Mini Workshop on TDA, Time Series & Statistics

Date: May 30 - 31, 2019

Venue: Waseda University, Nishi-Waseda Campus

Building 63 - 1 Meeting Room

(Access map: http://www.sci.waseda.ac.jp/eng/access)

Organizer: Masanobu TANIGUCHI

Supported by:

- JSPS KAKENHI Kiban (S) Grand-in-Aid No. 18H05290 (M. Taniguchi)
- Waseda Research Institute for Science & Engineering, Institute for Mathematical Science
- Waseda University, Rikou-Danwakai

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(Research Institute for Science & Engineering, Waseda University)

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Program (*speaker)

May 30

(i) 14:00- 14:30:
The asymptotic properties of the correlation estimator between latent processes
Akitoshi Kimura* (Waseda University)

(ii) 14:30- 15:00:
Dependence structures of the B-spline copulas
Xiaoling Dou* (Waseda University), Satoshi Kuriki (The Institute of Statistical Mathematics), Gwo Dong Lin (Institute of Statistical Science, Academia Sinica), Donald Richards (Pennsylvania State University)

(iii) 15:00- 15:30:
Fréchet-Hoeffding copula bounds for circular data
Hiroaki Ogata* (Tokyo Metropolitan University)

(iv) 15:30 – 16:00 :
Statistical Approaches in Topological Data Analysis for Non-stationary Time Series
Takayuki Shiohama* (Tokyo University of Science)

(v) 16:10 – 17:40 :
Exploring the Dependence Structure Between Oscillatory Activities in Multivariate Time Series
Hernando Ombao* (Biostatistics Research Group STAT Program King Abdullah University of Science and Technology (KAUST) , Saudi Arabia)

May 31

(vi) 14:00– 14:30:
Distance-based parameter curve clustering in time series

Yan Liu* (Kyoto University)

(vii) 14:30 – 15:00:
Robust local linear inference for spherical-linear regression models
Fumiya Akashi* (The University of Tokyo) & Holger Dette (Ruhr Universität Bochum)

(viii) 15:00 – 15:30:
Asymptotic Properties of Mildly Explosive Processes with Locally Stationary Disturbance
Junichi Hirukawa*(Niigata University) and Sangyeol Lee(SNU)

(ix) 15:45 – 17:15:
Local Gaussian correlation: A new modeling of dependence, conditional dependence, and nonlinearity in spectral analysis
Dag Tjostheim* (University of Bergen)

Abstracts

Title: The asymptotic properties of the correlation estimator between latent processes
Author: Akitoshi Kimura* (Waseda University)
Abstract: In this talk, we treat a model in which the finite variation part of a two-dimensional semi-martingale is expressed by time-integration of latent processes. We propose a correlation estimator between the latent processes and show its consistency and asymptotic mixed normality. Moreover, we propose two types of estimators for asymptotic variance of the correlation estimator and show their consistency in a high frequency setting. Our model includes doubly stochastic Poisson processes whose intensity processes are correlated It¥^o processes. A sketch of the proof will be shown.

Title: Dependence structures of the B-spline copulas
Author: Xiaoling Dou* (Waseda University), Satoshi Kuriki (The Institute of Statistical Mathematics), Gwo Dong Lin (Institute of Statistical Science, Academia Sinica), Donald Richards (Pennsylvania State University)
Abstract: Using B-spline functions, we propose a class of copulas which includes the Bernstein ones (Baker's distributions). The range of correlation of the B-spline copulas is examined, and the Frechet-Hoeffding upper bound is proved to be attained when the number of B-spline functions goes to infinity. On the other hand, the B-spline is well-known as an order complete weak Tchebycheff system, from which the property of total positivity of any order follows for the maximum correlation case. This improves significantly the previous results about the Bernstein copulas. Besides, we also derive an elegant explicit formula for moments of the related B-spline functions on the right-half real line in terms of Stirling numbers of the second kind.

Title: Fréchet-Hoeffding copula bounds for circular data
Author: Hiroaki Ogata* (Tokyo Metropolitan University)
Abstract: We propose the simple extension of Fréchet-Hoeffding copula bounds for circular data. The copula is powerful tool for describing the dependency of random variables. In two dimension, Fréchet-Hoeffding upper (lower) bound indicates the perfect positive (negative) dependence between two random variables. However, for circular random variables, the usual concept of dependency is not accepted because of their periodicity. In this talk, we redefine Fréchet-Hoeffding bounds and consider modified Fréchet and Mardia families of

copulas for modelling the dependency of two circular random variables. Simulation studies are also given to see the behavior of the model.

Title: Statistical Approaches in Topological Data Analysis for Non-stationary Time Series
Author: Takayuki Shiohama* (Tokyo University of Science)
Abstract: Topological Data Analysis (TDA) refers to a collection of methods for finding topological structure in data. Until recently, topological inference relied on deterministic approaches, and it is well known that these inference is easily affected by outliers and/or noisy datasets. Moreover, the high computational costs are required for computing persistence homology with complex datasets in time and space. To overcome these circumstances, two approaches are proposed in literature. The first approach is the bootstrap estimation for persistence diagrams and Landscapes of Chazal et al. (2015a). The second refers the methods of subsampling of Chazal et al. (2015b). In this study, we introduce an unsupervised classification learning for several non-stationary time series using topological features. The bootstrap and subsampling methods are implemented to compare the performance of classifications.

Title: Exploring the Dependence Structure Between Oscillatory Activities in Multivariate Time Series
Author: Hernando Ombao* (Biostatistics Research Group STAT Program King Abdullah University of Science and Technology (KAUST), Saudi Arabia)
Abstract: This work is motivated by the problem of characterizing multi-scale changes in multivariate time series resulting from an external shock to the system. The specific application in mind is to study the impact of events such as induced stroke (in rats) and stimulus presentation (in humans) on the observed multichannel brain signals.

A particular goal is to develop statistical tools for studying changes in the dependence structure between channels of a multivariate time series. There is no unique measure for characterizing dependence. In this talk, we shall use an approach that combines both time-domain and spectral-domain aspects of dependence. The first part of the talk will cover the classical measures: coherence, partial coherence and dual-frequency coherence and then introduce some non-stationary generalizations of these (in particular, the evolutionary dual-frequency coherence). We then discuss partial directed coherence (by Baccala and Sameshima) which, unlike the previously mentioned measures, can capture directionality between components under the framework of vector autoregressive processes.

Here we shall develop further tools for investigating dependence in multivariate time series. In particular, we shall discuss the notion of ``spectral causality" in the context of brain signals. This broadly characterizes the extent to which an oscillatory activity in one population of

neurons can predict various oscillatory activities in another population at a future time point. Our approach is to extract different oscillatory components via linear filtering and then examine cross-dependence between the band-pass filtered signals. The proposed spectral causality approach overcomes the limitations of classical measures such as coherence and partial coherence since these do not indicate directionality. In addition, the proposed approach improves upon partial directed coherence because it is able to precisely capture the time lag between oscillatory activity at different regions. Moreover, this approach can be used to capture potential non-linear dependence between different oscillatory components.

Title: Distance-based parameter curve clustering in time series
Author: Yan Liu* (Kyoto University)
Abstract: We propose a distance-based method for the clustering of parameter curves in time series. Using the rolling window method, we pay our attention to the local estimates instead of the global Gaussian likelihood approximation to specify the parameter curves. We apply the Whittle likelihood, as a distance measure, to the time series in order to monitor the changes in the parameter curves. Under suitable conditions, the changes in the distance are consistently captured by the cluster tree consisting of a collection of level sets. Especially, the feature of the parameter curves can be visualized by the persistence diagram. We give some numerical results in this talk. In addition, we apply our proposed method to a portfolio of stocks as a real data analysis.

Title: Robust local linear inference for spherical-linear regression models
Author: Fumiya Akashi* (The University of Tokyo) & Holger Dette (Ruhr Universität Bochum)
Abstract: This talk considers the nonlinear regression model whose predictor is a random vector on a hyper-sphere. This setting has various applications such as seismic wave analysis, analysis for orientation of wild fire, etc. It is well known that the classical method in “linear statistic” does not work for spherical random vectors. To construct a robust estimator for the nonlinear regression function, this talk employees L1-regression method and kernel-type objective function. The proposed local-linear estimator has asymptotic normality regardless of whether the innovation process has finite variance or dependence structure. Some simulation experiments illustrate desired finite sample properties of the proposed method.

Title: Asymptotic Properties of Mildly Explosive Processes with Locally Stationary Disturbance
Author: Junichi Hirukawa*(Niigata University) and Sangyeol Lee(SNU)
Abstract: In this talk the limit distribution of the least squares estimator for mildly explosive

autoregressive models with locally stationary disturbance is established, which is shown to be Cauchy as in the iid case. The result is then applied to identify the onset and the end of an explosive period of a financial time series. Simulations and data analysis are conducted to demonstrate the validity of the result.

Title: Local Gaussian correlation: A new modeling of dependence, conditional dependence, and nonlinearity in spectral analysis

Author: Dag Tjostheim* (University of Bergen)

Abstract: By approximating a multivariate density function by a family of Gaussian distributions, the correlations of each of these Gaussian distributions can be taken as local dependence measures. Properties will be given of the local Gaussian correlation (LGC) obtained in this manner. It will be compared to recent nonlinear dependence measures such as the Brownian distanse correlation and the HSIC dependence measure proposed in machine learning. It will be shown how the LGC can be extended to time series and used to derive a nonlinear spectral analysis. Finally, a local Gaussian partial correlation is introduced. It can be used to measure conditional dependence, and an application to testing of nonlinear Granger causality will be given.