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Revisiting the role of distance for spatial prediction

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Abstract:

The spatial dependency discovered by Tobler in his first law of geography has been one of the most prevalent guiding principles for spatial prediction and a widely accepted variable in numerous spatial analysis algorithms. When conducting the spatial prediction based on finite samples, the estimated position is expected to be influenced more by nearby than by distant samples, although the influence strength may vary in different directions. For example, the semivariogram in kriging is a function of distance. It describes how the variance decreases with the increase of the distance between a pair of samples. The spatial weight matrix of geographically weighted regression is also constructed according to the principle of distance decay.

Moreover, the universal assumption for the role of spatial distance may have different local flavors because of the generally uneven and heterogeneous distribution of geographical variables (Luo et al., 2022). Some scholars have found that two locations with similar geographical configurations would have a similar spatial pattern in the target variable (Zhu and Turner, 2022; Song, 2022). For example, when predicting the temperature of a location at greenery, the neighboring samples located in the same greenery are more valuable.

Indeed, nearby samples provide necessary information at most times, but they may also introduce wrong information to the spatial prediction. Due to naturally occurring boundaries, such as rivers or mountains, or artificially introduced boundaries, such as between different indoor environments, and between indoor and outdoor environments, spatial autocorrelation may be sharply interrupted, thus short spatial distances do not always lead to a strong spatial association. As shown in Figure 1, samples located in buildings may introduce wrong information to the prediction of value at the location labelled by the question mark, although they are near neighbors. It is therefore necessary to review the importance of spatial distance and refine spatial neighborhood for improved spatial prediction.

This work revisits the role of distance and similarity in prediction, with the aim to define a constrained first law of geography. In addition, we will combine spatial similarity and spatial distance for spatial prediction and try to improve the performance across a range of spatial prediction models.

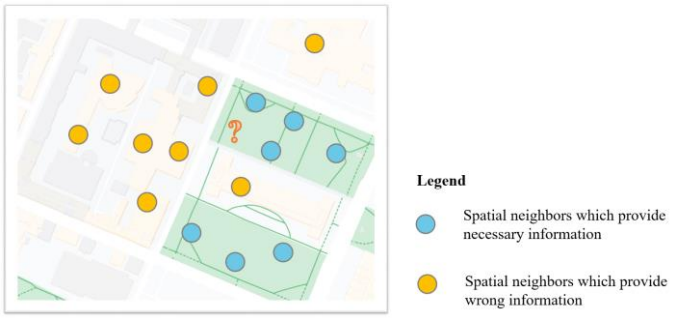

Figure 1. Not all nearby samples provide necessary information for the spatial prediction of the value in the location labelled by a question mark.

References

Luo, P., Song, Y., Zhu, D., Cheng, J. and Meng, L., 2022. A generalized heterogeneity model for spatial interpolation. International Journal of Geographical Information Science, pp.1-26.

Song, Y., 2022. Geographically Optimal Similarity. Mathematical Geosciences, pp.1-26.

Zhu, A.X. and Turner, M., 2022. How is the Third Law of Geography different?. Annals of GIS, 28(1), pp.57-67.