Geographic Data Science - Lecture VI

Exploring Space in Data

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Today

- ESDA
- Spatial Autocorrelation
- Measures
  - Global
  - Local

ESDA

Exploratory Spatial Data Analysis

[Exploratory]

Focus on discovery and assumption-free investigation

[Spatial]

Patterns and processes that put *space* and *geography* at the core

[Data Analysis]

Statistical techniques

Questions that **ESDA** helps...

Answer

- *Is the variable I'm looking at concentrated over space? Do similar values tend to locate closeby?*
- *Can I identify any particular areas where certain values are clustered?*

Ask

- *What is behind this pattern? What could be generating the process?*
- *Why do we observe certain clusters over space?*

Spatial Autocorrelation

Everything is related to everything else, but near things are more related than distant things

Waldo Tobler (1970)

Spatial Autocorrelation

-Statistical representation of Tobler's law

-Spatial counterpart of traditional correlation

Degree to which similar values are located in similar locations

Two flavors:

- **Positive**: similar values → similar location (*closeby*)
- **Negative**: similar values → disimilar location (*further apart*)

Examples

Positive SA: income, poverty, vegetation, temperature...

Negative SA: supermarkets, police stations, fire stations, hospitals...

Scales

[Global]

Clustering: do values tend to be close to other (dis)similar values?

[Local]

Clusters: are there any specific parts of a map with an extraordinary concentration of (dis)similar values?

Global Spatial Autocorr.

Global Spatial Autocorr.

"Clustering"

Overall trend where the distribution of values follows a particular pattern over space

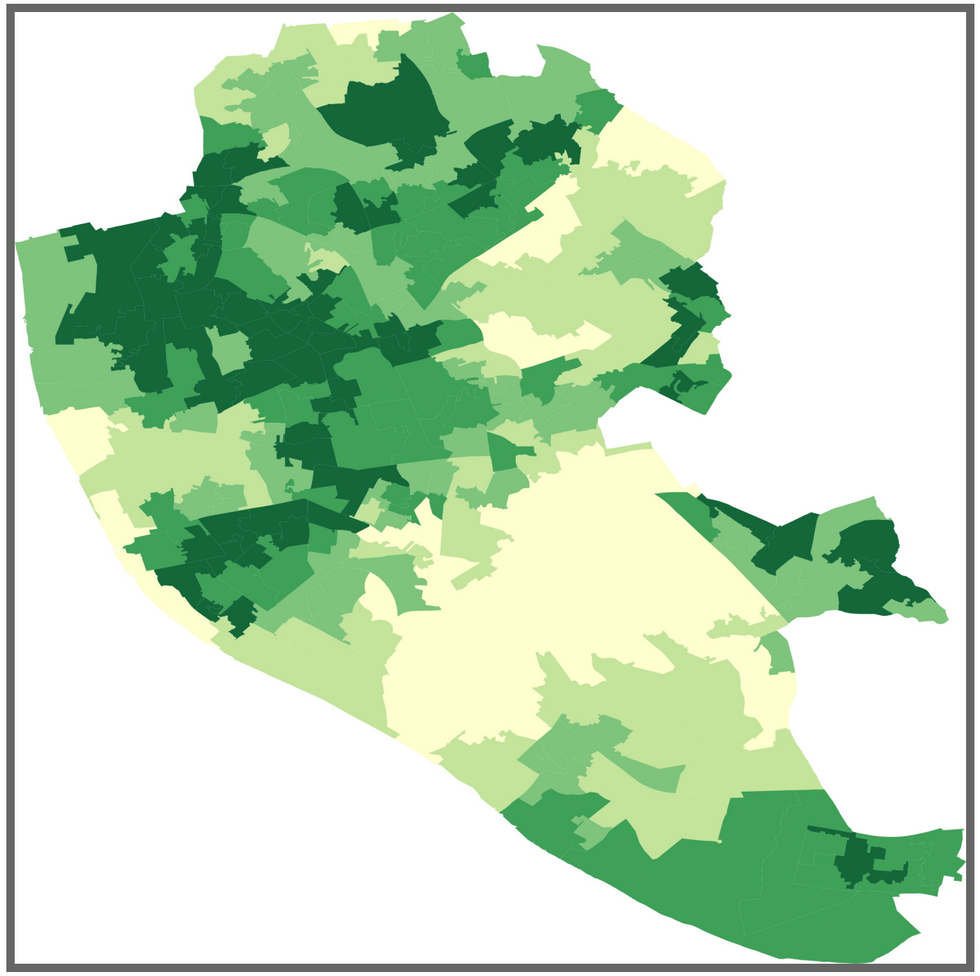
[Positive] Similar values close to each other (high-high, low-low)

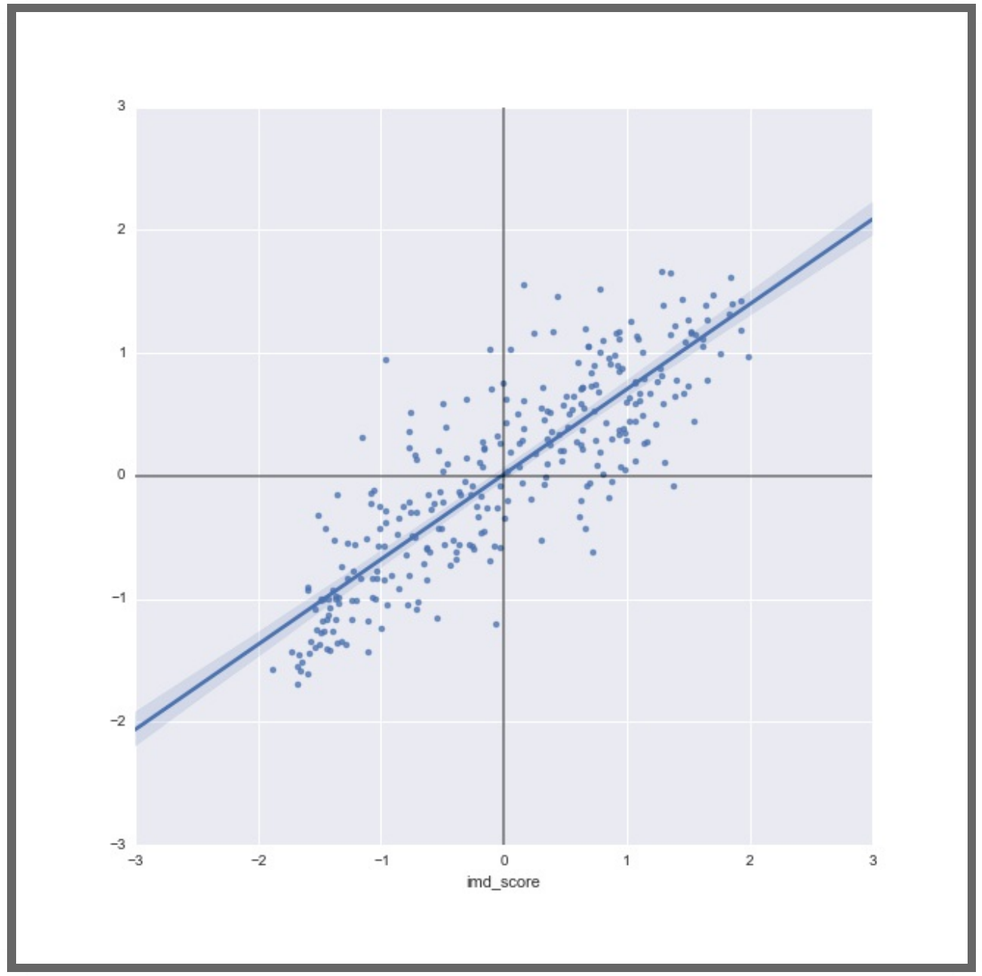
[Negative] Similar values far from each other (high-low)

How to measure it???

Moran Plot

- Graphical device that displays **a variable** on the horizontal axis against **its spatial lag** on the vertical one
- Variable and spatial weights matrix are preferably **standardized**
- Asssessment of the overall association between a variable in a given location and in its *neighborhood*




3
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[Interactive Demo]

Moran's I

Formal test of global spatial autocorrelation

Statistically identify the presence of clustering in a variable

Slope of the Moran plot

Inference based on how likely it is to obtain a map like observed from a purely random pattern

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(z_i)(z_j)}{\sum_i (z_i)^2}$$

Local Spatial Autocorr.

Local Spatial Autocorr.

"Clusters"

Pockets of spatial instability

Portions of a map where values are correlated in a particularly strong and specific way

[High-High] Positive sp. autocorr. of *high* values (*hotspots*)

[Low-Low] Positive sp. autocorr. of *low* values (*coldspots*)

[High-Low] Negative sp. autocorr. (*spatial outliers*)

[Low-High] Negative sp. autocorr. (*spatial outliers*)

LISAs

Local **I**ndicators of **S**patial **A**ssociation

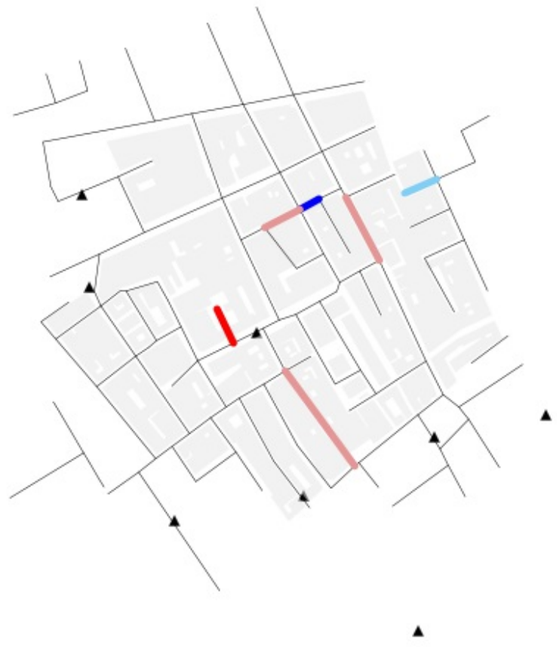
Statistical tests for **spatial cluster detection** →
Statistical significance

Compares the **observed** map with many **random**ly generated ones to see how likely it is to obtain the observed associations **for each location**

$$I_i = \frac{Z_i}{m_2} \sum_j W_{ij} Z_j \quad ; \quad m_2 = \frac{\sum_i Z_i^2}{N}$$

Cholera Deaths at the street level

LISA for Cholera Deaths



Recapitulation

ESDA is a family of techniques to explore and spatially interrogate data

Main function: characterize **spatial autocorrelation**, which can be explored:

- **Globa**lly (e.g. Moran Plot, Moran's I)
- **Loca**lly (e.g. LISAs)