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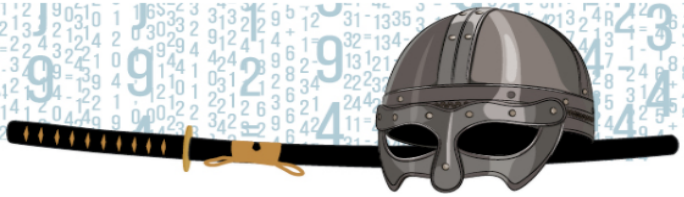
Spatial Analysis and GEOmatics 2017



Retail distribution in the city: analyzing point patterns in non-uniform network space

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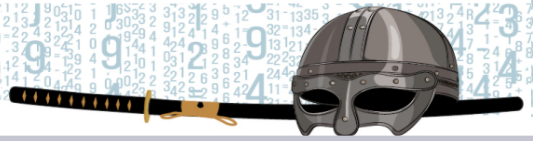

1.Research Problem

Retail activity in a city

↓

Point pattern analysis on network

2. Available approaches

Geo-Statistics | Fractals | Network Configuration

3. Convergence of Approaches

How to analyze the relation between network and point heterogeneity

↓

4. Application to a real case study:

Retail activities and urban street network

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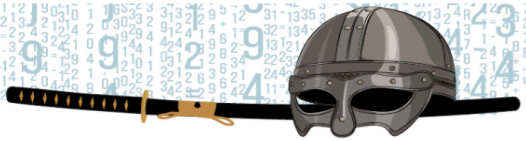

Research problem

In scientific literature point pattern analysis has been studied with *ad hoc* solutions (Perry et al.2002)

Dale et al. (2002) offer an overview on both mathematical and conceptual methods: redundancy in methods needed for deeper comprehension of the phenomenon

In this work we are interested in the application of some particular methods with an heuristic approach (Exploratory Data Analysis EDA)

The aim of this study is to identify relations between point pattern heterogeneity and network heterogeneity

FORM-FUNCTIONING within the city

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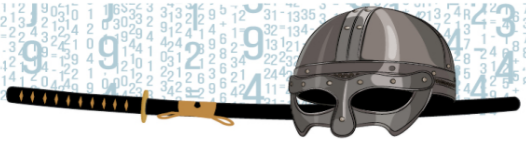


Research problem, some definitions

Spatial point process is a "*stochastic mechanism which generates a countable set of event* x_i *in the plane*" (Diggle 2003)

Point pattern is a realization of a spatial point process (Gartrell et al.1996)

Spatial Domain is the domain where the point pattern takes place

Points can be defined by their spatial coordinates and additional attributes (marked point patterns, Gartrell 1996)

In statistic analysis

Areas (Greig Smith 1952) or **Distance** Based (Clark and Evans 1954)

Density and Intensity are the most common analysis

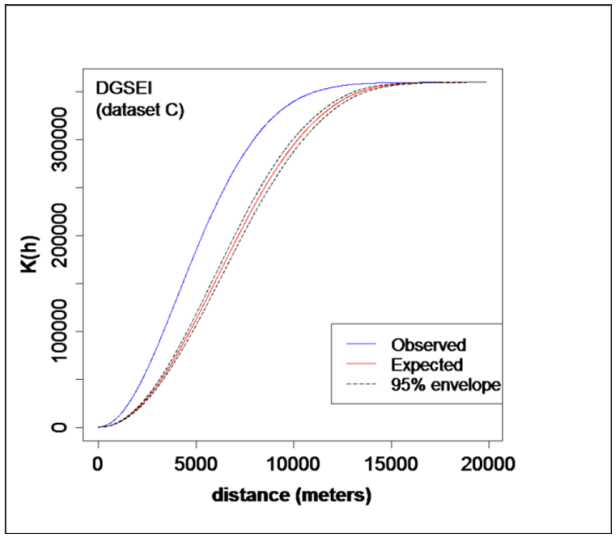
Kernel Density (on network Okabe 2012, Steenberghen2010)

LISA and ILINCS (Anselin 1995, Yamada and Thill 2004,2007)

Etc.

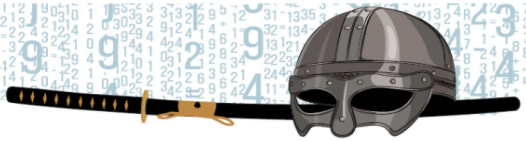
The geo-statistical approach

Ripley's K function: this function considers the mean of the count of events within disks of increasing radii, centered on each point.



This function is then compared to n realizations of a Poisson spatial process with known probability using a Monte Carlo sampling scheme.

K function method highlights clustering behaviors of point distribution



The geo-statistical approach

Two aspects of Ripley's K function:

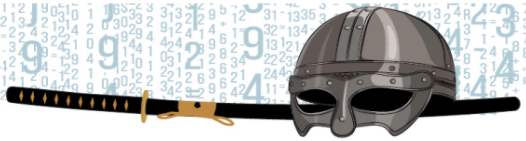
1.The Network Domain of the Point Pattern analyzed:

Yamada and Thill (2004), Lu et Chen (2007) demonstrated the overestimation of clusters of the planar method

2.The assumption of complete spatial randomness (intensity constant over the domain)

Okabe (2012)-> variation of the support

Baddeley (2000) -> variation of the intensity of the process over space

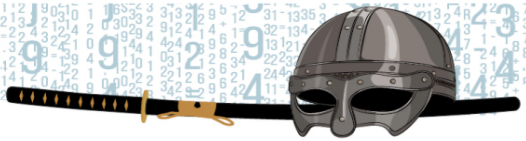


The geo-statistical approach

Ripley's K function observations:

- K function analyzes the clustering behaviors of a point patterns
- The network heterogeneity influence on point clustering behavior has been recently studied
- Okabe et al., Baddeley et al. study the resulting combined effect of the heterogeneity of point pattern with the heterogeneity of network pattern

How to analyze the different combinations of the heterogeneity of the point pattern and the heterogeneity of the domain?



The fractal approach

Fractal analysis tries to find a singular parameter, (fractal dimension) describing a repeating pattern at different scales (Mandelbrot 1977)

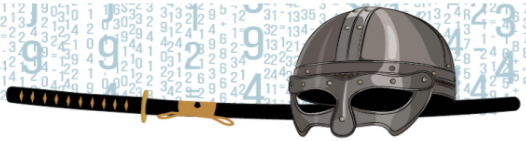
Local Fractal Analysis are based on radial analysis and on curves of scaling behavior

Box Counting Method has been widely applied on both planar and reticular space (Albert Barabasi 2002, Song et al. 2005 etc.)

Starting from one point, it counts the number of points (or elements) within an increasing distance …. Then determines the slope of the linear fit in a log-log diagram

$N(r) = r^{D}$ ⎓ $\log N(r) = D * \log r$

D = fractal dimension



The fractal approach

Box Counting Method observations

-D synthetically describes the apparently trans-scalar irregular distribution of events

-D describes how spatial domain size growth

This detailed approach studies the variation of local patterns " *by comparing the results obtained for different centers*": an instrument for the analysis of empirical structures through their comparison and classification (Frankhauser 1998)

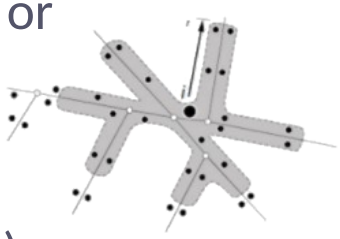
The configurational approach

The importance of the localization on a network has been widely studied (Bavelas 1948)

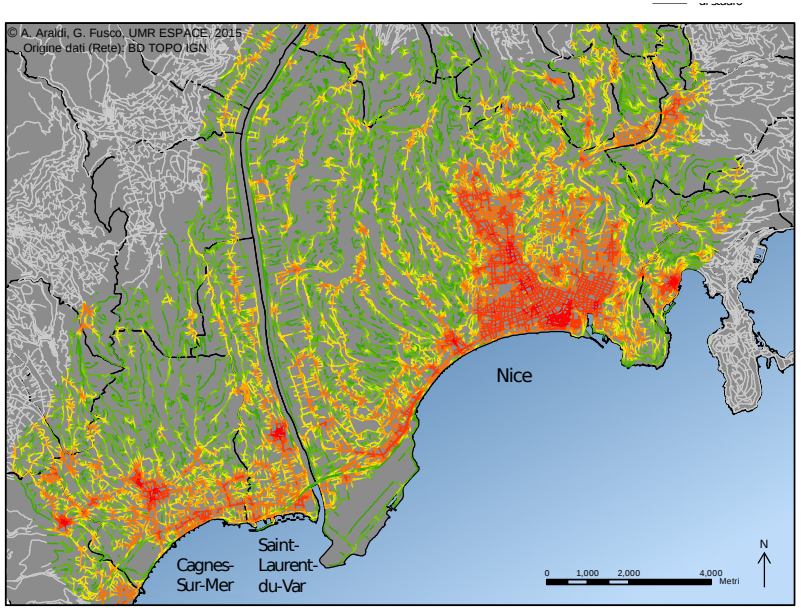
These theories have been applied to Urban street networks (Hillier 1996, Porta 2006, Svetsuk 2010) showing the importance of the network configuration on the functioning of a city

Reach indicator (MCA) or

Node count(SSx)



Reach r [i] =Σ d[i,j]≤ r (j)



Once again, in network studies, we identify the same underlying method:

Counting elements at given (increasing) radii

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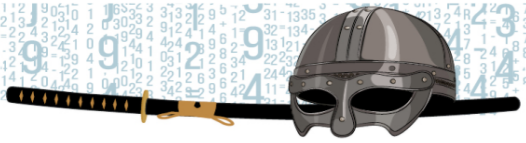


The **3 techniques** share the same counting method:

- K function focuses on significant clustering behavior as a function of distance
- Fractals summarize trans-scalar properties of spatial distribution
- Reach identifies local patterns around every center at a given radius

Proposal:

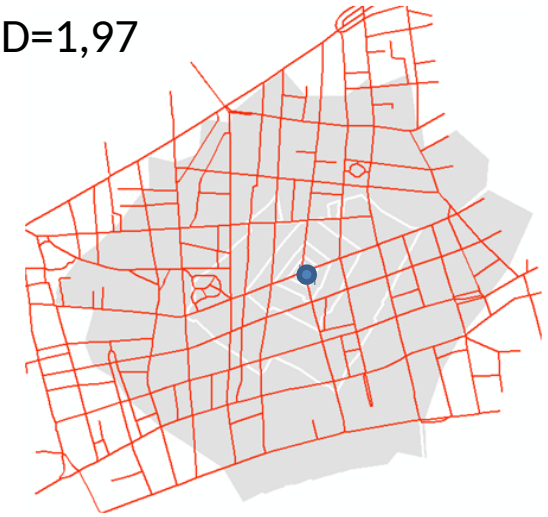
Counting method applied on a network constrained points pattern

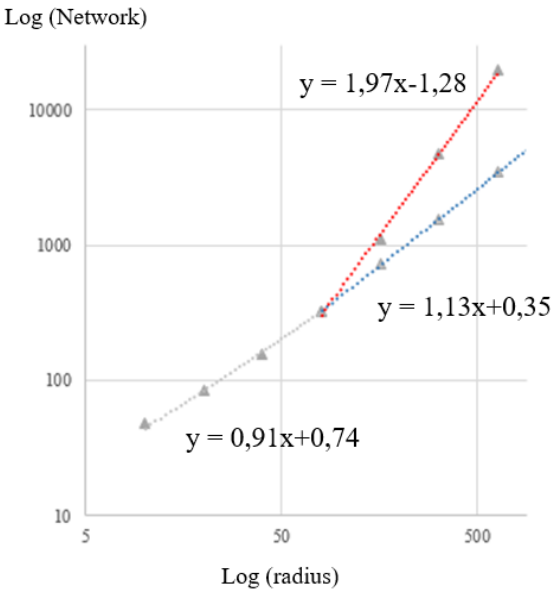
Counting method applied on network length

Combining two measures of spatial patterns

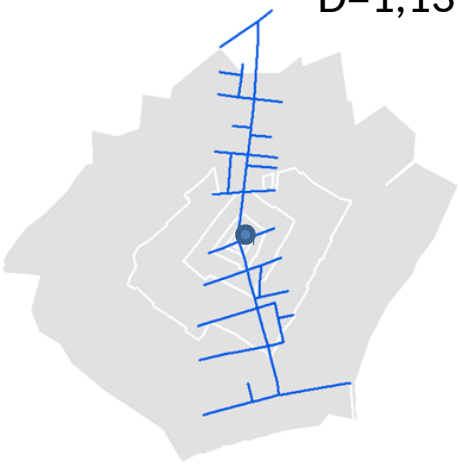
Proposal: counting method applied to network and points

D=1,97





D=1,13



Same procedure applied to the point pattern

R^2 of 0,989 (Network) and 0,936 (Points),
SD of 0,0254 and 0,0579
for the 18,000 series

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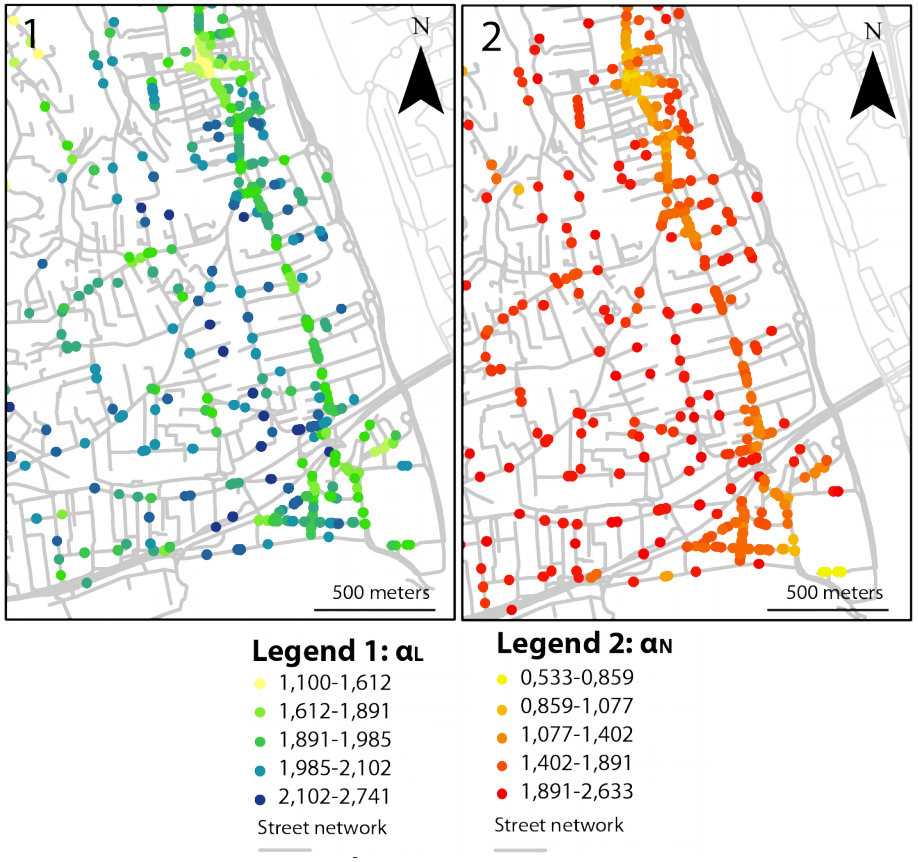
Proposal: application to retail activities on network



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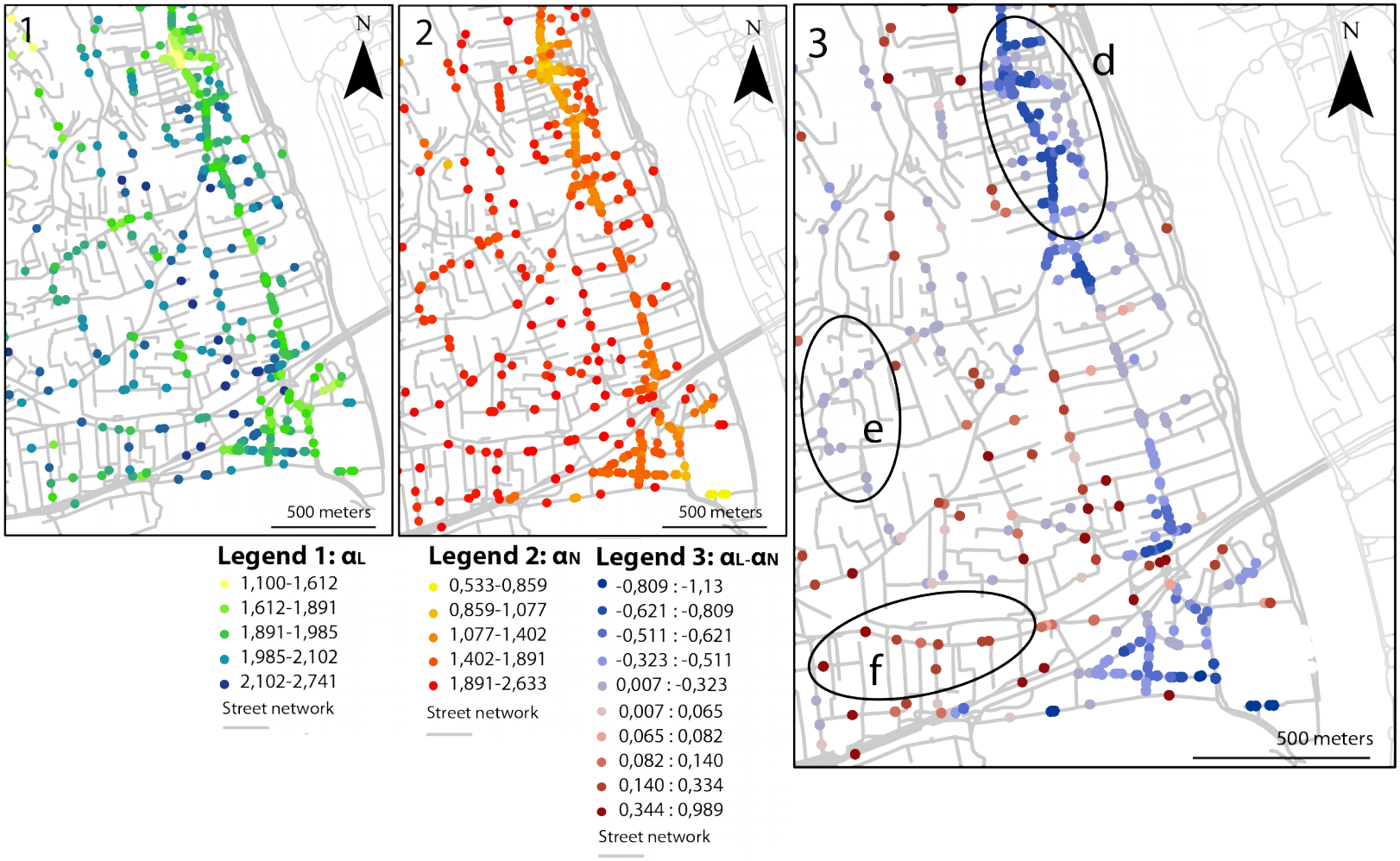
Proposal: application to retail activities on network



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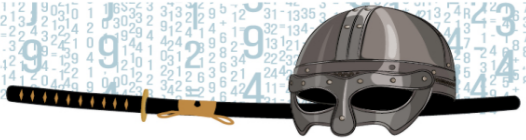


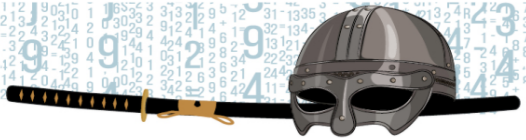
Results

With this method we obtain:

1) A local spatial description of the trans-scalar domain structure:
trans-scalar configuration of the street network

2) A local spatial description of the trans-scalar point pattern distribution:
how retail activities are distributed

3) The combination of 1 and 2 shows where the domain and the point distribution follow the same structure and where they diverge.



Perspective for future developments:

Method

1) Significance of local fractal deviations should be implemented (as in K function)

2) Marked point pattern could be analyzed (as in cross K function)

Domain

3) Retail: investigate reasons for local fractal deviations

4) Application to other domains: crime, accidents, etc…

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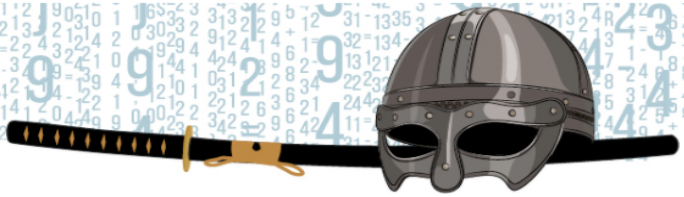

Thankyou

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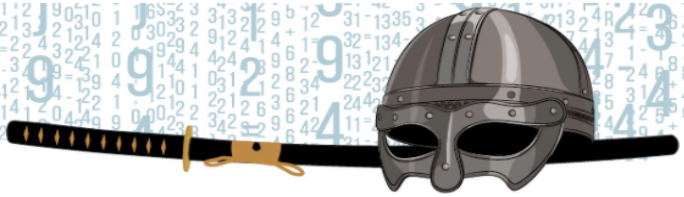

Last but not least …

12 months post-doc position in urban spatial analysis

At ESPACE, in Nice.

Applications until Nov 24th.

Contact & Info: Giovanni FUSCO giovanni.fusco@unice.fr

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