**Basic Statistical Analysis and data cleaning insight**

1. The results of basic statistical analysis (by running statistical\_analysis.py):

For some categorical attributes:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | SHIFT | METHOD | OFFENSE | NEIGHBORHOOD\_CLUSTER |
| mode | EVENING | OTHERS | THEFT/OTHER | Cluster 2 |
| unique | 3 | 3 | 9 | 39 |
| frequency | 0.4265 | 0.9304 | 0.4361 | 0.0816 |

|  |  |  |
| --- | --- | --- |
|  | BLOCK | VOTING\_PRECINCT |
| mode | 3100 - 3299 BLOCK OF 14TH STREET NW | Precinct 129 |
| unique | 447 | 143 |
| frequency | 0.0265 | 0.0427 |

For some numeric attributes:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | PSA | CENSUS\_TRACT | LATITUDE | LONGITUDE |
| mean | 373.48 | 6259.70 | 38.906884 | -77.007081 |
| median | 401 | 3600 | 38.906430 | -77.011367 |
| std | 194.17 | 3126.13 | 0.0298 | 0.036469 |

“SHIFT” is when the crime happens (day, night or midnight). We can see that crimes are more likely happen in the evening than in the daytime

“METHOD” is how the crime is committed (with a gun/knife or other way). From the above results we can conclude that most of reported crimes do not involve with weapons.

“OFFENSE” refers to crime offenses which includes many types of crime. But from the results most of crimes belong to a broad inclusion of Theft offenses including embezzlement, theft of services and fraud/false pretenses

The mode of attributes “NEIGHBORHOOD\_CLUSTER”, “BLOCK” and “VOTING\_PRECINCT” shows that where happens the most crimes.

The numeric attributes “LATITUDE”, “LONGITUDE” also shows where a crime happens. The mean or median may shows the center of the DC since crime happens everywhere.

Though PSA is a numeric attribute, the number is only a code. The mean, median or std doesn’t make much sense.

1. The strategy for handling missing values

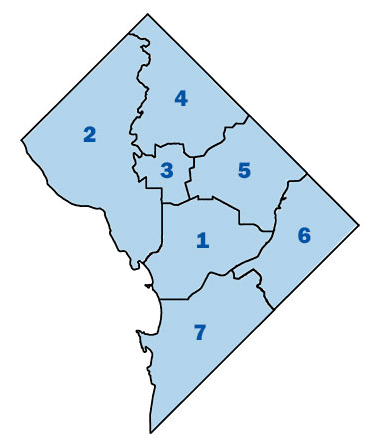
The attributes “DISTRICT” and “PSA” have a few missing values

Though they are numeric attributes, the number is only a code. So we use it’s mode to replace the missing values.

1. The binning strategy:

Since we may explore whether the location has a relationship with crime rate and PSA represents the locations well, we decided to bin the attribute “PSA”

For the attribute “PSA”, we use pre-binning strategy: {100, 200, 300, 400, 500, 600, 700, 800}. This is because the code between 100 and 200 belongs to the first district, the code between 200 and 300 belongs to the second district… and there are 7 districts in total:



1. Other strategies for data pre-processing:  
   a) drop the attributes which is not helpful for our further questions

Since the object\_id is a unique code for each observation and it is not helpful for us to do the association rule mining or machine learning. We decided to drop the attribute.

b) encode some nominal attributes or convert them to numeric attributes

For attribute “OFFENSE”, we encode this using number 1-9, where the bigger number indicates the higher level of crime.

And for some other attributes such as “SHIFT” or “METHOD”, we map them to do the following machine learnings.

5）LOF:

We used 3 different values of k(25,35,45) to detect outliers and get different results. And we set the parameter contamination 0.01 as a propotion of the outliers detected in the datasets.

**Histogram and Correlations**

1. run python/python3 plot.py --hvar SHIFT LATITUDE LONGITUDE --bins 3 10 10 --qvar WARD DISTRICT NEIGHBORHOOD\_CLUSTER

From the histograms, we can see most of the crimes happened in evening and mid night. Longitude and Latitude crimes happened at are near to gaussian distribution.

From the scatter plot, we can see the three attributes are relatively highly correlated. This indicates that these 3 types of area dividing are following the same order.

**Clustering:**

1. Strategies

We used KMeans, agglomerative clustering and DBSCAN to finish the clustering.

KMeans:

For n\_clusters = 5,The average calinski\_harabaz\_score is : 11889.238552083982

AgglomerativeClustering:

For n\_clusters = 5 The average calinski\_harabaz\_score is : 11261.811949709789

DBSCAN:

The average calinski\_harabaz\_score is : 2793.6947973013785

On the same dataset, according to the scores evaluated by the Calinski-Harabaz procedures, when we chose k=5 as the value of k in kmeans or as a case to end hierarchical clustering, these 2 clustering strategies had similar scores. However when we used DBSCAN on the data set, the score was really low, that is, the DBSCAN clustering did not well on our data set.

1. PCA projections

**path: ./plots/kmeans\_pca.png, ./plots/agglomerative\_pca.png, ./plots/dbscan\_pca.png,**

By plotting the 2D PCA projection it is easy to explain why the DBSCAN got such a low score. We can see directly that in the PCA of DBSCAN, the strategy produced more than 120 clusters and there are no obvious boundaries among those clusters. The reason that the clustering quality is poor may be that the density of the sample set is not uniform and the difference in cluster spacing is very different. At this time, DBSCAN clustering is generally not suitable.

**Association Rules/ Frequent Itemset Mining Analysis**

running association\_rules.py on dataset crime2017

Let the minimum confidence be 0.5 and set different minimum support

1. Minimum support = 0.2

|  |  |  |
| --- | --- | --- |
| patterns | support | confidence |
| {'DAY'}→{'OTHERS'} | 0.353 | 0.965 |
| {'EVENING'}→{'OTHERS'} | 0.400 | 0.939 |
| {'THEFT F/AUTO'}→{'OTHERS'} | 0.317 | 1.0 |
| {'THEFT/OTHER'}→{'OTHERS'} | 0.436 | 0.999 |
| {'THEFT/OTHER', 'EVENING'}→{'OTHERS'} | 0.221 | 1.0 |
| {'EVENING'}→{'THEFT/OTHER'} | 0.221 | 0.506 |

1. Minimum support = 0.3

|  |  |  |
| --- | --- | --- |
| patterns | support | confidence |
| {'DAY'}→{'OTHERS'} | 0.353 | 0.965 |
| {'EVENING'}→{'OTHERS'} | 0.400 | 0.939 |
| {'THEFT F/AUTO'}→{'OTHERS'} | 0.317 | 1.0 |
| {'THEFT/OTHER'}→{'OTHERS'} | 0.436 | 0.999 |

1. Minimum support = 0.4

|  |  |  |
| --- | --- | --- |
| patterns | support | confidence |
| {'EVENING'}→{'OTHERS'} | 0.400 | 0.939 |
| {'THEFT/OTHER'}→{'OTHERS'} | 0.436 | 0.999 |

The most frequent patterns are {'EVENING'}→{'OTHERS'} and {'THEFT/OTHER'}→{'OTHERS'}.

This is not surprising at all. Because through the basic statistical analysis, we can see that the frequency of value “OTHERS” is up to 0.93 for the attribute “METHOD”, which means it has a high chance of being included in the most frequent patterns.

These patterns do make sense: One shows us that most of crimes that happens in the evening do not involve with dangerous weapons like guns or knives. And the other one shows us that almost every theft, embezzlement, theft of services or fraud/false pretenses doesn’t involve with weapons.

**Hypothesis Testing**

1）run python/python3 stat.py -m ttest --attr SHIFT LONGITUDE --div 1 2

First, we can see distribution of longitude in day time and evening is near to gaussian distribution

The null hypothesis is that crimes happened in day time and evening has little difference H0：μ0 = μ1

The alternative hypothesis is that crimes happened in day time and evening has significant difference H1：μ0 ≠ μ1

The output of p value is around 5.88e-10, therefore reject the null hypothesis in support of the alternative hypothesis

2）run python/python3 stat.py -m logis --lab SHIFT

The hypothesis is that we can predict time crimes happened by other attributes related to area.

We use the logistic regression to test this hypothesis.

The output is

accuracy is 0.444789214637278

confusion matrix is

[[ 982 2274 174]

[ 888 2847 297]

[ 446 1110 328]]

We can see the hypothesis can not be proved. Area is not directly related to crime time.

**Predictive Analysis**

About the crime data in 2017, we chose 'METHOD', 'OFFENSE', 'DISTRICT', 'PSA', 'VOTING\_PRECINCT' and SHIFT as features for machine learning methods to study whether some features can classify others.

METHOD: 'OTHERS': 1, 'KNIFE': 2, 'GUN': 3

OFFENSE: 'THEFT/OTHER': 1, 'THEFT F/AUTO': 2, 'MOTOR VEHICLE THEFT': 3, 'BURGLARY': 4, 'ARSON': 5, 'ASSAULT W/DANGEROUS WEAPON': 6, 'ROBBERY': 7, 'SEX ABUSE': 8, 'HOMICIDE': 9

DISTRICT: the location of crime

VOTING\_PRECINCT: the voting precinct of crime

PSA: Police Service Area

SHIFT: 'DAY': 1, 'EVENING': 2, 'MIDNIGHT': 3

Hypothese1: 'METHOD', 'OFFENSE', 'DISTRICT', 'PSA', 'VOTING\_PRECINCT' can determine whether crimes happened in days or nights(SHIFT)

Treat evening and midnight as same.

kNN: accuracy 0.644

confusion matrix is:

[ 417 1028]

[ 397 2158]

Accuracy of SVM: 0.650

[ 262 1183]

[ 218 2337]

Accuracy of NaiveBayes: 0.639

[ 0 1445]

[ 0 2555]

Accuracy of random forest: 0.649

[ 251 1194]

[ 210 2345]

So, the location information, methods and offense can’t classify the time of crimes

Hypothese2 'SHIFT', 'OFFENSE', 'DISTRICT', 'PSA', 'VOTING\_PRECINCT' can determine what tools were used in crime(METHOD).

Treat 2,3 as one kind

Accuracy of SVM: 0.942

So, the location information, time of crimes and offense can determine whether the criminals used a weapon

Hypothese3: 'SHIFT', 'DISTRICT', 'METHOD', 'PSA', 'VOTING\_PRECINCT' can determine how serious the crime is(OFFENSE).

Treat 1-4 as a kind, 5-9 are another.

Accuracy of SVM: 0.938

So, the location information, time and methods can determine whether the crime is serious