Session: New Developments on time-dependent Functional Data
Organizer: Israel Martinez Hernandez
Chair: Carolina Euan Campos

Functional Data Analysis (FDA) has been studied intensively over the past ten years, due to its great applicability to a large number of different fields such as finance, climatology, medicine, oceanography, etc.. FDA is an alternative approach to deal with high dimensional data, temporal data, and spatial structure. FDA combines mathematics, probability, statistics, and computer science, which allow us to build multi-disciplinary research. In this session, novel models and methods for functional data with possible time-dependence are introduced. First, two model-based forecasting methods for functional time series are discussed. Then, two new nonparametric methodologies are presented, one for detecting clusters of functional data, and another for detecting extreme curves.

Speakers:

Diego Garcia Rivera, Ph.D.
Data science researcher
Coppel S.A. de C.V, Mexico

Tittle: *A Proposal for Robust Clustering of Time Series*

A robust clustering algorithm for stationary time series is proposed. The algorithm is based on the use of estimated spectral densities, which are considered as functional data, as the basic characteristic of stationary time series for clustering purposes. A robust algorithm for functional data is then applied to the set of spectral densities. Trimming techniques and restrictions on the scatter within groups reduce the effect of noise in the data and help to prevent the identification of spurious clusters. The procedure is tested in a simulation study and is also applied to a real data set.
Keyworks: Time Series Clustering, Robust Clustering, Robust Functional Data Clustering, Spectral Analysis.

Yang Yang,
Ph.D. student
Australian National University, College of Business and Economics

Tittle: *In pursuit of local patterns in functional time series analysis*

In this paper, we propose a new method for modeling a time series of curves. Conducting orthogonal decomposition of variance function has long been considered as the pivotal estimation step in many functional time series methods. However, this procedure can only isolate the dominant components of functional variation, not only neglecting local patterns identifiable over some particular subdomains of functions, but also failing to adequately incorporate temporal dependence in the time series of curves. As a consequence, valuable information of function dynamics is lost during estimation, leading to inferior forecasting results. To address this issue, we initially decompose long-run covariance function involving cross-covariance information of time series at different lags to obtain global patterns, and proceed to capture local patterns together with any remaining serial dependence via sparse functional autoregressive processes. In addition, asymptotic properties are established for the

proposed method. We illustrate the new method's improved forecasting accuracy with a simulation study and Japanese age-specific mortality rates.
Keywords: functional principal component analysis; long-run covariance estimation; sparse functional autoregressive process; age-specific mortality rates.

Kimihiro Noguchi. Ph.D.
Associate Professor
Western Washington University, USA

Title: *Forecasting Intraday Volatility Curves Using Singular Spectrum Analysis*

Intraday volatility curves, which arise from high-frequency financial time series data, vary day-by-day with a characteristic U-shaped pattern caused by relatively greater price changes toward the beginning and end of the trading day. Understanding the day-to-day changes in the shapes of the curves is an important subject of interest from the risk quantification point of view. Based on the scores of functional principal components, we discuss ways of flexibly capturing the curve dynamics by applying singular spectrum analysis and autoregressive models. Furthermore, to improve the forecast performance, we apply a symmetrizing transformation prior to model fitting. Empirical studies suggest that the proposed method provides reliable short-term forecasts and prediction bands.

Key words: econometrics; functional data; intraday volatility curves; singular spectrum analysis.

Greg Rice, Ph.D.
Assistant Professor
Department of Statistics and Actuarial Science at the University of Waterloo, Canada

Title: *Inference for the autocovariance of a functional time series, and Goodness-of-Fit tests for fGARCH models*

Most methods for analyzing functional time series rely on the estimation of lagged autocovariance operators or surfaces. Testing whether or not such operators are zero is an important diagnostic step that is well understood when the data, or model residuals, form a strong white noise. When functional data are constructed from dense records of, for example, asset prices or returns, a weak white noise model allowing for conditional heteroscedasticity is often more realistic. Applying inferential procedures for the autocovariance based on a strong white noise to such data often leads to the erroneous conclusion that the data exhibit significant autocorrelation. We develop methods for performing inference for the lagged autocovariance operators of stationary functional time series that are valid under general conditional heteroscedasticity conditions, and apply these to conduct goodness-of-fit tests for fGARCH models.