

Chapter 10

Crime Hotspot Detection: A Computational Perspective

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ABSTRACT

Given a set of crime locations, a statistically significant crime hotspot is an area where the concentration of crimes inside is significantly higher than outside. The motivation of crime hotspot detection is twofold: detecting crime hotspots to focus the deployment of police enforcement and predicting the potential residence of a serial criminal. Crime hotspot detection is computationally challenging due to the difficulty of enumerating all potential hotspot areas, selecting an interest measure to compare these with the overall crime intensity, and testing for statistical significance to reduce chance patterns. This chapter focuses on statistical significant crime hotspots. First, the foundations of spatial scan statistics and its applications (i.e. SaTScan) to circular hotspot detection are reviewed. Next, ring-shaped hotspot detection is introduced. Third, linear hotspot detection is described since most crimes occur along a road network. The chapter concludes with future research directions in crime hotspot detection.

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INTRODUCTION

Analyzing crime locations and using the spatial information associated with them is a fundamental task of environmental criminology since the main goal of a crime investigation is to locate the criminal and/or prevent more crimes from occurring. Two important spatial theories in environmental criminology are routine activity theory and crime pattern theory. *Routine activity theory* states that a crime location is related to a serial criminal's frequently visited areas (Burn, 1982). *Crime pattern theory* extends routine activity theory on a spatial model (Brantingham & Brantingham, 1993). When crime analysts study the locations of crime sites and make inferences that help track down a serial criminal or that identify areas where extra police presence is needed, they are using these theories. Thus, the motivation of crime hotspot detection can be summarized as:

1. To detect current/emerging crime hotspots to focus the deployment of police forces, and
2. To predict the location of a serial criminal's residence.

Previously, most analysis of crime locations was done manually. However, the task of enumerating potential hotspots by hand and detecting meaningful patterns in the data is arduous, even for experienced analysts. Rising crime numbers in larger cities increase analysts' workload and compound their stress. For example, a typical crime dataset of the continental United States includes around 10^7 crimes annually (FBI, 2015). Therefore, law enforcement agencies need computational tools that can automate hotspot detection. Moreover, these tools should eliminate the chance patterns (false positives). Most police departments and similar entities have limited resources for crime mitigation and prevention. Therefore, false positive results, that is, hotspots that occur only by chance, risk causing real harm. If a police department diverts money and manpower to a chance hotspot location that don't need it, may leave other areas less protected. *Chance hotspots* can have other harmful consequences as well. When police increase their presence in a location identified as a crime hotspot, people naturally begin to avoid the area out of fear for their safety, and the neighborhood may become stigmatized.

Hence there is a growing need for crime hotspot analysis tools which can handle large crime datasets as well as eliminate chance patterns. Such tools may help crime analysts accomplish their law enforcement goals with optimal resource allocation (Eck & others, 2005).

Many computational techniques (Spencer Chainey & Ratcliffe, 2013; Eck & others, 2005; Levine, 2006) are used for hotspot detection. One of the most common

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