Predicting burglary patterns through math modeling of crime

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Pattern formation in physical, biological, and sociological systems has been studied for many years. Despite the fact that these subject areas are completely diverse, the mathematics that describes underlying patterns in these systems can be surprisingly similar. Mathematical tools can be used to study such systems and predict their patterns.

One area where the study of pattern formation has been of growing interest is in crime modeling. It has been observed that criminal activity tends to cluster in space and time in urban settings. Analyzing spatio-temporal patterns of urban crime using mathematical modeling can reveal hidden patterns in the process of criminal activity, and potentially help establish methods for prevention.

The authors of a paper published this month in the *SIAM Journal on* Mathematical Analysis analyzed pattern formation as a model to predict burglaries. The rate of burglaries tends to be higher for houses that have been burglarized before or are close neighbors of those that have been burglarized. This leads to the creation of burglary hotspots. Authors Steve Cantrell, Chris Cosner, and Raúl Manásevich propose a model to generate patterns that would describe the specific location of such hotspots.

"Our research provides a mathematically rigorous way of connecting the geographical characteristics of a neighborhood [such as demographics, economics and ecology] to the patterns of burglary that would be seen in the neighborhood," says lead author Steve Cantrell. "Bringing geography into the model is an important step in understanding the model in realistic situations."

"Our work was inspired by models of burglary patterns that were developed by a group of mathematicians and scientists at UCLA," he goes on to explain. The UCLA group analyzed the dynamics of burglary hotspots based on the assumption that criminal agents strike based on a house's "attractiveness value."

The attractiveness value is a measure of how easily a house can be burgled without negative consequences for the burglar. Thus, when a house has been burglarized before, it increases the attractiveness value for the house and those nearby. Criminal agents move toward areas of high attractiveness values. If no additional burglaries occur in the vicinity, the attractiveness decreases.

Mathematical modeling of crime in general, and burglaries in particular, is based on the "broken window effect" or repeat victimization sociological effect, which implies that houses in areas of past burglaries have a higher chance of being burglarized.

Using two discrete models, one modeling the attractiveness of individual houses to burglars and the other modeling burglar movement, the authors of the UCLA study developed a continuum model based on a system of parabolic differential equations. Using this system as a starting point, the authors apply bifurcation theory, or the analysis of a system of ordinary differential equations under varying conditions, such as social or economic conditions of a neighborhood, to extend the scope of analysis. This paper expands on previous analyses and provides a general method to track social, economic or other conditions of a neighborhood over time.

More information: Global Bifurcation of Solutions for Crime

Modeling Equations, Robert Stephen Cantrell, Chris Cosner, and Raúl Manásevich, *SIAM Journal on Mathematical Analysis*, 44, pp. 1340-1358 (Online publish date: May 3, 2012)

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