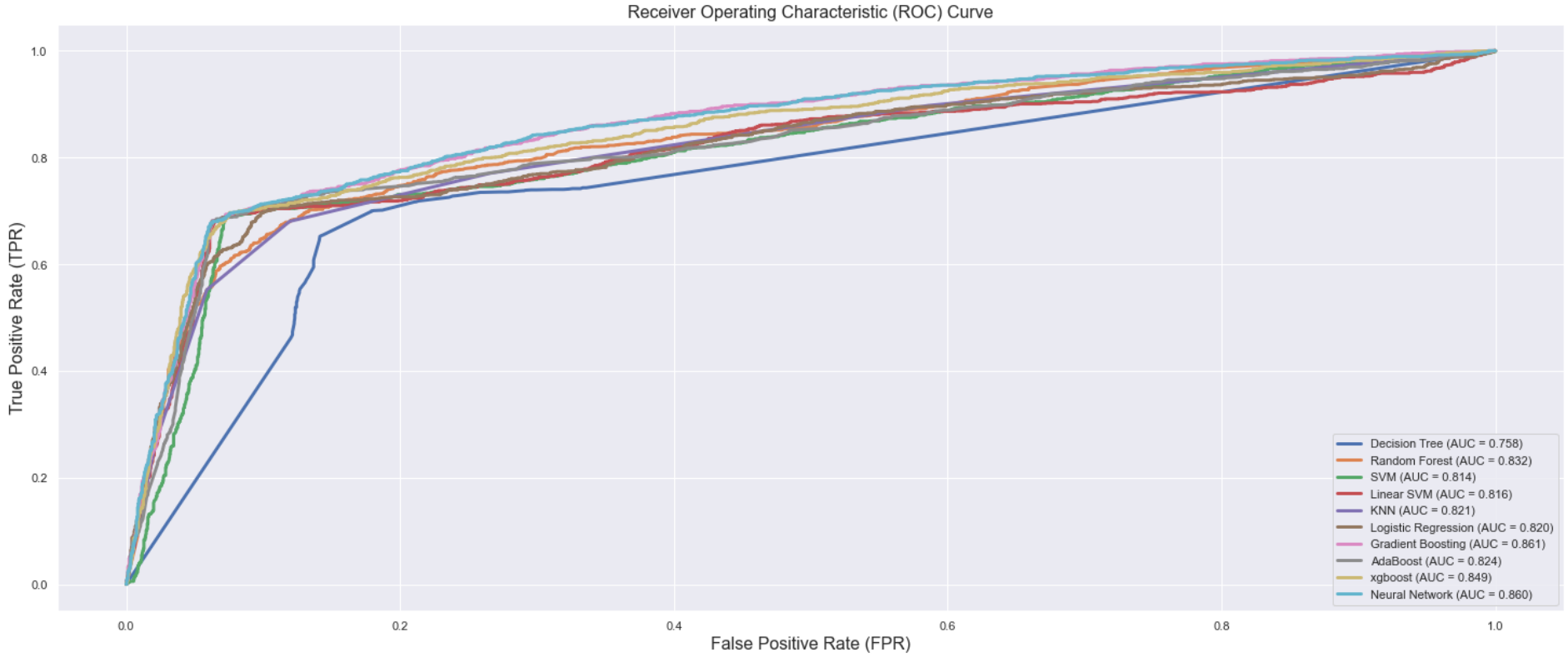
Out[75]: [<matplotlib.lines.Line2D at 0x1b5c364d820>]

Out[75]: Text(0.5, 1.0, 'Receiver Operating Characteristic (ROC) Curve')

Out[75]: Text(0.5, 0, 'False Positive Rate (FPR)')

Out[75]: Text(0, 0.5, 'True Positive Rate (TPR)')

Out[75]: <matplotlib.legend.Legend at 0x1b5c364d5e0>



In [ ]: