BRIN MATHEMATICS RESEARCH CENTER

Recent Advances in Time Series Analysis

March 21-22, 2024

About the workshop

This workshop aims to bring together some leading experts and researchers in Time Series Analysis to exchange ideas and experiences. Participants will present and explore recent methodological and theoretical advances in the field, both in the time and frequency domains.

Organizers

Victor De Oliveira, University of Texas at San Antonio
Donald Martin, North Carolina State University

Speakers

Radu Balan, University of Maryland
Richard Davis, Columbia University
Michael Eichler, Maastricht University, The Netherlands
Konstantinos Fokianos, University of Cyprus, Cyprus
Yuichi Goto, Kyushu University, Japan
Ta-Hsin Li, Thomas J. Watson Research Center
Tucker McElroy, U.S. Census Bureau
Eric Slud, University of Maryland
Xuze Zhang, University of Maryland

The workshop will also celebrate the illustrious career of Benjamin Kedem and his many contributions to Time Series Analysis, on the occasion of his retirement.

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DEPARTMENT OF MATHEMATICS

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Workshop Overview

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Organizing committee

Victor De Oliveira, University of Texas at San Antonio

Donald Martin, North Carolina State University

Workshop Schedule

Thursday, March 21, 2024

8:30 - 8:55	Breakfast
8:55 - 9:15	Victor De Oliveira *Opening*
9:15 - 10:00	Radu Balan (University of Maryland) *Source Separation using Sparse Discrete Prior Models*
10:00 - 10:45	Richard Davis (Columbia University) *Sample Splitting and Assessing Goodness-of-fit of Time Series*
10:45 - 11:15	Coffee Break
11:15 - 12:00	Michael Eichler (Maastricht University) *Trek Separation and Latent Variable Models for Multivariate Time Series*
12:00 - 1:45	Lunch
1:45 - 2:30	Konstantinos Fokianos (University of Cyprus) *Non-linear Network Autoregression*
2:30 - 3:15	Yuichi Goto (Kyushu University) *Test for the Existence of the Residual Spectrum with Application to Brain Functional Connectivity Detection*
3:15 - 3:45	Coffee Break
3:45 - 4:30	Ta-Hsin Li (Thomas J. Watson Research Center) *Spline Autoregression for Quantile Spectral Estimation and Granger Causality Analysis of Time Series*

Friday, March 22, 2024

8:30 - 9:00	Breakfast
9:00 - 9:45	Tucker McElroy (U.S. Census Bureau, Research and Methodology Directorate) *Optimal Linear Compression for Multivariate Time Series with Applications to Index Construction*
9:45 - 10:30	Eric Slud (University of Maryland) *Pairwise Singularity of Laws and Consistent Estimation of Gaussian Random Field Parameters*
10:30 - 11:00	Coffee Break
11:00 - 11:45	Xuze Zhang (University of Maryland) *A Density Ratio Model with Weakly Dependent Data*
11:45 - 12:00	Workshop Closing
12:00 - 12:15	Group Photo
12:15 - 2:00	Lunch

Abstracts of talks

Source Separation using Sparse Discrete Prior Models

Radu Balan

University of Maryland

Thursday, March 21, 2024 @ 9:15 AM

In this talk we present a blind source separation method based on dynamic sparse source signal models. Source signals are modeled in frequency domain as a product of a Bernoulli selection variable with a deterministic but unknown spectral amplitude. The Bernoulli variables are modeled in turn by first order Markov processes with transition probabilities learned from a training database. We consider a scenario where the mixing parameters are estimated by calibration. The MAP signal estimators is shown to be equivalent to a Belief Propagation Network. Separation performance results are obtained using TIMIT database.

Sample Splitting and Assessing Goodness-of-fit of Time Series

Richard Davis

Columbia University

Thursday, March 21, 2024 @ 10:00 AM

A fundamental and often final step in time series modeling is to assess the quality of fit of a proposed model to the data. Since the underlying distribution of the innovations that generate a model is often not prescribed, goodness-of-fit tests typically take the form of testing the fitted residuals for serial independence. However, these fitted residuals are inherently dependent since they are based on the same parameter estimates and thus standard tests of serial independence, such as those based on the autocorrelation function (ACF) or distance correlation function (ADCF) of the fitted residuals need to be adjusted. The sample splitting procedure in Pfister et al. (2018) is one such fix for the case of models for independent data, but fails to work in the dependent setting. In this paper sample splitting is leveraged in the time series setting to perform tests of serial dependence of fitted residuals using the ACF and ADCF. Here the first f_n of the data points are used to estimate the parameters of the model and then using these parameter estimates, the last l_n of the data points are used to compute the estimated residuals. Tests for serial independence are then based on these l_n residuals. As long as the overlap between the f_n and l_n data splits is asymptotically 1/2, the ACF and ADCF tests of serial independence tests often have the same limit distributions as though the underlying residuals are indeed iid. In particular if the first half of the data is used to estimate the parameters and the estimated residuals are computed for the entire data set based on these parameter estimates, then the ACF and ADCF can have the same limit distributions as though the residuals were iid. This procedure ameliorates the need for adjustment in the construction of confidence bounds for both the ACF and ADCF in goodness-of-fit testing. (This is joint work with Leon Fernandes.)

Trek Separation and Latent Variable Models for Multivariate Time Series

Michael Eichler

Maastricht University

Thursday, March 21, 2024 @ 11:15 AM

In systems that are affected by latent variables conditional independences are often insufficient for inference about the structure of the underlying system. One common example is a system in which four observed variables X_1, X_2, X_3, and X_4 are conditionally independent given a fifth unobserved variable Y. While there are no conditional independences among the observed variables, they must satisfy the so-called tetrad constraints (e.g. Spirtes *et al.*, 2001)

$$
\begin{aligned}
\rho_{X_1X_2}\,\rho_{X_3X_4} - \rho_{X_1X_4}\,\rho_{X_2X_3} &= 0,\\
\rho_{X_1X_3}\,\rho_{X_2X_4} - \rho_{X_1X_4}\,\rho_{X_2X_3} &= 0,\\
\rho_{X_1X_2}\,\rho_{X_3X_4} - \rho_{X_1X_3}\,\rho_{X_2X_4} &= 0.
\end{aligned}
$$

Recently, Sullivant *et al.* (2010) discussed such additional non-Markovian constraints and provided a characterisation in terms of low-rank conditions on submatrices of the covariance matrix. Graphically these general constraints can be identified by a new separation concept called trek separation. In this talk, we discuss the extension of the results to the multivariate time series case. Because of the commonly present serial correlation, the results are not directly applicable. For instance, the above tetrad constraints do not hold if the variables $X_1, \ldots, X_4$ and Y (as time series) have non-zero auto-correlation. Graphically, this corresponds to that fact that any instances of the variables $X_1, \ldots, X_4$ cannot be separated by a single instance of Y. As an alternative, we consider mixed graphs in which each node corresponds to a complete time series. Such graphical descriptions for time series have been considered for instance by Dahlhaus (2000) and Eichler (2007). We show that trek separation in such graphs corresponds to low-rank conditions on the spectral matrix of the process. In particular, we obtain a spectral version of the above tetrad constraints in terms of spectral coherences. We discuss tests for vanishing tetrad constraints in the frequency domain based on asymptotic results and on bootstrap techniques.

Non-linear Network Autoregression

Konstantinos Fokianos

University of Cyprus

Thursday, March 21, 2024 @ 1:45 PM

We study general nonlinear models for time series networks of integer and continuous valued data. The vector of high dimensional responses, measured on the nodes of a known network, is regressed non-linearly on its lagged value and on lagged values of the neighbouring nodes by employing a smooth link function. We study stability conditions for such multivariate process and develop quasi maximum likelihood inference when the network dimension is increasing. In addition, we study linearity score tests by treating separately the cases of identifiable and non-identifiable parameters. In the case of identifiability, the test statistic converges to a chi-square distribution. When the parameters are not-identifiable, we develop a supremum-type test whose p-values are approximated adequately by employing a feasible bound and bootstrap methodology. Simulations and data examples support further our findings.

Test for the Existence of the Residual Spectrum with Application to Brain Functional Connectivity Detection

Yuichi Goto

Kyushu University

Thursday, March 21, 2024 @ 2:30 PM

Coherence is a similarity measure between two time series and takes the form of the time series extension of Pearson's correlation. However, only a linear relationship between two time series can be measured by coherence. In this talk, we introduce a residual spectrum in order to measure non-linear relationships and show the existence and uniqueness of the residual spectrum by decomposing the regression model we consider into orthogonal processes. Moreover, we propose a test for the existence of the residual spectrum and show that our proposed test has asymptotically correct size and is consitent. Finally, we highlight the utility of the residual spectrum in brain functional connectivity detection.

Spline Autoregression for Quantile Spectral Estimation and Granger Causality Analysis of Time Series

Ta-Hsin Li

Thomas J. Watson Research Center

Thursday, March 21, 2024 @ 3:45 PM

Quantile spectra and cross-spectra were introduced in Li (2012; 2014) as bivariate functions of frequency and quantile level for time series analysis. A novel method is proposed in this paper for estimating the quantile spectra and cross-spectra. Facilitated by the quantile discrete Fourier transform (QDFT) through trigonometric quantile regression, the proposed estimator is derived from a spline autoregression (SAR) model. This SAR model is fitted to a set of quantile series (QSER) produced by the inverse Fourier transform of the QDFT. The autoregressive coefficients in the SAR model are represented by spline functions of the quantile level and penalized for their roughness when fitted to the QSER series by the method of least squares. The SAR model leads to a spectral estimator which is parametric as a function of frequency and nonparametric as a function of quantile level. The SAR model also enables a quantile-dependent Granger causality analysis based on a bootstrap procedure of testing its functional autoregressive coefficients. The proposed SAR method is evaluated by a simulation study. The method is further demonstrated through an application to daily closing values of the Dow Jones Industrial Average index and the Financial Times Stock Exchange index.

Optimal Linear Compression for Multivariate Time Series with Applications to Index Construction

Tucker McElroy

U.S. Census Bureau, Research and Methodology Directorate

Friday, March 22, 2024 @ 9:00 AM

We study the problem of optimal linear compression, which seeks a linear filter of a stationary multivariate time series so as to generate a lower-dimensional output that is as close as possible in mean square to a given target time series. We constrain the filter to be concurrent, which places a restriction on the problem of time series canonical analysis. The resulting compression of the input time series is interpreted as an index that yields the best concurrent estimate of the target. Applications are discussed to index construction corresponding to business cycles and extreme values.

Pairwise Singularity of Laws and Consistent Estimation of Gaussian Random Field Parameters

Eric Slud

University of Maryland

Friday, March 22, 2024 @ 9:45 AM

Michael Stein's (1999) book on Spatial Statistics discussed the problem of estimation of parameters in Gaussian spatial models based on large-sample data in bounded domains or so-called 'infill' asymptotics. This is the setting in "geostatistics" for many local spatial-data applications such as mineral exploration or local economics. Following earlier authors (Parzen 1962, Yadrenko 1983), Stein developed criteria related the possibility of consistent estimation of spatial model parameters to the pairwise mutual singularity ('microergodicity') of process laws with distinct parameters. This property is necessary for consistent parameter estimation (Zhang 2004) and is sufficient in some special examples with scalar parameter (Zhang 2004, Nathan Yu thesis 2022). But there are no known general conditions under which multidimensional parameters for microergodic spatial models are consistently estimable. In this talk we describe a class of triangular-array Gaussian, parametric linear model, microergodic infill examples in which neither the maximum likelihood estimator nor any other is consistent.

A Density Ratio Model with Weakly Dependent Data

Xuze Zhang

University of Maryland

Friday, March 22, 2024 @ 11:00 AM

Nowadays, the statistical analysis of data from diverse sources has become more prevalent. Density Ratio Model (DRM) is one of the methods for fusing and analyzing such data. Inferences about the distribution of interest are made based on not only the sample from this distribution but also the samples from other related distributions. This analysis is made possible when data in each sample are independent and identically distributed (IID). However, in many cases, statistical analysis is entailed for time series in which data appear to be sequentially dependent. An extension is made for DRM to account for weakly dependent data, which allows us to investigate the structure of the time series of interest on the strength of alternative ones. The weak convergence of the density ratio estimator is established with the IID assumption replaced by proper stationary, mixing and moment conditions.

The Brin Mathematics Research Center

The Brin Mathematics Research Center is a research center that sponsors activity in all areas of pure and applied mathematics and statistics. The Brin MRC was funded in 2022 through a generous gift from the Brin Family. The Brin MRC is part of the Department of Mathematics at the University of Maryland, College Park.

Activities sponsored by the Brin MRC include long programs, conferences and workshops, special lecture series, and summer schools. The Brin MRC provides ample opportunities for short-term and long-term visitors that are interested in interacting with the faculty at the University of Maryland and in experiencing the metropolitan Washington DC area.

The mission of the Brin MRC is to promote excellence in mathematical sciences. The Brin MRC is home to educational and research activities in all areas of mathematics. The Brin MRC provides opportunities to the global mathematical community to interact with researchers at the University of Maryland. The center allows the University of Maryland to expand and showcase its mathematics and statistics research excellence nationally and internationally.

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