Miyazaki Statistical Workshop

Covariance Geometry in Nonlinear Time Series

Date: March 19~21, 2026

Venue: Aoshima Community Center, Miyazaki

(Access map: https://www.hotel-grantia.co.jp/aoshima/)

Organizer: Yan Liu (Waseda University)

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- JSPS Grant-in-Aid for Scientific Research (C) 23K11018
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Program

March 19, 2026

20:00 – 20:40　Yosei Yoshida (Waseda Univ.)
Multivariate Linear Process Bootstrap for Testing Sphericity in High-Dimensional Time Series

20:40 – 21:20　Yuto Hamazaki (Waseda Univ.)
Ball Correlation for Betti Number

21:20 – 22:00　Kazuma Noda (Waseda Univ.)
Multivariate Spectral Energy Statistics for Gaussian Stationary Processes

March 20, 2026

09:00 – 09:40　Takayuki Shiohama (Nanzan Univ.)
Spherical Time Series Modeling and Its Applications

09:40 – 10:20　Ching-Kang Ing (National Tsing Hua Univ.)
Adaptive banding and tapering estimation for high-dimensional covariance matrices under operator norms

10:20 – 11:00　Masanobu Taniguchi (Waseda Univ.)
Hellinger Distance Estimation for Non-Regular Spectra

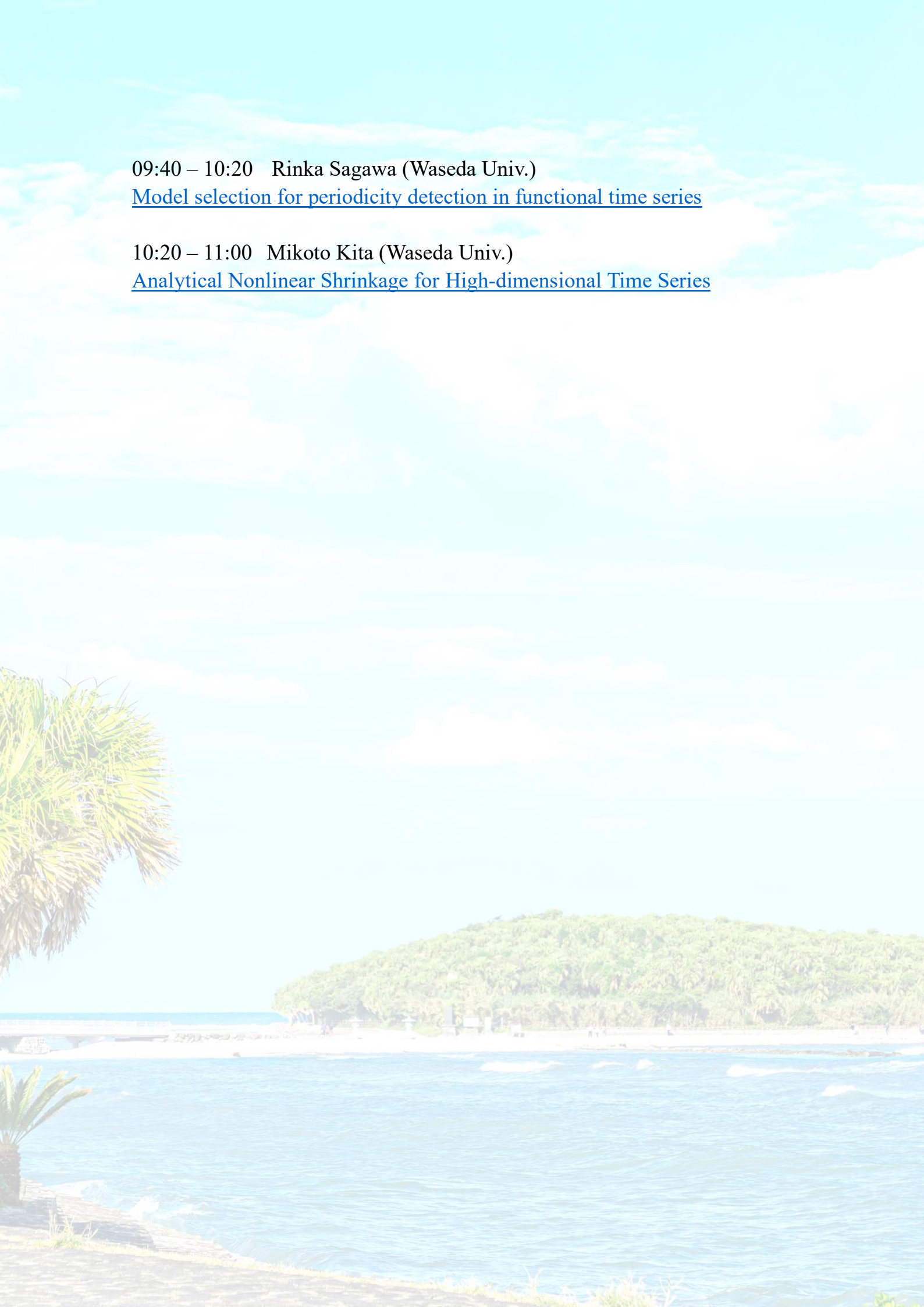
13:00 –　General Discussion

March 21, 2026

09:00 – 09:40　Shi Chen (Waseda Univ.)
Nonlinear Independent Component Analysis via Signature Cumulants

09:40 – 10:20 Rinka Sagawa (Waseda Univ.)
Model selection for periodicity detection in functional time series

10:20 – 11:00 Mikoto Kita (Waseda Univ.)
Analytical Nonlinear Shrinkage for High-dimensional Time Series



Abstract

Chen, Shi

Title: Nonlinear Independent Component Analysis via Signature Cumulants

Abstract: We propose a nonlinear independent component analysis method via signature cumulants (ScICA) for blind source separation under nonlinear mixtures. The method combines the invertible flow network using a Glow-style architecture to ensure exact invertibility and numerical stability. To make the estimation of signature cumulants feasibly stable, we introduce an adaptive blockwise algorithm. The empirical signature cumulants are theoretically risk-consistent under mild conditions. The signature cumulants loss is incorporated as a regularization term to ensure statistical independence in downstream tasks. Simulation results reveal that the proposed method outperforms the established ICA methods in both signal recovery and classification tasks, while the application of the regularized end-to-end model to neural signal data demonstrates its practical utility. This is a joint work with Yan Liu.

Hamazaki, Yuto

Title: Ball Correlation for Betti Number

Abstract: This study proposes a new framework for testing dependence between the Betti curves obtained from topological data analysis by employing the ball correlation. The Betti curves provide functional summaries that encode the evolution of topological features over a filtration, while the ball correlation measures dependence using only distance matrices and does not rely on distributional assumptions. Although the Betti curves have been widely studied as topological descriptors, systematic methods for assessing dependence between such curves remain limited. We focus in particular on the ability of ball correlation to detect nonlinear dependence structures that are not captured by conventional correlation measures. Owing to its theoretical consistency against all forms of dependence, the ball correlation offers a clear advantage over classical approaches. Simulation studies based on point clouds on circles illustrate that the proposed method successfully distinguishes independent from dependent Betti curves, thereby extending statistical inference for complex

geometric data.

Ing, Ching-Kang

Title: Adaptive banding and tapering estimation for high-dimensional covariance matrices under operator norms

Abstract: Banding and tapering are two fundamental approaches for estimating high-dimensional bandable covariance matrices. A central challenge in this setting is adaptive estimation, that is, the data-driven selection of the bandwidth parameter required to attain optimal convergence rates. Although various heuristic procedures have been used in practice, rigorous theoretical guarantees under the operator norm remain limited.

In this talk, I introduce a novel two-index information criterion for bandwidth selection. Based on this criterion, we establish the first adaptive estimation results for both banding and tapering estimators under the operator norm. I will also discuss an extension of the proposed methodology to high-dimensional Toeplitz covariance matrices, highlighting its broader applicability.

Kita, Mikoto

Title: Analytical Nonlinear Shrinkage for High-dimensional Time Series

Abstract: This study reviews the theoretical structure of analytical nonlinear shrinkage under high-dimensional setting. We also examine its applicability to time series data. As a nonlinear shrinkage method for covariance matrix estimation, analytical nonlinear shrinkage has attracted attention for its accuracy and computational efficiency in high-dimensional settings. However, its theoretical foundation is built under the assumption of independent and identically distributed observations. Under such assumption, the empirical spectral distribution of the sample covariance matrix converges to the Marčenko–Pastur law, whose theoretical justification relies on the properties of the Stieltjes transform. We review the roles of these properties when constructing analytical nonlinear shrinkage, and theoretical changes in the presence of temporal dependence, especially focusing on the uniform convergence of the empirical spectral distribution. Our numerical simulations reveal that the conventional analytical nonlinear shrinkage method is deficient when the data have serial

correlations. This result suggests the importance of theoretical frameworks that incorporate temporal dependence. This is a joint work with Yan Liu.

Noda, Kazuma

Title: Multivariate Spectral Energy Statistics for Gaussian Stationary Processes

Abstract: We propose a class of multivariate spectral energy statistics for Gaussian time series. The statistics are constructed from matrix-valued discrete Fourier transforms of strictly stationary and ergodic processes. The proposed statistics are defined through Hermitian matrix-valued weight functions and involve quadratic and quartic forms of the underlying observations. The proposed statistics quantify the similarity between two multivariate time series by measuring an energy-type distance between their spectral density matrices. We prove the consistency of the statistics and derive their asymptotic normality by analyzing cumulants of arbitrary order. In particular, we obtain an explicit representation of the second-order cumulant and show that all higher-order cumulants vanish asymptotically under suitable normalization. These proofs provide a rigorous theoretical foundation for inference based on multivariate energy statistics in Gaussian time series with temporal dependence.

Sagawa, Rinka

Title: Model selection for periodicity detection in functional time series

Abstract: In time series analysis, the development of modeling frameworks in Banach spaces has enabled rigorous statistical inference for functional time series. One of the key characteristics of functional time series is the presence of periodic structures, and identifying such periodicities is essential for understanding their underlying functional dynamics. In this study, we propose a BIC-type information criterion for trigonometric models in functional time series, together with an iterative algorithm for estimating the number of periodic components based on least-squares residuals. We establish the consistency of the estimated number of periodicities through minimization of the proposed information criterion. The performance of the procedure is demonstrated through simulation studies. To assess its practical applicability, we further apply the proposed information criterion to sunspot and temperature data.

Shiohama, Takayuki

Title: Spherical Time Series Modeling and Its Applications

Abstract: This study introduces statistical models for time series data defined on a unit sphere. It demonstrates that an autoregressive model on the sphere can be constructed by extending higher-order Markov models defined on a circle. The framework for Yule-Walker and maximum likelihood estimators is presented, and their asymptotic properties are investigated. The theoretical results are validated through numerical simulations, and examples of analyses using the spherical time series model are provided, including applications to seismic wave data and the Dst index, which measures magnetic storm activity driven by solar wind.

Taniguchi, Masanobu

Title: Hellinger Distance Estimation for Non-Regular Spectra

Abstract: For Gaussian stationary process, we derive the time series Hellinger distance for spectra f and g: T(f, g). Evaluating T(f_θ, f_θ+h) of the form O(h^α), we elucidate the 1/α-consistent asymptotics of the maximum likelihood estimator of θ for non-regular spectra. For regular spectra, we introduce the minimum Hellinger distance estimator ¥hat{θ} = arg minθ T(f_θ, gˆn), where gˆn is a nonparametric spectral density estimator. We show that ¥hat{θ} is asymptotically efficient, and more robust than the Whittle estimator. Small numerical studies will be provided. This is a joint work with Yujie Xue.

Yoshida, Yosei

Title: Multivariate Linear Process Bootstrap for Testing Sphericity in High-Dimensional Time Series

Abstract: We study bootstrap inference for sphericity testing in high-dimensional multivariate time series, where both the dimension and the sample size may diverge and temporal dependence is present. Based on the Multivariate Linear Process Bootstrap (MLPB), we propose a null-adjusted procedure, referred to as the Sphericity MLPB, which enforces the spherical structure at lag zero while preserving the empirical dependence structure at nonzero lags through tapered covariance estimation. We establish the asymptotic validity of the bootstrap for the nonlinear statistics U and V under a general (N, p)-asymptotic framework

and derive explicit convergence rates that characterize the effects of dimension and dependence. Monte Carlo experiments demonstrate accurate size control and satisfactory power across a range of dependence structures. This is a joint work with Mikoto Kita and Yan Liu.