

Chapter XI

Crime Simulation Using GIS and Artificial Intelligent Agents

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ABSTRACT

This chapter presents an innovative agent-based model for crime simulation. The model is built on the integration of geographic information systems (GIS) and artificial intelligence (AI) technologies. An AI algorithm (reinforcement learning) is applied in designing mobile agents that can find their ways on a street network. The multi-agent system is implemented as a Windows desktop program and then loosely coupled with ESRI ArcGIS. The model allows users to create artificial societies which consist of offender agents, target agents, and crime places for crime pattern simulation purposes. This is a theory-driven system, in which the processes that generate crime events are explicitly modeled. The simulated crime patterns are shown to have similar properties as seen in reported crime patterns.

INTRODUCTION

Environmental criminologists argue that crime patterns are the result of the complex interactions among offenders, victims and their environment. This complexity includes learning and adaptation

by all actors involved in a crime event (Brantingham & Brantingham, 2004; Eck, 2003). The research introduced in this chapter represents an effort to provide a tool to study such complexity and to help develop crime theories and inform crime prevention policy.

The agent-based model presented in this chapter, named spatial adaptive crime event simulation (SPACES), is a crime simulation system for street robbery based on routine activities in an urban area. In a typical simulation designed in SPACES, offender agents and target agents are scheduled to perform routine activities in a spatial environment. The interaction among agents during their routine activities generates crime events and crime patterns for analysis. Offender agents, target agents and crime places are all adaptable, which means that they can modify their actions as a consequence of past offending and victimization experience. Agent routine activity schedules and adaptabilities can be changed to simulate different crime patterns. The simulation process is visual in SPACES as animations. The simulation results could also be exported to commercial GIS software packages for further analysis.

BACKGROUND

Environmental criminology consists of a set of related theories: routine activity theory, crime pattern theory, and rational choice theory. These theories explain crime patterns by focusing on micro crime events.

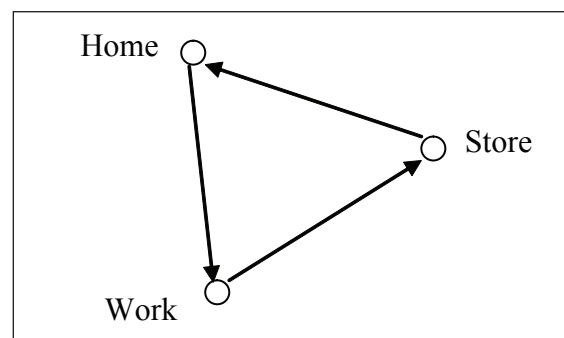
Routine activity theory (Cohen & Felson, 1979) argues that the occurrence of a direct contact predatory crime event is the result of the convergence of three elements in space and time: a likely offender, a suitable target, and the absence of guardians for the target (Clark & Felson, 1993). Routine activity theory has been expanded to account for third party agents, in addition to guardians, and to explicitly account for crime locations (Felson, 1995). Formalizing expanded routine activity theory, Eck (1995) presented the likelihood of a crime event at a local situation in a mathematical formula. This equation is the foundation of the crime event likelihood evaluation for offender agents in SPACES.

Based on routine activity theory, crime pattern theory (Brantingham & Brantingham, 1993) argues that the distribution of crime events can be explained by the distribution of offenders, targets, and controllers during their daily routines in space and time. Furthermore, it argues that offenders spend most of their time in legal routine activities. They learn an awareness space during legal routine activities. Crime events are most likely to take place in their awareness space. The awareness space defined by routine activities serves as another foundation of SPACES.

In the geographic literature, routine activity is defined as “a recurring set of episodes in a given unit of time” (Golledge & Stimson, 1997, p290). For example, for the daily routine of going from home to work place, from work place to a shopping store, and then returning home, there are three episodes (as shown in Figure 1). The basic element of any complex routine activity is a single episode (as shown in Figure 2). Following this definition, SPACES defines the routine activity of each agent as a set of episodes. At each moment, an agent can only be involved in one episode.

Rational choice theory (Cornish & Clarke, 1986) views a crime event as the result of a series of decisions by offenders. When choosing targets, offenders attempt to increase gains and reduce losses. Human targets, guardians and others also make rational choices. Consistent with this theory,

Figure 1. A three-episode routine activity (arrows indicate movement direction)



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