Global measures of spatial autocorrelation

Bayesian modelling for spatial and spatio-temporal data

MSc in Epidemiology

Week 6

Measuring spatial autocorrelation

- Global measures of spatial autocorrelation share a common structure: calculate the similarity of values at locations i and j, then weight the similarity by the proximity of locations i and j.
- Null hypothesis: spatial randomness (independent observations).
- Form of global measure of spatial autocorrelation:

$$T = c \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij} \times \text{similarity}_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}}$$

- c constant
- N number of areas
- w_{ij} weights reflecting the proximity between areas i and j
- similarity_{ij} measure of similarity between data values in areas i and j

Global Moran's I test for spatial autocorrelation

- Moran's I test can be applied to the data directly, or to the residuals from a regression model (as shown in tutorial 6.1).
- Let $\{Z_i : i, \ldots, N\}$ represent spatially referenced data (or residuals) for N spatial locations.
- The global Moran's I statistic is:

$$I = \frac{N \sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}(Z_i - \overline{Z})(Z_j - \overline{Z})}{\left(\sum_i \sum_j w_{ij}\right) \sum_{i=1}^{N} (Z_i - \overline{Z})^2}$$

where $\overline{Z} = (1/N) \sum_i^N Z_i$ is the spatial mean and w_{ij} are the spatial weights

Global Moran's I interpretation

I tell us if most pairs of neighbouring areas have the same sign regarding their deviation from the mean.

- If there is no spatial dependence, I will be close to 0 (i.e. spatial pattern is random)
- If $I > 0$ and significant, then areas close together (as defined by w_{ij}) will tend to have similar values (i.e. clustering of like value)
- If $I < 0$ and significant, clustering of dissimilar (i.e. alternating) values
- "Significance" will be done using Monte Carlo (MC) approach (i.e. the data are repeatedly randomly assigned to different areas, and the statistic calculated under each permutation, yielding a comparison distribution)

References

- Haining R., Guangquan L. (2020), Modelling Spatial and Spatial-Temporal Data. A Bayesian Approach, CRC Press, Section 6.2.4.2

- Waller L. A., Gotway C.A. (2004), Applied Spatial Statistics for Public Health Data. John Wiley & Sons, Section 7.4