



UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Statistical Modelling III

2425-104R-StatM-III

Title

Statistical Modelling III - Discrete latent variable models

Teacher(s)

Dr. Luca Brusa

Language

English

Short description

The Ph.D. course on *Discrete latent variable models* introduces the theory of latent variables models for the analysis of cross-sectional and longitudinal data with both categorical and continuous variables arising from different fields. The lectures will be devoted to summarizing the most important aspect of this modeling framework: assumptions, advanced parameterizations, estimation, and inferential procedures also considering the computational issues. During the course, case studies and applications will be presented mainly by using different R libraries.

Schedule of the main arguments:

- Introduction to latent variable models with a focus on discrete latent variables. Maximum likelihood estimation using the expectation-maximization algorithm.
- Basic features of the latent class model with reference to the estimation methods and to the expectation-maximization algorithm. More advanced versions of the latent class model. Introduction to the **R** package **MultiLCIRT**.
- Basic features of the hidden Markov models for continuous and categorical longitudinal data. Introduction to the **R** package **LMest**.
- Recent hidden Markov model formulations and extensions with multivariate data, covariates and more complex data. Recent case studies and applications.
- Introduction to stochastic block models for network data and to the approximate maximum likelihood estimation using the variational EM algorithm. Introduction to the **R** package **sbm**.

Main reading materials:

- Bartolucci F., Farcomeni A., Pennoni F. (2013). *Latent Markov models for longitudinal data*. Chapman and Hall/CRC, Boca Raton.
- Bartolucci, F., Pandolfi, S., Pennoni, F. (2017). **LMest**: An **R** package for latent Markov models for longitudinal data. *Journal of Statistical Software*, **81**, 1--38.
- Bartolucci, F., Pandolfi, S., Pennoni, F. (2022). Discrete latent variable models. *Annual Review of Statistics*, **9**, 425--452.
- Brusa, L., Pennoni, F., (2025). Stochastic Block Model Based on Variational Inference and its Extensions: An Application to Examine Global Migration Dynamics. In: Nakai, M. (eds) *Advances in Quantitative Approaches to Sociological Issues*, 1--27.
- Daudin J.J., Picard F., Robin S. (2008). A mixture model for random graphs. *Statistics and Computing*, **18**, 173--183.
- Pennoni F. (2014). Issues on the estimation of latent variable and latent class models, with applications in the social sciences. Scholars' Press, Saarbücken.

CFU / Hours

The course consists of 12 hours, including lectures (theory and applications) and laboratory sessions using **R**.

Teaching period

From October 7th to October 10th, 2025

Sustainable Development Goals
