This article is adapted from Jennifer Bachner, Predictive Policing: Preventing Crime with Data and Analytics, *(Washington, DC: IBM Center for The Business of Government, 2013).*

Predictive Policing: Preventing Crime with Data and Analytics

By Jennifer Bachner

The history of quantitative crime analysis spans centuries. Crime mapping first appeared in the 19th century. In 1829, an Italian geographer and French statistician designed the first maps that visualized crime data. The maps included three years of property crime data as well as education information obtained from France's census. The maps revealed a positive correlation between these two layers of information; areas with higher levels of education experienced a higher incidence of property crimes.

The discipline of crime analysis emerged following the formation of London's Metropolitan Police, the first organized law enforcement service. The service's detective branch, formed in 1842, was tasked with using pattern recognition to prevent and solve crimes. Formal police departments were established throughout the U.S. in the 1850s, though their use of analytical techniques lagged behind London's.

In 1900, the U.S. federal government began collecting national data that aided the development of crime statistics. Mortality statistics, which indicate the cause of death, were used to calculate homicide rates. Additional measures, such as prison rates and arrest data, were collected by cities and states during the 1920s. In 1930, the Federal Bureau of Investigation (FBI) was given the authority to collect and disseminate crime data. The FBI continues to publish *Crime in the United States* annually, and this comprehensive publication served as the chief data input for crime analysis models in the latter half of the 20th century.

With the advent of affordable computers, both police organizations and scholars began to explore automated crime mapping. Academic researchers investigated the relationship between environmental characteristics and the incidence for crime. Sociologists, for example, used mapping to uncover a quantifiable, causal relationship between the presence of taverns and the incidence of violent and property crimes. Police forces initially hoped crime mapping would serve as a means of improving resource allocation's efficiency. The technical and personnel demands of mapping, however, prevented police departments from integrating this tool into everyday police work until recently.

Today, the availability of massive data sets, data storage, sophisticated software, and personnel that can both perform analyses and communicate actionable recommendations to officers in the field has rendered crime analysis a central component of modern policing. Further, collaborative efforts between police officers, scholars, and businesses have led to the development of analytical techniques that have strong theoretical foundations; accompanying tools, such as software programs, enable their widespread use.

The Role of Predictive Analytics in Crime Prevention

Crime prevention, defined as efforts to restrict crime from occurring, is generally considered to encompass three pillars:

- **Primary prevention strategies** attempt to minimize the risk factors associated with criminal behavior. These programs, often housed in schools and community centers, are intended to improve the health and well-being of children and young adults.
- **Criminal justice strategies** address known offenders; juvenile correctional facilities and prison rehabilitation aim to prevent convicted criminals from offending again.
- **Law enforcement strategies** focus on decreasing the probability that crime occurs in a particular area. This is achieved by reducing the opportunity for criminal acts and increasing the risk of arrest. Predictive analytics is one law enforcement strategy to accomplish this form of prevention. By compiling and analyzing data from multiple sources, predictive methods identify patterns and generate recommendations about where crimes are likely to occur.

The reliance on statistics and automated mapping, termed CompStat, has been widespread since 1995, when it was first implemented by the New York City Police Department. This philosophy has since been adopted by nearly every

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law enforcement agency in the country. Under the original framework of CompStat, crime data are collected and analyzed—primarily using geographic information systems (GIS)—to improve accountability and resource allocation. By mapping the distribution of criminal activity across low-level geographic units (e.g., city blocks and individual buildings), police can deploy officers to high-crime areas and track changes over time.

Whereas traditional uses of CompStat are fundamentally *reactive*, the goal of predictive policing is *proactive*—to prevent crime from occurring in the first place. Predictive policing is therefore a component of intelligence-led policing that is focused on what is likely to occur rather than what has already happened. It is the frontier of crime prevention, and the data and methods required for this approach have only recently been developed and employed.

Predictive Methodologies

There are three categories of analysis techniques that police departments use to predict crime:

- Analysis of space
- Analysis of time and space
- Analysis of social networks

These categories are not intended to be all-inclusive, as the number of methodologies available to analysts is large and increasing. Instead, the following provides an overview of the different types of analysis commonly undertaken and the advantages and disadvantages of each.

Predictive Methodology One: Analysis of Space

One of the original uses of crime mapping is the identification of criminal hot spots, namely areas in which there is a greater likelihood of crime than in the surrounding areas. In a retrospective context, hot spot detection has increased our understanding of the characteristics associated with high-crime areas, such as transportation routes, entertainment establishments, and a high population density. In terms of predictive policing, hot spot detection can inform short-term decision-making about resource allocation and long-term policies related to crime reduction.

It is important to keep in mind that a hot spot is a perceptual construct. Because geographical space is inherently continuous, the placement of a boundary to delineate a hot spot is somewhat arbitrary. The final location, size, and shape of a hot spot are influenced by judgments made by the analysts, such as:

- Which criminal incidents are included in the analysis
- Whether the hot spots are determined by the concentration—or clustering—of past criminal incidents, environmental characteristics associated with crime, or both
- The amount of time captured by the analysis (e.g., one year of crime data vs. five years of crime data)
- The weighting scheme applied to past criminal incidents

Predictive Methodology Two: Analysis of Time and Space

Various statistical methods to analyze clustering are all aimed at identifying areas with high crime levels. In a forecasting context, clustering methods detect locations or areas where crime is likely to occur based on where crime has occurred in the past and, in the case of risk-terrain modeling, environmental characteristics. These methods, however, do not take advantage of temporal patterns in crime. Although some clustering algorithms weight recent events more heavily in generating forecasts, they do not illustrate how the incidence of crime changes over time. Clustering does not illuminate movement in criminal activity.

In practice, clustering without much regard to the temporal dimension of criminal activity is often sufficient. Hot-spot

maps are easy to read and can help officers make quick, informed decisions about how to allocate their time during a shift. Some tasks, however, demand attention to temporal patterns. If a police department has observed a rash of robberies and is attempting to predict the next incident in the string, it is critical to identify both the spatial and temporal path taken by the suspected offender.

CrimeStat III, a software program developed by sociologist Ned Levine and the National Institute of Justice, allows users to analyze both the spatial and temporal components of crime patterns. If the analyst is interested in a descriptive summary of a sequence of events, they can compute a spatial-temporal moving average (STMA). An STMA permits examination of the path a criminal has taken. It is calculated using the average time and location for a subset of incidents. For each incident, the averages are calculated using the incidents that occurred just before and just after. A subset generally includes three, five, or seven incidents. The resulting map includes a line through the incidents, which marks that "average" path taken by the offender.

To forecast when and where the next crime in a sequence will occur, an analyst can perform a correlated walk analysis (CWA). A CWA examines the temporal and spatial relationships between incidents in a given sequence to predict the next incident. The first step in performing a CWA is to determine if there is a systematic pattern in an observed sequence of criminal incidents. This is accomplished by computing the correlation between intervals.

Predictive Methodology Three: Analysis of Social Networks

The chief purpose of the previous two categories of methods discussed is the targeting of geographic locations in which to focus time and resources. Social network analysis (SNA) is a third category of methods on the cutting edge of crime analysis, but it is primarily used to detect *persons* of interest, as opposed to *locations* of interest. Through SNA, police can identify individuals that are central to criminal organizations, such as gangs and drug networks, and develop effective interdiction strategies.

The relevance of social networks to criminological analysis is well-established. Organized crime, such as drug trafficking, gang violence, and serial robbery, requires the creation and maintenance of various relationships. A drug-dealing network, for example, may include suppliers, distributors, smugglers, buyers, and money-launderers. Further, criminal networks are embedded in the social context in which they operate; they are nourished by, and victimize, members of the community, including family, friends, and retailers. SNA is a tool police agencies can use to map these numerous interpersonal connections and mine them for actionable information.

The building blocks of a social network are relationships between two actors (either individuals or entities). Actors are referred to as nodes and the relationships between them are termed links or edges.

In crime-fighting applications, social network analysis is frequently used to identify central nodes—individuals who have a high level of connectivity within the network.

Using centrality measures, an analyst can identify individuals of interest in the context of a given problem. If a police agency seeks to acquire information about a network without dismantling it, contacting an actor with a high level of closeness might be effective. Alternatively, a goal of inserting information into a network might best be achieved using an actor with a high betweenness measure. If an agency's mission is to take custody of a network's leaders or central actors, the measure of degree may be most useful.

Places on the Frontier of Predictive Policing

Santa Cruz, California

The Santa Cruz Police Department (SCPD) was one of the first in the nation to employ predictive policing in its daily operations. The software in use was developed by researchers at the University of California, Los Angeles, and Santa Clara University, with input from crime analysts from SCPD. The program was first implemented in July 2011. In July 2012, the program moved from its experimental phase into full operational use.

The core of the SCPD program is the continuous identification of areas that are expected to experience increased levels of crime in a specified time frame. A computer algorithm draws upon a database of past criminal incidents to assign probabilities of crime occurring to 150x150 meter squares on a grid on a map of Santa Cruz. The database includes the time, location, and type of each crime committed. In the calculation of probabilities, more recent crimes are given greater weight. The program then generates a map that highlights the 15 squares with the highest probabilities. Prior to their shifts, officers are briefed on the locations of these 15 squares and encouraged to devote extra time to monitoring these areas. During their shifts, officers can log into the web-based system to obtain updated, real-time, hot-spot maps.

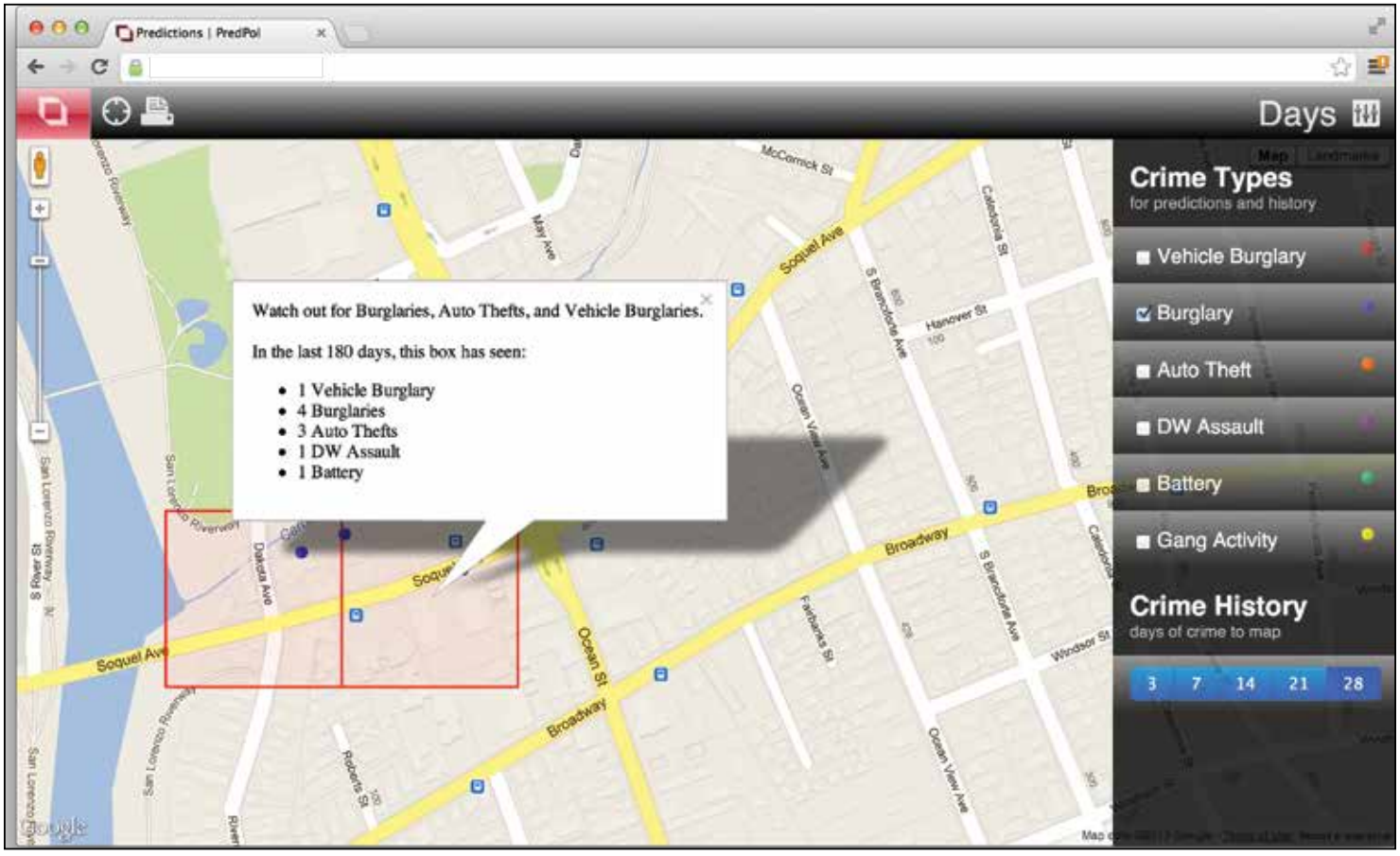
The department opted to use 15 squares after experimenting with different numbers; analysts observed a dropoff in probability after 15. Further, the department has the resources to devote extra personnel time to 15 squares. Larger departments identify a far greater number of high-risk squares. The Los Angeles Police Department, for example, generates 20 high-risk squares for each of its 19 divisions.

The developers of the software took great care to ensure its accessibility by officers with minimal technical training. The program is relatively simple to use and its output (maps with square hot spots) can be tailored to specific crime types and times of day. Moreover, the department has adopted the perspective that predictive policing tools are intended to empower officers, not replace them. Officers are not required to base their decision-making solely on the hot-spot maps. Instead, officers are encouraged to view the maps as additions to their existing toolkits.

SCPD has achieved a high level of officer buy-in with respect to predictive policing. Zach Friend, a crime analyst with SCPD, emphasizes that for predictive policing to take root in a department, there cannot be top-down implementation; it cannot be imposed on unwilling officers and treated as a replacement for experience and intuition. Friend draws an analogy to fishing, explaining that predictive methods can tell officers where the best fishing holes are located but not how to cast a line or bait a hook. And once officers begin using the predictive tools, they usually observe positive results. Officers who use the tools see reductions in crime on their beats, and these success stories motivate other officers to do so as well.

It is critical that SCPD find efficient ways to reduce crime, as their current staff level is 20 percent lower than in 2000. Further, the department is not expected to increase the size of its staff in the foreseeable future. As a result, the department must take steps to ensure its officers are each achieving the most benefit possible. The software itself is affordable and requires minimal training. Further, predictive methods supplement experience, thereby standardizing the talent level in a police department between seasoned officers and novices. By

Santa Cruz PredPol's Crime Probability Predictions



simply being in the right place at the right time, as dictated by a hot-spot map, novice officers can make a valuable contribution to reducing crime.

The department currently assesses changes in crime rates to determine whether or not the program is working. Preliminary evidence indicates that the program has been successful, particularly with respect to burglaries. A comparison of burglaries in July 2011 (when the program was first implemented) to July 2010 indicates a 27 percent decline (down to 51 from 70). Aggregating over the six months prior to implementation (January 2011 to June 2011) and comparing this number to the amount of burglaries in the same time period in 2012 (January 2012 to June 2012) reveals a 14 percent decline (down to 263 from 305). It is not surprising that SCPD has experienced the most success with preventing burglaries, as this type of crime lends itself to prediction. Potential burglars carefully design their plan of attack, often taking into consideration the environmental characteristics of the geographical area.

In contrast to Santa Cruz, other departments instead measure success using arrest rates. The concern with this measure is that predictive policing is intended to reduce the incidence of crime through deterrence. When potential criminals see police officers monitoring an area, they are less inclined to commit an offense. It is, of course, quite difficult to measure deterrence, as we cannot calculate how many crimes would have occurred if not for the increased police presence. ■

TO LEARN MORE

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The report can be obtained:

- **In .pdf (Acrobat) format at the Center website, www.businessofgovernment.org**
- **By e-mailing the Center at businessofgovernment@us.ibm.com**
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