

# DataScience-Machine\_Learning-Capstone-Project

March 2, 2021

## 1 IBM-Capstone-Project

### 1.1 Description of the Problem and Discussion of the Background

#### 1.1.1 Introduction Section:

The police of Denver, Colorado patrolling in the whole city. However, various crimes occurred in any part of the city. Due to the limited number of patrolling cars of the police department, most of the area is not covered by the police cars. Therefore, police need to know those areas, where most crimes have occurred. So that, they can cover most of the area by sending police car. The less crime area can be omitted.

To understand these, the police needs answers to several questions. The answers to those questions must be supported by data and analytics. These are their questions:

- 1) How can we find those areas, where the most crimes have occurred?
- 2) How can we find the most offensive crimes and the area?
- 3) How can we find the most most ocured crime?

#### 1.1.2 Target Audience

The analysis would help any the police department of the city of Denver to predict the place of the crimes and types of the crimes. Moreover, the police can increase/decrease the number of patrolling cars in an area, where it's needed. The crime data frame was modeled using a Random Forest algorithm. The classification of crimes was based on location, time and date.

#### 1.1.3 Data Description and Data Sources

Data used in this project is collected from several sources. A brief description of the sources of data are given below:

This dataset includes criminal offenses in the City and County of Denver for the previous five calendar years plus the current year to date. The data is based on the National Incident Based Reporting System (NIBRS) which includes all victims of person crimes and all crimes within an incident. The data is dynamic, which allows for additions, deletions and/or modifications at any time, resulting in more accurate information in the database. Due to continuous data entry, the number of records in subsequent extractions are subject to change. Crime data is updated Monday through Friday. The following image shows an some data from the crimes data:

	INCIDENT_ID	OFFENSE_ID	OFFENSE_CODE	OFFENSE_CODE_EXTENSION	OFFENSE_TYPE_ID	OFFENSE_CATEGORY_ID	FIRST_OCCURRENCE_DATE	
0	20176005213	20176005213239901	2399		1	theft-bicycle	larceny	6/8/2017 1:15:00 PM
1	2016461725	2016461725549900	5499		0	traf-other	all-other-crimes	7/21/2016 6:40:00 PM
2	2017409119	2017409119549900	5499		0	traf-other	all-other-crimes	6/22/2017 5:20:00 PM
3	2016829592	2016829592110200	1102		0	sex-aslt-rape	sexual-assault	12/30/2016 11:00:00 PM
4	2017455505	2017455505544100	5441		0	traffic-accident	traffic-accident	7/10/2017 6:00:00 PM

For more info please check the following link:

<https://www.denvergov.org/opendata/dataset/city-and-county-of-denver-crime>

Foursquare API to explore venue types surrounding each neighborhood of the city of Denver. The query was made for the number of venues in each category within a 1000m radius around each neighborhood (“Documentation — Foursquare Developer”, 2020).

#### 1.1.4 importing all necessary dependencies

```
[4]: %matplotlib inline

import datetime
import folium
import geocoder
import geojson
import json
import re
import requests
import urllib

import matplotlib.pyplot as plt
import matplotlib.cm as cm
import matplotlib.colors as colors
import numpy as np
import pandas as pd

from bokeh.io import show
from bokeh.models import HoverTool
from bokeh.plotting import figure, output_file, save
from bs4 import BeautifulSoup
from folium import plugins
from geopy.distance import great_circle
from geopy.geocoders import Nominatim
from haversine import haversine
from pandas.io.json import json_normalize
from scipy.spatial.distance import euclidean, cityblock
from sklearn import metrics, preprocessing
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
```

```
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', None)
plt.rcParams['axes.grid'] = True
```

### 1.1.5 Loading crime data of Denver City, CO.

To speed up processing, the data was stored locally on the machine after it was formatted as desired. To keep computing costs relatively low, only the crimes from 2017 were chosen.

```
[68]: #loading crimes data of Denver City.
df=pd.read_csv('crimes1.csv')
df.head()
```

```
[68]:
```

	Offence Types	Offense Catagory	Latitude	Longitude	\
0	theft-bicycle	larceny	-104.999264	39.753669	
1	traf-other	all-other-crimes	-104.973097	39.740032	
2	traffic-accident	traffic-accident	-104.925197	39.678463	
3	burglary-residence-no-force	burglary	-105.042398	39.787581	
4	traffic-accident	traffic-accident	-104.940906	39.742085	

	District	Neighborhood	Crime	Traffic	Date	Time	Year
0	6	Union Station	1	0	12/06/2017	08:44	2017
1	6	Capitol Hill	1	0	22/06/2017	17:20	2017
2	3	Goldsmith	0	1	10/07/2017	18:45	2017
3	1	Regis	1	0	05/07/2017	21:54	2017
4	2	City Park	0	1	12/09/2017	15:59	2017

Data observation and some further process for our goal.

```
[69]: #Shape of the dataframe before drop NaN values
df.shape
```

```
[69]: (67462, 11)
```

```
[70]: #dropping NaN values from the dataframe
df.dropna(inplace=True)
df.head()
```

```
[70]:
```

	Offence Types	Offense Catagory	Latitude	Longitude	\
0	theft-bicycle	larceny	-104.999264	39.753669	
1	traf-other	all-other-crimes	-104.973097	39.740032	
2	traffic-accident	traffic-accident	-104.925197	39.678463	
3	burglary-residence-no-force	burglary	-105.042398	39.787581	
4	traffic-accident	traffic-accident	-104.940906	39.742085	

	District	Neighborhood	Crime	Traffic	Date	Time	Year
0	6	Union Station	1	0	12/06/2017	08:44	2017
1	6	Capitol Hill	1	0	22/06/2017	17:20	2017

2	3	Goldsmith	0	1	10/07/2017	18:45	2017
3	1	Regis	1	0	05/07/2017	21:54	2017
4	2	City Park	0	1	12/09/2017	15:59	2017

```
[71]: #Shape of the datafram
df.shape
```

```
[71]: (67462, 11)
```

```
[72]: df[["Day", "Month", "Year"]] = df["Date"].str.split("/", expand=True)
df[["Hour", "Min"]] = df["Time"].str.split(":", expand=True)
df.head()
```

```
[72]:
```

	Offence Types	Offense Catagory	Latitude	Longitude	\
0	theft-bicycle	larceny	-104.999264	39.753669	
1	traf-other	all-other-crimes	-104.973097	39.740032	
2	traffic-accident	traffic-accident	-104.925197	39.678463	
3	burglary-residence-no-force	burglary	-105.042398	39.787581	
4	traffic-accident	traffic-accident	-104.940906	39.742085	

	District	Neighborhood	Crime	Traffic	Date	Time	Year	Day	Month	\
0	6	Union Station	1	0	12/06/2017	08:44	2017	12	06	
1	6	Capitol Hill	1	0	22/06/2017	17:20	2017	22	06	
2	3	Goldsmith	0	1	10/07/2017	18:45	2017	10	07	
3	1	Regis	1	0	05/07/2017	21:54	2017	05	07	
4	2	City Park	0	1	12/09/2017	15:59	2017	12	09	

	Hour	Min
0	08	44
1	17	20
2	18	45
3	21	54
4	15	59

```
[73]: df['Date'] = pd.to_datetime(df['Date'])
df['day_name'] = df['Date'].dt.day_name()
df['month_name'] = df['Date'].dt.month_name()
df.head()
```

```
[73]:
```

	Offence Types	Offense Catagory	Latitude	Longitude	\
0	theft-bicycle	larceny	-104.999264	39.753669	
1	traf-other	all-other-crimes	-104.973097	39.740032	
2	traffic-accident	traffic-accident	-104.925197	39.678463	
3	burglary-residence-no-force	burglary	-105.042398	39.787581	
4	traffic-accident	traffic-accident	-104.940906	39.742085	

	District	Neighborhood	Crime	Traffic	Date	Time	Year	Day	Month	\
--	----------	--------------	-------	---------	------	------	------	-----	-------	---

0	6	Union Station	1	0	2017-12-06	08:44	2017	12	06
1	6	Capitol Hill	1	0	2017-06-22	17:20	2017	22	06
2	3	Goldsmith	0	1	2017-10-07	18:45	2017	10	07
3	1	Regis	1	0	2017-05-07	21:54	2017	05	07
4	2	City Park	0	1	2017-12-09	15:59	2017	12	09

	Hour	Min	day_name	month_name
0	08	44	Wednesday	December
1	17	20	Thursday	June
2	18	45	Saturday	October
3	21	54	Sunday	May
4	15	59	Saturday	December

```
[74]: #Types of the dataframes
df.dtypes
```

```
[74]: Offence Types          object
Offense Catagory          object
Latitude                  float64
Longitude                 float64
District                  int64
Neighborhood              object
Crime                     int64
Traffic                   int64
Date                      datetime64[ns]
Time                      object
Year                      object
Day                       object
Month                     object
Hour                      object
Min                       object
day_name                  object
month_name                object
dtype: object
```

**1.1.6 In our analysis, we only used crime dataset. This dataset also included the traffic related data.**

```
[75]: df_crime=df[df['Crime'] == 1]
df_crime.head()
```

```
[75]:      Offence Types  Offense Catagory  Latitude  Longitude \
0      theft-bicycle          larceny -104.999264   39.753669
1      traf-other    all-other-crimes -104.973097   39.740032
3  burglary-residence-no-force      burglary -105.042398   39.787581
5  burglary-residence-no-force      burglary -105.018501   39.784790
7  burglary-residence-no-force      burglary -104.997312   39.757979
```

	District	Neighborhood	Crime	Traffic	Date	Time	Year	Day	Month	\
0	6	Union Station	1	0	2017-12-06	08:44	2017	12	06	
1	6	Capitol Hill	1	0	2017-06-22	17:20	2017	22	06	
3	1	Regis	1	0	2017-05-07	21:54	2017	05	07	
5	1	Chaffee Park	1	0	2017-04-16	23:36	2017	16	04	
7	6	Five Points	1	0	2017-11-08	11:38	2017	11	08	

	Hour	Min	day_name	month_name
0	08	44	Wednesday	December
1	17	20	Thursday	June
3	21	54	Sunday	May
5	23	36	Sunday	April
7	11	38	Wednesday	November

```
[76]: df_crime.shape
```

```
[76]: (50855, 17)
```

```
[77]: df_traffic=df[df['Traffic'] == 1]
df_traffic.head()
```

```
[77]:
```

	Offence Types	Offense Catagory	Latitude	Longitude	\
2	traffic-accident	traffic-accident	-104.925197	39.678463	
4	traffic-accident	traffic-accident	-104.940906	39.742085	
6	traffic-accident-hit-and-run	traffic-accident	-105.081457	39.665548	
13	traffic-accident	traffic-accident	-105.008765	39.689478	
31	traffic-accident	traffic-accident	-104.987587	39.669484	

	District	Neighborhood	Crime	Traffic	Date	Time	Year	Day	Month	\
2	3	Goldsmith	0	1	2017-10-07	18:45	2017	10	07	
4	2	City Park	0	1	2017-12-09	15:59	2017	12	09	
6	4	Bear Valley	0	1	2017-10-05	18:25	2017	10	05	
13	4	Ruby Hill	0	1	2017-08-28	18:46	2017	28	08	
31	3	Overland	0	1	2017-06-14	15:36	2017	14	06	

	Hour	Min	day_name	month_name
2	18	45	Saturday	October
4	15	59	Saturday	December
6	18	25	Thursday	October
13	18	46	Monday	August
31	15	36	Wednesday	June

```
[11]: df_traffic.shape
```

```
[11]: (16646, 13)
```

### 1.1.7 Visualization

We can now visualize the crimes that were committed in 2017 based on various parameters such as number of crimes per:

Type of crime

Per month

Per day of the month

Per time of day

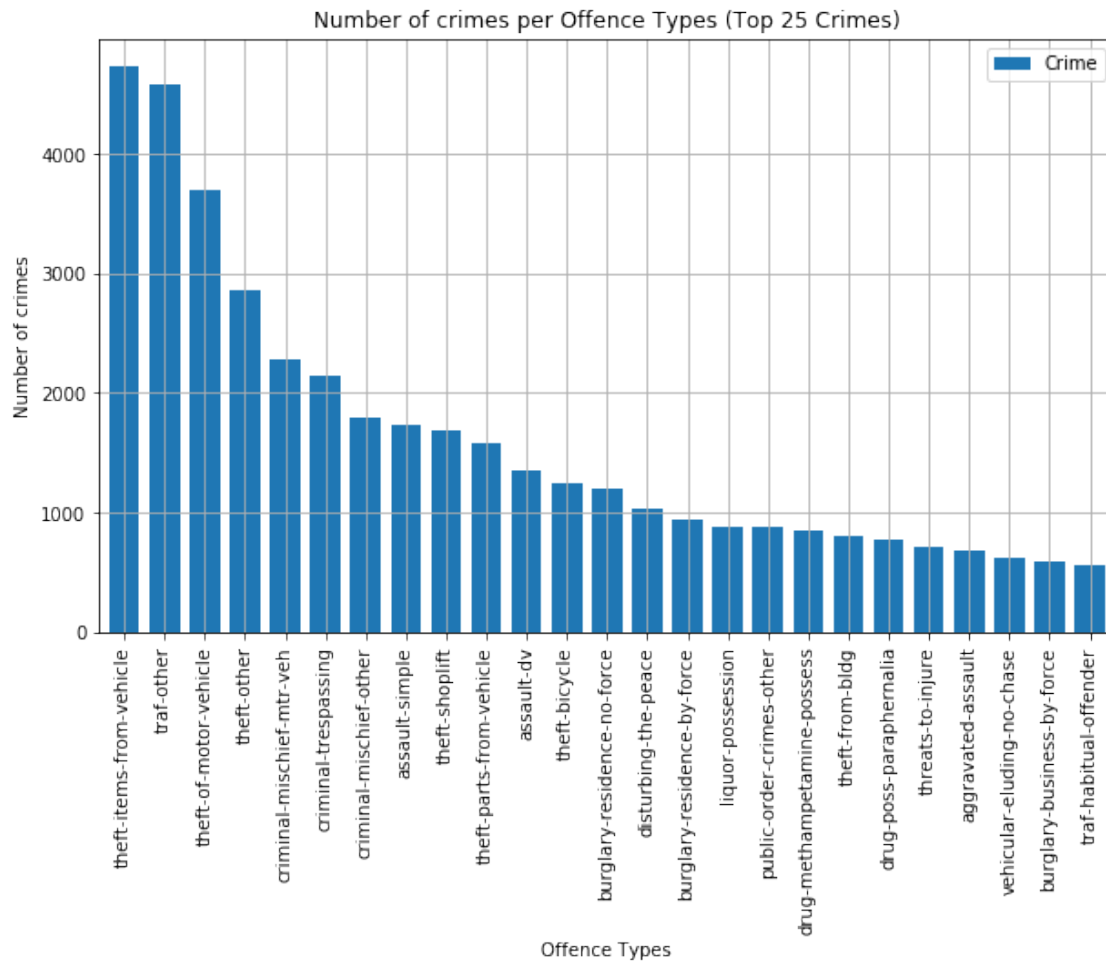
Per Neighborhood

### 1.1.8 Number of crimes per Crime Code Description¶

The top 25 crimes from 2017 were plotted on a bar chart. It was not very surprising to see there were a lot of theft item from vehicle related crimes. The large number of Identity Theft cases was a surprise than other crime.

```
[11]: df_crime_merge = df_crime.groupby('Offence Types').count().
      ↪sort_values(['Crime'], ascending=False)
df_crime_merge.head(25)
df_crime_merge[:25].plot(y='Crime', kind='bar', figsize=(10,6), width=0.75, )
plt.xlabel('Offence Types')
plt.ylabel('Number of crimes')
plt.title('Number of crimes per Offence Types (Top 25 Crimes)')
```

```
[11]: Text(0.5, 1.0, 'Number of crimes per Offence Types (Top 25 Crimes)')
```

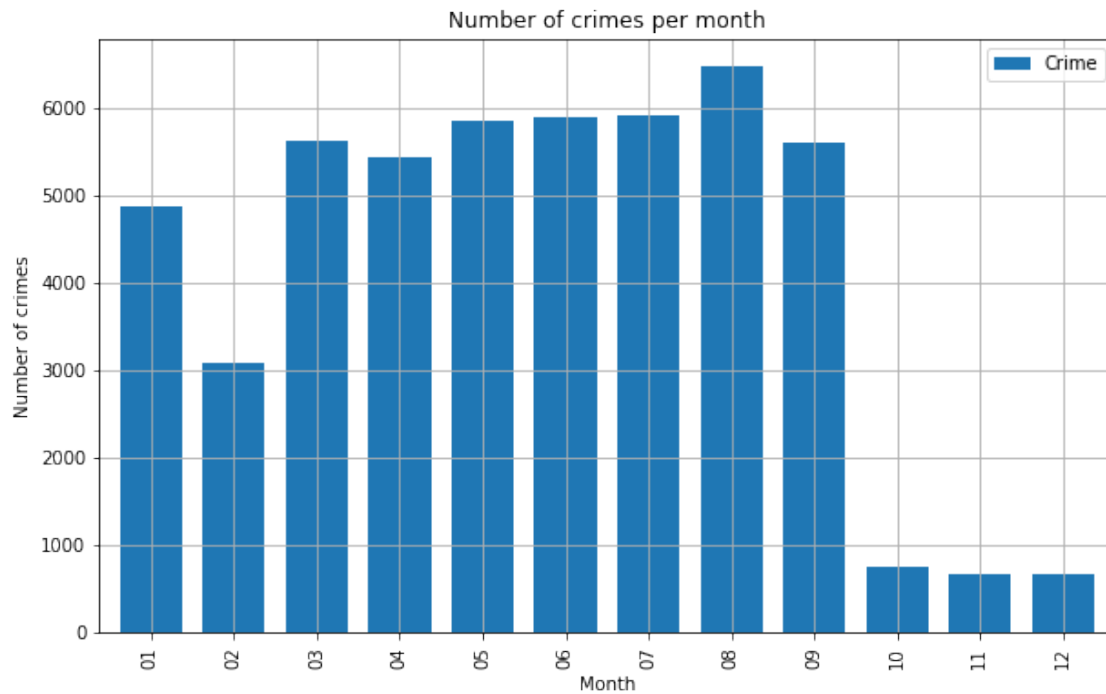


### 1.1.9 Number of crimes per Month

The crimes from 2017 were plotted on a bar chart as number of crimes per month. The number of crimes stayed consistent with a dip in October, November, and December, which can be attributed to a lower number of days in the month and an increase in the other months.

```
[13]: df_crime_month = df_crime.groupby('Month').count()
df_crime_month.head(25)
df_crime_month.plot(y='Crime', kind='bar', figsize=(10,6), width=0.75, )
plt.xlabel('Month')
plt.ylabel('Number of crimes')
plt.title('Number of crimes per month');
```

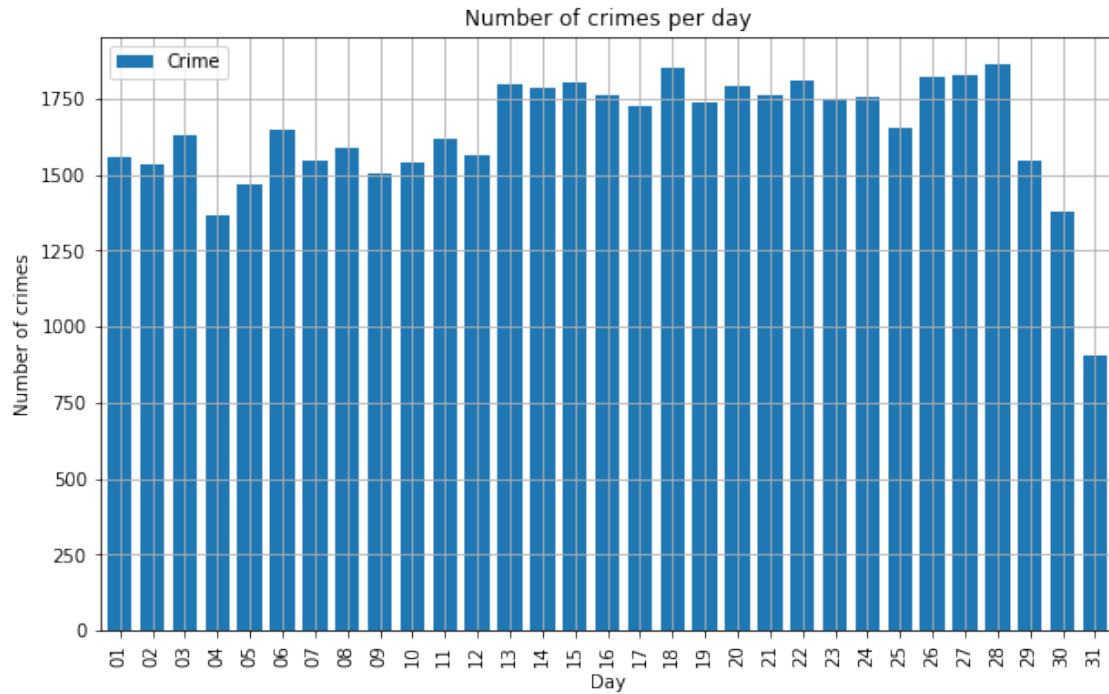




#### 1.1.10 Number of crimes per Day of the Month

The crimes from 2017 were plotted on a bar chart as number of crimes per day of the month. The number of crimes stayed consistent throughout the month typically. The drop in number of crimes on the 31st is because not every month has 31 days. Similarly with reduced contributions from February (29th and 30th). It could potentially be an issue and the data would likely need a weighted average of some kind to scale it uniformly.

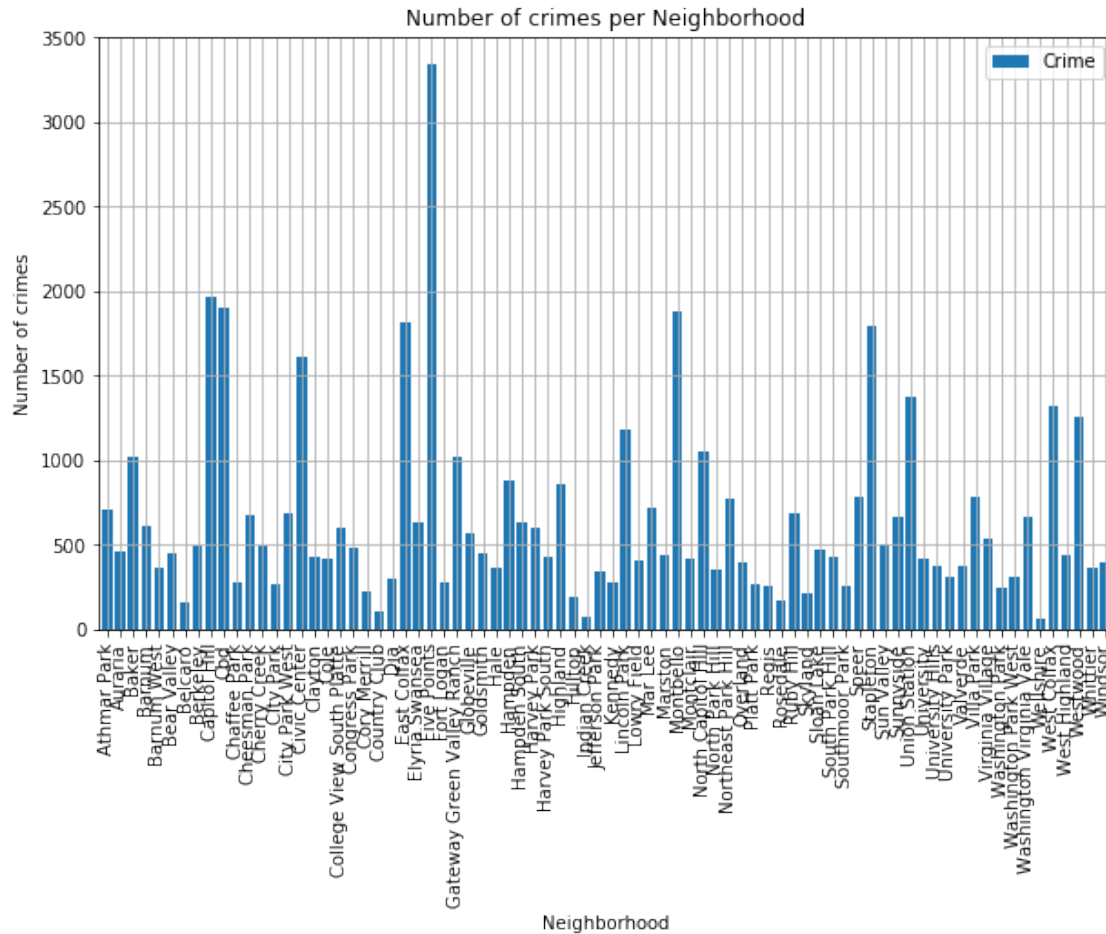
```
[14]: df_crime_day = df_crime.groupby('Day').count()
df_crime_day.head(25)
df_crime_day.plot(y='Crime', kind='bar', figsize=(10,6), width=0.75, )
plt.xlabel('Day')
plt.ylabel('Number of crimes')
plt.title('Number of crimes per day');
```



### 1.1.11 Number of crimes per Area

The crimes from 2017 were plotted on a bar chart as number of crimes per neighborhood of occurrence. It is clear which areas are the most dangerous -Five Points is the worst neighborhoods in the city. Wellshire and Indian Creek are the best neighborhoods in the city.

```
[15]: df_crime_area = df_crime.groupby('Neighborhood').count()
df_crime_area.head(25)
df_crime_area.plot(y='Crime', kind='bar', figsize=(10,6), width=0.75, )
plt.xlabel('Neighborhood')
plt.ylabel('Number of crimes')
plt.title('Number of crimes per Neighborhood');
```



```
[16]: df_crime_top5 = df_crime_merge.head(5).index.tolist()
df_crime_data_top5 = df_crime[df_crime['Offence Types'].isin(df_crime_top5)].
    ↪reset_index(drop=True)

colors = ['red', 'blue', 'green', 'orange', 'purple']
colordict = dict(zip(df_crime_top5, colors))
df_crime_data_top5['color'] = df_crime_data_top5['Offence Types'].apply(lambda
    ↪x: colordict[x])
```

The crimes by count were selected from the 2017 crime dataframe. These were assigned a blue color and the result was charted using folium. The next section show the crime distributions in the city using heat maps and cluster maps.

```
[17]: # create map for Denver City
map_denver = folium.Map(location=[39.744137, -104.950050], zoom_start=11)

# add markers to map
```

```

for lat, lng, neighborhood in zip(df_crime['Longitude'], df_crime['Latitude'],
    ↪df_crime['Neighborhood']):
    label = '{}'.format(neighborhood)
    label = folium.Popup(label, parse_html=True)
    folium.CircleMarker(
        [lat, lng],
        radius=1,
        popup=label,
        color='blue',
        fill=True,
        fill_color='#3186cc',
        fill_opacity=0.3,
        parse_html=False).add_to(map_denver)

map_denver

```

[17]: <folium.folium.Map at 0x1d3e51dd8c8>

```

[18]: denver_cluster_map = folium.Map(location = [39.744137, -104.950050], zoom_start=
    ↪11)

incidents = plugins.MarkerCluster().add_to(denver_cluster_map)

for lat, lng, label, in zip(df_crime_data_top5['Longitude'],
    ↪df_crime_data_top5['Latitude'],
    ↪df_crime_data_top5['Offence Types']):
    folium.Marker(
        location = [lat, lng],
        icon = None,
        popup = label,
    ).add_to(incidents)

denver_cluster_map

```

[18]: <folium.folium.Map at 0x1d3951e5b88>

```

[19]: denver_heat_map = folium.Map(location = [39.744137, -104.950050], zoom_start =
    ↪11)

map_data = [[row.Longitude, row.Latitude] for _, row in df_crime.iterrows()]

plugins.HeatMap(map_data,
    min_opacity = 0.5,
    max_zoom = 18,
    max_val = 1.0,
    radius = 12.5,
    blur = 25,

```

```
gradient = None,
overlay = True).add_to(denver_heat_map)
```

```
denver_heat_map
```

```
C:\Users\hafiz\anaconda3\lib\site-packages\ipykernel_launcher.py:12:
UserWarning: The `max_val` parameter is no longer necessary. The largest
intensity is calculated automatically.
    if sys.path[0] == '':
```

```
[19]: <folium.folium.Map at 0x1d3a614f088>
```

### 1.1.12 Foursquare Venue Data

The next step was to use the Foursquare API to retrieve data for businesses and services around a particular neighborhood. Using the Venue ID, a subsequent call was designed to extract the venue rating. However, this is a Premium endpoint and was limited to only 500 requests per day which was not sufficient to handle our dataset of approximately 50,000 venues. While the code is shown below, we subsequently discard the venue\_rating column from our dataset. The dataframe was stored locally on the machine for faster retrieval.

```
[26]: CLIENT_ID = '2ITIJOBIMJWSM5YZKMW5CIEC3GZVBTEPXEMKZWN30Q1ASSV3' # your_
↳Foursquare ID
CLIENT_SECRET = 'C2ZVPDC1AZZWYXAM54JQEVQEYCAKZ1GZ54YYRPJMA1Q10IU2' # your_
↳Foursquare Secret
VERSION = '20180605' # Foursquare API version

LIMIT = 10

categories = {
    'Arts & Entertainment': ('4d4b7104d754a06370d81259', 'film', 'blue'),
    'Fitness Center': ('4bf58dd8d48988d175941735', 'tower', 'gray'),
    'Food': ('4d4b7105d754a06374d81259', 'cutlery', 'purple'),
    'Medical Center': ('4bf58dd8d48988d104941735', 'heart', 'red'),
    'Nightlife Spot': ('4d4b7105d754a06376d81259', 'glass', 'darkpurple'),
    'Shop & Service': ('4d4b7105d754a06378d81259', 'shopping-cart',
↳'cadetblue'),
}

print('Your credentails:')
print('CLIENT_ID: ' + CLIENT_ID)
print('CLIENT_SECRET: ' + CLIENT_SECRET)
```

Your credentails:

CLIENT\_ID: 2ITIJOBIMJWSM5YZKMW5CIEC3GZVBTEPXEMKZWN30Q1ASSV3

CLIENT\_SECRET: C2ZVPDC1AZZWYXAM54JQEVQEYCAKZ1GZ54YYRPJMA1Q10IU2

```
[27]: def getNearbyVenues(names, latitudes, longitudes, radius=500):

    venues_list=[]
    for name, lat, lng in zip(names, latitudes, longitudes):
        print(name)

        # create the API request URL
        url = 'https://api.foursquare.com/v2/venues/explore?
→&client_id={}&client_secret={}&v={}&ll={},{}&radius={}&limit={}'.format(
            CLIENT_ID,
            CLIENT_SECRET,
            VERSION,
            lat,
            lng,
            radius,
            LIMIT)

        # make the GET request
        results = requests.get(url).json()["response"]['groups'][0]['items']

        # return only relevant information for each nearby venue
        venues_list.append([
            name,
            lat,
            lng,
            v['venue']['name'],
            v['venue']['location']['lat'],
            v['venue']['location']['lng'],
            v['venue']['categories'][0]['name']) for v in results])

    nearby_venues = pd.DataFrame([item for venue_list in venues_list for item
→in venue_list])
    nearby_venues.columns = ['Neighborhood',
                            'Neighborhood Latitude',
                            'Neighborhood Longitude',
                            'Venue',
                            'Venue Latitude',
                            'Venue Longitude',
                            'Venue Category']

    return(nearby_venues)

[28]: denver_city_venues = getNearbyVenues(names=df_crime.Neighborhood,
→latitudes=df_crime.Longitude,
                                           longitudes=df_crime.Latitude)
```

Union Station  
Capitol Hill

Regis  
Chaffee Park  
Five Points  
Five Points  
Five Points  
East Colfax  
Baker  
Barnum  
Montbello  
Gateway Green Valley Ranch  
Dia  
Fort Logan  
Virginia Village  
Stapleton  
Barnum West  
Chaffee Park  
Five Points  
Cherry Creek  
Capitol Hill  
Highland  
Westwood  
College View South Platte  
Five Points  
Hilltop  
City Park West  
Westwood  
Barnum West  
Skyland  
Lincoln Park  
Capitol Hill  
Montbello  
Baker  
Virginia Village  
University  
Gateway Green Valley Ranch  
Montbello  
Civic Center  
City Park West  
Montbello  
Virginia Village  
Jefferson Park  
Union Station  
Sloan Lake  
Washington Park West  
Montbello  
Cbd  
North Capitol Hill  
Athmar Park

Montbello  
Civic Center  
Union Station  
Marston  
South Park Hill  
Cory Merrill  
Whittier  
Globeville  
Westwood  
Hampden  
Northeast Park Hill  
North Park Hill  
Westwood  
Sloan Lake  
Clayton  
City Park West  
Speer  
Jefferson Park  
Valverde  
Sun Valley  
Kennedy  
East Colfax  
Globeville  
Clayton  
East Colfax  
Bear Valley  
Speer  
Union Station  
Barnum West  
East Colfax  
West Colfax  
Northeast Park Hill  
Civic Center  
Villa Park  
Overland  
Five Points  
Ruby Hill  
Villa Park  
Lowry Field  
Athmar Park  
Five Points  
Chaffee Park  
Dia  
Marston  
Marston  
Cbd  
Mar Lee  
North Capitol Hill



Stapleton  
Five Points  
Harvey Park  
Baker  
City Park West  
South Park Hill  
Stapleton  
Barnum  
College View South Platte  
Baker  
Montbello  
Globeville  
Westwood  
East Colfax  
Harvey Park South  
Five Points  
Cbd  
Cherry Creek  
Baker  
East Colfax  
College View South Platte  
Stapleton  
Westwood  
University Park  
Villa Park  
City Park West  
Barnum West  
East Colfax  
East Colfax  
Hampden  
Montbello  
Civic Center  
Globeville  
Fort Logan  
Five Points  
Baker  
Regis  
Sun Valley  
North Capitol Hill  
Congress Park  
Hampden South  
West Colfax  
Hampden  
Globeville  
Lincoln Park  
Bear Valley  
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College View South Platte  
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Whittier  
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East Colfax  
University Park  
Speer  
Villa Park

↳ -----

↳ KeyError Traceback (most recent call↳  
↳last)

```
<ipython-input-28-87a857a8b9f0> in <module>
    1 denver_city_venues = getNearbyVenues(names=df_crime.Neighborhood,↳
↳latitudes=df_crime.Longitude,
----> 2                                longitudes=df_crime.Latitude)
```

```
<ipython-input-27-8c9a08363335> in getNearbyVenues(names, latitudes,↳
↳longitudes, radius)
    16
    17         # make the GET request
```

```

---> 18         results = requests.get(url).
↳ json()["response"]["groups"][0]['items']
    19
    20         # return only relevant information for each nearby venue

```

```

KeyError: 'groups'

```

```

[30]: df_crime['Offence Types'].unique()

```

```

[30]: array(['theft-bicycle', 'traf-other', 'burglary-residence-no-force',
'police-false-information', 'criminal-trespassing',
'assault-simple', 'theft-of-motor-vehicle',
'burglary-residence-by-force', 'theft-parts-from-vehicle',
'theft-items-from-vehicle', 'assault-dv',
'drug-poss-paraphernalia', 'robbery-street', 'theft-shoplift',
'aggravated-assault', 'criminal-mischief-graffiti',
'drug-methamphetamine-possess', 'theft-other',
'weapon-unlawful-discharge-of', 'weapon-by-prev-offender-powpo',
'curfew', 'aggravated-assault-dv', 'menacing-felony-w-weap',
'weapon-fire-into-occ-veh', 'criminal-mischief-mtr-veh',
'criminal-mischief-other', 'threats-to-injure',
'drug-cocaine-possess', 'robbery-business',
'violation-of-court-order', 'public-fighting',
'violation-of-restraining-order', 'burglary-vending-machine',
'fireworks-possession', 'fraud-identity-theft',
'burglary-business-by-force', 'prostitution-engaging-in',
'liquor-possession', 'public-order-crimes-other',
'drug-methamphetamine-sell', 'traf-habitual-offender',
'drug-marijuana-cultivation', 'drug-heroin-sell',
'vehicular-eluding-no-chase', 'police-interference',
'theft-from-bldg', 'sex-off-fail-to-register',
'public-peace-other', 'theft-unauth-use-of-ftd',
'drug-marijuana-sell', 'weapon-fire-into-occ-bldg',
'disturbing-the-peace', 'theft-stln-vehicle-trailer',
'burglary-business-no-force', 'drug-heroin-possess',
'drug-marijuana-possess', 'police-resisting-arrest',
'weapon-carrying-prohibited', 'theft-pick-pocket',
>window-peeping', 'drug-hallucinogen-possess',
'police-disobey-lawful-order', 'theft-of-services',
'fraud-by-telephone', 'theft-stln-veh-const-eqpt',
'fraud-by-use-of-computer', 'theft-embezzle',
'drug-synth-narcotic-sell', 'weapon-other-viol',
'drug-pcs-other-drug', 'harassment-sexual-in-nature',
'forgery-checks', 'false-imprisonment',
'fraud-criminal-impersonation', 'bomb-threat', 'homicide-other',

```

```

'assault-police-simple', 'stolen-property-buy-sell-rec',
'indecent-exposure', 'harassment', 'burglary-safe',
'burg-auto-theft-resd-w-force', 'contraband-possession',
'vehicular-eluding', 'theft-fail-return-rent-veh',
'property-crimes-other', 'weapon-poss-illegal-dangerous',
'theft-from-mails', 'forgery-other',
'other-environment-animal-viol', 'arson-public-building',
'robbery-residence', 'theft-purse-snatch-no-force',
'homicide-family', 'drug-fraud-to-obtain',
'violation-of-custody-order', 'burglary-poss-of-tools',
'liquor-sell', 'drug-cocaine-sell', 'forgery-poss-of-forged-inst',
'prostitution-pimping', 'arson-residence',
'fraud-nsf-closed-account', 'illegal-dumping',
'weapon-carrying-concealed', 'robbery-purse-snatch-w-force',
'animal-cruelty-to', 'reckless-endangerment',
'drug-synth-narcotic-possess', 'contraband-into-prison',
'accessory-conspiracy-to-crime', 'traf-vehicular-assault',
'harassment-dv', 'robbery-car-jacking', 'drug-opium-or-deriv-sell',
'kidnap-adult-victim', 'weapon-altering-serial-number',
'arson-other', 'weapon-flourishing', 'probation-violation',
'drug-barbiturate-sell', 'forgery-poss-of-forged-ftd', 'littering',
'kidnap-dv', 'police-obstruct-investigation', 'pawn-broker-viol',
'drug-barbiturate-possess', 'burg-auto-theft-resd-no-force',
'loitering', 'drug-make-sell-other-drug',
'forgery-counterfeit-of-obj', 'harassment-stalking-dv',
'explosive-incendiary-dev-pos', 'drug-hallucinogen-mfr',
'aslt-agg-police-gun', 'theft-of-rental-property',
'drug-forgery-to-obtain', 'obstructing-govt-operation',
'intimidation-of-a-witness', 'obscene-material-possess',
'explosives-posses', 'agg-aslt-police-weapon', 'arson-business',
'parole-violation', 'drug-hallucinogen-sell', 'escape',
'extortion', 'arson-vehicle', 'escape-aiding',
'burg-auto-theft-busn-w-force', 'traf-vehicular-homicide',
'burg-auto-theft-busn-no-force', 'drug-opium-or-deriv-possess',
'gambling-gaming-operation', 'prostitution-aiding',
'impersonation-of-police', 'forgery-posses-forge-device',
'theft-confidence-game', 'gambling-device',
'police-making-a-false-rpt', 'drug-methamphetamine-mfr',
'theft-gas-drive-off', 'robbery-bank', 'bribery',
'animal-poss-of-dangerous', 'disarming-a-peace-officer',
'explosive-incendiary-dev-use', 'traf-impound-vehicle',
'liquor-misrepresent-age-minor'], dtype=object)

```

### 1.1.13 Data Modeling

The 2017 crime data frame was modeled using a Random Forest algorithm. The classification of crimes was based on location, time and date.

The first step was to classify dangerous crimes such as assault and theft related crimes and assign them a value 1. All other crimes were classified with a 0.

The next step was applying One-Hot Encoding on the hour of day, day of month, month, latitude and longitude where the crime occurred.

```
[84]: dangerous_crimes = [ 'criminal-trespassing', 'theft-of-motor-vehicle',
    'burglary-residence-by-force', 'theft-parts-from-vehicle',
    'theft-items-from-vehicle', 'assault-dv',
    'drug-poss-paraphernalia', 'robbery-street', 'theft-shoplift',
    'aggravated-assault', 'criminal-mischief-graffiti',
    'drug-methamphetamine-possess',
    'weapon-unlawful-discharge-of', 'weapon-by-prev-offender-powpo',
    'aggravated-assault-dv',
    'weapon-fire-into-occ-veh', 'criminal-mischief-mtr-veh',
    'criminal-mischief-other', 'threats-to-injure',
    'drug-cocaine-possess', 'robbery-business',
    'violation-of-court-order', 'public-fighting',
    'violation-of-restraining-order', 'burglary-vending-machine',
    'fraud-identity-theft', 'drug-methamphetamine-sell',
    ↪ 'traf-habitual-offender',
    'drug-marijuana-cultivation', 'drug-heroin-sell',
    'vehicular-eluding-no-chase', 'police-interference',
    'theft-from-bldg', 'drug-marijuana-sell', 'weapon-fire-into-occ-bldg',
    'drug-heroin-possess', 'drug-marijuana-possess',
    ↪ 'police-resisting-arrest',
    'weapon-carrying-prohibited', 'drug-hallucinogen-possess',
    'police-disobey-lawful-order',
    'drug-synth-narcotic-sell', 'weapon-other-viol',
    'drug-pcs-other-drug', 'harassment-sexual-in-nature',
    'forgery-checks', 'false-imprisonment',
    'fraud-criminal-impersonation', 'bomb-threat', 'homicide-other',
    'assault-police-simple', 'indecent-exposure', 'harassment',
    ↪ 'burglary-safe',
    'burg-auto-theft-resd-w-force', 'contraband-possession',
    'vehicular-eluding', 'theft-fail-return-rent-veh',
    'property-crimes-other', 'weapon-poss-illegal-dangerous',
    'theft-from-mails', 'drug-fraud-to-obtain',
    'violation-of-custody-order', 'drug-cocaine-sell',
    ↪ 'robbery-purse-snatch-w-force',
    'animal-cruelty-to', 'reckless-endangerment',
    'drug-synth-narcotic-possess', 'contraband-into-prison',
    'accessory-conspiracy-to-crime', 'traf-vehicular-assault',
    'harassment-dv', 'robbery-car-jacking', 'drug-opium-or-deriv-sell',
    'kidnap-adult-victim', 'weapon-altering-serial-number',
    'arson-other', 'weapon-flourishing', 'probation-violation',
    'drug-barbiturate-sell', 'forgery-poss-of-forged-ftd', 'littering',
    'kidnap-dv', 'police-obstruct-investigation', 'pawn-broker-viol',
```

```
'drug-barbiturate-possess', 'burg-auto-theft-resd-no-force',
'loitering', 'drug-make-sell-other-drug',
'forgery-counterfeit-of-obj', 'harassment-stalking-dv',
'explosive-incendiary-dev-pos', 'drug-hallucinogen-mfr',
'aslt-aggr-police-gun', 'theft-of-rental-property',
'drug-forgery-to-obtain', 'obstructing-govt-operation',
'intimidation-of-a-witness', 'obscene-material-possess',
'explosives-posses', 'agg-aslt-police-weapon', 'arson-business',
'parole-violation', 'drug-hallucinogen-sell', 'escape',
'extortion', 'arson-vehicle', 'escape-aiding',
'burg-auto-theft-busn-w-force', 'traf-vehicular-homicide',
'burg-auto-theft-busn-no-force', 'drug-opium-or-deriv-possess',
'gambling-gaming-operation', 'prostitution-aiding',
'impersonation-of-police', 'forgery-posses-forge-device',
'theft-confidence-game', 'gambling-device',
'police-making-a-false-rpt', 'drug-methamphetamine-mfr',
'theft-gas-drive-off', 'robbery-bank', 'bribery',
'animal-poss-of-dangerous', 'disarming-a-peace-officer',
'explosive-incendiary-dev-use', 'traf-impound-vehicle',
'liquor-misrepresent-age-minor']
```

```
[85]: features = df_crime[['Offence Types', 'Latitude', 'Longitude']]
features = features.join(pd.get_dummies(df_crime.Hour, prefix='Hour'))
features = features.join(pd.get_dummies(df_crime.day_name))
features = features.join(pd.get_dummies(df_crime.month_name))
features['dangerous_crime'] = 0

features.loc[features['Offence Types'].isin(dangerous_crimes),
↳ 'dangerous_crime'] = 1
features.head()
```

```
[85]:
```

	Offence Types	Latitude	Longitude	Hour_00	Hour_01	\
0	theft-bicycle	-104.999264	39.753669	0	0	
1	traf-other	-104.973097	39.740032	0	0	
3	burglary-residence-no-force	-105.042398	39.787581	0	0	
5	burglary-residence-no-force	-105.018501	39.784790	0	0	
7	burglary-residence-no-force	-104.997312	39.757979	0	0	

	Hour_02	Hour_03	Hour_04	Hour_05	Hour_06	Hour_07	Hour_08	Hour_09	\
0	0	0	0	0	0	0	1	0	
1	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	

	Hour_10	Hour_11	Hour_12	Hour_13	Hour_14	Hour_15	Hour_16	Hour_17	\
0	0	0	0	0	0	0	0	0	



1	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
7	0	1	0	0	0	0	0	0

	Hour_18	Hour_19	Hour_20	Hour_21	Hour_22	Hour_23	Friday	Monday	\
0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	
3	0	0	0	1	0	0	0	0	
5	0	0	0	0	0	1	0	0	
7	0	0	0	0	0	0	0	0	

	Saturday	Sunday	Thursday	Tuesday	Wednesday	April	August	December	\
0	0	0	0	0	1	0	0	1	
1	0	0	1	0	0	0	0	0	
3	0	1	0	0	0	0	0	0	
5	0	1	0	0	0	1	0	0	
7	0	0	0	0	1	0	0	0	

	February	January	July	June	March	May	November	October	September	\
0	0	0	0	0	0	0	0	0	0	
1	0	0	0	1	0	0	0	0	0	
3	0	0	0	0	0	1	0	0	0	
5	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	1	0	0	

	dangerous_crime
0	0
1	0
3	0
5	0
7	0

#### 1.1.14 Random Forest Algorithm

The RF algorithm was chosen to model and classify the dataset. This algorithm searches for the best feature among a random subset of features while splitting a node. Another important advantage of this algorithm is the ability to visualize the relative importance of different features.

The dataset was split into train and test datasets.

```
[86]: X = features.drop(['dangerous_crime', 'Offence Types'], axis=1)
X = preprocessing.StandardScaler().fit(X).transform(X)
y = features.dangerous_crime.values

X_train, X_test, y_train, y_test = train_test_split( X, y, test_size=0.2,
↪random_state=4)
```

```
[87]: N = [5, 10, 20, 40, 100, 200, 500]
scores = []
f1 = []
jaccard = []

for n in N:
    rf_model = RandomForestClassifier(n_estimators=n, max_features='auto').
    ↪fit(X_train, y_train)
    yhat_rf = rf_model.predict(X_test)

    rf_score = rf_model.score(X_test, y_test)
    rf_f1 = metrics.f1_score(y_test, yhat_rf, average='weighted')
    rf_jaccard = metrics.jaccard_similarity_score(y_test, yhat_rf)

    scores.append(rf_score)
    f1.append(rf_f1)
    jaccard.append(rf_jaccard)
```

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: jaccard\_similarity\_score has been deprecated and replaced with jaccard\_score. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: jaccard\_similarity\_score has been deprecated and replaced with jaccard\_score. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: jaccard\_similarity\_score has been deprecated and replaced with jaccard\_score. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: jaccard\_similarity\_score has been deprecated and replaced with jaccard\_score. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: jaccard\_similarity\_score has been deprecated and replaced with jaccard\_score. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

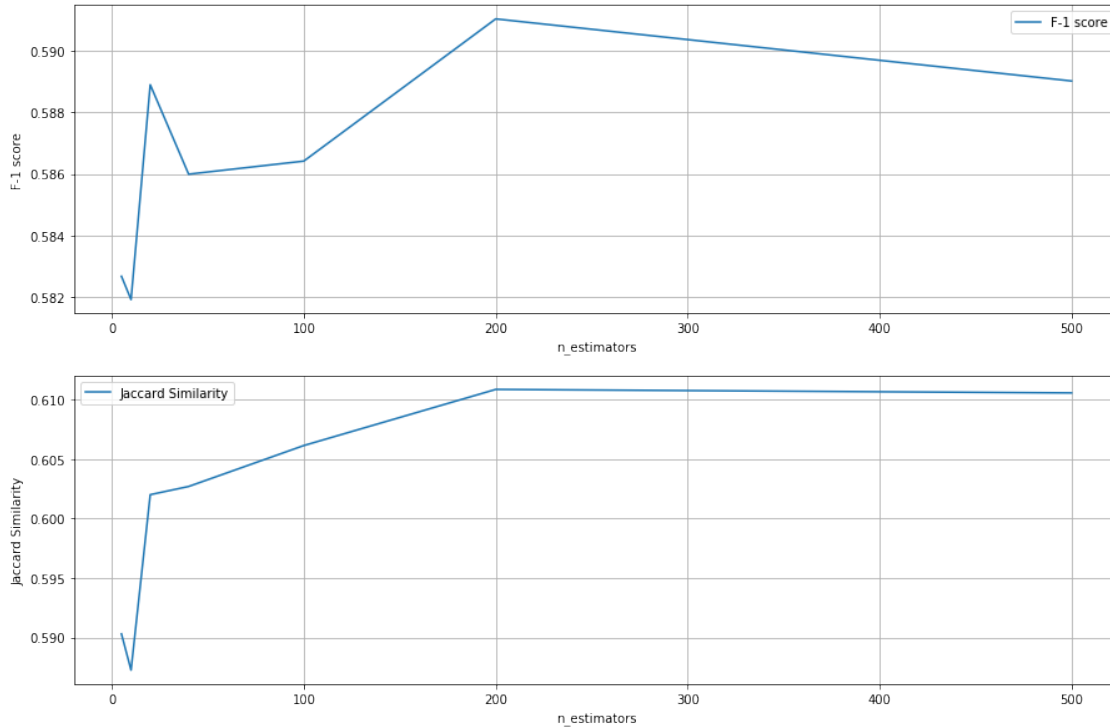
```
C:\Users\hafiz\anaconda3\lib\site-  
packages\sklearn\metrics\_classification.py:664: FutureWarning:  
jaccard_similarity_score has been deprecated and replaced with jaccard_score. It  
will be removed in version 0.23. This implementation has surprising behavior for  
binary and multiclass classification tasks.
```

```
FutureWarning)
```

```
C:\Users\hafiz\anaconda3\lib\site-  
packages\sklearn\metrics\_classification.py:664: FutureWarning:  
jaccard_similarity_score has been deprecated and replaced with jaccard_score. It  
will be removed in version 0.23. This implementation has surprising behavior for  
binary and multiclass classification tasks.
```

```
FutureWarning)
```

```
[88]: fig, ax = plt.subplots(2, 1, sharex=True)  
fig.set_size_inches(15,10)  
  
plt.subplot(2, 1, 1)  
ax[0] = plt.plot(N, f1, label='F-1 score')  
plt.xlabel('n_estimators')  
plt.ylabel('F-1 score')  
plt.legend()  
  
plt.subplot(2, 1, 2)  
ax[1] = plt.plot(N, jaccard, label='Jaccard Similarity')  
plt.xlabel('n_estimators')  
plt.ylabel('Jaccard Similarity')  
plt.legend()  
plt.show()
```



The hyperparameter `n_estimators` was tuned over a range of values. The accuracy looked to be topping out at `n = 200`. The other hyperparameters were left to be at their default values.

```
[89]: n_best = 200

rf_model = RandomForestClassifier(n_estimators=n_best, max_features='auto').
    ↪ fit(X_train, y_train)
yhat_rf = rf_model.predict(X_test)
```

```
[90]: rf_score = rf_model.score(X_test, y_test)
rf_f1 = metrics.f1_score(y_test, yhat_rf, average='weighted')
rf_jaccard = metrics.jaccard_similarity_score(y_test, yhat_rf)
rf_logloss = metrics.log_loss(y_test, yhat_rf)

print('F-1 score: {}'.format(rf_f1))
print('Jaccard Similarity: {}'.format(rf_jaccard))
```

F-1 score: 0.5903449709907572

Jaccard Similarity: 0.6113459836790877

C:\Users\hafiz\anaconda3\lib\site-packages\sklearn\metrics\\_classification.py:664: FutureWarning: `jaccard_similarity_score` has been deprecated and replaced with `jaccard_score`. It will be removed in version 0.23. This implementation has surprising behavior for binary and multiclass classification tasks.

FutureWarning)

[ ]: