USING GEOGRAPHIC INFORMATION SYSTEMS
IN ANALYSING THE PATTERN OF CRIME INCIDENTS AND
THE RELATIONSHIP BETWEEN LANDUSE AND THESE INCIDENTS

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Abstract

The rate of crime incidents is increasing in all developing countries due to change of technology and materialistic way of life and also due to poor social, political, economic and environmental conditions. Distribution of the incidents across the landscape is not geographically random since incidents are human phenomena. For incidents to occur, offenders and their targets - the victims and/or property - be required to exist at the same location for a period of time. Several factors, including the lure of potential targets and simple geographic convenience for an offender, influence where people choose to break the law.

The location where crime events occur is an important factor in the analysis of crime. It is not only important where a crime incident takes place but also the characteristics of those places and the environment in which incident occurs. Thus, examination of spatial data such as street networks, parcel information, school locations, commercial and residential zoning, is imperative for effective crime analysis, crime prevention and police activities.

Using variables, relating to incident types, which are recorded by the police in 2003 and including the information of where and when crime incident occurs, this study attempt to analyze the high-incident areas and the relationship between these incidents and land uses for two important police precincts of Cankaya district of Ankara; Centre of Cankaya Police Station Zone and Bahcelievler Police Station Zone.

Data used in the study are complied from governmental organizations and private companies. The study concentrates on five incident types: murder, burglary, auto, pickpocket and usurp which are represented by point feature. Spatial and temporal information regarding to these incidents were obtained from Ankara Police Directorate. The data of the incidents include the information of the number, address, occurrence time, location and type.

The other data that include the land use types were obtained by digitizing the satellite imagery that was acquired in 2003. Digitizing 1m resolution IKONOS satellite imagery land use data set is obtained which contains the information of each parcel such as residential, commercial, park, public association and military; landmark types such as school, police stations, subway stops, hospitals, carparks; and roads.

The aim of the study is to see how the results of the methods related to the spatial data analysis are utilized for identifying the pattern of the crime incidents such as clustered or regular; determine if there is a relationship between some specific land uses and the incidents; and find out whether the potential crime areas could be determined by referring to these relationships.

In order to answer these questions two basic steps are performed. Firstly the locations of the highest concentrations of recorded incidents and changes in the locations of these areas are identified based on incident types by hot spot analysis, within the software of CrimeStat and ArcGIS 8.2. Since there are numerous methods that can be used to analyze hotspot areas and which provide different results, a few of them are generated in order to find the best visualization. Secondly the relationship between the incident locations and the land use types is tried to be established with the help of SPSS and ArcGIS.

For finding out the land use parameters that are supposed to be more prone for incidents the land use types within the hotspot areas are investigated. After selecting land use parameters, the relationship between these land use and the incidents are studied by the calculation of correlation coefficients. Thus the strength and the direction of these relationships are determined. By referring to the properties of these correlations some values which indicate the importance on the occurrence of the incidents, are given to each land use parameter. Then, potential risky areas for the occurrence of the incidents are determined without considering the information of incidents and the results are compared with the hotspot areas in order to test the accuracy of these risky areas.

1. Introduction

Brantingham and Brantingham (1991) describe crime as a complex event and outline four things that have effects on the occurrence of an incident: a law, an offender, a target, and a place. A crime occurs when these four dimensions are in concurrence. Without a law there is no crime.

Without an offender, someone who breaks the law, there is no crime. Without some object, target, or victim, there is no crime. Without a place in time and space where the other three come together, there is no crime.

Many authors like Lab (2000), Weisburd and McEwen (1998), Bowers and Hirschfield (1999) mentioned the relationship between land use, time and incidents in their studies. They argue that particular areas may be devoted to different types of land use (residential development, retailing, industry, leisure, open space) and based on its land use type the activities and population profile of an area may vary considerably according to the day of the week or time of day.

Naturally crime does not disappear on its own. Police departments are on the duty of protecting the citizens' safety and taking precautions to minimize the risk of incidents. It has long been common practice for the police to identify locations and times that are more prone to criminal activity (Lab, 2000). To reduce or completely eliminate the incident, some actions such as crime prevention methods should be taken. Crime prevention can be signified as a set of ideas for combating incident and includes the activities taken by individuals and groups, both public and private.

The usage of Geographic Information Systems (GIS) in data storage, manipulation and display makes incident prevention process more manageable, more realistic and case specific. CrimeStat, which is the most widely used software for determining the pattern of incidents in American police agencies (web1) is used to show hotspot areas in the study area. The results of integrated CrimeStat into GIS give an idea about the current status of incident pattern. Due to its spatial operation capability, GIS helps police and also other people who are interested in incidents, to visualize and analyze the spatial relationships between different data layers such as incidents and land use, to forecast and take precautions for future incidents.

With improving a methodology this study aimed to answer the questions such as whether or not the events within a certain area on the map are densely clustered and what land use types are prone to incident and how land use types are used in order to detect the risky incident areas. In addition considering five different incident types (burglary, auto, pick pocket, usurp and murder) the study examines if the spatial pattern of each incident are similar.

The lack of systematic records and the geographic database with regard to both land use and crime incidents, make it difficult to reach more detailed and correct results. Especially, it is the most problematic step to obtain the incident data from the police who would not like to publish the information of crime, occurred in their precincts. On the other hand, some land use and incident data that were obtained for this study, may not be concerned to the same period. Because, it is impossible to get the required data from one source and for the same time in Turkey. Thus many organizations and companies had to be visited while collecting the necessary data in this study. However, within the framework of the data that can be reached, following steps are carried in the chapters below.

2. Generation of Crime Incident Analysis in the Study Area

The methods of analysis where various summary statistics or plots are derived from the observed distribution of events are taken into consideration. The results are used to investigate hypothesis of interest or to suggest possible models. Some of these methods are more concerned with investigating first order effects in the process; others address the possibility of spatial dependence or second order effects. In general main objective is to ascertain if there is a tendency for points to exhibit a systematic pattern, for example regularity or clustering and to investigate how intensity of points varies across the study area.

The pattern analysis which helps to identify the distribution of these points contains such methods: quadrat analysis, kernel estimation, nearest neighbour distances, K-function, Nearest Neighbor Hierarchical Clustering (Nnh), Spatial and Temporal Analysis of Crime (STAC) and K-Means Clustering. ArcGIS 8.2, Crime Stat II and Golden Software Surfer 8 are employed to carry out these analyses. In some stages of these methods Microsoft Excel is used.

The kernel estimation gives smoother results than quadrat analyses. So it can be said that kernel estimation is more preferable for finding the distribution of the incidents based on their density in the extension of the study area, in other words for finding their overall pattern.

In addition nearest neighbour distances and K-function are performed for the study area. They give the information of the relationship between inter-event distances. However while nearest neighbour distances method uses distances only closest events and therefore only considers the

smallest scales of pattern and ignore larger scales of the pattern, K-function provides more effective summary of spatial dependence over wider range of scales.

In order to find some specific areas in which the incidents are more clustered, there are three alternative methods; Nnh, STAC and K-Means Clustering. The results of each method provide rather different clusters. If the amount of incidents is fewer, the results of Nnh and STAC become similar. But with the increase of the number of incidents, the ellipses – clusters are located in different areas.

On the other hand both of these three methods could be used for different purposes. For example, K-Means Clustering technique is useful when a user wants to control grouping. This method may be used for determining new police precincts or new locations for police stations. As for determining specific targeting areas Nnh and STAC may be more helpful. Because, they define smaller areas than K-means clustering. The patrolling routes with the high priority could be determined based on these areas which have a certain boundaries.

In addition, these small clusters could be investigated according to the land use types which are located inside these clustered areas. Surely this investigation will light the way for further studies like done in this study.

3. Determination of the Relationship Between Incidents Land Use

The correlation calculations are introduced in order to find the properties of the relationship between incidents and land use. The inputs of the correlation analysis are determined by referring to previous analyses. These inputs are schools, subway stops, hospitals, car parks, parks, residential end commercial areas. Additionally, assuming that police stations and also minor roads have significant effects on the incidents, these variables are studied too.

The strongest relation is distinguished in commercial areas with the exception of auto incidents, as predictable. Since offenders travel shorter distances and prefer the places where quick escape is possible, it is found that the subway stops have strong relations with all incidents especially burglary and usurp. Thus it can be said that commercial areas and the places closer to the subway stops are the most attractive places for the offenders of burglary, pick pocket, usurp and murder.

Regarding to the results, if commercial areas are more preferred it is unsurprising that residential areas have pushing effects on the occurrence of the incidents. They have a relation only with the auto incidents which is not so strong.
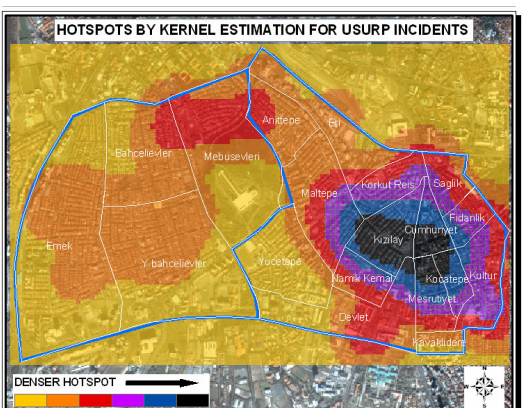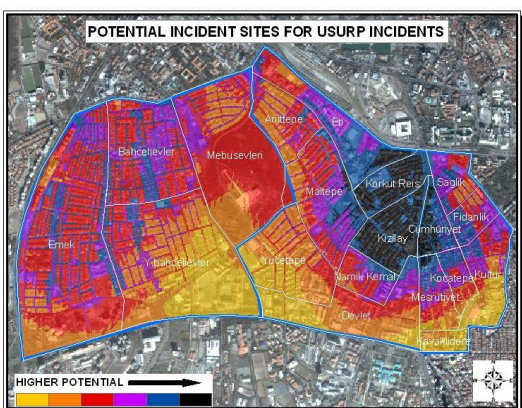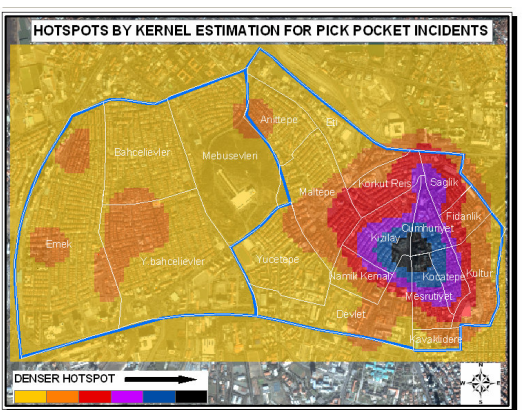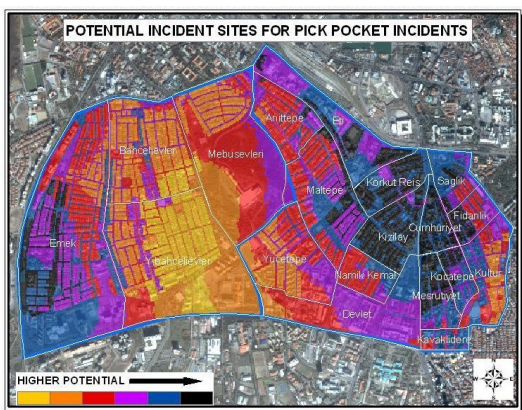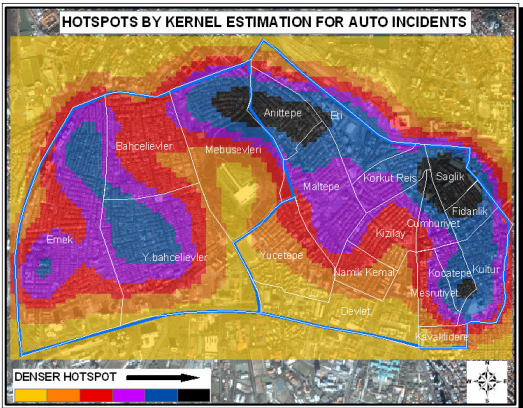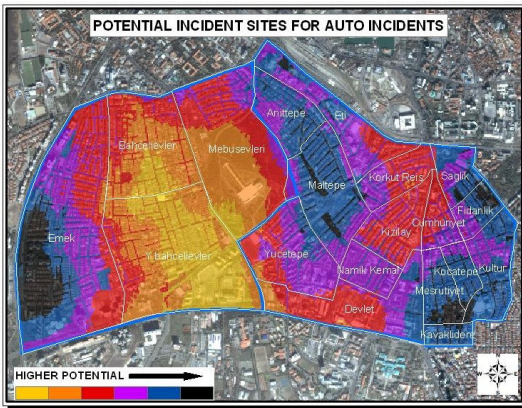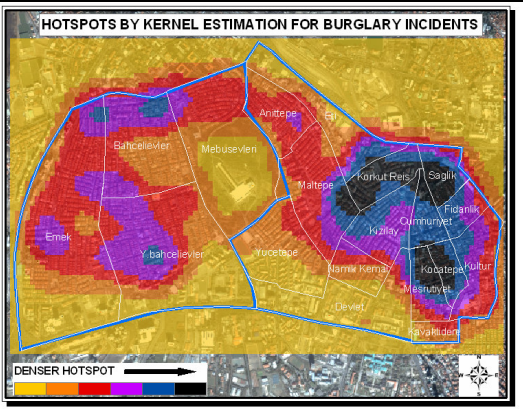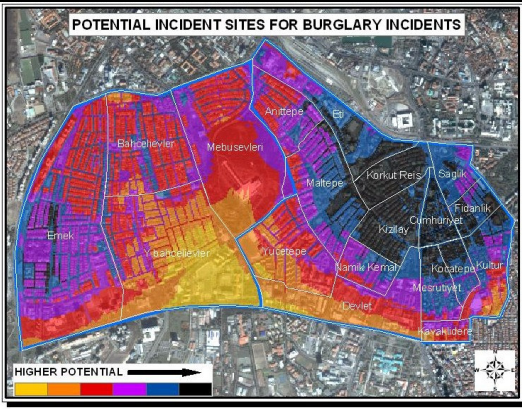
As an expected result minor roads have a remarkable relation with the all five incidents. Similar to subway stops they may provide an easy way to escape rapidly. Also victims are partly lonelier in the streets and streets are more desolated and uncontrolled comparing to the major roads. Thus most of the offenders prefer places near to the minor roads.
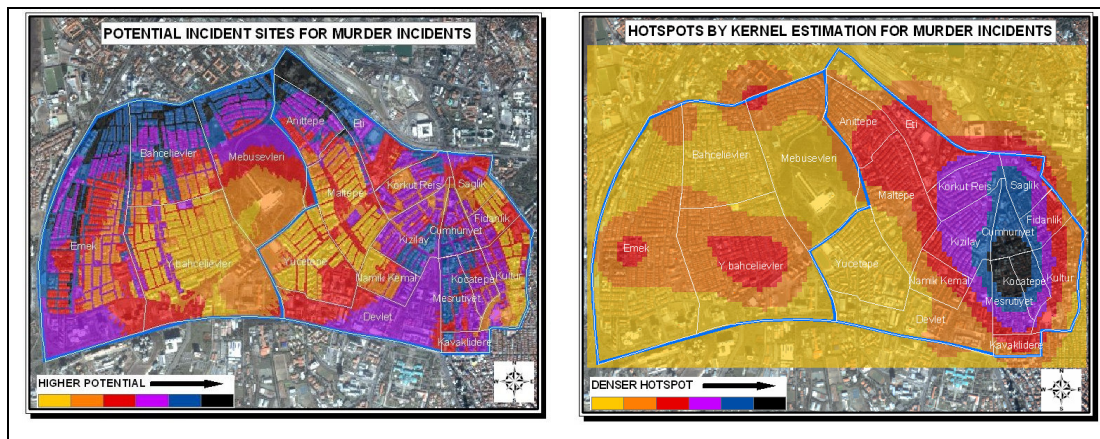
On the other hand car parks have a relation with the incidents of auto and pick pocket though they are not so strong. This relation is not surprising but the direction of the relation demonstrates that car parks in this study area may be uncontrolled and distrustful.

In spite of the weak correlation between parks and the incidents, a partly relation is seen with auto, murder and burglary incidents. Similarly hospitals have not a strong relation with any incidents. Only burglary and usurp have a relation with hospitals but not remarkable.

However the most surprising result is obtained between the police stations and the incidents. There is not any strong correlation between them but the results indicate that usurp, burglary and pick pocket incidents occur in the places closer to the police stations. Whereas it is expected that police stations are dissuasive function on the occurrence of the incidents. But in this study area it is noticed that police stations have not important effects on the incidents.

In order to find the number of incidents inside or a certain distance to the related variable, ArcGIS 8.2 functions are utilized. Then, the correlation coefficient values are found and the correlations are presented again with the help of SPSS. Finally the potential risky areas are determined according to the results of the correlations and with the opportunities of ArcGIS 8.2 functions.

POTENTIAL INCIDENT SITES FOR BURGLARY INCIDENTS

HOTSPOTS BY KERNEL ESTIMATION FOR BURGLARY INCIDENTS

POTENTIAL INCIDENT SITES FOR AUTO INCIDENTS

HOTSPOTS BY KERNEL ESTIMATION FOR AUTO INCIDENTS

POTENTIAL INCIDENT SITES FOR PICK POCKET INCIDENTS

HOTSPOTS BY KERNEL ESTIMATION FOR PICK POCKET INCIDENTS

POTENTIAL INCIDENT SITES FOR USURP INCIDENTS

HOTSPOTS BY KERNEL ESTIMATION FOR USURP INCIDENTS

Map 1: Comparison of Potential Crime Areas with Hotspot Areas

Left column of the figure shows the areas which are more potential for the occurrence of the incidents. In the result of the raster calculation dark areas in the left column denote the best places for the offenders to commit a crime. On the other hand right column of the figure indicates the hotspot areas in which most of the incidents happened in the year of 2003.

In the case of comparing these two columns - the potential risky areas, acquired by raster calculation, with the hot spot areas, acquired by kernel estimation - similar results can be detected. Surely, completely same results could not be expected since one analysis provides the probability of the occurrence; the other one presents the existing structure. The results of the hotspot analysis naturally point specific locations which include happened incidents, while the results of the raster calculation evaluate every point – pixel of the area according to the possibility of an occurrence of an incident. The darker areas in the left column show the areas in which there is a possibility of an incident to occur. Hence the darker areas in the left column cover larger areas than the darker areas in the right column.

Of course, this way could not be the unique or the best method to determine the risky areas, since there must be much more criterions that have an effect on the incidents. But it can be said that using such this way with adding more variables provide better and more realistic information about the risk of the land use in an area.

4. Conclusion

This study aimed to apply GIS to crime incident analysis and to present and evaluate the contributions of GIS in order to understand the status of incidents' pattern and also to predict the possible occurrence of the future incidents based on the structure of the land use.

Main findings of the study can be classified into two themes. The first one is on the contributions of GIS-based methods in incident pattern analysis which provides some clustered areas include more incidents. Several different visualization techniques for visualizing spatial incident data on a GIS are presented in this first theme. The second one is on the advantages of using GIS integrated correlation results for the relationship between incident locations and land use.

By integration capability of GIS with statistical tools realistic results are obtained which allows police personnel to plan effectively for emergency response, determine mitigation priorities, analyze historical events, and predict future events. According to the results of incident area analysis urban policy priority areas can be determined by the police. Thus, finding out the areas which are required emergency intervene saves the individuals or values before being damaged.

Study of incident trends in some specific areas like commercial areas or places near to the subway stops would be guiding pole for crime prevention methods. By analyzing those factors it can be possible to provide accurate and pertinent information relative to crime patterns and correlations to aid in the investigative process of crime analysis.

It is observed that giving similar weights to the land use and landmark functions in another study area gives information about potential crime areas. However the study area should include similar usages, similar structure and also similar social characteristics. In order to test the accuracy of these weights it will be more realistic if these weights are applied in another study area. Than it will be more than appropriated if the results are compared with the incident data of that study area. But since it is hard to obtain the incident data for another area, it was not possible to realize this second test in this study.

In addition to the police, many organizations can influence the extent of the incidents. Professional Organizations such as Chamber of City Planners, Chamber of Architectures and

Chamber of Engineers come into picture when one is talking about physical environment within which crime takes place. Both short and long-term measures can be taken by these organizations which will reduce the likelihood of crime and the fear of crime. For instance highway engineers may improve street lightning in a particularly vulnerable area, or the planners might design a residential layout so as to avoid the creation of crime-prone areas.

Further studies may focus directly on physical design components of crime prevention. The physical characteristics of an area can influence the behavior of both residents and potential offenders. Increase lighting, use of surveillance equipment, access control, alarms and other physical changes are intended to bring about greater social cohesion, citizen concern and involvement, and ultimately, reduced crime and fear of crime.

In addition, in the further studies the rate of the incidents may be examined in certain periods which are determined by the time of taking a precaution. For example; in the potential target areas such as, commercial areas and places near to subway stops which are determined in this study, patrolling routes may be designed again and the rate of the incidents are examined after three months. Thus it will be possible to test the impression of this precaution.

Considering the outcomes of this study it can be stated that the significance of adopting an interagency approach to crime prevention and fostering the development of co-ordination and co-operation among organizations are important for reducing crime. All organizations will not necessarily be relevant to every crime prevention initiative, but there are times when man will have a part to play. Looking first at the statutory bodies, most lists of organizations with an interest in crime prevention would include police, probation and social services, and education, planning, highways, housing and architects' organizations. For this co-operation, utilizing the GIS-based methods for the data suppliers and decision makers is unavoidable.

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