Predicting the Home Base of Serial Offender

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1 Introduction

People's movement is patterned. It is commonly known that people travel more often to the nearby area of their home than further away. According to a so called utility theory reason for this kind of behaviour is that people try to maximize the value and minimize travel costs. For example, for a consumer faced with two retail shops selling the same product, one being closer but more expensive while the other being farther but less expensive, the consumer has to trade off the value to be gained against the increased travel time required.

The function representing the travel behaviour is called a distance decay function. The function shows how the frequency of travels varies in relation

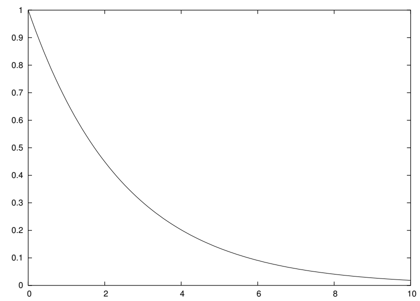

Figure 1: Example of distance decay function.

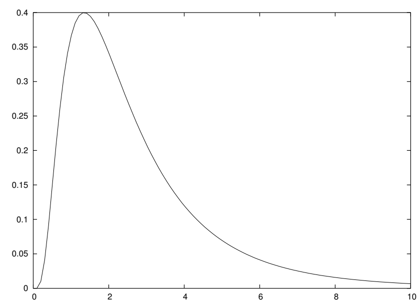

Figure 2: Example of journey to crime distance decay function.

to distance. Depending on the domain it's form is slightly different, but it is something like presented in figure 1.

When examining journey to crime trips i.e. offender's travel behaviour from his/her residence to crime sites, it has been shown that the trips follow same kind of pattern. Brantingham and Brantingham (1984) have made substantial work on conceptualizing crime patterns. One of their results is that there is a decreased criminal activity near to an offender's home, a sort of a safety area (or 'buffer zone') around their near neighborhood. Presumably, offenders go a little farther from their home so as to decrease the likelihood that they will get caught. Beyond that zone, however, the number of crime trips would decrease according to a distance decay model (see fig. 2).

Travel behaviour varies also by crime types. Particularly those committing property crimes, tend to travel farther distances than offenders committing crimes against people. Many homicides (at least in Finland) are committed at home, so there is no buffer zone at all. In addition there are other factors affecting: method of operation, time of day, the value of the property realized (in property crimes) etc.

Sometimes crime trips may not even begin at an offender's residence. According to a routine activity theory crime opportunities appear in the activities of everyday life. The routine patterns of work, shopping, and leisure affect the convergence in time and place of would be offenders, suitable targets, and absence of guardians. Many crimes may occur while an offender is traveling from one activity to another. Thus, modeling crime trips as if they are referenced relative to a residence is not necessarily going to lead to better prediction.

Despite the problems mentioned, information about journey to crime behaviour has been used for predicting the home base [1] of serial offender. The idea is that reversing the distance decay function it is possible to estimate the offender's home base. The distribution of incidents describes an activity area by an offender, who lives somewhere in the center of the distribution. It is a sample from the offender's activity space. Using the Brantingham's terminology, there is a search area by an offender within which the crimes are committed; most likely, the offender also lives with in the search area.

As an automated process the prediction of home base can be described as follows:

1. Learn the appropriate distance decay function from data of solved crimes.

2. Given the serial offender's crime incident locations, place the distance decay function on every location.

3. Sum up the densities.

4. The highest density area is the likely place for offender's home base.

In this study three models for the distance decay function learning and use are presented. Two first, the Rossmo model and the Canter model, are specifically designed for home base location analysis. They use predefined function, that is fitted to data of known crime trips. The third model is implemented in the CrimeStat program, that is a spatial statistics program for the analysis of crime incident locations. It uses a method called kernel density estimation for finding the best function for the data. Then there's a discussion about the models' strenghts and weaknesses. Before the conclusion, there's a discussion about the problems related to domain, and suggestions for the future.

[1] The term home base refers also to situations where the offender leaves not from his/her home but e.g. from work working place.

2 Models for offender's home base prediction

2.1 Rossmo Model

Rossmo has adapted location theory, particularly travel behavior modeling, to serial offenders. His mathematics represent a formulation of the Brantingham and Brantingham search area model, in which the search behavior of an offender is seen as following a distance decay function with decreased activity near the offender's home base.

2.2 Canter Model

Canter's group in Liverpool have modified the distance decay function for journey to crime trips by using a negative exponential term, instead of the inverse distance. Their Dragnet program uses the negative exponential function

$$Y = \alpha e^{\frac{-\beta D_{ij}}{P}}, \tag{1}$$

where Y is the likelihood of an offender traveling a certain distance to commit a crime, D_{ij} is the distance (from a home base location to an incident site), α is an arbitrary constant , β is the coefficient of the distance (and, hence, an exponent of e), P is a normalization constant, and e is the base of the natural logarithm.

2.3 CrimeStat Model

The Jtc routine builds on the Rossmo framework, but extends its modeling capability.

2.3.1 Kernel Density Estimation

Kernel density estimation involves placing a symmetrical surface over each point, evaluating the distance from the point to a reference location based on a mathematical function, and summing the value of all the surfaces for that reference location. This procedure is repeated for all reference locations. It is a technique that was developed in the late 1950s as an alternative method for estimating the density of a histogram.

Kernel density estimation is one of the 'modern' spatial statistical techniques. There is currently research on the use of this technique in both the statistical theory and in developing applications.

3 Discussion

3.1 Strengths and weaknesses of the models

3.2 Choice of calibration sample

4 Conclusion

5 References

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