STA465H1 / STA2016H1:

Theory and Methods for Complex Spatial Data

Hours: 36L

1. Course Description:

Data acquisition trends in the environmental, physical and health sciences are increasingly spatial in character and novel in the sense that modern sophisticated methods are required for analysis. This course will cover different types of random spatial processes and how to incorporate them into mixed effects models for Normal and non-Normal data. Students will be trained in a variety of advanced techniques for analyzing complex spatial data and, upon completion, will be able to undertake a variety of analyses on spatially dependent data, understand which methods are appropriate for various research questions, and interpret and convey results in the light of the original questions posed.

Big data allows the researcher to assume complex dependent structures. In this course we describe several ways of defining dependence among data, staring from exchangeability, Markov, temporal and spatial dependences. The basic idea is to exploit conjugacy properties in Bayesian parametric models.

Prerequisite STA302H1/ STAC67H3/ STA302H5, STA303H1

2. Course schedule

Lecture times:

Tuesdays 16:00 – 18:00 Room UC 140, and
Thursdays 16:00 – 17:00 Room SS 2117

3. Instructor

Luis E. Nieto-Barajas, Visiting Professor at DoSS, University of Toronto
luis.nietobarajas@utoronto.ca
Please do not use email to contact me, use *inbox* in Quercurs instead

4. Office hours

Tuesdays 14:30 – 15:30 (in-person starting week 2) in Room 9177 at DoSS

5. Evaluation

Total grade will be split in the following five parts:

i)	Weekly homeworks	20%	Due midnight of the following Sunday
ii)	Theoretical assessment	20%	Sunday 3rd March
iii)	Midterm exam	30%	Tuesday 5th March
iv)	Practical assessment	20%	Due last day of class
v)	Final presentation	10%	Thursday 4th April (last day of class)

Assessments (i), (ii) and (iii) are individual, whereas assessments (iv) and (v) are in groups from 2 to 4 people. No individual assessments (iv) and (v) are allowed.

Weekly homeworks should be submitted through Quercus and marks will be given as a proportion of homeworks submitted.

Assessment (iv) will consist on a practical data analysis where students have to show the use of some of the models covered in class. Datasets and appropriate models are free to choose from the students. Each time has to write a report that contains: context of the problem, objectives, description of available data, models to use and a detail explanation of the results in terms of the context of the problem. The use of graphs is advisable to show their findings, but marks will be given for the words and not for the graphs.

Assesment (v) will consist in a presentation of the whole team and grading will be individually. Power point or pdf presentation files will not be graded and do not have to be delivered.

6. Missed Assessments

There are no accommodations nor make-ups for assessments (i), (ii), (iv), (v). If the midterm exam is missed, then you will be given an opportunity to write a makeup midterm. If you miss both the scheduled midterm and the makeup midterm then you will receive a grade of zero on the midterm.

Undergraduate students: To request accommodation for a missed assignment or midterm to complete one of the following supporting documents that covers the date(s) of your missed assessments:

- Absence declaration via ACORN (see https://www.artsci.utoronto.ca/current/academics/student-absences for important information on eligibility)

- U of T Verification of Illness or Injury Form (VOI) – see http://www.illnessverification.utoronto.ca/index.php
- College Registrar's letter
- Letter of Academic Accommodation from Accessibility Services

If you are absent for an extended period of time, please contact your College Registrar's Office as soon as possible to seek advising and support.

Graduate students: Contact the professor within 24 hours of missing the assessment. Late assessments will receive a grade of zero, unless a prior arrangement has been made.

7. Re-grading

Regrading requests should only be made for genuine grading errors, and should be initiated by writing a complete explanation of your concern (together with your full name, student number, and e-mail address) via Quercus within two weeks of when the graded item was first available. Note that your mark may end up going down rather than up.

8. Course structure

This course will cover mainly theoretical, but also practical aspects, relevant to the analysis of temporal and spatial data.

The course will cover some of the following topics

- Introduction: statistical diagram, types of inference, Bayesian statistics, common probability distributions, stationary processes
- Conjugate models in Bayesian analysis
- Exchangeable sequences: de Finetti Theorem, construction, invariant, hierarchical models
- Markov sequences: parametric examples, beta, gamma, normal, applications
- Temporal dependence: general, beta, gamma normal, poisson, negative binomial
- Spatial dependence: latent areas and latent edges
- General dependences: spatio-temporal, graphical, seasonal, periodic

Lectures will be delivered mainly with board and chalk and a few presentations in pdf. Implementations of models will be done in R and Openbugs codes.

9. References

- Banerjee, S., Carlin, B. P. & Gelfand, A. (2014). Hierarchical Modeling and Analysis for Spatial Data, 2a. edición. Chapman & Hall: Boca Raton.

- Bernardo, J.M. and Smith, A.F.M. (2000). *Bayesian theory*. Wiley, New Jersey.
- Chatfield, C. (2003). *The analysis of time series: An introduction*. Chapman and Hall, London.
- Mood, A.M., Graybill, F.A. and Boes, D.C. (1974). *Introduction to the theory of statistics*. McGraw Hill, New York.
- The list of papers reported in https://gente.itam.mx/lnieto/

10. Accessibility services

The University of Toronto provides accommodations through accessibility services to students with diverse learning styles and needs. If you have a consideration that may require accommodations, please contact Accessibility Services: https://www.studentlife.utoronto.ca/as, accessibility.services@utoronto.ca, or 416-978-8060.

11. Equity, diversity and inclusion

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.