

## Lecture outline and reading list

Lecture: Geospatial Data Analysis, Prediction, and GeoAI: New Theories, Methods, and Software

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Lecturer:

Yongze Song, Associate Professor, Curtin University, Australia

Website: <https://yongzesong.com/>

### Contents

1. Introduction to spatial modelling and prediction
2. Spatial modelling for heterogeneity and determinant analysis
3. Spatial modelling for prediction
4. Spatial patterns for prediction
5. Research design, spatial and remote sensing data collection, and pre-processing
6. Spatial validation methods
7. Spatial decision-making and applications
8. Geospatial intelligence (GeoAI) and spatial big data for urban sustainability

### Reading list

#### Books

- Fischer, Manfred M., and Arthur Getis, eds. Handbook of applied spatial analysis: software tools, methods and applications. Berlin: Springer, 2010.
- Fahrmeir, Ludwig, Thomas Kneib, Stefan Lang, Brian Marx. Regression: Models, Methods and Applications. Springer Berlin Heidelberg, 2013.
- Goovaerts, Pierre. Geostatistics for natural resources evaluation. Oxford University Press, USA, 1997.
- Haining, Robert P. Spatial data analysis: theory and practice. Cambridge university press, 2003.

#### Journal articles

- McKinley, Jennifer M., Ulrich Ofterdinger, Michael Young, Amy Barsby, and Anna Gavin. "Investigating local relationships between trace elements in soils and cancer data." Spatial statistics 5 (2013): 25-41. GWR model

PDFs of the following articles are available at <https://yongzesong.com/publications/>

- Song, Y., 2022. The second dimension of spatial association. International Journal of Applied Earth Observation and Geoinformation. 111, 102834. SDA model
- Song Y., 2023. Geographically Optimal Similarity. Mathematical Geosciences. 8:1-26. GOS model
- Song, Y., Helmholz, P., Su, F., Zhou, C., Lotfata, A., Zohar, M., González Leonardo, M., & Sila-Nowicka, K. 2025. Advancing geospatial methods

for addressing global resource and sustainability challenges. Resources, Conservation and Recycling. Advanced geospatial methods

- Song, Y., Kalacska, M., Gašparović, M., Yao, J. & Najibi, N., 2023. Advances in geocomputation and geospatial artificial intelligence (GeoAI) for mapping. International Journal of Applied Earth Observation and Geoinformation. p.103300. GeoAI
- Song, Y., Wang, J.F., Ge, Y., et al., 2020. An optimal parameters-based geographical detector model enhances geographic characteristics of explanatory variables for spatial heterogeneity analysis: cases with different types of spatial data. GIScience & Remote Sensing. 57(5): 593-610. Highly Cited Paper; No. 1 Most Cited Article in the history of the journal GIScience & Remote Sensing (over 40 years). OPGD model
- Song, Y., Wang, X.Y., Wright, G., Thatcher, D., et al., 2019. Traffic Volume Prediction with Segment-Based Regression Kriging and its Implementation in Assessing the Impact of Heavy Vehicles. IEEE Transactions on Intelligent Transportation Systems. (20)1: 232 – 243. SRK model
- Song, Y., Wu, P., Hampson, K., and Anumba, C., 2021. Assessing Block-level Sustainable Transport Infrastructure Development Using a Spatial Trade-Off Relation Model. International Journal of Applied Earth Observation and Geoinformation. 105, 102585. STOR model
- Song, Y., Wu, P., 2021. An interactive detector for spatial associations. International Journal of Geographical Information Science. IDSA model
- Zhang, Z., Song, Y., Karunaratne, L. and Wu, P., 2024. Robust interaction detector: A case of road life expectancy analysis. Spatial Statistics, p.100814. RID model
- Ren, K., Song, Y. and Yu, Q., 2025. Second-dimension outliers for spatial prediction. International Journal of Geographical Information Science. SDO model
- Hu, J., Song, Y. and Zhang, T., 2025. A local indicator of stratified power. International Journal of Geographical Information Science. LISP model
- Yang, X., Song, Y., Yoo, C., Ren, K. and Wu, P., 2025. Irregular anisotropy in surface urban heat island footprint. Sustainable Cities and Society, p.106779. AIA model
- Luo, P., Li, Y., Song, Y., Li, Z. and Meng, L., 2025. Measuring univariate effects in the interaction of geographical patterns. International Journal of Geographical Information Science, pp.1-32. GPI model
- Hu, J., Qu, R., Song, Y. and Wu, P., 2025. Local pathways of association. International Journal of Applied Earth Observation and Geoinformation, 139, p.104531. LPA model
- Zhang, Z., Li, Z. and Song, Y., 2024. On ignoring the heterogeneity in spatial autocorrelation: consequences and solutions. International Journal of Geographical Information Science, pp.1-27. HSA model
- Luo, P., Song, Y., Zhu, D., Cheng, J., & Meng, L., 2023. A generalized heterogeneity model for spatial interpolation. International Journal of Geographical Information Science. 37(3): 634-659. GHM model
- Zhang, Z., Song, Y., Luo, P., & Wu, P., 2023. Geocomplexity explains spatial errors. International Journal of Geographical Information Science. Geocomplexity model

- Zhang, Z., Song, Y., & Wu, P., 2022. Robust geographical detector. International Journal of Applied Earth Observation and Geoinformation. 109, 102782. RGD model
- Luo, P., Song, Y., Huang, X., Ma, H., et al., 2022. Identifying determinants of spatio-temporal disparities in soil moisture of the Northern Hemisphere using a geographically optimal zones-based heterogeneity model. ISPRS Journal of Photogrammetry and Remote Sensing. 185, 111-128. GOZH model

### Important concepts in geospatial analysis (proposed by our team)

1. Spatial association: [second-dimension spatial association](#), [interactive detector for spatial association](#), [local pathways of association](#)
2. Spatial autocorrelation: [heterogeneous spatial autocorrelation](#),
3. Geostatistics or Kriging: [segment-based regression kriging](#),
4. Spatial heterogeneity: [spatial stratified heterogeneity](#), [local stratified heterogeneity](#), [generalized heterogeneity](#), [geographically optimal zones-based heterogeneity](#), [locally explained heterogeneity](#), [wavelet geographically weighted regression](#), [spatio-temporal unmixing with heterogeneity](#),
5. Spatial interaction: [robust Interaction](#), [interactive detector for spatial association](#), [geographical pattern interaction](#),
6. Geographical similarity: [geographically optimal similarity](#),
7. Geocomplexity: [geocomplexity](#),
8. Spatial local outliers: [second-dimension outliers](#),
9. Spatial graph network: [geographical graph neural network](#), [dynamic spatiotemporal graph network](#),
10. Spatial fusion: [spatial context-aware fusion](#),
11. Spatial anisotropy: [spatial irregular anisotropy](#),
12. Spatial accessibility: [D2SFCA spatiotemporal accessibility](#),
13. Spatial decision-making: [MFSD spatial decision making](#),
14. Spatial big data: [spatial big data-based city redefinition](#),
15. Spatial path analysis: [local pathways of association](#)
16. Spatial segmentation: [spatial heterogeneity-based segmentation](#), [gaussian mixture segmentation](#),
17. Spatial trade-off: [spatial trade-off relation](#), [dynamic trade-off](#), [spatial delta model](#),
18. Spatial unmixing: [spatio-temporal unmixing with heterogeneity](#)
19. Robust spatial models: [robust geographical detector](#), [robust interaction detector](#)
20. Advanced geographical detector models: [Optimal Parameters-based Geographical Detector \(OPGD\)](#), [Robust Interaction Detector \(RID\)](#), [Local indicator of stratified power \(LISP\)](#), [Geographically Optimal Zones-based Heterogeneity \(GOZH\)](#), [Geographical Pattern Interaction \(GPI\)](#), [Interactive Detector for Spatial Associations \(IDSA\)](#), [Robust Geographical Detector \(RGD\)](#), [Locally explained heterogeneity model](#), [Generalized Heterogeneity Model \(GHM\)](#), [Heterogeneous spatial autocorrelation \(HSA\)](#)