

Chapter XIII

Mastermind: Computational Modeling and Simulation of Spatiotemporal Aspects of Crime in Urban Environments

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ABSTRACT

Pattern and routine activities theories suggest that through a combination of decisions and innate understandings of environmental cues, likely offenders are able to separate good criminal opportunities from bad risks. The nature of this process is highly structured and allows researchers to anticipate likely concentrations for a variety of regular, daily activities, including criminal offences. This chapter sets out to model and test these theoretical principles. Mastermind represents an interdisciplinary research project in computational criminology jointly managed by ICURS and the Software Technology Lab at Simon Fraser University. Using the abstract state machine (ASM) formalism in combination with a multi-agent based modeling paradigm, we devise a formal framework for semantic modeling and systematic integration of the theories for crime analysis and understanding crime patterns. We focus on crime in urban areas and model spatial and temporal aspects of crime potentially involving multiple offenders and multiple targets. Mastermind is used in a hypothetical analysis of motor vehicle theft.

INTRODUCTION

Crimes are complex, multidimensional events comprised of at least four necessary dimensions—the law, the offender, the target and the place (Brantingham & Brantingham, 1978, 1984, 1991). For several decades, criminologists have contended that there is definite patterning in the temporal and spatial characteristics of physical crime (Bottoms, Claytor, & Wiles, 1992; Kennedy & Forde, 1990; Roncek, 1981; Sherman, Gartin, & Buerger, 1989). In particular, environmental criminology argues that in spite of their complexity, criminal events can be understood against the context of people's movements in the course of everyday routines. Environmental criminology posits that the large majority of offenders will commit most of their offenses near places they spend most of their time, and similarly, victims are victimized near places where they spend most of their time (Brantingham & Brantingham 1993b; Felson, 1987). Pattern and routine activities theories contend that crime locations are not random, but rather, are determined through a combination of normal movement and activity patterns, each of which is at least partly determined by the perceptions of the physical and social environment. Through both rational decisions (c.p., Cornish & Clarke, 1986) and innate understandings of environmental cues, likely offenders are able to separate good criminal opportunities from bad risks. This decision-making process takes place within, and is predicated upon, the nature of the built environment. In most cities, these important features include street and transportation networks, as well as land use features. Each of these topographical entities are formative features in guiding the movement of people in space-time, and as such, represent a valuable source of information about what situational and ecological contexts attract crime, and under what conditions.

The structured nature of this process allows researchers to anticipate likely concentrations for a variety of regular, daily activities, includ-

ing criminal offences. The importance of street networks in the distribution of social events (criminal or otherwise) cannot be overstated; major transportation pathways and the attractiveness of certain land uses (entertainment districts, shopping malls, licensed premises, or schools, for example) are well known in criminology (Brantingham & Brantingham, 1984). What is new to the field, however, is the recent energy devoted to developing computational methodologies for testing these principles against both archival data and in simulations.

Conventional research in crime analysis strongly supports this theoretical framework for a broad range of crimes (Bottoms & Wale, 2002; Rossmo, 2000; Wright, & Decker, 1997), but such work, although empirical in nature, tends to use methods that rely upon past data. However, empirical deduction and inference are no longer sufficient. Although theories of crime are well established, the lack of a unifying framework for integrating the four dimensions of crime (e.g., a law, offender, a victim/target, and a setting converging in space-time) in a coherent and consistent way inhibits their applicability to real-life scenarios. Novel research directions (Bowers, 2007; Brantingham & Brantingham, 2004; Brantingham, Brantingham, & Glässer, 2005a; Groff, 2006; Gunderson & Brown, 2000; Liu, Wang, Eck & Liang, 2005), however suggest a fundamentally different approach to overcome limitations of statistical methods that are based on measures of association on observed or measured data. High levels of autocorrelation, lack of independence of observations, and analyses that make it difficult to track individuals in a changing environment create limits to statistics as the model building technique. The need to handle continual change and the interdependence of dimension and individual entities or agents calls for methods that facilitate model building based on abstract definition of the theoretical structure and a process that makes it possible to move incrementally towards complexity. The complex dynamics and

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