GIS for Crime Analysis, Law Enforcement, and Public Safety

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Law enforcement agencies face unique and new challenges combating crime in the 21st century. To address the ever-changing activities of some of the most sophisticated criminals to small time offenders, GIS has helped manage enormous amounts of location-based data to create actionable intelligence that is used and shared within an agency and other law enforcement partners. Agencies are increasingly realizing the importance of applying geospatial technology to police work.

Over 20 years ago when I first became a police officer, the term “GIS” in police work was unheard of, although to some degree it was being applied to crime fighting strategies. The crime maps were police beats or police sectors that were drawn on transparencies and projected on a screen. There was a transparency for minor crimes, arrests, calls, and major incidents. This kind of manual process was long and tedious. In addition, officers were using hardcopy push pin maps to track crime trends and patterns. Later on, we upgraded to the use of Microsoft PowerPoint.

The benefit of GIS is the ability to merge and manage massive amounts of law enforcement data into geodatabases and create feature classes and datasets. You can then almost instantly analyze, map, and aggregate the data. This gives agencies unlimited abilities to create interactive maps using refreshed and updated data. Subsequently, because of this technology, citizens are informed through the use of crime alerts and map portals.

Most people recognize that crime is not uniformly distributed. In most cases, some areas or neighborhoods have more crime than others as well as different types of crimes. Identifying high crime areas or hot spots can be useful for strategic and tactical approaches from law enforcement agencies. This type of GIS analysis helps law enforcement agencies prioritize and allocate resources to specific areas to address specific criminal activity. Customized hot spot density maps can display both the spatial distribution as well as the temporal patterns throughout the day, week, or month.

Using a Grid Analysis or Fishnet Analysis to count crime and crime indicators. Although, there are several methods for determining crime hot spots, one method that I think is most effective is via the use of grid cell values. This concept is an algorithm using a 1,320-square-foot grid as a fishnet over the city and spatially joining the crime incidents to the individual grid cells. This produces a count per grid cell in a defined and manageable area. Symbology is applied to show areas of clustering or concentration. This type of analysis is particularly helpful for resource allocation. Alternatively, you may be interested in identifying areas with unexpectedly high values in relation to some other variable.
Very often, GIS crime analysts are asked to identify the top ten areas for certain types of crime. By bringing together layers of location data into a GIS, such as arrests, calls-for-service, and various types of crime, this output directs officers in a particular beat to the offenses that are happening. Furthermore, other types of data that may be considered indicators of crime such as counts of the number of gang members, sex offenders, probationers, and parolees can be incorporated to enrich the GIS dataset. Such ancillary data can be used by analysts to predict the likelihood of victimization, public disorder, and criminal behavior in different areas of the city.

The experience and knowledge that I have received from the GIS program at American Sentinel University has far surpassed my expectations. I find myself creating solutions to solve real-world GIS problems such as automating processes with model building applications, building geodatabase and programming -- all of which I have studied in American Sentinel's GIS program.

With my GIS degree, I went from being a practitioner to specializing in GIS, using geospatial methodologies to analyze and develop systematic approaches that help identify high crime areas.

Geographic information system (GIS) technology provides the geographic advantage for law enforcement agencies to combat crime by using computers, analysis, and programming skills to make crime predictions based on proprietary algorithms. By predicting the time, place, and the types of crimes, law enforcement can make decisions about the deployment of staff and resources. By implementing a geographic approach to combat and analyze crime, law enforcement can efficiently and effectively meet the challenge of reducing crime.

**NOTE:** Grid analysis and fishnet analysis is the same thing. Once a grid cell size is established, the fishnet grid is positioned over the incident points and the points within each polygon cell are counted and used as the analysis field.
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Introduction

We live in a world of growing complexity and challenge. Law enforcement is no different. Federal, state, and local agencies face a growing population, shifting demographics, an evolving drug culture, and emerging technologies that facilitate more sophisticated criminal activity.

For all the challenges they face, law enforcement professionals, like everyone else, must work with constrained resources. Because the scale and nature of issues are changing, a reliance on old methods of combatting crime is short-sighted and ineffective. New situations require new strategies and solutions. Even if old methods could deal with a scale of threat never before imagined, reinforced by technology and shifting changing approaches to crime, there would be insufficient people and support to scale up previous types of efforts. It would be like insisting that a furniture factory use only hand tools and no power saws, planers, or joiners.

One of the important tools that law enforcement organizations have increasingly adopted is GIS, or geographic and geospatial information systems. A combination of mapping and visualization systems, databases, analytic tools, and specialized data sources allow agencies to combine and compare disparate forms of data to uncover patterns that would be next to impossible to identify without assistance.

For example, Denver police use the city's multi-departmental GIS system to give citizens the ability to track crime in their neighborhoods. Akron, Ohio has found that GIS can help its law enforcement officials track gang territories and behaviors. The U.S. Postal Service tracks crimes with the technology.
The Department of Homeland Security has called GIS the backbone of its efforts, as it helps monitor critical infrastructure, identify areas susceptible to attack, and analyze information of all sorts³.

GIS offers a useful set of tools for law enforcement because most crime follows a pattern. Criminals have specific goals. To achieve them, they will undertake particular acts in the locations they perceive as most likely to provide what they need. However, being people, they bring biases and habits, finding what seemed to work in the past and attempting to replicate the experience. Each criminal leaves a pattern that can be analyzed.

Other information can influence the ways in which a law enforcement agency enforces peace and public safety. Demographics, socio-economic characteristics of neighborhoods, and even factors such as the number of streetlights can provide additional insight into previous patterns and the likelihood of future illegal actions. Reports from other public safety agencies can help identify larger patterns. Understanding what could be called the supply chain of crime—the interrelationship of various operations, like the link between robbery suspects and drug purchases—can shed even more light into dark activities.
Taken together, all this information, brought together through the locations of where they occur, creates a combination of statistics and geography. That is the material law enforcement GIS personnel can manipulate and study. By tracking the data, one can begin to visualize the ways in which specific types of crimes fit into the context of overall criminal patterns and begin to discern individual actors and often anticipate their next moves.

GIS has truly opened a world of new tools for law enforcement. At the same time, it has given practitioners in the field a way to create professional advantages for themselves. The technology and its use are still not fully understood by officials. A solid knowledge of GIS not only lets you better support the ultimate goal of reducing crime, but it allows you to differentiate yourself as a crime analysis professional. The more knowledge and experience you can bring, the more attractive you are to existing or potential employers.

1Esri; “Denver GIS Web Site Helps Citizens Track Crime in Their Neighborhoods”; http://mtncad.com/node/203
3American Sentinel University; “GIS Careers at the CIA, FBI and other Homeland Security Positions”; http://www.americansentinel.edu/blog/2012/10/15/gis-careers-at-the-cia-fbi-and-other-homeland-security-positions/
Technology and Its Application

It can be easy to forget how far law enforcement (and the entire world, for that matter) has come since the 1950s and 1960s. Computers were massive contraptions owned only by large corporations or educational and research institutions. Mobile telephones that you could fit into a pocket were the stuff of science fiction or Dick Tracy comics. No one imagined complex arrays of satellites that could power handheld GPS devices capable of pinpointing your position to within a few feet. The FBI’s National Crime Information Center didn’t exist until 1967.

The silicon-charged capabilities have made all the difference. Policing became more than feet on the street, bubbling test tubes in labs, and detectives trying to channel a cross between Sherlock Holmes and Sam Spade. Collecting and comparing information became easier. Squad cars would come to have computers and wireless Internet connections. Forensics, a practice of growing importance in the past century, would harness the power of genetics to give true DNA fingerprinting. The entire field would become so popular that its practice would become a basic element in multiple prime-time television shows.

It was inevitable that law enforcement would further harness computation and analytic tools to find new ways to fight crime, just as the power of data became clear in so many other disciplines. Companies learned that computers could make quick work of laborious number-crunching. Visualization software could let people see relationships that otherwise would be hidden in eye-crossing columns of numbers.
Although the genesis of GIS software stretches back to the 1960s, it wasn’t until the 1990s that software packages appeared for PCs and put the technology within the reach of almost anyone. That included police departments and federal agencies. 

Law enforcement has faced a basic problem similar to most government agencies. Although population continues to grow, as do inhabited areas, budget allocations are constrained. The mission to protect and defend cannot rely on past approaches because the resources to scale with growth are no longer available. The increased need to collaborate and cooperate with Homeland Security in anti-terrorism activities adds another layer of professional responsibilities. 

Being pilloried between increased demand and restricted resources, law enforcement groups at all levels have had to find newer methodologies to address changing circumstances. They include the following: 

• **From feet on the ground to data** — Public police presence remains critical. With fewer officers than most departments would like, there is an urgent need to determine where to have officers visible. 

• **From guts to analytics** — In order to become smarter in the allocation and effective use of resources, departments must move from professional instincts to data and information that can offer new insights and alternative plans of action to produce more meaningful impacts.
• From reaction to anticipation — Even with police presence used to discourage crime, departments have historically reacted to crime by responding when something happened. Through the use of data and analytics, a more proactive approach can be adopted in which issues are identified and resources are deployed to prevent or deter criminal activity throughout a community.

The strengths of GIS tools and techniques play to all these needs. Why wait for a crime to happen when you can statistically predict when and where it might be likely to occur? Why not provide citizens with access to actual crime data so they can make decisions about where to live and work and become active participants in helping to protect their communities?

GIS can pull together disparate sources and types of information and analyze their relationships, giving professionals insights that would not be possible otherwise. In addition, the technologies and techniques have an additional benefit. Although law enforcement agencies operate under significant legal restrictions, most of the insights gained via the use of GIS are possible through the use of publicly available data. That means there is little to no potential to run afoul of constitutional rights and protections of individuals, minimizing the risk of disrupting later prosecution on procedural grounds.
Types of Uses

The best way to see the efficacy of GIS technology in law enforcement is to understand better the techniques and the way in which they are employed. For starters, there is a vast body of mathematical techniques that can be used to help better understand data patterns and relationships and make projections. In the context of law enforcement and GIS, the analysis involves the interaction of statistical data in a geographic setting. In other words, GIS ingests historical crime rates, currently reported incidents, details of officer deployments, department vehicle travel routes, locations of critical infrastructure or gang territories, traffic patterns, camera footage, and other variables and displays them on maps. Practitioners then use queries to produce the results of data analysis. Law enforcement professionals can then see the relationship of aggregate data to a city’s geography and also observe trends, inferences, and relationships at a local level.

Officials have a number of analytic techniques available to them. Here are three common ones:

- **Hot spots** — A hot spot analysis refers to taking a count over time of events sorted by geographic area. In a simple example, you might display the frequency of graffiti reports throughout a city. Some blocks might show a greater incidence of graffiti beyond the rationale of higher population density. Hot spot displays typically use a statistical technique called cluster analysis, which separates data into logical groupings.
• **Correlation** — When trying to understand crime through GIS, it is important to examine correlations, or how closely two separate factors are related. Although correlation alone does not prove causality, or whether a change in one factor causes a change in another, it shows when there appear to be connections between factors.

• **Regression** — Regression analysis is a body of techniques that help find the natural relationships among the characteristics someone is studying. If hot spots show where something is happening and correlation shows apparent relationships among factors, regression helps show why by demonstrating how the factors interact. Although regression is important, not all techniques work because of some quirks in spatially-related data.

The analytical capabilities of GIS software are rigorous and sophisticated. Understanding effective ways to manage the data and apply the appropriate techniques while casting results into an easily understood visual format is a daily challenge that GIS professionals face.

An example is the research done by Max Lu and Jessica Burnum at Kansas State University. Using GIS tools and analytic techniques, the two looked at data from 2002 to 2005 on seizures of meth lab equipment and the locations of dumped toxic by-products. Not only did they prove that the practice was spreading through middle-class neighborhoods in Colorado Springs, Colo., but found predictive factors that enabled them to identify likely locations of new meth labs. That research has been used in Connecticut and Massachusetts to combat increased meth activity.
Another example comes from Dallas, where GIS skills are employed in mapping and pattern analysis to respond to crime in real-time. By mapping and analyzing data, the police department has been able to track and interpret criminal activity. Spatial analysis helps officials make strategic decisions to keep citizens safer.

Just as there are many types of analytic techniques that law enforcement utilize, there are also many types of criminal and security concerns that could benefit from GIS analysis.

- **Drugs** — As the meth lab tracking and predictive analysis example shows, drug crimes are good subjects for GIS analysis. Ironically, the widespread and repetitive nature of the activity builds a useful body of data. The physical and even business requirements of manufacturers, distributors, and others in the trafficking industry create a web of interdependent elements that aid public officials in better understanding the underlying patterns and practices.

- **Auto theft** — Although there are one-off cases of auto theft, the practice is often tied to nexuses of rings that take cars and either strip them for parts or sell them to third parties. Elaborate systems that involve acquisition and delivery of supplies, deconstruction or remodeling facilities, distribution and delivery of products, and payment systems offer significant data to track and correlate geographically distributed activities.

- **Smuggling** — This criminal activity involves the movement of goods and people across some type of border. Based on the volume, size, and shape of the smuggled items, spatial constraints are introduced into the route network that can be analyzed via GIS.
Knowing the likely mix of crimes an organization might face leads to a more effectively allocation of resources.

• **Terrorism** — One of the most extensive uses of GIS technology by law enforcement is in anti-terrorism. The complex movement of people and materials, extensive planning, logistical intricacies, and typical physical targets make GIS a critical tool in trying to unravel plots before they are executed.

• **White collar** — White collar crimes such as fraud, insider trading, and embezzlement often involve complex schemes and electronic transactions that can be tracked spatially and temporally in GIS. Understanding the relationships of the participants in space and time can help to crack the code.

Law enforcement and homeland security officials apply GIS in a number of ways. One of the primary uses is to predict where given crimes might happen and situate appropriate personnel to deter the acts. Knowing the likely mix of crimes an organization might face leads to a more effectively allocation of resources.

Another major use is in disaster response. Officials can combine information from personnel on the ground with additional data sources from other agencies and even civilian posts from social media. A unified approach to data compilation not only improves situational awareness, it is critical to logistics and resource allocation of personnel and equipment.

These applications and others have propelled many agencies to embrace GIS systems and use the techniques to more effective undertake their responsibilities.
Training and Background

With GIS becoming an integral part of law enforcement and public safety, it is understandable that learning more about GIS can aid a professional’s career. Although in wide use, geospatial information systems are fully understood by a relative few in policing and security. Become one of the experts in the field and you will have competitive strengths that are unavailable to people without the necessary training and background.

Training is critical because no one grasps the intricacies and practices of GIS without learning the best practices to employ it. A proper background starts with learning about geography, mapping, geospatial technologies, data management, and statistics and mathematical analysis. In addition, professionals will learn the specialized software, both proprietary systems and open source, to apply them in practical settings.

That helps create a GIS foundation. Then come more specialized topics, including visualizing data specifically for crime and homeland security applications, using and querying maps, compiling data for planning and operations, employing advanced analysis techniques, and animating and automating maps.

All of these endeavors require practice in applying the theories using specialized software. It isn’t enough to study the topic; an officer or data specialist must be able to apply what they have learned in pragmatic ways.
There are various ways, each with trade-offs, to get the necessary training:

- **Self-study** — The most flexible way to learn how to apply GIS in a law enforcement or homeland security setting is to get the books and software and then study and practice on your own. However, this is likely the most difficult approach. Maintaining the internal motivation to continue work can be trying. Without feedback from someone who knows the topic, you may not know when you are making mistakes. Also, to acquire the necessary software and hardware could be expensive.

- **Local schools** — A nearby university or community college might offer instruction in GIS. That could help provide the background, but unless the institution has a degree course in GIS, it may not have the extended array of courses that offer specialized opportunities in applying the technology to your professional interests. A physical school also requires attendance at specific days and times, meaning that the professional must juggle work and school schedules.

- **Online education** — An approach that combines flexibility with imposed rigor and feedback is an online study program, like those offered by American Sentinel University. Although there are fixed timelines for assignments, the online approach provides the working professional with significant flexibility. In addition, students get feedback from professionals in the field and access to current, cutting-edge software.

Whatever approach makes sense for you, studying GIS and applying it to law enforcement and security is a doubly successful choice. You advance your own career while you make a significant contribution to public safety and order. Think of it as two benefits for one effort.