Crime Mapping and Analysis Using GIS

C.P. JOHNSON

Geomatics Group, C-DAC, Pune University Campus, Pune 411007

johnson@cdac.ernet.in

1. Introduction

The traditional and age-old system of intelligence and criminal record maintenance has failed to live up to the requirements of the existing crime scenario. Manual processes neither provide accurate, reliable and comprehensive data round the clock nor does it help in trend prediction and decision support. It also results in lower productivity and ineffective utilisation of manpower. The solution to this ever-increasing problem lies in the effective use of Information Technology.

Geographic Information System (GIS) uses geography and computer-generated maps as an interface for integrating and accessing massive amounts of location-based information. GIS allows police personnel to plan effectively for emergency response, determine mitigation priorities, analyse historical events, and predict future events. GIS can also be used to get critical information to emergency responders upon dispatch or while en route to an incident to assist in tactical planning and response. GIS helps identify potential suspects to increase investigators suspect base when no leads are evident.

GIS plays an important role in crime mapping and analysis. Response capabilities often rely on a variety of data from multiple agencies and sources. The ability to access and process information quickly while displaying it in a spatial and visual medium allows agencies to allocate resources quickly and more effectively. In the 'mission-critical' nature of law enforcement, information about the location of a crime, incident, suspect, or victim is often crucial to determine the manner and size of the response. GIS software helps co-ordinate vast amounts of location-based data from multiple sources. It enables the user to layer the data and view the data most critical to the particular issue or mission. It is used world over by police departments, both large and small, to provide mapping solutions for crime analysis, criminal tracking, traffic safety, community policing, Intranet/Internet mapping, and numerous other tasks.

GIS helps crime officers determine potential crime sites by examining complex seemingly unrelated criteria and displaying them all in a graphical, layered, spatial interface or map. It also helps them map inmate populations, fixtures, and equipment to provide for the safety of inmates by separating gang members, identifying high-risk or potentially violent inmates, and identifying hazardous locations in an area. It reduces the potential for internal violence by providing better command and control. GIS functions, when combined with capabilities of location identification devices such as GPS facilitate tracking the movement of high-risk inmates or at-risk personnel throughout an area. It is more cost-effective for the crime analyst to come up with the information than for patrol officers to do it themselves.

Virtually every operational activity in the police department includes spatial relationships. Traditionally, these activities have been supported by paper maps and pins. Police officers now have the ability to immediately generate maps directly relevant to the situation at hand. Police agencies collect vast amounts of data from many sources including called-for-services, arrests, first information reports and daily report. Data in this form, however, can be difficult to visualise. The same information displayed graphically provides a powerful decision making tool for investigators, supervisors, and administrators. The visual format shows relationships and patterns that are buried in the data. GIS could also be used to explore the relationship between crime and the environment.

1.1 Role of Internet/Intranet: Internet/Intranet capability enables an agency to serve various information to substations and remote offices, and to serve maps regionally to other agencies. It provides the ability to serve multiple applications from a single server to any number of clients, and serve dynamic maps and data quickly on a variety of servers. It also centralises the administration of both data and applications, and can easily accommodate expansion of the system as the number of clients rises. Officers will be able to access several reports including summaries of activity for a user-specified period, lists of incidents occurring at a single address, and charts analysing day-of-week and time-of-day relationships for aggravated assaults and robberies.

Another benefit of the Intranet-based application will be the team's ability to turn around late-breaking information immediately. It helps distribute the mapping functions to each of the district offices, enabling any officer or detective to generate customised maps. The more information officers have, the better equipped they are to do their job. The Intranet-based application should be very secure and safe against unauthorised usage. To maintain the confidentiality of information, access to the system could be controlled through passwords.

2.   Crime mapping

Maps offer crime analysts graphic representations of crime-related issues. An understanding of where and why crimes occur can improve attempts to fight crime. Mapping crime can help police protect citizens more effectively. Simple maps that display the locations where crimes or concentrations of crimes have occurred can be used to help direct patrols to places they are most needed. Policy makers in police departments might use more complex maps to observe trends in criminal activity, and maps may prove invaluable in solving criminal cases.

2.1 Display spatial patterns of events: Digital maps are the quickest means of visualising the entire crime scenario. The locations of crime events, arrests, etc. can be routinely displayed on maps. This provides an easy method of viewing activities in an area rather than searching through a listing of events. Maps can also be used to convey more than one type of information at a time. Crime locations can be symbolised according to the day of week, type of crime, modus operandi (a particular suspect's method of operation when committing a crime) or frequency.

2.2 Integrate community characteristics: Community characteristics (for e.g., slums, markets, colleges, parks, alcohol permit locations, red light area, etc.) can be routinely displayed on maps while analysing crime patterns to interpret relationship between these characteristics and the crime. For example, the locations of aggravated assaults, robberies and alcohol permits can be displayed to see if crime is clustering around locations that sell alcohol. Other mapping data such as bus routes and public housing can also be displayed at the same time to analyse relationships between neighbourhood characteristics and crime.

2.3 Produce thematic maps: Maps can be produced at any geographic level (e.g. Police stations, divisions, or zones) to aid in the analysis of crime patterns. Each response area can be shaded to represent the number of crimes that occurred in that area during a specific time frame. The darker the shade, the more events that occurred within the response area. These thematic maps can also be used to show the change in an area's crime rate. The percent change in the number of crime incidents can be displayed by shading each area according to whether there was an increase, decrease or no change.

3. Crime analysis

Crime Analysis is defined as a set of systematic, analytical processes directed at providing timely and pertinent information relative to crime patterns and trend correlations to assist the operational and administrative personnel in planning the deployment of resources for the prevention and suppression of criminal activities, aiding the investigative process, and increasing apprehensions and the clearance of cases. It supports a number of department functions including patrol deployment, special operations, and tactical units, investigations, planning and research, crime prevention, and administrative services. Crime analysis can be divided into three categories:

Tactical: An analytical process that provides information used to assist operations personnel (patrol and investigative officers) in identifying specific and immediate crime trends, patterns, series, sprees and hotspots, providing investigative leads and clearing cases. Analysis includes associating criminal activity by method of the crime, time, date, location, suspect, vehicle, and other types of information.
Strategic: Concerned with long-range problems and projections of long-term increases or decreases in crime (crime trends). Strategic analysis also includes the preparation of crime statistical summaries, resource acquisition, and allocation studies.
Administrative: Focuses on provision of economic, geographic, or social information to administration.

3.1 Perform radial analysis: GIS can be used to measure the extent and type of problem within a certain distance around a particular location (e.g., street intersection, slum, bar, etc.). The distance can be anything that one wants to use as a radius around a particular location. For instance, we can quickly examine the type and number of offences and arrests that occurred within 500m of a particular location. GIS allows an analyst to quickly eliminate excess information. In addition to focusing on a single location, GIS can also be used to examine events that occurred within a certain distance of multiple

locations. For example, an analyst can determine the number and types of offences that have occurred within 500m of all schools. A radial analysis can also be performed to determine which residents might need to be notified when a particular offender has moved into the area.

3.2 Identify clusters of events (hotspots): GIS identifies areas that contain dense clusters of events (*hotspots*). These high concentration areas usually demand special police attention. For example, GIS allows an analyst to identify all of the areas in a police station area where at least 5 robberies occurred within a 1km radius. These areas are then outlined on the map. Using GIS to identify *hotspots* provides a consistent method to measure concentrations of criminal events over time. *Hotspots* of violent crime, robbery, residential burglary, commercial burglary, auto theft, rape, etc. can be calculated every month for each police station area.

3.3 Compare locations of hotspots across time: Crime *hotspots* that have been identified over several months can be displayed at the same time. This allows for the identification of areas with chronic problems and indicates the direction in which a particular crime may be shifting. These types of maps can also be used to solicit resources for an area from other public and/or private agencies.

3.4 Compare hotspots of different crime types: *Hotspots* of different offence types can be displayed to identify where they overlap. For instance, residential burglary *hotspots* can be displayed along with robbery *hotspots* to discover where they overlap. A more detailed analysis of these intersecting areas can then be performed.

3.5 Shade grid cell maps: While multiple crimes (or events) at the same location are not visible on a pin map, they are clearly accounted for in a grid cell map. For instance, ten thefts occurring at a single location would be represented by a single point on a pin map. Using grid cell mapping, all ten thefts would be counted toward the total for the grid cell that would determine the shade of the cell. The darker the shade, the higher the number of incidents occurred at that particular location.

3.6 Analyse multiple variables: The relationship between one variable with another can be analysed and this would indicate the strength and direction of the relationship between the two variables. For instance one could analyse the relationship between the number of alcohol permit locations and the number of fighting. Regression analysis is used to predict the value of a dependent variable such as violent crime rate based on the values of independent variables such as the poverty level within an area. Regressing allows for additional variables like illiteracy, backwardness, habits, etc. to be included in the model. The results of this type of analysis might be used to solicit resources from other public/private agencies to help reduce the crime rate.

4. Crime investigation

Historically, the causes and origins of crime have been the subject of investigation. Some factors known to affect the volume and type of crime occurring from place to place are:

- ?? Population density and degree of urbanization.
- ?? Racial heterogeneity.
- ?? Variations in composition of the population, particularly youth concentration.
- ?? Stability of population with respect to residents' mobility, commuting patterns, and transient factors.
- ?? Modes of transportation and highway system.
- ?? Economic conditions, including median income, poverty level, and job availability.
- ?? Cultural factors and educational, recreational, and religious characteristics.
- ?? Family conditions with respect to divorce and family cohesiveness.
- ?? Climate.
- ?? Effective strength of law enforcement agencies.
- ?? Administrative and investigative emphases of law enforcement.
- ?? Policies of other components of the criminal justice system (e.g. prosecutorial, judicial, correctional, and probational).
- ?? Citizens' attitudes toward crime.
- ?? Crime reporting practices of the citizenry.

GIS helps identify potential suspects to increase investigators suspect base when no leads are evident.

4.1 Investigate serial offences: The home addresses, work addresses, and places frequented by victims and suspects of serial offences can be displayed. When details of both suspects and victims are viewed in this manner, intersections between the two can be seen. The spatial patterns of less serious offences that often lead up to more serious crimes can be examined. This is especially important since serial rapists often begin their criminal careers committing other offences such as peeping tom incidents, indecent exposures, or residential burglaries.

4.2 Predict behaviour: Based on the crime history, models can be developed to predict behaviour of criminals. Using these models, the probable location of an offender's home can be identified. The geographic area where the next crime is most likely to occur can also be predicted.

4.3 Identify suspects: Crime data consisting of spatial patterns, suspect information and method of operation characteristics can be combined with arrest locations to provide investigators a tool to identify potential suspects. Investigators can quickly see *hotspot* locations and the people who have been previously arrested for the particular crime around these locations.

References

1. Using GIS to support community problem-oriented policing (www.charmeck.nc.us)
2. Law enforcement and criminal justice (www.esri.com)
3. Crime analysis (www.state.ia.us)
4. 1995 comparison of Iowa, regional and national crime rates (www.ci.gilbert.az.us)