MATH4341: Spatio-Temporal Statistics IV Michaelmas term 2024

Description of the course

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The following details concern the module Spatio-Temporal Statistics IV (MATH4341) in Michaelmas term. The description below is informal and aims at helping students organize their study. The official description of the course can be found in

https://apps.dur.ac.uk/faculty.handbook/2024/UG/module/MATH4341.

1 Description of the course

Aim

This course provides an introduction to the theory, computation and practice of the statistical analysis of problems involving aspects of space (Michaelmas term) and time (Epiphany term). We will gain the necessary background for the design, theory, and practical implementation of the aforesaid concepts.

Intended learning outcomes

The students will be able to:

[ILO1] identify, explain, and theoritise spatial dependencies in statistical problems.

[ILO2] explain, apply, and generalize appropriate statistical methodology to address spatial problems.

[ILO3] design, explain, interpret, and extend statistical models appropriate for spatial data sets, as well as make inferences and draw conclusions from the analysis of such models.

[ILO4] have a coherent understanding of the theory, computation and application of the mathematics underlying the introduced statistical models and methods.

[ILO5] use appropriate software to facilitate spatial statistical analysis.

Requirements / preparation

A well prepared student aiming to attend this course is expected to have a good understanding of statistical modelling, probabilities, and statistical inference (classical and Bayesian), as well as in R programming with fluency in seeking information about packages/routines from help or CRAN online resources.

Teaching and learning activities

[TLA1] Lectures

Students will be introduced to the theory, and be exposed to a small number of examples.

- Major focus [ILOs 1-4]

[TLA2] Computer practical classes

Students will learn how to implement the introduced methods in a programming language, use existing routines in R related to the introduced concepts.

- Major focus [ILOs 5 (mainly) & 2, 3 (secondary)]

[TLA3] Office hours

Students will ask further questions. When coming to the office, students are requested to have their questions written down in a piece of paper.

- Major focus [ILO 1-5]

Assessment activities

Formative assessment

[FA1] Four homework assignments will be assigned regularly. The homework sheet will contain a number of problems which have to be assessed and returned. Homework problems and solutions will be available from Blackboard Ultra. The submission of the solution will be done Gradescope. Feedback will be given via Gradescope and emails. Major focus [ILOs 1-5].

Summative assessment

[SA1] ILOs 1-4 will be assessed in the end-of-year examination.

[SA2] ILO 5 & 1-4 will be assessed in a computer based examination.

2 Syllabus

[S1] Types of spatial data [ILO 2 & 5]:

- Geostatistical data, Lattice/aerial data, Point patterns.

[S2] Spatial analysis concepts [ILO 1 & 5]:

- variables, stationarity, random functions, variograms.

[S3] Geostatistical data modelling [ILOs 1-5]:

- regionalized variables, kriging, co-kriging, Gaussian process regression models

[S4] Lattice / areal data modelling [ILO 1-5]:

- spatial models on lattices, Gibbs-Markov random fields on networks, spatial autoregressive models

[S5] Point pattern data modelling (if time allows) [ILO 1-5]:

- Poisson, Cox, Gibbs and Markov point processes

[S6] Handling, plotting, and modelling spatial data in R [ILO 5]:

- R packages: sp, sf, terra ggplot2, tmap, mapview; gstat; spdep, spData; spatstat, and spatialreg.

3 Reading list

Following is a comprehensive list of references that cover all the concepts discussed in the course. However it is possible for some details introduced in lectures to be available in articles available from the library. In such cased, references will be given in the corresponding handouts.

Main textbooks (methods, implementation, and theory):

- Cressie, N. (2015). Statistics for spatial data. John Wiley & Sons.
- Kent, J. T., & Mardia, K. V. (2022). Spatial analysis (Vol. 72). John Wiley & Sons.
- Gaetan, C., & Guyon, X. (2010). Spatial statistics and modeling (Vol. 90). New York: Springer.
- Moller, J., & Waagepetersen, R. P. (2003). Statistical inference and simulation for spatial point processes. CRC press.

Main textbooks (software):

- Bivand, R. S., Pebesma, E. J., Gómez-Rubio, V., & Pebesma, E. J. (2008). Applied spatial data analysis with R (Vol. 747248717, pp. 237-268). New York: Springer.
- Moraga, P. (2023). Spatial statistics for data science: theory and practice with R. CRC Press.

Supplementary textbooks (methods, implementation, and theory):

- Banerjee, S., Carlin, B. P., & Gelfand, A. E. (2014). Hierarchical modeling and analysis for spatial data. CRC press.
- Ripley, B. D. (2005). Spatial statistics. John Wiley & Sons.
- Schabenberger, O., & Gotway, C. A. (2005). Statistical methods for spatial data analysis. CRC press.
- Wackernagel, H. (2003). Multivariate geostatistics: an introduction with applications. Springer Science & Business Media.
- Diggle, P. J. (2013). Statistical analysis of spatial and spatio-temporal point patterns. CRC press.

- van Lieshout, M. N. M. (2019). Theory of spatial statistics: a concise introduction. CRC Press.