Study of Spatial-Temporal Characteristics of Crimes in Washington D.C.

As the capital city and international tourist place of America, Washington D.C has always been suffering from its high crime rate these years. According to the newest statistics, Washington D.C. has an overall crime rate that is 86% higher than the national average, and a violent crime rate that is 148% higher than the national average. It is also dangerous than 96% of the cities in America, and each person in Washington D.C. has a 1 in 20 chance to become a victim of any crime…The high crime rate problem has seriously damaged the reputation and hindered the development of Washington D.C., the government is also seeking for the cause of the problem and the ways to solve it.

This report analyses the spatial-temporal characteristics and the mechanism of urban crime in the Washington, D. C. which serves to police department of Washington, D. C. in the United States of America (hereafter referred to as the ‘client’). The aim of this report is to answer the question of “What factors contribute to the high crime rate of Washington D.C. and the solutions”. In this report, we gathered and filtered data that are probably relevant to Washington D.C.’s high crime rate, and analysed the spatial and temporal relations between these data and the crime rate. Finally, we presented our client the expected outcome including a result illustrating several primary factors which contribute to the level of crime rate in different area, and suggestions for improving safety and security of D.C..

In the next section, we will introduce the data collection of this research, which contains a collection of maps and tables about the distribution of different kinds of crime, population density, unemployment rate and police stations etc. Then, the third section will be the detailed analysis about the relations between these characteristics and crime rate using a series of methodologies. After that, we will present the expected outcome for our client in the fourth section and the rest parts of the report will be our time plan and individuals inflections.

2 Data Collection

2.1 Base Map

The base map used in our research is a clipped version (around Washington D.C.) of the topographic base map provided by ArcGIS, shown as follows:

Fig 2-1. The base map

Reasons that we use this topographic base map are:

1. It draws a clear boundary of District of Columbia, which is the main area that we study.
2. The main roads and sub roads are differentiated using dark grey lines and white lines respectively.
3. The land use is marked on the map with different color, e.g., purple for educational buildings, blue for health infrastructures, green for vegetated areas, etc.

It is believed that the reasons above may potentially give us insights on specifying the characteristics of crime, as well as the influences of topography on crime.

2.2 Spot map of violent crimes

Fig 2-2. The violent crime spot map

The map above shows all violent crimes happened from 01/01/2011 to 24/08/2015. Source data are from http://crimemap.dc.gov, and data used contain records categorized as “Arson”, “Assault with dangerous weapon”, “Homicide”. The weapon and the time of a day for each crime incident are also recorded for further analysis.

2.3 Spot map of property crimes

Fig 2-3. The property crime spot map

This map describes the property crimes (including robbery, theft of auto/motor vehicle, burglary and others) in Washington from 2011 to 2015, of which data are also retrieved from http://crimemap.dc.gov. Information such as the time of a day and method of the crimes are recorded as well.

2.4 Spot map of sexual abuse incidents

Fig 2-4. The sexual abuse spot map

Above is the map of all sexual offences occurred from 2011 to 2015 in D.C. The data source is http://crimemap.dc.gov, which contains the approximate time and location of each crime.

2.5 Population density

Fig 2-5. The population density map

This is a clipped version of the USA population density map in 2012. The original data is from Esri’s 2012 updated demographics (https://www.esri.com/en-us/arcgis/products/esri-demographics) which has four scale levels: persons per square miles by block group, by tract, by county and by state, respectively. We will focus on block group scale because it has the highest accuracy thus provides more details for the population distribution.

According to data shown below [1], the population in Washington D.C. appears a steadily increasing trend from 2011 to 2015.

Year Population Growth Annual Growth Rate

2015 672,736 11,939 1.81%

2014 660,797 10,683 1.64%

2013 650,114 14,484 2.28%

2012 635,630 15,294 2.47%

2011 620,336 15,296 2.53%

Fig 2-6. Population growth in Washington D.C. from 2011 to 2015

Although it can be more accurate to do the research based on each year's statistics, it is less efficient and would add extra work. Therefore, we decide to use the population density of 2012 for the study.

2.6 Unemployment rate

Fig 2-7. 2012 Unemployment rate in Washington D.C.

The data of unemployment rate in D.C., 2012, is from Esri's 2012 updated demographics (https://www.esri.com/en-us/arcgis/products/esri-demographics). This map reflects the estimate for July 1, 2012. It is worth mentioned that the figures do not contain seasonal workers and only count civilians beyond 16. The average employment rate of Washington in 2012 is 8.1%, which is the same as the overall figure in USA [2].

2.7 Liquor licenses location

Fig 2-8. Liquor licenses in Washington D.C.

2.8 Homeless service facilities

The dataset records the spatial distribution of homeless facilities and service locations in the D.C. and created as part of the DC Geographic Information System. Those facilities provide different services to homeless people including clothing, computers and food groceries. Furthermore, these locations show a service area to homeless people and can evaluate population compared with unemployment rate.

Fig 2-9. Homeless service facilitiese in Washington D.C.

2.9 Closed circuit TV street cameras

The dataset demonstrates locations and attributes of CCTV and cameras. This sensor plays an important role to solve crimes. In addition, the CCTV can protect evident to help victims and investigate offenders, so it will improve deterrent to potential criminals.

Fig 2-10. Homeless service facilitiese in Washington D.C.

2.10 Bank Locations

This is a map showing all the positions of the banks in D.C. The dataset contains locations and attributes of bank branches, created as part of the D.C. Geographic Information System (D.C GIS) for the D.C. Office of the Chief Technology Officer (OCTO) and participating D.C. government agencies.

(Map source: http://opendata.dc.gov/datasets/bank-locations)

Fig 2-11. Bank locations in Washington D.C.

2.11 ATM Banking

Fig 2-12. ATM banking in Washington D.C.

This map illustrates the distribution of ATM in Washington. Data retrieved from https://opendata.dc.gov/, where the Chief Technology Office (OCTO) has captured the majority of ATM banking locations in the District of Columbia.

2.12 Low Food Access Areas

The original form of this map represents the low food access areas of the District of Columbia which are estimated to be more than a 10-minute walk from the nearest full-service grocery store. We selected some instances from the original data, which are areas having a population of more than 883 people (883 is the mean number of population per area). Then we made another selection, which filtered out the areas where more than 50% of the people have household income below 185% of the federal poverty line. We believe that the new form of this map can represent the sections where people are having trouble even satisfying the basic needs of life.

(Map source: http://opendata.dc.gov/datasets/low-food-access-areas)

Fig 2-13. Low Food Access Areas in Washington D.C.

2.13 Police Stations

This is a map containing the point locations of all publicly identified sites and offices including headquarters, station, field office and investigative unit locations. This dataset was created as part of the D.C. Geographic Information System (D.C. GIS) for the D.C. Office of the Chief Technology Officer (OCTO), MPD and participating D.C. government agencies.

(Map source: http://opendata.dc.gov/datasets/police-stations)

Fig 2-14. Police Stations in Washington D.C.

2.14 Shopping centers

Fig 2-15. Shopping centers in Washington D.C.

This map shows the location of major shopping centers in Washington, including their name and other attributes. The source of data is https://opendata.dc.gov/, where the dataset is created as part of the D.C. GIS for D.C. Office of OCTO and other D.C. government agencies.

3 Analysis

3.1 Spatial Characteristics

Rossmo [1] explained that geographic profiling combines several spatial information to contribute the topic of crime prevention, particularly in the urban environment. Our research concentrates on typical urban crimes in Washington D. C.. Furthermore, this report references from different relevant literature review to decide the approach about evaluating the spatial and temporal characteristics of D. C.. Overall, this report will discuss three types of crime including violence crime, sexual offence and property crime. In addition, there are different multi-criteria evaluation to different crimes.

3.1.1 Sexual offences

Among all common crimes, sexual offences cause the most damaging psychological trauma and are highly concerned by the public, especially females. Previous study indicates that males who commit sexual crime makes up more than 1% of the overall male population, and around 10% to 15% will recidivate in 5 years [4]. It is widely recognized that behavior of sexual offenders is influenced by various aspects, including the offender's background (ethnicity, education, family, etc.), abnormal psychology of the offender (deviant sexual interests or antisocial orientation [5]), and the environmental backcloth. We will give several hypotheses related to spatial characteristics of sexual offence based on studies of sexual criminology, and examine with the data collected whether they fit for Washington. Eventually, we want to find places where sexual crimes are likely to occur, so that prevention can be done in advance.

According to the model proposed by D. Canter and P. Larkin, sexual offenders can be characterized as commuters and marauders, where the former travels a distance to commit his crime and the latter prefers to be within the range of his base [6]. In their study of UK offenders, the majority of their sample (86%) fits the marauder model, and further research done by R. Meaney suggests that major sexual offenders are young marauders who live in urban regions [7]. These studies give us the insight that the population density and the kind (urban/rural) of an area have an impact on the occurrence of sexual offense, which leads to the following hypothesis: Sexual offences are more likely to happen in or close to highly-populated metropolitan areas.

It is also found that high education level can reduce individual's probability of committing crimes [8]. However, as for sexual crimes, studies done by J.M. Cantor's team on teleiophilic men indicate that sexual offenders and non-offenders yield similar results in terms of school performance, thus suggest that education level does not reflect propensity of carrying out sexual offence [9]. Therefore, we decide to use the data we have to discover whether education environment have impact on the spatial distribution of sexual crimes. Our hypothesis is: Areas that are rich in educational facilities have lower occurrence of sexual offence.

To examine our hypotheses, we intend to work with ArcGIS, which provides numerous tools for spatial analysis, and the datasets we collected. Since there are various possible factors, we need study the correlation between one and each other and find out true determinants for further analysis.

3.1.2 Property crime

The crime of property including burglary, theft and robbery is a crime about obtaining property from other people in illegal ways. Additionally, Douglas, Burgess, Burgess and Ressler [10] mention that property crime may cause a felony murder and is a critical motivation for a homicide. Therefore, it is important to prevent property crime in the urban environment for safety and security of residents. Gibbons [11] also points out that there is a positive correlation between urban decay and property crime. Particularly, criminal damage, one of property crime, including vandalism and graffiti can be the critical factors to influence the average house price of a community[11]. In the geographical perspective of researching property crime in the urban environment, both FENG, HUANG, DONG and SONG [12] and Sjoquist [13] demonstrate the significance of the property crime distribution on the spatial and temporal aspects. Furthermore, there are two primary principles of criminal geographical targeting, distance decay function and perceptual geographies of crime. Firstly, the distance decay function is about indicating the relationship between geography and social physics. It shows the negative correlation of distance and the object of social economy. In particular, the distance containing the distance of spatial, time and cost will reduce the impact of the social object in geographical space [14]. Then, the perceptual geographies of crime proposes the relevant research on criminal area combining nature perceptions and spatial analysis. McCormick [15] classifies the perception into five classes including environmental perception and experiences. Furthermore, the perceptual geographies of crime combine a dimension of mental geography to make decisions in daily life.

The characteristics of property crime can be discussed in spatial distribution and temporal trends. For example, the spatial distribution of burglary concentrates on a high population mobility area. The important factor of this phenomenon is perceptual environment. A high population mobility area means a low-level vigilance of residents due to a significant number of strangers living around. Therefore, it is conducive to the burglar to enter a building and commit the crime. By contrast, residents living in the area with low population mobility improve their attention of strangers [12]. The robbery is another type of property crime with different characteristics compared with burglary. Areas with low population density have significant risk for robbery. Particularly, the area with both low population density and high population mobility is the danger zone of committing robbery. In a high-risk area, the location of ATM banking is a place that needs to be protected. Because these areas provide robbers a positive environment to force victims and avoid other people to break the incident. Furthermore, a majority number of offenders will plan an escape route before committing the robbery. The students and female are vulnerable people to a robber [12]. The crime of theft includes larceny theft and motor vehicle theft [10]. FENG, HUANG, DONG and SONG [12] points out the positive correlation between the high population density and theft. It is conducive of the thief to touch victims in the crowd. Compared with male, female usually be a victim of theft incident due to the shortage of women’s shoulder bags. However, the moto vehicle theft is different to the larceny theft. Firstly, in the high population density area, the thief cannot reduce risk of being caught by police. Secondly, the offenders of moto vehicle theft tend to commit crime at night because of a low-level attention during this period. Another point is that entertainment venue can be a high risk area [12].

The project of Washington D. C. plans to combine relevant data to illustrate the spatial distribution of property crime in the city. Firstly, the location of alcohol licenses demonstrates the primary entertainment venue area in the Washington D. C. Then the closed-circuit television data shows the distribution. In addition, Freiberg [16] mentions the positive correlation between unemployment rate and the number of property crime. The data about ATM banking provide the resource of robbery research.

3.1.3 Violence crime

A violence crime or crime of violence is a crime in which an offender or perpetrator uses or threatens to use force upon a victim. This entails both crimes in which the violent act is the objective, such as murder or rape, as well as crimes in which violence is the means to an end [17]. In the context of this document, however, violence crimes refer only to crimes in which arson, dangerous weapon, or homicide is involved, in order to separate those serious crimes from the milder ones. According to recent studies, overall crime has continued to decrease in the past decade. Taking England and Wales for example, the percentage of whose adults / households who were victims of a crime has dropped from 20% (year 2007) to less than 15% (year 2017). However, although people are experiencing less crimes overall, the occurrence of serious violence crimes, including those involving knives and firearms, is on the rise. Therefore, to study the latent relationship between the incidents and the spatial and temporal characteristics could be of useful help to possibly generate strategies to reduce violence crimes.

Among all the possible factors causing crimes found on Internet, “poverty” and “unemployment” are two words that appear the most. Many studies have shown that individuals at the lower end of the socioeconomic status scale are more likely to participate in violence crimes [18]. However, there are also some notable exceptions to this rule [19]. Therefore, we plan to use the data containing the unemployment rate and low-food-access areas to find the possible links between those factors and violence crimes in Washington D.C., our hypothesis being that violence crimes occur more in low-food-access areas or in sections with a low unemployment rate.

Some studies also point out that geographic factors, including areas with population size, neighborhood quality, alcohol density, and temperature could also affect crime rate [20]. Therefore, with the existing data, we decide to verify whether there is a relationship between population / alcohol density and violence crimes. The hypothesis is that the crime rate is higher in high population / alcohol density areas than that in low population / alcohol density areas.

It is also found that Closed Circuit Television (CCTV) might have an influence on reducing crimes. There are mainly two voices overall, the former being that CCTV has the ability to prevent property crime, the latter being that CCTV has no effect on violence crimes. With the data of street CCTV locations in Washington D.C., we plan to verify whether the crime rate is lower in areas covered by CCTV. Similarly, we will also verify if areas with a police station nearby have a lower rate of violence crimes. And both of our hypotheses are positive.

3.2 Temporal Analysis

Spatial analysis of crime has already made significant achievement in identifying and finding the patterns of crime. Analysis on temporal characteristics of crime will also contribute to making both tactical and strategic decisions for solving and preventing crime. Temporal analysis is like a time analyzer which identifies the most likely time of a day, day of a week, and days of a year that a particular type of crime will occur. Especially in regard to high volume offences, such as vehicle theft and burglary, temporal analysis will be of great help for identifying the high time and dispatching police efficiently. This section will demonstrate a series of methodologies such as using START and END times to generate a crime occurrence of probability at any given time that can be mapped and visualized graphically. We will also discuss whether the temporal

characteristics like seasons and public holidays which may affect the crime rate or not.

3.3 Research Approaches

To perform spatial analysis, first we need to generate the heat map from the spot map for each kind of crime. It can be achieved by integrating the spots (in this case, 40 meters should be a reasonable range of integration because the standard block size of US cities are around 100m*100m [21]), and then aggregate the data. ArcMap provides tools named Integrate and Collect Events to do these operations. To proceed, an incremental spatial autocorrelation to find the most appropriate band distance value, which will be used in generating hot spot map. Next is to perform interpolation to draw heat map out of hot spot map. ArcMap provides several algorithms for us, which will be discussed in later stage to choose the best one in this case. After obtaining the heat map for crimes, we can combine them with other data to analyze the spatial patterns.

4 Expected Outcome

Based on our works, there are multiple data sources to demonstrate characteristics of urban crime in D.C. This project will deliver a multi-perspective result which will illustrate several primary factors contributing to the level of crime rate in different area, and also provide suggestions to Washington D.C. government for improving safety and security of environment. Overall, our study combines spatial, temporal and humanity to analysis the potential high-risk area, and proposes several solutions to improve safety for those community.

5. Time Plan

6. References

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