MATH4341: Spatio-Temporal Statistics IV | Michaelmas term 2023

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/2023/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 and time. 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] Problem classes

Students will be exposed to use the introduced theoretical concepts for the design of statistical tools aiming to analyse spatial data sets.

- Major focus [ILOs 1, 2, & 4]

statial 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 2, 3, & 5]

[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 1-5 will be assessed in the end-of-year examination.

2 Syllabus

[S1] Types of spatial data [ILO2]:

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

[S2] Introduction to regionalized statistical concepts [ILO2]:

- variables, stationarity, random functions, variograms.

[S3] Geostatistical data modelling [ILO]:

- Gaussian process regression models, kriging, co-kriging

[S4] Lattice / areal data modelling [ILO]:

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

~~**[S5]** Point pattern data modelling (if time allows)~~

- ~~Poisson, Cox, Gibbs and Markov point processes~~

[S6] Computations [ILO]:

- Integrated Nested Laplace Approximation methods

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 texts:

- Gaetan, C., & Guyon, X. (2010). Spatial statistics and modeling (Vol. 90). New York: Springer.
- Wackernagel, H. (2003). Multivariate geostatistics: an introduction with applications. Springer Science & Business Media.
- van Lieshout, M. N. M. (2019). Theory of spatial statistics: a concise introduction. CRC Press.
- Ripley, B. D. (2005). Spatial statistics. John Wiley & Sons.
- Banerjee, S., Carlin, B. P., & Gelfand, A. E. (2014). Hierarchical modeling and analysis for spatial data. CRC press.

Supplementary textbooks:

- Schabenberger, O., & Gotway, C. A. (2005). Statistical methods for spatial data analysis. CRC press.
- Wikle, C. K., Zammit-Mangion, A., & Cressie, N. (2019). Spatio-temporal statistics with R. CRC Press.
  - It demonstrate how to implement spatial, and spatio-temporal concepts in R by using descent R/CRAN packages mainly developed by the authors. Major focus on [S1, S2, S4].
- ~~Diggle, P. J. (2013). Statistical analysis of spatial and spatio-temporal point patterns. CRC press.~~
  - ~~Major focus on [S5] - Notice that this concept may not be introduced due to the time~~
- Cressie, N. (2015). Statistics for spatial data. John Wiley & Sons.
  - Classic book in spatial statistics, and a bit outdated. It requires some good knowledge of spatial statistics and it required probability theory.
- Gómez-Rubio, V. (2020). Bayesian inference with INLA. CRC Press.
  - It demonstrate how to implement Integrated Nested Laplace Approximation methods . Major focus on [S1, S2, S4].