Project

November 21, 2019

In [2]:
```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_score, recall_score, confusion_matrix, classifica

# ML Libraries
from sklearn.ensemble import RandomForestClassifier,VotingClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.svm import SVC
import xgboost as xgb

# Evaluation

from sklearn import metrics

# Visualization Libraries
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns
```

In [3]:
```
df =pd.read_csv('Chicago_Crimes_2012_to_2017.csv')
df.head()
```

Out[3]:
```
   Unnamed: 0        ID Case Number                    Date  \
0           3  10508693    HZ250496  05/03/2016 11:40:00 PM
1          89  10508695    HZ250409  05/03/2016 09:40:00 PM
2         197  10508697    HZ250503  05/03/2016 11:31:00 PM
3         673  10508698    HZ250424  05/03/2016 10:10:00 PM
4         911  10508699    HZ250455  05/03/2016 10:00:00 PM

                Block  IUCR           Primary Type            Description  \
0    013XX S SAWYER AVE  0486                BATTERY  DOMESTIC BATTERY SIMPLE
1    061XX S DREXEL AVE  0486                BATTERY  DOMESTIC BATTERY SIMPLE
2   053XX W CHICAGO AVE  0470  PUBLIC PEACE VIOLATION       RECKLESS CONDUCT
3     049XX W FULTON ST  0460                BATTERY                 SIMPLE
4     003XX N LOTUS AVE  0820                  THEFT         $500 AND UNDER
```

```
  Location Description  Arrest            ...               Ward  \
0            APARTMENT    True            ...               24.0
1            RESIDENCE   False            ...               20.0
2               STREET   False            ...               37.0
3             SIDEWALK   False            ...               28.0
4            RESIDENCE   False            ...               28.0

   Community Area  FBI Code  X Coordinate  Y Coordinate  Year  \
0            29.0       08B     1154907.0     1893681.0  2016
1            42.0       08B     1183066.0     1864330.0  2016
2            25.0        24     1140789.0     1904819.0  2016
3            25.0       08B     1143223.0     1901475.0  2016
4            25.0        06     1139890.0     1901675.0  2016

               Updated On   Latitude  Longitude                        Location
0  05/10/2016 03:56:50 PM  41.864073 -87.706819  (41.864073157, -87.706818608)
1  05/10/2016 03:56:50 PM  41.782922 -87.604363   (41.782921527, -87.60436317)
2  05/10/2016 03:56:50 PM  41.894908 -87.758372  (41.894908283, -87.758371958)
3  05/10/2016 03:56:50 PM  41.885687 -87.749516  (41.885686845, -87.749515983)
4  05/10/2016 03:56:50 PM  41.886297 -87.761751  (41.886297242, -87.761750709)

[5 rows x 23 columns]
```

In [4]: df.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1456714 entries, 0 to 1456713
Data columns (total 23 columns):
Unnamed: 0              1456714 non-null int64
ID                      1456714 non-null int64
Case Number             1456713 non-null object
Date                    1456714 non-null object
Block                   1456714 non-null object
IUCR                    1456714 non-null object
Primary Type            1456714 non-null object
Description             1456714 non-null object
Location Description    1455056 non-null object
Arrest                  1456714 non-null bool
Domestic                1456714 non-null bool
Beat                    1456714 non-null int64
District                1456713 non-null float64
Ward                    1456700 non-null float64
Community Area          1456674 non-null float64
FBI Code                1456714 non-null object
X Coordinate            1419631 non-null float64
Y Coordinate            1419631 non-null float64
Year                    1456714 non-null int64
Updated On              1456714 non-null object
```

```
Latitude                1419631 non-null float64
Longitude               1419631 non-null float64
Location                1419631 non-null object
dtypes: bool(2), float64(7), int64(4), object(10)
memory usage: 236.2+ MB
```

```
In [5]: #droppping empty cells
        df = df.dropna()
```

We will take a subset sample of the data to work upon

```
In [6]: df = df.sample(n = 100000)
```

Dropping Unnamed, ID and Case number as this can have no relation with the class of crime

```
In [7]: df = df.drop(['Unnamed: 0'], axis = 1)
        df = df.drop(['ID'], axis=1)
        df = df.drop(['Case Number'], axis=1)

        df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 100000 entries, 708596 to 1296987
Data columns (total 20 columns):
Date                    100000 non-null object
Block                   100000 non-null object
IUCR                    100000 non-null object
Primary Type            100000 non-null object
Description             100000 non-null object
Location Description    100000 non-null object
Arrest                  100000 non-null bool
Domestic                100000 non-null bool
Beat                    100000 non-null int64
District                100000 non-null float64
Ward                    100000 non-null float64
Community Area          100000 non-null float64
FBI Code                100000 non-null object
X Coordinate            100000 non-null float64
Y Coordinate            100000 non-null float64
Year                    100000 non-null int64
Updated On              100000 non-null object
Latitude                100000 non-null float64
Longitude               100000 non-null float64
Location                100000 non-null object
dtypes: bool(2), float64(7), int64(2), object(9)
memory usage: 14.7+ MB
```

In [ ]:

Converting dates to numerical values for correlation

In [8]:
```
df['date_new'] = pd.to_datetime(df['Date'])
df['Hr'] = df['date_new'].dt.hour
df['Min'] = df['date_new'].dt.minute
df['Sec'] = df['date_new'].dt.second
df['YY'] = df['date_new'].dt.year
df['MM'] = df['date_new'].dt.month
df['DD'] = df['date_new'].dt.day



df = df.drop(['Date'], axis=1)
df = df.drop(['date_new'], axis=1)
df = df.drop(['Updated On'], axis=1)
df.head()
```

Out[8]:
```
                            Block  IUCR       Primary Type  \
708596            028XX N LONG AVE  0841              THEFT
26540            006XX N UNION AVE  0460            BATTERY
370153            124XX S STATE ST  0460            BATTERY
1103299  0000X W CHECKPOINT 6 ST  5007      OTHER OFFENSE
1010405      044XX N MAGNOLIA AVE  1350  CRIMINAL TRESPASS

                             Description  \
708596   FINANCIAL ID THEFT:$300 &UNDER
26540                             SIMPLE
370153                            SIMPLE
1103299         OTHER WEAPONS VIOLATION
1010405                TO STATE SUP LAND

                                Location Description  Arrest  Domestic  Beat  \
708596                             SMALL RETAIL STORE   False      True  2514
26540                                           OTHER   False     False  1214
370153                        SCHOOL, PUBLIC, GROUNDS   False     False   523
1103299  AIRPORT TERMINAL UPPER LEVEL - SECURE AREA   False     False  1653
1010405                        CHA PARKING LOT/GROUNDS    True     False  1913

         District  Ward ...  Year   Latitude  Longitude  \
708596       25.0  31.0 ...  2013  41.931564 -87.761343
26540        12.0  27.0 ...  2014  41.892896 -87.645888
370153        5.0   9.0 ...  2012  41.667504 -87.622283
1103299      16.0  41.0 ...  2016  41.975869 -87.902593
1010405      19.0  46.0 ...  2015  41.962581 -87.660979

                              Location  Hr  Min  Sec    YY  MM  DD
```

```
708596    (41.931564146, -87.761343076)  15   30    0  2013  12  26
26540     (41.892895925, -87.645887668)   8    8    0  2014   8  14
370153    (41.667503644, -87.622282981)  10   40    0  2012  11  16
1103299    (41.97586893, -87.902593203)   5    0    0  2016   4  10
1010405   (41.962581499, -87.660978843)  21   30    0  2015   4  23

[5 rows x 24 columns]
```

Converting Categorical Features to Numerical

In [9]:
```python
df['Block'] = pd.factorize(df["Block"])[0]
df['FBI Code'] = pd.factorize(df["FBI Code"])[0]

df['Location Description'] = pd.factorize(df["Location Description"])[0]

df['Location'] = pd.factorize(df["Location"])[0]

df['IUCR'] = pd.factorize(df["IUCR"])[0]
df['Description'] = pd.factorize(df["Description"])[0]
```

In [10]:
```python
df.head()
```

Out[10]:
```
         Block  IUCR       Primary Type  Description  Location Description  \
708596       0     0              THEFT            0                     0
26540        1     1            BATTERY            1                     1
370153       2     1            BATTERY            1                     2
1103299      3     2      OTHER OFFENSE            2                     3
1010405      4     3  CRIMINAL TRESPASS            3                     4

         Arrest  Domestic  Beat  District  Ward ...  Year   Latitude  \
708596    False      True  2514      25.0  31.0 ...  2013  41.931564
26540     False     False  1214      12.0  27.0 ...  2014  41.892896
370153    False     False   523       5.0   9.0 ...  2012  41.667504
1103299   False     False  1653      16.0  41.0 ...  2016  41.975869
1010405    True     False  1913      19.0  46.0 ...  2015  41.962581

         Longitude  Location  Hr  Min  Sec    YY  MM  DD
708596  -87.761343         0  15   30    0  2013  12  26
26540   -87.645888         1   8    8    0  2014   8  14
370153  -87.622283         2  10   40    0  2012  11  16
1103299 -87.902593         3   5    0    0  2016   4  10
1010405 -87.660979         4  21   30    0  2015   4  23

[5 rows x 24 columns]
```

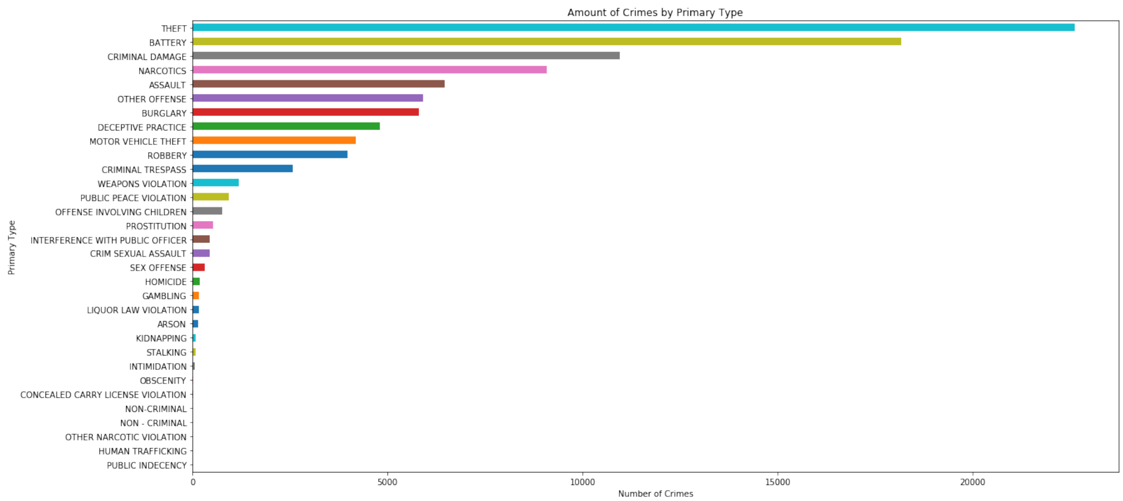
Now we have all the features with numerical values and we can plot the graphs

In [12]:
```python
# Plot Bar Chart visualize Primary Types
plt.figure(figsize=(20,10))
```

```
plt.title('Amount of Crimes by Primary Type')

plt.xlabel('Number of Crimes')
plt.ylabel('Type of Crime')
graph = df.groupby([df['Primary Type']]).size().sort_values(ascending=True)
graph.plot(kind='barh')

plt.show()
```



We can see that some crimes have very less frequeny and we can club them as others

In [13]:
```
# we sum up the amount of Crime Type happened and select the last 10classes
crime_classes = df.groupby(['Primary Type'])['IUCR'].size().reset_index()
#print(all_classes.head())
crime_classes.rename(columns={"IUCR":"Size"},inplace=True)
crime_classes = crime_classes.sort_values(['Size'], ascending=[False])

other_classes = crime_classes.tail(10)
other_classes
```

Out[13]:

	Primary Type	Size
14	KIDNAPPING	75
29	STALKING	73
13	INTIMIDATION	50
20	OBSCENITY	10
4	CONCEALED CARRY LICENSE VIOLATION	7
19	NON-CRIMINAL	6
18	NON - CRIMINAL	3
22	OTHER NARCOTIC VIOLATION	3
11	HUMAN TRAFFICKING	2
25	PUBLIC INDECENCY	1

```
In [ ]:
```

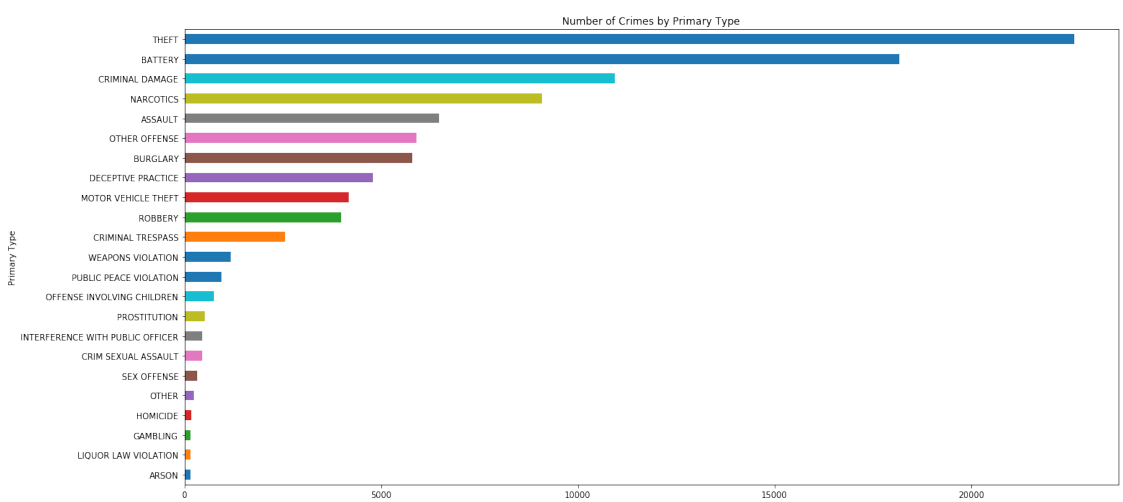
```
In [14]: name_dic = {"KIDNAPPING":"OTHER",
         "STALKING":"OTHER",
         "INTIMIDATION":"OTHER",
         "OBSCENITY":"OTHER",
         "PUBLIC INDECENCY":"OTHER",
         "CONCEALED CARRY LICENSE VIOLATION":"OTHER",
         "NON-CRIMINAL":"OTHER",
         "NON - CRIMINAL":"OTHER",
         "HUMAN TRAFFICKING":"OTHER",
         "OTHER NARCOTIC VIOLATION":"OTHER"}
         # After that, we replaced it with label 'OTHERS'

         df.replace({"Primary Type":name_dic},inplace=True)
         #df.loc[df['Primary Type'].isin(unwanted_classes['Primary Type']), 'Primary Type'] =

         # Plot Bar Chart visualize Primary Types
         plt.figure(figsize=(20,10))
         plt.title('Number of Crimes by Primary Type')
         plt.ylabel('Type of Crime')
         plt.xlabel('Number of Crimes')

         df.groupby([df['Primary Type']]).size().sort_values(ascending=True).plot(kind='barh')

         plt.show()
```




```
In [15]: #Now we have 23 classes to predict
         Classes = df['Primary Type'].unique()
         len(Classes)
```

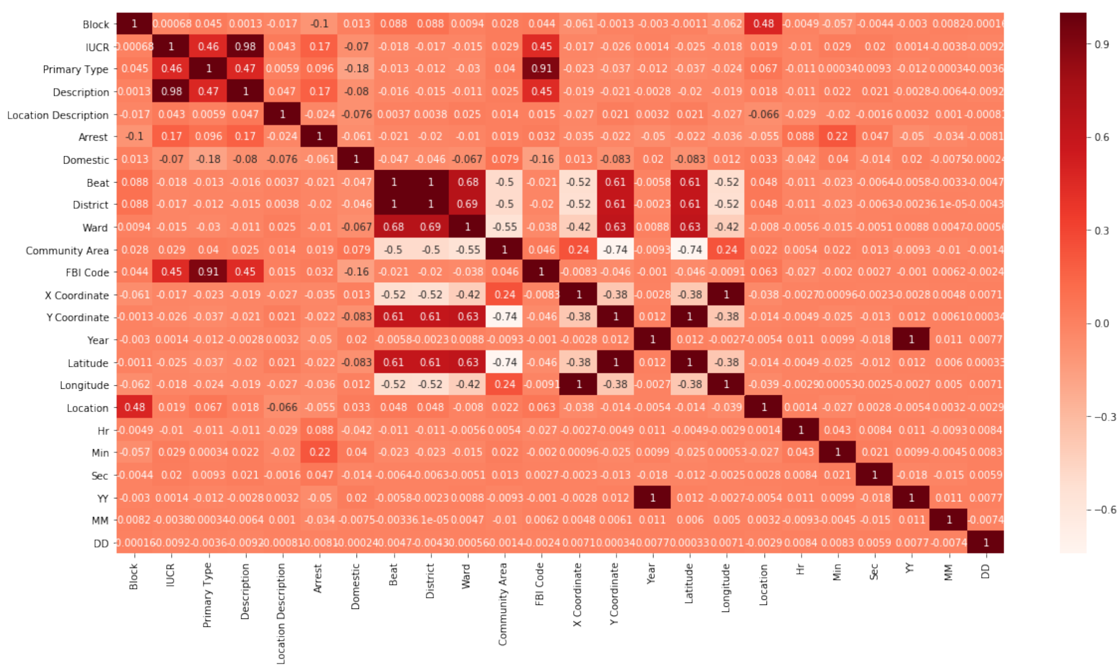
```
Out[15]: 23
```

```
In [16]: #Encode target class
         df['Primary Type'] = pd.factorize(df["Primary Type"])[0]
         df['Primary Type'].unique()
```

```
Out[16]: array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
                17, 18, 19, 20, 21, 22], dtype=int64)
```

```
In [17]: # Split Dataframe to target class and features
         X_data = df.drop(['Primary Type'], axis=1)
         Y_data = df['Primary Type']
```

```
In [18]: #Using Pearson Correlation and heatmap foe feature selection
         plt.figure(figsize=(20,10))
         cor = df.corr()
         sns.heatmap(cor, annot=True, cmap=plt.cm.Reds)
         plt.show()
```




```
In [19]: Features = ["IUCR","Description","Arrest","Location Description","Domestic"]
         print('Full Features: ', Features)
         Target = "Primary Type"
```

```
Full Features:  ['IUCR', 'Description', 'Arrest', 'Location Description', 'Domestic']
```

In [22]:
```
#Split dataset to Training Set & Test Set
x, y = train_test_split(df,
                        test_size = 0.2,
                        train_size = 0.8,
                        random_state= 3)

x1 = x[Features]    #Features to train
x2 = x[Target]      #Target Class to train
y1 = y[Features]    #Features to test
y2 = y[Target]      #Target Class to test

print('Features  : ', Features)
print('Target Class        : ', Target)
print('Training Set   : ', x.shape)
print('Test Set     : ', y.shape)
```

```
Features  :  ['IUCR', 'Description', 'Arrest', 'Location Description', 'Domestic']
Target Class        :  Primary Type
Training Set   :  (80000, 24)
Test Set     :  (20000, 24)
```

In [23]:
```
# Random Forest
# Create Model with configuration
rf_model = RandomForestClassifier()

# Model Training
rf_model.fit(X=x1,
             y=x2)

# Prediction
result = rf_model.predict(y[Features])
```

```
C:\Users\tanma\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The 
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

In [24]:
```
print("Random Forest Results")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
Random Forest Results
Accuracy    :  0.992
Recall      :  0.992
Precision   :  0.9919089395908662
F1 Score    :  0.992
```

In [25]:
```
rf_model = RandomForestClassifier(n_estimators=20, # Number of trees
                                  min_samples_split = 30,
                                  bootstrap = True,
                                  max_depth = 20,
                                  min_samples_leaf = 25)
rf_model.fit(X=x1,
             y=x2)

# Prediction
result = rf_model.predict(y[Features])
```

In [26]:
```
print("Random Forest Results (Tuned)")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
Random Forest Results (Tuned)
Accuracy    :  0.9694
Recall      :  0.9694
Precision   :  0.9693551768577167
F1 Score    :  0.9694
```

In [27]:
```
knn_model = KNeighborsClassifier()
knn_model.fit(X=x1,y=x2)
result = knn_model.predict(y[Features])
```

In [28]:
```
print("KNN Results")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
KNN Results
Accuracy    :  0.98365
Recall      :  0.98365
Precision   :  0.98359532945818
F1 Score    :  0.98365
```

In [29]:
```
knn_model = KNeighborsClassifier(n_neighbors=7,weights='distance')
knn_model.fit(X=x1,y=x2)
result = knn_model.predict(y[Features])
```

In [30]:
```
print("KNN Results(Tuned)")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
KNN Results(Tuned)
Accuracy    :  0.9884
Recall      :  0.9884
Precision   :  0.9884235088414384
F1 Score    :  0.9884
```

In [31]:
```
xg_model = xgb.XGBClassifier()
xg_model.fit(X=x1,y=x2)
result = xg_model.predict(y[Features])
```

In [32]:
```
print("XGB Results")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
XGB Results
Accuracy    :  0.984
Recall      :  0.984
Precision   :  0.9848091467665612
F1 Score    :  0.984
```

In [33]:
```
xg_model = xgb.XGBClassifier(max_depth=5,learning_rate=0.1,n_estimator=150)
xg_model.fit(X=x1,y=x2)
result = xg_model.predict(y[Features])
```

In [34]:
```
print("XGB Results")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
XGB Results
Accuracy    :  0.99665
Recall      :  0.99665
Precision   :  0.9966657653162163
F1 Score    :  0.99665
```

In [35]:
```
MLP_model = MLPClassifier()
xg_model.fit(X=x1,y=x2)
result = xg_model.predict(y[Features])
```

In [65]:
```
print("MLPClassifier Results")
print("Accuracy    : ", accuracy_score(y2, result))
print("Recall      : ", recall_score(y2, result, average="weighted"))
print("Precision   : ", precision_score(y2, result, average="weighted"))
print("F1 Score    : ", f1_score(y2, result, average='micro'))
```

```
MLPClassifier Results
Accuracy     :  0.9968
Recall       :  0.9968
Precision    :  0.9968296360098488
F1 Score     :  0.9968
```

In [66]:
```
MLP_model = MLPClassifier(hidden_layer_sizes=(150,2))
xg_model.fit(X=x1,y=x2)
result = xg_model.predict(y[Features])
```

In [67]:
```
print("MLPClassifier Results")
print("Accuracy     : ", accuracy_score(y2, result))
print("Recall       : ", recall_score(y2, result, average="weighted"))
print("Precision    : ", precision_score(y2, result, average="weighted"))
print("F1 Score     : ", f1_score(y2, result, average='micro'))
```

```
MLPClassifier Results
Accuracy     :  0.9968
Recall       :  0.9968
Precision    :  0.9968296360098488
F1 Score     :  0.9968
```

In [ ]: