MGT-416

Network analytics

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Cursus	Sem.	Type
Civil Engineering	MA2, MA4	Obl.
Financial engineering	MA2, MA4	Opt.
Management, Technology and Entrepreneurship minor	E	Opt.
Managmt, tech et entr.	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	During the semester
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Students will learn the core concepts and techniques of network analysis with emphasis on causal inference. Theory and application will be balanced, with students working directly with network data throughout the course.

Content

This course will cover a broad range of approaches pertaining to network causal analysis for analyzing real world network data ranging from financial to social and biological networks. The assignments, mid-term and final project will require students to have a theoretical understanding of the concepts as well as to be able to analyze and interpret real network data.
Specific topics include, but are not limited to, the following:

- Introduction: What is causal inference?
- Review of Useful Probability concepts
  - Random variable, predictors, divergences
- Introduction to Applications
  - Computational neuroscience
  - Financial markets
  - Social networks
- Pearl Causality
  - Causal Bayesian Networks (CBNs)
  - Learning CBNS: Faithfulness and identifiably
  - Algorithms
- Potential Outcome Model
  - Counterfactuals and identification problems
  - Graphical causal models
- Randomized Experiments
  - Identification of causes in randomized experiments
  - Effect modification

- Causality in Times Series
  - Granger causality
  - More general linear predictors
  - Beyond linear models and Granger causality
  - Directed information graphs
  - Efficient algorithms

- Concrete Applications
  - Computational neuroscience
  - Financial markets
  - Social networks

Keywords

Statistics; Causal Inference; Network Analytics

Learning Prerequisites

Required courses

This course attempts to be as self contained as possible, but it does approach the topic from a quantitative point of view and, as such, students should be comfortable with the basics of (*i.e.* have taken at least one course in) the following topics before enrolling:

- Statistics
- Probability Theory
- Linear Algebra
- Calculus (integral and differential)

As course work will be largely computational, experience with at least one programming language is also required.

Recommended courses

Statistics and probability experience beyond the introductory level are recommended.

Learning Outcomes

By the end of the course, the student must be able to:

- Identify situations in which a problem/data can be thought of as a network.
- Analyze data appropriately using a variety of network analytic techniques.
- Interpret the results of applying network analytics.
- Propose action based on sound interpretation of network analytics.

Transversal skills

- Demonstrate the capacity for critical thinking
- Use both general and domain specific IT resources and tools
- Access and evaluate appropriate sources of information.
- Continue to work through difficulties or initial failure to find optimal solutions.

Teaching methods

The weekly lectures integrate both theory and application. Exercise sessions give students "hands on" experience writing and running analysis code, and interpreting results. In both, care is taken in both to help develop computational thinking skills.

Expected student activities

- Attendance of lecture and exercise sessions.
- Completion of regularly scheduled assignments.
- Mid-term exam.
- Completion of a group end-of-year project in which the students analyze and extract knowledge from a network data set.

Assessment methods

Regular individual assignments: 45%
Final group project: 55%

Supervision

Office hours	Yes
Assistants	Yes
Forum	No

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Lecture notes.

Ressources en bibliothèque

- Data science and complex networks : real cases studies with Python / Caldarelli
- Social and Economic Networks / Jackson
- Networks, crowds, and markets : reasoning about a highly connected world / Easley
- Networks : an introduction / Newman
- Network Science / Barabási