Spatio-temporal point pattern analysis on networks

ESR12: Mohammad Mehdi Moradi
Universitat Jaume I, Spain

Context

There are some factors that have a direct impact on the safety of cities, such factor could be crimes or accidents. In order to improve the quality of life and having a better management system, organizations such as the Police department and Town Hall need to know where the high-risk areas are in the city and also to find what causes the problem. There are some kind of problems which happen only on the streets or along them such as accidents, car thefts, snatch the phone and so forth. The behavior of such events is clearly restricted to their own network so that the study of these events on networks can not be approached by just using the classical statistical techniques designed by ignoring the network. The reference locations for events of interest in a geographical region can be considered as a point pattern in the plane. Events on networks often need to deal with the shortest-path distance on the network instead of the Euclidean distance. In order to estimate the intensity function through kernel smoothing, Okabe et al. (2009) defined two algorithms. Ang et al. (2012) tried to improve the K-function which was defined by (Okabe and Yamada; 2001) because their K-function depends on the location.

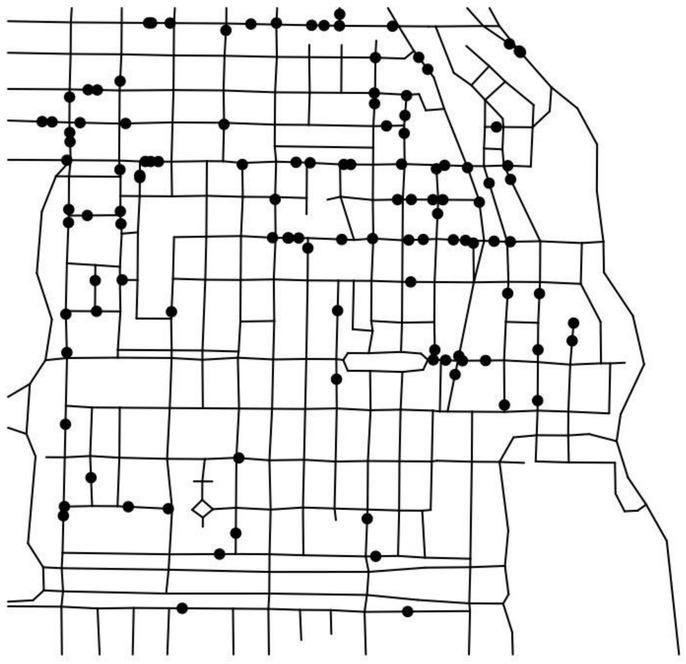

Figure 1: Chicago Crime data

Figure 2: Castellon street anti-social behavior

Challenges

Based on society's needs and after restricting the spatio-temporal point process to the its own network, we are interested to know:

- Where are the high-risk (in term of the event) streets in the cities?
- How do events interact each other? Tend to happen close to each other? Regular? Or repulsion?
- What covariate has a significant effect on the behavior of events?

Actions

As sometimes the citizens complain about the social problems in the cities, the focus of this project is to figure out a general insight into the problems which are happening in the streets such as street crimes and vehicle accidents. In the first place, the aim is to come up with some methodologies that can find the high-risk streets within a city so that we focus on estimating intensity function non-parametricly. Then, we are going to make a link between spatially and temporally measurements and covariates to reach an insight into the problems and reveal what causes the problems. In order to attain that target, estimating the intensity function parametrically is the first idea that comes to mind. Then, having enough strong approaches to find the high-risk streets, we are interested in the type of interaction among the points on their corresponding network in which we stand on summary statistics such as K-, J- and pair correlation function. Finally, sufficient knowledge about the intensity function and the type of interaction among the events persuade us to suggest a point process which the events may be generated from using the residual analysis of summary statistics.

Scaling Up

The intensity estimators and summary statistics can be efficiently applied to any kind of data happens on networks and disclose the high and low intensity segments, the kind of interaction between the events and even suggest a model i.e. it is independent of the type of data and network. Moreover, the whole recipe of this research can be used to build complex models of point processes on linear networks. In addition, network point pattern data can even be found in other fields such as geography, neuroscience, biology, physics, etc. Therefore, not only for data happens on the cities´ streets such as street crimes, accidents, anti-social behavior, one can even use summary statistics of point processes on networks such as intensity function, K-, pair correlation and J-function to analyze network point data in other fields.

Results

- Two new methods to find the high/low intensity parts of city street in terms of street crimes, vehicle accidents, etc.
  - ❖ Kernel intensity estimator.
  - ❖ Smoothed Voronoi intensity estimator.
- J-Function on networks.
- Spatio-temporal intensity estimator for the events happen on a network.
- Spatio-temporal K- and pair correlation function so that they enable us to disclose the type of interaction among the events.

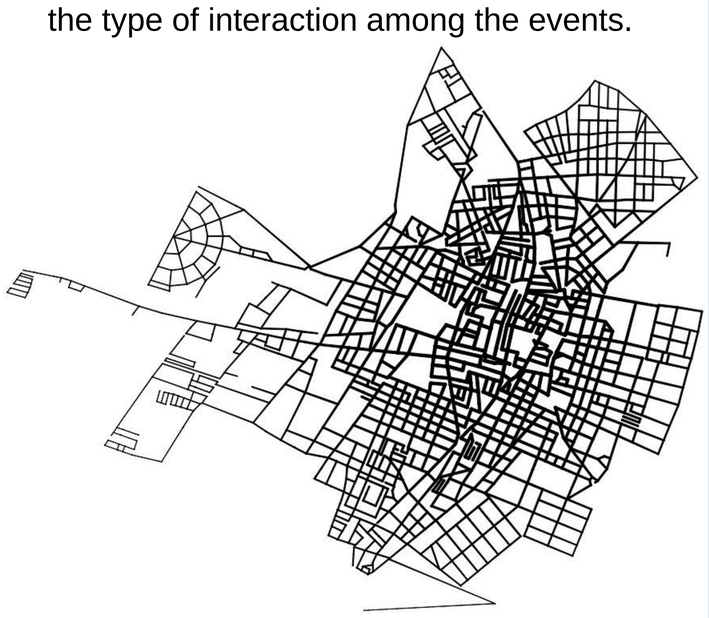

Figure 3: Estimated intensity using kernel intensity estimator for Castellon anti-social behavior data

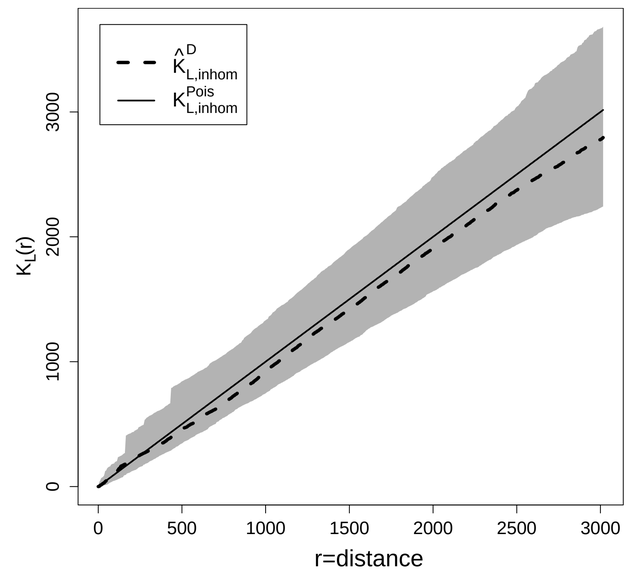

Figure 4: K-function for street anti-social behavior in Castellon

Impact

In order to have a sufficient system to manage a city, we need to have all events happen in the city under control. As we are analyzing the events happened on the street network of cities, the methodology of this research can be used by Town Hall or the Police department. Having an enough good approach to find the high-risk streets (in terms of any event) can lead Town Hall or the Police department to rethink and rebuild their policies and it may bring up a better management system. Moreover, knowing what causes a problem in street can help them to prevent current problems in the streets of a city. As a result, sufficient system can improve the quality of life and city becomes more livable.

Consortium

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