Sessions on Graphical Markov Models at CMStat 2018

Session EO388 — ***Room:*** **B1**
Graphical Markov models I: Multivariate dependence structures — *Friday 14.12.2018* 10:20 - 12:00
Chair: Monia Lupparelli — *Organizer:* Monia Lupparelli

B0881: A. Roverato, R. Castelo
On the interpretation of path weights in undirected Markov random fields
B0959: W. Bergsma
Regression modelling with I-priors
B1198: M. Kateri
Multivariate dependence structures for ordinal data: A ϕ-divergence based approach
B0696: C. Tarantola
Some issues on Bayesian analysis of binary bidirected graphs

Session EO681 — ***Room:*** **B1**
Graphical Markov models II — *Friday 14.12.2018* 14:40 - 16:20
Chair: Giovanni Maria Marchetti — *Organizer:* Giovanni Maria Marchetti

B1480: G. Letac
Random covariance associated to a weighted graph
B1694: S.W. Mogensen, N.R. Hansen
Marginalized local independence graphs
B1701: S. Massa
Mixed graphical models for metabolic biomarkers
B1423: T. Rudas, A. Klimova
Coordinate-free analysis of multivariate categorical data

Session EO687 — ***Room:*** **B1**
Graphical Markov models III — *Friday 14.12.2018* 16:50 - 18:30
Chair: Nanny Wermuth — *Organizer:* Nanny Wermuth

B1439: M. Lupparelli
Direct and indirect effect for a class of discrete regression graph models
B1466: H. Massam, Q. Li, X. Xin Gao
A Bayesian approach to coloured graphical Gaussian models
B1622: G.M. Marchetti, N. Wermuth
On maximum likelihood estimation for mean zero versus general Ising graphical Markov models
B1680: R. Wilkerson, J. Smith
Bayesian diagnostics for chain event graphs

Session EO685 — ***Room:*** **B1**
Graphical Markov models IV — *Saturday 15.12.2018* 16:20 - 18:00
Chair: Elena Stanghellini — *Organizer:* Elena Stanghellini

B1399: K. Sadeghi
Markov properties of determinantal point processes
B1418: V. Bazinas
Causal transmission in reduced-form models
B1702: M. Studeny
On integer linear programming approach to learning decomposable graphical models
B1759: A. Gottard, A. Panzera
Graphical models for circular data

Session EO683 — ***Room:*** **B1**
Graphical Markov models V — *Sunday 16.12.2018* 14:40 - 16:20
Chair: Kayvan Sadeghi — *Organizer:* Kayvan Sadeghi

B1410: K. Yang, A. Katcoff, C. Uhler
Characterizing and learning equivalence classes of causal DAGs under interventions
B1669: N. Wermuth, G.M. Marchetti
On linear generating processes for joint distributions of binary variables having an undirected Markov graph structure
B1649: J. Mooij, T. Blom
A causal modeling framework in search of a graphical representation
B1733: M. Eichler
Testing for tetrad constraints in multivariate time series

Abstracts

Session EO388: Graphical Markov models I: Multivariate dependence structures
Chair: Monia Lupparelli

Title: On the interpretation of path weights in undirected Markov random fields
Authors:
lberto Roverato - University of Bologna (Italy) [presenting]
Robert Castelo - Universitat Pompeu Fabra (Spain)
Abstract: In graphical Gaussian models an undirected graph is used to represent the association structure of variables as a network, and if a pair of variables is not joined by an edge in the graph, then the corresponding partial correlation is equal to zero. Although in graphical Gaussian models the structure of the network can be inferred from the zero pattern of the inverse covariance matrix, if the probability distribution of the variables is faithful to the network, then paths along the network connect random variables with non-zero entries in the covariance matrix. In the analysis of graphical Gaussian models, it has been associated a weight with every path in the network and showed that the covariance between two variables can be computed as the sum of the weights of all the paths joining the two variables. Path weights allow one to identify the relative contribution of a path to the value of the corresponding covariance. However, it is not clear either how to interpret the value of a single path or how to compare two paths with different endpoints. We provide an interpretation of the value taken by the weight of a path by decomposing it into a partial weight and an inflation factor. Furthermore, we identify a class of paths, called chordless paths, whose weights have a remarkably straightforward interpretation.

Title: Regression modelling with I-priors
Author: Wicher Bergsma - London School of Economics (United Kingdom) [presenting]
Abstract: The I-prior modelling approach for regression with multiple, possibly multidimensional covariates, and with possible interaction effects, is introduced. The I-prior is a maximum entropy Gaussian prior for the regression function, with covariance function proportional to the Fisher information on the regression function. The proposed approach is a general, practical, methodology unifying a variety of models, including multilevel, varying coefficient, longitudinal, and multidimensional or functional response models. In contrast to Gaussian process regression, a simple EM algorithm can be constructed for I-prior models. This is especially important when there are many hyperparameters, when direct optimization of the marginal likelihood may be difficult. The approach has high model parsimony, in particular for models involving many interaction effects. As a consequence of this model parsimony, we obtain a simple semi-Bayes methodology for selecting interaction effects. Whereas in previous approaches the reproducing kernel Hilbert space framework was adequate, in the I-prior approach it is necessary to consider regression functions in a reproducing kernel Krein space.

Title: Multivariate dependence structures for ordinal data: A ϕ-divergence based approach
Author: Maria Kateri - RWTH Aachen University (Germany) [presenting]
Abstract: Dependence structures among ordinal variables will be studied in connection to ϕ-divergence measures. Log-linear models for ordinal classification variables will be redefined through the Kullback-Leibler divergence and embedded in generalized families of models derived by replacing the Kullback-Leibler by the ϕ-divergence. The scaling role of the ϕ-divergence in constructing models for ordinal data and its effect on describing the underlying dependence structure will be discussed. The focus will be on high-dimensional contingency tables. Representative applications for members of the ϕ-divergence based model families will be presented.

Title: Some issues on Bayesian analysis of binary bidirected graphs
Author: Claudia Tarantola - University of Pavia (Italy) [presenting]
Abstract: Bayesian analysis of binary bidirected graphs has not been developed as much as traditional methods. No conjugate analysis is available and MCMC methods must be employed. The likelihood of the model cannot be analytically expressed as a function of the marginal log-linear interactions, but only in terms of the probability parameters. Hence, at each step of the MCMC an iterative procedure needs to be applied in order to calculate the cell probabilities and consequently the model likelihood. Finally, in order to have a well-defined model of marginal independence, the considered MCMC algorithm should generate parameter values leading to a joint probability distribution with compatible marginals. We will present a novel MCMC strategies that handles the previously discussed problems. A simulation study will be discussed.

Session EO681: Graphical Markov models II
Chair: Giovanni Maria Marchetti

Title: Random covariance associated to a weighted graph
Author: Gerard Letac - Universite Paul Sabatier (France) [presenting]
Abstract: Given an undirected graph with n vertices and with given weights $w(e)$ on the edge e, we consider a positive definite matrix M of order n such that the off diagonal entries are 0 or $-w(e)$. We provide the diagonal of M with a family of distributions already considered by a group of physicists around 2010 called `Multivariate reciprocal inverse Gaussian laws' (MRIG). This family has many interesting properties: stability by marginalization and conditioning,

simplicity of the Laplace transform and moments. The one dimensional margins are the familiar reciprocal inverse Gaussian (RIG). If the graph is connected the inverse of M has positive coefficients and this makes MRIG an interesting choice for a priori probabilities on concentration matrices for Gaussian graphical models.

Title: Marginalized local independence graphs
Authors:
Soeren Wengel Mogensen - University of Copenhagen (Denmark) [presenting]
Niels Richard Hansen - University of Copenhagen (Denmark)
Abstract: Local independence is an asymmetric notion of independence which describes how a system of stochastic processes evolves over time. Let A, B, and C be three subsets of the coordinate processes of the stochastic system. Intuitively speaking, B is locally independent of A given C if at every point in time knowing the past of both A and C is not more informative about the present of B than knowing the past of C only. Previous work has used directed graphs equipped with δ-separation for graphical representation of local independence structures. In such local independence graphs each node corresponds to an entire coordinate process rather than to a single random variable. We consider marginalization of local independence graphs and introduce a class of graphs which describe partially observed local independence models. We also introduce μ-separation, a generalization of δ-separation. This class of graphs satisfies a central maximality property which allows one to construct a simple graphical representation of an entire Markov equivalence class of marginalized local independence graphs. This is convenient as the equivalence class can be learned from data and its graphical representation concisely describes what underlying structure could have generated the observed local independencies.

Title: Mixed graphical models for metabolic biomarkers
Author: Sofia Massa - University of Oxford (United Kingdom) [presenting]
Abstract: Metabolic profiling using NMR spectroscopy measures a range of circulating metabolites among other biomarkers measures. The association of these metabolic biomarkers with a phenotype of interest can help understanding the biological mechanism through which disease risk is influenced. We present a mixed graphical model for studying the association between metabolic biomarkers and a phenotype of interest. The potential of this approach will be illustrated in both simulated and real data settings.

Title: Coordinate-free analysis of multivariate categorical data
Authors:
Tamas Rudas - Hungarian Academy of Sciences Centre for Social Sciences (Hungary) [presenting]
Anna Klimova - IST Austria (Austria)
Abstract: Graphical models generalize the notion of conditional independence among variables which, most often, is equivalent to a factorization of the joint distribution. Relational models consider more general factorizations, and generalize conditional independence to situations when the sample space is not a Cartesian product of ranges of variables, and the effects entering the factorization are not related to cylinder sets of the sample space, i.e., to groups of variables. Basic concepts of statistical modeling are introduced, which can be applied in this situation. First, motivating examples are presented, then coordinate free exponential families of probability distributions are introduced, which postulate simple multiplicative structures. Some of the properties of these families are similar to that of log-linear or graphical models, but the maximum likelihood estimates under relational models have a few very surprising characteristics.

Session EO687: Graphical Markov models III
Chair: Nanny Wermuth

Title: Direct and indirect effect for a class of discrete regression graph models
Author: Monia Lupparelli - University of Bologna (Italy) [presenting]
Abstract: In linear regression modelling the distortion of effects after marginalizing over variables of the conditioning set has been widely studied in several contexts. For Gaussian variables, the relationship between marginal and partial regression coefficients is well-established. Possible generalizations beyond the linear Gaussian case have been developed, nevertheless the case of discrete variables is still challenging, in particular in medical and social science settings. A multivariate regression framework is proposed for binary data with regression coefficients given by the logarithm of relative risks and a multivariate relative risk formula is derived to define the relationship between marginal and conditional relative risks. The method is illustrated through the analysis of the morphine data in order to assess the effect of preoperative oral morphine administration on the postoperative pain relief.

Title: A Bayesian approach to coloured graphical Gaussian models
Authors:
Qiong Li - York University (Canada)
Helene Massam - York University (Canada) [presenting]
Xin Xin Gao - York University (Canada)
Abstract: The focus is on graphical Gaussian models $N_p(0, \Sigma)$ Markov with respect to an undirected graph G, with additional symmetry constraints on the entries of the precision matrix $K=\Sigma^{-1}$. We give an overview of recent results for estimation and model selection in this class of models: the Diaconis-Ylvisaker conjugate prior, called the coloured G-Wishart, a Bayesian estimate of Σ and K, its asymptotic behaviour when p is fixed and the

number n of sample points tends to infinity or, when both p and n tend to infinity, and also an efficient double reversible jump Markov chain Monte Carlo algorithm for estimating Bayes factors in model selection.

Title: On maximum likelihood estimation for mean zero versus general Ising graphical Markov models
Authors:
Giovanni Maria Marchetti - University of Florence (Italy) [presenting]
Nanny Wermuth - Chalmers University of Technology (Sweden)
Abstract: The properties of the class of mean zero Ising models in fitting graphical Markov models to binary data are summarized. Moreover, we address parameter estimation by maximum likelihood with a comparison to the larger class of general Ising models. We discuss how to simplify estimation using mean zero Ising models when the marginal distributions of data have skewed margins.

Title: Bayesian diagnostics for chain event graphs
Authors:
Jim Smith - Warwick University (United Kingdom)
Rachel Wilkerson - University of Warwick (United Kingdom) [presenting]
Abstract: The class of chain event graphs has now been established as a practical Bayesian graphical tool for modeling a variety of processes. However, although a number of techniques for estimating this and performing model selection on this class have now been developed no bespoke methods of diagnostically checking representatives within this family have been yet developed. We rectify this situation and provide a number of new Bayesian diagnostics that parallel those available for the more restrictive class of Bayesian network models. These are designed to check the continued validity of the selected model as data about a population continues to be collected.

Session EO685: Graphical Markov models IV
Chair: Elena Stanghellini

Title: Markov properties of determinantal point processes
Author: Kayvan Sadeghi - University of Cambridge (United Kingdom) [presenting]
Abstract: Determinantal point processes (DPPs) have been widely used in machine learning for statistical modelling. Here we discuss the conditional independence structure of DPPs. In particular, we show that the induced independence model by DPPs can be naturally captured by bidirected graphs. In addition, we show that the context-specific induced independence models by DPPs (conditioning on variables being all equal to 1) act in the same way as the independence model induced by Gaussian distribution. This leads to context-specific DPP undirected as well as directed acyclic graphical models.

Title: Causal transmission in reduced-form models
Author: Vassilios Bazinas - International Monetary Fund (United States) [presenting]
Abstract: A method is proposed to explore the causal transmission of a catalyst variable through two endogenous variables of interest. The method is based on the reduced-form system formed from the conditional distribution of the two endogenous variables given the catalyst. The method combines elements from instrumental variable analysis and Cholesky decomposition of structural vector autoregressions. We give conditions for uniqueness of the causal transmission.

Title: On integer linear programming approach to learning decomposable graphical models
Author: Milan Studeny - Institute of Information Theory and Automation of the CAS (Czech Republic) [presenting]
Abstract: The decomposable graphical models, described by chordal undirected graphs, are crucial in famous local computation method, used widely in probabilistic graphical models. The basic ideas of the integer linear programming approach to learning these graphical models will be recalled. We propose to represent them by special zero-one vectors, which idea leads to the study of a special polytope, called chordal graph polytope. The focus will be on a conjecture; what are all facet-defining inequalities for this polytope.

Title: Graphical models for circular data
Authors:
Anna Gottard - University of Firenze (Italy) [presenting]
Agnese Panzera - University of Florence (Italy)
Abstract: Graphical models have been successfully used to characterise conditional independence structures among random variables. For instance, in proteomics, we would now like to analyse the structure of proteins in terms of their characterising angles. For this, the first task is to study conditional independence in multivariate distributions on angles. One example is the multivariate von Mises distribution, also known as the multivariate sine distribution. We review the existing literature on graphical models for circular data and propose possible extensions both for model specifications and inference.

Session EO683: Graphical Markov models V
Chair: Kayvan Sadeghi

Title: Characterizing and learning equivalence classes of causal DAGs under interventions
Authors:
Karren Yang - MIT (United States) [presenting]
Abigail Katcoff - MIT (United States)
Caroline Uhler - Massachusetts Institute of Technology (United States)
Abstract: The problem of learning causal DAGs in the setting where both observational and interventional data is available is considered. This setting is common in biology, where gene regulatory networks can be intervened on using chemical reagents or gene deletions. It has been previously characterized the identifiability of causal DAGs under perfect interventions, which eliminate dependencies between targeted variables and their direct causes. We extend these identifiability results to general interventions, which may modify the dependencies between targeted variables and their causes without eliminating them. We define and characterize the interventional Markov equivalence class that can be identified from general (not necessarily perfect) intervention experiments. We also propose the first provably consistent algorithm for learning DAGs in this setting and evaluate our algorithm on simulated and biological datasets.

Title: On linear generating processes for joint distributions of binary variables having an undirected Markov graph structure
Authors:
Nanny Wermuth - Chalmers University of Technology (Sweden) [presenting]
Giovanni Maria Marchetti - University of Florence (Italy)
Abstract: In general, linear relations among binary variables are not suitable to capture conditional dependences or independences among categorical variables. But, we can give necessary and sufficient conditions on undirected Markov graphs so that the associated joint distributions of standardised binary variables have recursive, linear generating processes. Surprisingly, graphs of chordless cycles belong to the class. The attractive properties of these models and of their parameters are summarised.

Title: A causal modeling framework in search of a graphical representation
Author:
Joris Mooij - University of Amsterdam (Netherlands) [presenting]
Tineke Blom - University of Amsterdam (Netherlands)
Abstract: Structural Causal Models (SCMs) provide a causal modeling framework that is used in many fields such as economy, the social sciences, and biology. It offers appealing features, e.g., a graphical representation that simultaneously expresses conditional independence properties and causal properties of the model, which lies at the basis of many of the theoretical and algorithmic results in the area. We show that SCMs are not flexible enough to give a complete causal representation of equilibrium states of dynamical systems in general. We propose a generalization of the notion of SCM, that we call Causal Constraints Model (CCM), and prove that CCMs are flexible enough to capture the essential causal semantics of dynamical systems at equilibrium. As an illustration we consider a simple and ubiquitous chemical reaction. The price one pays for the improved generality and flexibility of CCMs over SCMs is that no appropriate graphical representation of CCMs that simultaneously expresses conditional independence properties and causal properties is known. We challenge the graphical modeling community to invent such a representation.

Title: Testing for tetrad constraints in multivariate time series
Authors:
Michael Eichler - Maastricht University (Netherlands) [presenting]
Abstract: Tetrad constraints play a key role in the identification of latent variables structures. In the context of multivariate time series such tetrad constraints can be formulated in terms of the spectral density matrix. We present a test whether a tetrad constraint is satisfied and investigate its performance by a simulation study.