Program

Date: February 11–13, 2019
Venue: Room 603, 6F High-Rise Wing, Nakano Campus, Meiji University

Monday, February 11

10:00-10:10	Opening: Kokichi Sugihara (Director of MIMS)
Invited Session 1: Particle Filter and Data Assimilation	
Chair:	Kazuyuki Nakamura (Meiji University, Japan)
10:10-10:40	**Arnaud Doucet (University of Oxford, UK)** "Iterative Particle Sampling for Bayesian Computation"
10:40-11:10	**Norikazu Ikoma (Nippon Institute of Technology, Japan)** "On Some Realistic Instances of Particle Filter in Engineering Field"
11:10-11:40	**Kazuyuki Nakamura (Meiji University, Japan)** "Applications of Data Assimilation and Error Analysis to Biological and Geophysical Systems"
11:40-13:10	Lunch
Invited Session 2: Earth Science	
Chair:	Hiromichi Nagao (The University of Tokyo, Japan)
13:10-13:40	**Peng Hui (Central South University, China)** "State-Space Modeling for Signal Extraction of Earthquake and Precision Weighing"
13:40-14:10	**Hiromichi Nagao (The University of Tokyo, Japan)** "Seismic Wavefield Imaging of Long-Period Ground Motion in the Tokyo Metropolitan Area, Japan"
14:10-14:40	**Koji Tamaribuchi (Meteorological Research Institute, Japan)** "Real-time Monitoring System of Earthquakes by Bayesian Estimation"
14:40-15:00	Coffee break
Invited Session 3: Time Series Modeling	
Chair:	Seisho Sato (The University of Tokyo/Meiji University, Japan)
15:00-15:30	**Genshiro Kitagawa (The University of Tokyo/Meiji University, Japan)** "Gaussian-sum Filter and Smoother for Nonlinear or Non-Gaussian Smoothing"
15:30-16:00	**Koki Kyo (Obihiro University of Agriculture and Veterinary Medicine, Japan)** "Analysis of the Structure of Economic Growth and Business Cycles in the Prefectures of Japan"
16:00-16:30	**Seisho Sato (The University of Tokyo/Meiji University, Japan)** "Term Structure Models During the Global Financial Crisis: A Parsimonious Text Mining Approach"
16:30-16:45	Coffee break

Special Short Session I	
Chair:	Koki Kyo (Obihiro University of Agriculture and Veterinary Medicine, Japan)
16:45-17:00	**Takeru Matsuda (The University of Tokyo, Japan)** "Oscillator Decomposition of Time Series Data"
17:00-17:15	**Tomoya Haba (The University of Tokyo, Japan)** "Decomposition of Multiple Seasonal Components in A Seasonal Adjustment Model"
17:15-17:30	**Shin-ichi Ito (The University of Tokyo, Japan)** "Data Assimilation for Grain Growth Prediction based on A Second-order Adjoint Method"
17:30-17:45	**Masayuki Yokoyama (National Institute for Fusion Science, Japan)** "An Attempt for the Thermal Transport Modelling of Fusion Plasmas based on the Statistical Approach"

Tuesday, February 12

Invited Session 4: Econometrics and Data Analysis	
Chair:	Naoto Kunitomo (Meiji University, Japan)
10:00-10:30	**Duc Khuong Nguyen (IPAG Business School, France)** "On the Network of Global Currencies: Does Lead-lag Connectedness Matter?"
10:30-11:00	**Naoto Kunitomo (Meiji University, Japan)** "Non-Stationary Errors-in-Variables Models and Their Econometric Applications"
11:00-11:30	**Tatsuyoshi Okimoto (Australian National University, Australia)** "How Does Unconventional Monetary Policy Affect the Global Financial Markets?: Evaluating Policy Effects by Global VAR Models"
11:30-12:00	Group photo
12:00-13:30	Lunch
Invited Session 5: Data Science I	
Chair:	Genshiro Kitagawa (The University of Tokyo/Meiji University, Japan)
13:30-14:00	**Ryo Yoshida (The Institute of Statistical Mathematics, Japan)** "Machine Learning for Accelerated Materials Discovery"
14:00-14:30	**Ippei Obayashi (RIKEN/Tohoku University, Japan)** "Topological Data Analysis for Materials Science"
14:30-15:00	**Tomoyuki Miyaji (Meiji University, Japan)** "Application of A Topological Computation Method to Biomedical Signals"
15:00-15:20	Coffee break
Special Short Session II	
Chair:	Tomoyuki Miyaji (Meiji University, Japan)
15:20-15:35	**Ayuki Sekisaka (Meiji University, Japan)** "Motion of Spots on the Curved Surface"
15:35-15:50	**Nina Sviridova (The University of Tokyo, Japan)** "Filtration Effect on the Dynamical Characteristics of the Photoplethysmogram at Green Light"

15:50-16:05	**Takahiro Tanabe (Meiji University, Japan)** "Interaction between Two Intruders in Granular Flow"
16:05-16:20	**Lorenzo Contento (Meiji University, Japan)** "Competitor-mediated Coexistence and Complex Patterns in a Three-species Competition-diffusion System"
16:20-16:35	Coffee break
Special Short Session III	
Chair:	Yoshiro Yamamura (Meiji University, Japan)
16:35-16:50	**Kengo Nakai (The University of Tokyo, Japan)** "Machine-learning Inference of Variables of a Chaotic Fluid Flow from Data using Reservoir Computing"
16:50-17:05	**Tomoro Kimura (Meiji University, Japan)** "Application of Hamiltonian Monte Carlo Method to Bayesian Estimation of Sika Deer Population Dynamics for Effective Wildlife Management"
17:05-17:20	**Daisuke Kurisu (Tokyo Institute of Technology, Japan)** "Nonparametric Inference for Lévy Models"
17:20-17:35	**Hiroumi Misaki (University of Tsukuba, Japan)** "On the Error of Realized Measures of Volatility in Finance"
18:00-20:00	Banquet **Special Presentation** "Mathematical Study of Impossible Objects in MIMS" **Kokichi Sugihara (Meiji University, Japan)**

Wednesday, February 13

Invited Session 6: Data Science II	
Chair:	Jiancang Zhuang (The Institute of Statistical Mathematics, Japan)
10:00-10:30	**Aapo Hyvärinen (University College London, UK)** "Nonlinear Independent Component Analysis: A Principled Framework for Unsupervised Deep Learning"
10:30-11:00	**Shunsuke Ono (Tokyo Institute of Technology, Japan)** "Nonsmooth Convex Optimization and Sparse Regularization in Signal and Information Processing"
11:00-11:30	**Jiancang Zhuang (The Institute of Statistical Mathematics, Japan)** "A Semi-parametric Spatiotemporal Hawkes-type Point Process Model with Periodic Background for Crime Data"
11:30-13:00	Lunch
Invited Session 7: Financial Time Series Modeling	
Chair:	Yoko Tanokura (Meiji University, Japan)
13:00-13:30	**Yoshiro Yamamura (Meiji University, Japan)** "Dynamics of Commercial Real Estate Market in Tokyo"
13:30-14:00	**Yoko Tanokura (Meiji University, Japan)** "On Trend Change Factors of Financial Markets"
14:00-14:10	Closing: Genshiro Kitagawa (Chair of Organizing Committee)

Invited Session 1: Particle Filter and Data Assimilation

10:10-10:40 on February 11

Iterative Particle Sampling for Bayesian Computation

Arnaud Doucet - Oxford University

October 29, 2018

Abstract

Particle methods, also known as Sequential Monte Carlo methods, are numerical schemes used to sample approximately from a sequence of probability distributions. In statistics and related fields, these methods are often used to approximate the posterior distributions of state variables in non-linear non-Gaussian state-space models or to approximate a complex posterior distribution by using a sequence of targets bridging smoothly the prior to the posterior. They also provide unbiased estimators of their normalizing constants which have been exploited in many applications to perform inference using the pseudo-marginal method. However, contrary to Markov chain Monte Carlo schemes, standard particle algorithms require specifying before execution a number of Monte Carlo samples, named particles in this context, and do not allow us to iteratively improve the corresponding Monte Carlo estimators. To address this limitation, various schemes where particles are added incrementally have been previously proposed so as to make best use of the computational budget available. Unfortunately, these algorithms provide either biased estimators of the normalizing constants or high variance unbiased estimators of them. We propose here a novel iterative particle sampling scheme which returns unbiased estimators of normalizing constants and estimators of expectations with respect to the target distributions whose variances can be controlled under standard regularity assumptions. This scheme can be additionally parallelized. In the spirit of particle Markov chain Monte Carlo methods, we also propose novel Markov chain Monte Carlo schemes based upon the iterative particle sampler. We demonstrate the methodology on a variety of Bayesian inference tasks.

Keywords: Conditional sequential Monte Carlo; Normalizing constants; Particle methods; Sequential Monte Carlo methods; State-space models.

Invited Session 1: Particle Filter and Data Assimilation
10:40-11:10 on February 11

On Some Realistic Instances of Particle Filter in Engineering Field

Norikazu IKOMA
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Abstract

Mathematical optimality in sequential state estimation based on state space modeling and sequential Bayes inference is nice property. Many of theoretical papers based on the property contain numerical examples in order to show efficiency of each proposed content, and some of them may contain real data analyses. Despite of good performance in these examples / analyses, there still exist significant gap between mathematical theory and practice in real world where theoretical assumptions are not sufficiently satisfied due to complexity of real world. Furthermore, real-time requirement of state estimation is necessary in many of realistic applications. This invited talk presents a survey on some realistic instances of particle filter in engineering field, such as human motion estimation [1][2], mobile robot localization[3] with simultaneous mapping[4], reliability estimation simultaneously with original state variable[5] and its combination with CNN (Convolutional Neural Network)[6], in order to figure out such the gaps and problematic issues in realistic applications.

References

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[2] Sangeun Lee and Keiichi Horio, "Human Tracking with Particle Filter Based on Locally Adaptive Appearance Model" *Journal of Signal Processing* (RISP in Japan), Vol.18, No.4, pp.229-232, 2014.
[3] Jian Mi and Yasutake Takahashi, "Design of an HF-Band RFID System with Multiple Readers and Passive Tags for Indoor Mobile Robot Self-Localization", Sensors, Vol.16, No.8, #1200, 20 pages, 2016.
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[5] Naoki Akai, Luis Yoichi Morales and Hiroshi Murase, "Reliability estimation of vehicle localization result", *Proc. of the IEEE Intelligent Vehicles Symposium* (IV), pp. 740-747, 2018.
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Invited Session 1: Particle Filter and Data Assimilation
11:10-11:40 on February 11

Applications of Data Assimilation and Error Analysis to Biological and Geophysical Systems

Kazuyuki Nakamura[1,2]

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Abstract

Data assimilation (DA) is the technique which aims at combining computer simulations with observation data. DA is originally developed in the meteorology and the oceanography, but nowadays application fields of DA are expanding, such as life sciences, geotechnics and material sciences.

In biology, especially in molecular biology, interactions among biomolecules such as proteins are written as network. In systems biology, these relationships are often modelled as ordinary differential equations. The parameters included in these models have uncertainties and quantification of these uncertainties can give useful information on the biological systems. Data assimilation is useful for quantification of these uncertainties. In this presentation, we will show several assimilation results of a gene regulatory network and a metabolic pathway system.

To manage and estimate these uncertainties, some tools imported from dynamical system might be useful. We will also discuss applicability of system error analysis to data assimilation method. Local translation error analysis is used for Lorenz 96 model that is a reduced atmospheric flow model.

Invited Session 2: Earth Science
13:10-13:40 on February 11

State-Space Modeling for Signal Extraction of Earthquake and Precision Weighing

Hui Peng[a], Genshiro Kitagawa[b], and Satoshi Miura[c]

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[b] Mathematics and Informatics Center, the University of Tokyo, Tokyo 113-8656, Japan

[c] Graduate School of Science, Tohoku University, Sendai 980-8578, Japan

Abstract: In this talk, we introduce a time series modeling method for geodetic signal and small-weight weighing signal, which are contaminated by some environment variables. Geodetic signals such as strain, gravity and groundwater level data usually are greatly affected by atmospheric pressure, earth tide, precipitation, and missing observations due to instrument maintenance or breakdown. In on-line weighing process of small-weight drug bottle, the weighing signal is very sensitive to the ambient wind pressure and equipment vibration. To detect meaningful geodetic signal or accurate weighing result from heavily noise-affected data, we build a time series model for decomposition of the data taking into account the characteristics of effects from these covariates. This talk presents the time series modeling method for detecting geodetic signal from observed time series and weighing result from continuous weighing data of small-weight drug bottle. Using the modeling approach, a geodetic time series can be decomposed into several components including geodetic trend signal, barometric pressure response, earth tidal response, precipitation response and data level shift due to mechanical maintenance or breakdown., While, a weighing sample data can be decomposed into weighing result, ambient wind pressure response and equipment vibration response. In the model parameter estimation process, we introduce the model stability constraint for guaranteeing model stability. On the other hand, for the traditional modeling method that regards the process noise as Gauss random signal with constant variance, by introducing GARCH (Generalized Autoregressive Conditional Heteroskedasticity) structure into the signal extraction model, we may improve the modeling performance. Finally, case studies of real geodetic time series and weighing data demonstrate the effectiveness of the presented modeling method that leads to some important findings in seismology or obtains accurate weighing result.

Invited Session 2: Earth Science
13:40-14:10 on February 11

Seismic Wavefield Imaging of Long-Period Ground Motion in the Tokyo Metropolitan Area, Japan

Hiromichi Nagao[1,2]

Masayuki Kano[3], Kenji Nagata[4,5], Shin-ichi Ito[1,2], Shin'ichi Sakai[1], Shigeki Nakagawa[1], Muneo Hori[1], and Naoshi Hirata[1]

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4: Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, Japan
5: Presto, Japan Science and Technology Agency, Japan

Long-period ground motions due to large earthquakes can cause devastating disasters, especially in urbanized areas located on sedimentary basins. To assess and mitigate such damage, it is essential to rapidly evaluate seismic hazards for infrastructures, which can be simulated by seismic response analyses that use waveforms at the base of each infrastructure as an input ground motion. The present study reconstructs the seismic wavefield in the Tokyo metropolitan area located on the Kanto sedimentary basin, Japan, from seismograms of the Metropolitan Seismic Observation network (MeSO-net). The obtained wavefield fully explains the observed waveforms in the frequency band of 0.10-0.20 Hz. This is attributed to the seismic wavefield imaging technique proposed by Kano *et al*. (Geophys. J. Int., 2017), which implements the replica exchange Monte Carlo method to simultaneously estimate model parameters related to the subsurface structure and source information. Further investigation shows that the reconstructed seismic wavefield lower than 0.30 Hz is of high quality in terms of variance reduction (VR), which quantifies a misfit in waveforms but that the VR rapidly worsens in higher frequencies. Meanwhile, the velocity response spectra show good agreement with observations up to 0.90 Hz in terms of the combined goodness of fit (CGOF), which is a measure of misfit in the velocity response spectra. Inputting the reconstructed wavefield into seismic response analyses, we can rapidly assess the overall damage to infrastructures immediately after a large earthquake.

References

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Kano, M., H. Nagao, D. Ishikawa, S. Ito, S. Sakai, S. Nakagawa, M. Hori, and N. Hirata, Seismic wavefield imaging based on the replica exchange Monte Carlo method, Geophys. J. Int., Vol. 208, pp. 529-545, doi:10.1093/gji/ggw410, 2017.

Invited Session 2: Earth Science
14:10-14:40 on February 11

Real-time Monitoring System of Earthquakes by Bayesian estimation

Koji Tamaribuchi[1]
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Abstract

Earthquake Early Warning (EEW) system is a real-time monitoring alert system of earthquake that detects signals of seismic waves, estimates hypocenters, and predicts future ground shakes. After the 2011 Mw 9.0 Tohoku earthquake, the extremely active seismic activity caused serious issues for the earthquake real-time monitoring system in Japan. Since the hypocenter was estimated based on arrival times of the seismic waves, the EEW system issued many false alarms due to the failure of correctly determining the source location and magnitude in the case of the multiple concurrent earthquakes. It can be regarded as a classification problem which earthquake triggers observation stations. Conventionally, it was difficult to properly classify simultaneous occurrence of earthquakes automatically because it was based only on the arrival times of earthquakes.

We then proposed the IPF method (Integrated Particle Filter method) to distinguish multiple concurrent events in real time by using a particle filter. We used amplitudes as well as P-wave arrival times of triggered stations. The particle filter can also consider the uncertainty of the hypocenter. The IPF method have started its operation for the JMA EEW in December 2016.

The production system of earthquake catalog in JMA also faced severe problems. Since the all events were required the visual inspection, the large number of aftershocks and induced earthquakes caused delay of the catalog production. We also applied Bayesian estimation to identify multiple concurrent earthquakes of the JMA unified earthquake catalog which includes micro-earthquake that nobody felt shaking. This method (Phase combination Forward search method; PF method) makes integrated use of P- and S-wave arrival times and maximum amplitude. The PF method have started its operation in April 2016. In the 2016 Kumamoto earthquake, which began on April 14, the ability of the method was fully demonstrated. The real-time monitoring technology is an indispensable and extremely important task. We have to develop the monitoring system that process their big data in real time.

Invited Session 3: Time Series Modeling
15:00-15:30 on February 11

Gaussian-sum Filter and Smoother for Nonlinear or Non-Gaussian Smoothing

Genshiro Kitagawa

Mathematics and Informatics Center, the University of Tokyo, Tokyo 113-8656, Japan

Abstract:

Gaussian-sum filter can produce very accurate prediction and filtering distributions for linear state-space model with the noise inputs whose distributions are given as a mixture of several Gaussian distributions. On the other hand, a critical problem with this method is that the number of Gaussian components increased exponentially with time step. Therefore, in order to apply this filter for actual time series modeling, we need to develop an efficient method of reducing the number of Gaussian components in terms of both accuracy and computational cost.

In this talk, mixture reduction methods such as the one proposed by Runnalls (2007) and a resampling method are considered to improve the previously developed filtering and smoothing methods. The developed methods are tested for jump detection problem and seasonal adjustment problems.

The developed method will be also applied to nonlinear smoothing problem. Based on the Taylor expansion of the nonlinear functions in the state and observation models, the extended Kalman filter can be applied to nonlinear state-space model. However, the main problem with this extended Kalman filter appears when the predictive distribution becomes bimodal or multi-model due to the nonlinear transition function in the system model. Namely, if the state distribution becomes bimodal, it may yield disastrous results. We develop a Gaussian-sum extended Kalman filter that can properly handle multi-modal state distributions. By a well-known nonlinear test example, it will be shown that a Gaussian-sum extended Kalman smoother can recover unknown signal of nonlinear system based on a state-dependent predictive density.

References

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Kitagawa, G. (2014). Computational aspects of sequential Monte Carlo filter and smoother. *Annals of the Institute of Statistical Mathematics*, 66(3), 443-471.

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Invited Session 3: Time Series Modeling
15:30-16:00 on February 11

Analysis of the Structure of Economic Growth and Business Cycles in the Prefectures of Japan

Koki Kyo
Obihiro University of Agriculture and Veterinary Medicine, Japan

In this study, we analyze the structure of economic growth and business cycles in the prefectures of Japan. We take a quarterly time series of gross domestic product (GDP) in whole Japan as a reference. So, for a quarterly time series y_n (in logarithmic scale) of GDP in Japan, we use the soft of *Decomp* to decompose the time series y_n into a trend component t_n, a seasonal component, a cyclical component r_n, and a irregular component.

Based on the above results, we construct a model for analyzing the structure of the prefectural GDP in Japan as follows:

$$x_{mi} = a_i + b_i f_m^{(1)} + c_i f_m^{(2)}(L) + d_{mi} + \epsilon_{mi}, \quad \epsilon_{mi} \sim \mathrm{N}(0, \sigma_i^2) \quad (i = 1, 2, \ldots, 47).$$

In this model, x_{mi} is an annual time series of GDP (in logarithmic scale) for the i-th prefecture, $f_m^{(1)}$ the first common factor which is determined by $f_m^{(1)} = \log \sum_{j=1}^{4} \exp(\widehat{t}_{4*(m-1)+j})$, $f_m^{(2)}$ the second common factor which is given by $f_m^{(2)}(L) = \log \sum_{j=1}^{4} \exp(\widehat{r}_{4*(m-1)+j-L})$, where $\widehat{t}_{4*(m-1)+j}$ and $\widehat{r}_{4*(m-1)+j}$ denote the estimates for the trend component and the cyclical component in the GDP of whole Japan. d_{mi} the individual trend for the i-th prefecture, and ϵ_{mi} the error term, a_i, b_i and c_i are constants, especially, b_i and c_i are the factor loadings of the common factors, Also, L is a lag parameter expressing the lead-lag relationship between cyclical movements in GDP for each prefecture and the whole Japan in the number of quarter. We introduce a second order smoothness prior to d_{mi}. So, a set of state space models for d_{mi} is constructed, the estimate of d_{mi} is obtained based on Kalman filter algorithm and so on.

Thus, following knowledge about the prefectural economies can be obtained. (a) From the value of L, we see the lead-lag relationship between the movements of GDP in the whole Japan and each prefecture. (b) From the estimates of b_i and c_i we can analyze the economic dependence of each prefecture on whole Japan. (c) From the estimates of d_{mi}, the feature of the individual trend for each prefecture can be investigated. Furthermore, the similarities between the individual trends for all prefectures can analyzed by employing methods of cluster analysis.

Invited Session 3: Time Series Modeling
16:00-16:30 on February 11

Term Structure Models During the Global Financial Crisis: A Parsimonious Text Mining Approach

Kiyohiko G. Nishimura
National Graduate Institute for Policy Studies (GRIPS) and CARF, University of Tokyo
Seisho Sato
Graduate School of Economics and CARF, University of Tokyo
Akihiko Takahashi
Graduate School of Economics and CARF, University of Tokyo

Abstract

This work develops and estimates a three-factor term structure model with explicit sentiment factors in a period including the global financial crisis, where market confidence was said to erode considerably. It utilizes a large text data of real time, relatively high-frequency market news and takes account of the difficulties in incorporating market sentiment into the models. To the best of our knowledge, this is the first attempt to use this category of data in term-structure models.

Although market sentiment or market confidence is often regarded as an important driver of asset markets, it is not explicitly incorporated in traditional empirical factor models for daily yield curve data because they are unobservable. To overcome this problem, we use a text mining approach to generate observable variables which are driven by otherwise unobservable sentiment factors. Then, applying the Monte Carlo filter as a filtering method in a state space Bayesian filtering approach, we estimate the dynamic stochastic structure of these latent factors from observable variables driven by these latent variables.

Special Short Session I
16:45-17:00 on February 11

Oscillator decomposition of time series data

Takeru Matsuda
The University of Tokyo

Many time series are considered as a superposition of several oscillation components. For example, electroencephalogram (EEG) time series include oscillation components such as alpha, beta, and gamma. We propose a method for decomposing time series into such oscillation components like the Bayesian seasonal adjustment method. The proposed method is based on the following Gaussian linear state-space model, which describes several oscillators $x_t^{(1)}, \cdots, x_t^{(K)}$ underlying the given time series y_t.

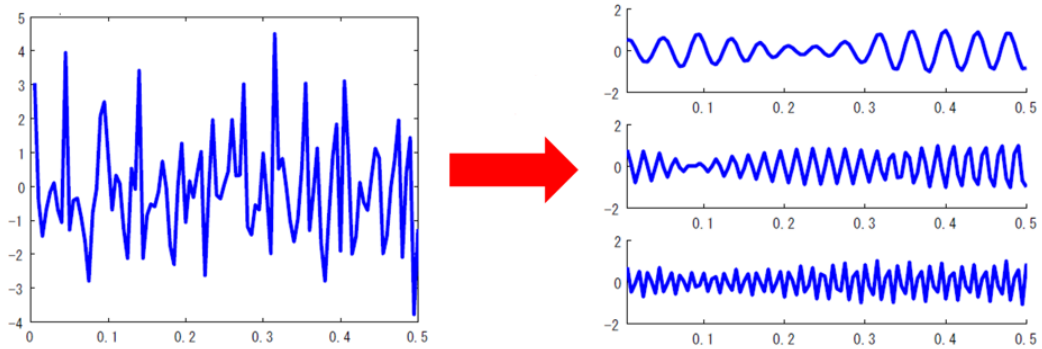
$$\begin{pmatrix} x_{t+1,1}^{(k)} \\ x_{t+1,2}^{(k)} \end{pmatrix} = a_k \begin{pmatrix} \cos(2\pi f_k \Delta t) & -\sin(2\pi f_k \Delta t) \\ \sin(2\pi f_k \Delta t) & \cos(2\pi f_k \Delta t) \end{pmatrix} \begin{pmatrix} x_{t,1}^{(k)} \\ x_{t,2}^{(k)} \end{pmatrix} + \begin{pmatrix} v_{t,1}^{(k)} \\ v_{t,2}^{(k)} \end{pmatrix} \quad (k = 1, \cdots, K),$$

$$\begin{pmatrix} v_{t,1}^{(k)} \\ v_{t,2}^{(k)} \end{pmatrix} \sim \mathrm{N}_2 \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_k^2 & 0 \\ 0 & \sigma_k^2 \end{pmatrix} \right) \quad (k = 1, \cdots, K),$$

$$y_{t,1} = \sum_{k=1}^{K} x_{t,1}^{(k)} + w_{t,1}, \quad y_{t,j} = \sum_{k=1}^{K} (c_{jk,1} x_{t,1}^{(k)} + c_{jk,2} x_{t,2}^{(k)}) + w_{t,j} \quad (j = 2, \cdots, J),$$

$$(w_{t,1}, \cdots, w_{t,J})^\top \sim \mathrm{N}_J(0, \tau^2 I).$$

The model parameters and the number of oscillators are determined from data by using the empirical Bayes method and Akaike Information Criterion (AIC), respectively. Thus, the proposed method extracts underlying oscillators in a data-driven manner and enables investigation of the phase dynamics of a given time series. We apply the proposed method to real data from various fields such as astronomy, ecology, chronobiology, and neuroscience. For example, from the mouse actogram data, an oscillator corresponding to the circadian rhythm is extracted and its phase reveals the progression of jet lag.



References

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Special Short Session I
17:00-17:15 on February 11

Decomposition of multiple seasonal components in a seasonal adjustment model

Tomoya Haba, Hiromichi Nagao and Shin-ichi Ito
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A nonparametric seasonal adjustment model [1] is possible to decompose a given time series y_t into multiple components such as trend component u_t, seasonal component s_t and observation noise w_t, i.e., $y_t = u_t + s_t + w_t$. The Kalman filter conducts such a decomposition based on appropriate system model defined for each of the components. A unique decomposition is possible when the system model of the seasonal component s_t is given as

$$(1 + B + \cdots + B^{p-1})s_t = v_{s,t} \ , \tag{1}$$

where B is a backwards shift operator, e.g., $Bs_t = s_{t-1}$, p is the period of s_t, and $v_{s,t}$ is a system noise that follows a normal distribution. However, when an observation model contains multiple seasonal components with different periods, e.g., $y_t = u_t + s_t^1 + s_t^2 + w_t$, the conventional decomposition method using the system model equation (1) for each seasonal component is often impossible to uniquely decompose the trend and seasonal components.

In this study, we propose a method to extract multiple seasonal components in the framework of the seasonal adjustment. In the case that an observation model contains two seasonal components, our method considers three cases according to the relation between the periods of seasonal components, and gives system model that achieves the unique decomposition for each case. We also propose a selection method using the Akaike Information Criterion (AIC) [2], which enables us to select dominant seasonal components in a given time series. Numerical experiments and applications to real data show the validity of our method.

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Special Short Session I

17:15-17:30 on February 11

Data assimilation for grain growth prediction based on a second-order adjoint method

Shin-ichi Ito[1,2], Hiromichi Nagao[1,2], Takashi Kurokawa[2], Tadashi Kasuya[3], and Junya Inoue[4,3]

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Abstract

Data assimilation (DA) is a fundamental computational technique that integrates numerical simulation models and observation data on the basis of Bayesian statistics. Originally developed for meteorology, especially weather forecasting, DA is now an accepted technique in various scientific fields such as materials science to evaluate unknown material parameters and/or unmeasurable inner structures in objective materials. One key issue that remains controversial is the implementation of DA in massive simulation models used in materials science under the constraints of limited computation time and resources. For the purpose of obtaining accurate prediction of the grain growth in metals and steel alloys, we propose an adjoint-based DA method that produces optimum estimates and their uncertainties within reasonable computation time and resource constraints. The uncertainties are given as several diagonal elements of an inverse Hessian matrix, which is the covariance matrix of a multivariate normal distribution that approximates the target posterior probability density function in the neighborhood of the optimum. Although conventional algorithms for deriving the inverse Hessian matrix require a huge computational cost since a full description of the Hessian matrix is needed, our methodology implementing a second-order adjoint method enables us to extract the diagonal elements without computing the full description of the matrix. The proposed method is validated through numerical tests using some massive phase-field models, which describe growing dynamics of grain structure. We confirm that the proposed method correctly reproduces the parameter and initial grain structure assumed in advance, and successfully evaluates the uncertainty of the parameter. Furthermore, we confirm that the influence of the obtained uncertainties to the grain growth prediction is correctly estimated. Such information regarding uncertainty is valuable, as it can be used to optimize the design of experiments.

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Special Short Session I
17:30-17:45 on February 11

An attempt for the thermal transport modelling of fusion plasmas based on the statistical approach

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Abstract

A statistical approach has been attempted for the thermal transport modelling for plasmas in fusion experiment [1]. It can provide regression expressions for the heat diffusivities, to be valuable for predicting the temperature profile evolution. This approach should outstrip the conventional scaling laws for the global confinement time since it also deals with profiles (temperature, density, heating depositions etc.). This approach has become possible with the analysis database accumulated by the extensive application of the integrated transport analysis suite, TASK3D-a [2], to the LHD (Large Helical Device) experiment at NIFS [3]. After the first attempt that was published in Ref. [1], the validity check of the obtained regression expression for the ion heat diffusivity profiles has been made through its implementation into the predictive TASK3D calculations to be compared with several LHD experimental results. Furthermore, the improvement for statistical treatment has been promoted by establishing collaborations with experts in statistics. The first attempt [1] and the successive progress will be reported in the workshop, as one of possible and innovative “data-driven” modelling approaches in fusion research.

Acknowledgements: The author appreciates valuable advices on statistics from Prof. K. Shimizu and Prof. Y. Iba (The Institute of Statistical Mathematics, ISM). Dr. H. Yamaguchi (National Institute for Fusion Science) is also acknowledged his contributions for validity check of this approach. This work has been supported by the NIFS Collaborative Research Programs, NIFS14KNTT025, NIFS14UNTT006 and NIFS18KNTT046, and by the ISM Collaborative Research Program, H30-1002. The participation to this workshop is supported by the NINS Joint Research Program.

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ICMMA 2018
Data Science, Time Series Modeling and Applications

Invited Session 4: Econometrics and Data Analysis

10:00-10:30 on February 12

On the network of global currencies: Does lead - lag connectedness matter?

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Abstract

In this paper, we augment Billio et al. (2012) by using conditional Granger causality to measure lead-lag network connectedness among the most globally traded currencies. From this, we then investigate the informational content of system-wide dynamic connectedness and examine the relationship between node connectedness and exchange rate variations. Our panel regression results reveal that node connectedness has significant effects on mean return, standard deviation and Value at Risk after controlling for certain fundamental and market-behavior variables. More importantly, increase in a currency's lead-lag connectedness predicts greater variations in its values vis-à-vis the USD in the following year. We also find evidence that node with higher centrality before the global financial crisis faced more extreme depreciation in the crisis period. At the broader level, the dynamic system-wide lead-lag connectedness is seen to spike during high-risk episodes, become more stable in lower-risk environment and co-integrate with VIX, Vstoxx and rolling TED spread. It could also capture major systemic events like Lehman Brothers' collapse, the get-through of European Stability Mechanism in September 2012 as well as Brexit.

Keywords: exchange rates, conditional granger causality, network, connectedness, systemic risk, risk and return.

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Invited Session 4: Econometrics and Data Analysis
10:30-11:00 on February 12

Non-Stationary Errors-in-Variables Models and their Econometric Applications

Naoto Kunitomo

Abstract:

Kunitomo, Sato and Kurisu (2018, Springer) have developed a new way to handle non-stationary (high-frequency) financial data with micro-market noise. We apply their method (the separating information maximum likelihood method) to analyze many economic data including macroeconomic time series. There are at least three important characteristics of macro-economic time series. (i) the time series observations are mixtures of non-stationary components, seasonal components and stationary components, (ii) measurement errors usually exist because macro-economic (official) data are usually constructed from various sources including sampling surveys, and (iii) the sample size of macro-economic data is usually small. The main interest of statistical analysis of macro-economic variables has been to find statistical relationships among multivariate time series. Since the sample size is small and there are several components, it is important to use an appropriate statistical procedure in both time domain and frequency domain to extract information on trend components, seasonal components and noise (or measurement error) components in a systematic way from non-stationary and noisy time series data. We propose a simple filtering method to detect trend components and seasonal components from noise components.

ICMMA 2018
Data Science, Time Series Modeling and Applications

Invited Session 4: Econometrics and Data Analysis
11:00-11:30 on February 12

How Does Unconventional Monetary Policy Affect the Global Financial Markets?: Evaluating Policy Effects by Global VAR Models

Tomoo Inoue* Tatsuyoshi Okimoto†

Abstract

Since the beginning of the new century, we have observed a number of so-called "unconventional monetary policies," conducted by central banks in the major economies. In this paper, we re-investigate the policy effects of the Bank of Japan and the Federal Reserve (Fed), in regards to financial markets, by employing the Global Vector Autoregression (GVAR) approach.

Using generalized impulse response function analysis, we compare the monetary policy effects of the BOJ and those of the Fed on four financial indices, i.e., sovereign bond price, corporate bond price, equity price, and exchange rate, both in the domestic markets and the global markets. Possible structural changes during the sample period are also modeled.

Some of the main results are: 1) the BOJ's expansionary monetary policy rises the Japanese corporate bond price only temporarily, but sovereign bond price and equity price of the domestic market persistently. However, in terms of its global influence, the effects are rather limited; 2) the Fed's expansionary monetary policy increases US sovereign bond price temporarily, but corporate bond and equity price for a long-run; and 3) the different magnitude of policy effects in the different time periods by two central banks are illustrated by the use of ST-GVAR.

Keywords: Monetary policy, Bank of Japan, Federal Reserve, GVAR, Financial linkage
JEL Codes: C32, E44, F41

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Invited Session 5: Data Science I
13:30-14:00 on February 12

Machine Learning for Accelerated Materials Discovery

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The ability of machine intelligence trained on massive amounts of data to reach or even outperform humans has been demonstrated in intellectually demanding tasks across various fields. Under such circumstance, there has been a growing interest in using machine learning (ML) to accelerate the discovery and development of new materials. In this talk, I will describe some key drivers of ML technologies to achieve this goal.

The first topic is the ML-assisted materials design. In general, the material spaces are considerably high-dimensional. For instance, the chemical space of small organic molecules is known to contain as many as 10^{60} candidates. The problem entails a considerably complicated combinatorial optimization where it is impractical to fully explore the vast landscape of structure-property relationships. We developed an inverse material design algorithm by the integration of ML and quantum chemistry calculation. The design objective is to generate promising hypothetical materials that exhibit desired properties of various kinds. The emergence of such ML algorithms to exhaustively search in such a huge space is expected to accelerate the pace of expanding the frontier in the vast universe of materials.

The second topic is a subject of data scarcity. In recent years, various kinds of databases have begun to emerge with the aim to transform materials science into being fully data driven. However, the volume and diversity of data being accumulated remain far from enabling us to fully enjoy remarkable advances recently made in ML. A ML framework called transfer learning has the great potential to break this barrier. For a target property with a limited supply of training data, models on physically related proxy properties are pre-trained on large amounts of data, which capture features of materials generally applicable to the target task. Re-purposing such ML-acquired knowledge on a new task provides an outstanding prediction ability as highly experienced experts can make rational inferences even on considerably less experienced tasks. We have developed a pre-trained model library, XenonPy.MDL, which can be used to predict various properties of small molecules, polymers and inorganic solid-state materials. Along with this library, I will demonstrate some outstanding successful applications of transfer learning.

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Invited Session 5: Data Science I
14:00-14:30 on February 12

TOPOLOGICAL DATA ANALYSIS FOR MATERIALS SCIENCE

IPPEI OBAYASHI*,**

In this presentation, I will talk about Persistent Homology (PH) and its applications to materials science.

PH is one of the most important tool of Topological Data Analysis (TDA) [1, 2]. TDA is a data analysis approach from the viewpoint of topology, and TDA enables us to characterize the "shape of data". Homology is a classical mathematical theory in the field of topology and homology has 100 years history. Persistent homology [3, 4, 5] is invented to apply the idea of homology to the data analysis, and is developed from the theory to the applications. Persistent homology characterizes the shape of data quantitatively and effectively by using homology.

From the viewpoint of mathematics, PH is the homology theory on an increasing sequence of topological spaces, called a filtration, and PH relates many mathematical fields such as algebraic topology, representation theory, and probability theory. From the viewpoint of data analysis, we can encode multiscale information on a filtration to characterize the shape of data. PH has an advantage for the analysis of disordered and heterogeneous data. PH is applied to various data analysis, such as materials science [6, 7] and biology[8]. Computer science such as algorithms[9], computer geometry, and machine learning[10], are also important for the practical applications of PH. We need various sciences and technologies for PH.

In this talk, I introduce the fundamental concepts of PH, and some applications to materials science. HomCloud[11], the software based on PH developed by our research group, is also introduced.

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Invited Session 5: Data Science I
14:30-15:00 on February 12

Application of a topological computation method to biomedical signals

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Abstract

In this study, biomedical photoplethysmogram (PPG) signals are analyzed from a viewpoint of dynamical systems. The PPG is used for estimating the heart rates and blood oxygen saturation via non-invasive stationary and wearable health monitoring devices. Although dynamics and applications of PPG signals have been extensively studied for several decades, the understanding of PPG signals is not yet sufficient for further development of the PPG applications for human health monitoring. Moreover, no mathematical model, which is realistic and capable of simulation of PPG signals under various conditions, has been established. For creating such a model, it is important to understand essential dynamical properties of PPG signals. In this study, we employ topological computation methods. Originally, these methods were developed for studying the phase space structure of a given dynamical system. These enable us to capture not only attractors but also repellers and saddles, in contrast to ordinary computation methods. Recently, there have been some attempts to apply such a method to experimental data. This study is aimed at capturing the dynamical structure including saddle equilibria from PPG signals.

Special Short Session II
15:20-15:35 on February 12

Motion of spots on the curved surface

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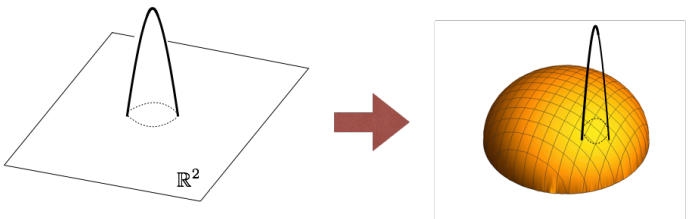
Abstract

Reaction-diffusion systems are expected to describe the several phenomena. In particular, spot solutions are important because they correspond to spot-like pattern in phenomena, and they may trigger a complicated phenomenon. In order to avoid difficulty of the analysis, reaction-diffusion systems are usually considered in the Euclidian space. However, when we consider the polarity of chemical reaction on the cell membrane, the space is not flat and the curvature of space must be considered.

From the above motivation, we consider the spot solution on the curved surface. We assume that the spot solution of reaction-diffusion systems on the two dimensional Euclidian space exist. We replace the Laplacian to the Laprace-Bertrami operator to consider the reaction-diffusion system on the curved surface. The Laprace-Bertrami operator depends on the Riemannian metric tensor, and it is determined by the diffusivity of specific material (for example, it is given by a chemical substance) on the curved surface. We then introduce the reduction equation in the local coordinate from the spot solution of reaction-diffusion system on the curved surface. The motion of spot solution on the curved surface is given by the solution of the reduction equation. In particular, our analysis does not depend on the Riemannian metric and hence, it is applicable to many phenomena.
In this short talk, we show the developed method, and several phenomena of the motion of spot solutions on the curved surface.

$$U_t = \Delta U + F(U), \mathbf{x} \in \mathbb{R}^2, t > 0 \qquad U_t = \delta^2 \Delta_{\mathcal{M}} U + F(U),$$

$\Delta_{\mathcal{M}}$:Laprace-Beltrami operator



Special Short Session II
15:35-15:50 on February 12

Filtration effect on the dynamical characteristics of the photoplethysmogram at green light

Nina Sviridova[1], Kazuyuki Aihara[1], Tiejun Zhao[2], Akimasa Nakano[3]

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Abstract

Human photoplethysmogram (PPG) is a biomedical signal which is widely used for health monitoring in clinical settings and wearable devices. PPG signal is measured by an optical and noninvasive technique from the surface of skin tissue. The signal measurement in realistic settings cannot be entirely controlled, and therefore the raw signal always contains a certain amount of experimental noise and various artifacts that may limit the PPG applicability. Various filtration techniques are typically applied to the PPG signal for denoising prior to the calculation of the physiological parameters that can be used for health condition estimations, such as heart rates. While, indeed, application of filtering may decrease the amount of noise in the data and does not demonstrate any negative effect on the heart rate estimation, the dynamic properties of the complex PPG signal might be affected. This study explores the effects produced by commonly used filtration techniques on the dynamical characteristics of the PPG signal. Among various types of the PPG, the signal measured with green light is investigated.

Special Short Session II
15:50-16:05 on February 12

Interaction between two intruders in granular flow

Takahiro Tanabe[1] , Hisao Hayakawa[2] and Hiraku Nishimori[3]
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Abstract

There are various effective interactions in nonequilibrium situations, for examples, depletion force, which is an attractive force between suspending large colloidal particles in a dilute solution, and Casimir-like force in jammed-granular system, which shows both the attractive and repulsive interactions due to long-ranged fluctuations [1, 2]. Although there are variety of interactions depending on the environments, we focus on the interactions in two-dimensional granular media.

Since granular materials are of significant for our daily life and industrial applications, it is one of the important themes to understand the behavior of the interaction in the granular flow. Recently, the studies of the drag forces for one-intruder in the granular media have been proposed, nevertheless, there are few studies of the interactions between intruders in granular media [3]. In this presentation, we consider the interactions between two intruders surrounded by granular disks on a plane under a uniform flow and oscillatory flow based on discrete element method (DEM) simulations.

The interaction is repulsive under uniform granular disks flow. By contrast, the interaction shows both attractive and non-attractive interactions under oscillatory flow depending on their oscillation conditions. We will discuss the mechanism and origin of the interactions.

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Special Short Session II
16:05-16:20 on February 12

Competitor-mediated coexistence and complex patterns in a three-species competition-diffusion system

Lorenzo Contento[1] and Masayasu Mimura[2]

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The competitive exclusion principle states that two biological species competing for the same limited resources cannot coexist, resulting in the eventual extinction of one of them. However, a rich biodiversity is observed in natural ecosystems. The search for the mechanisms behind such biodiversity is an ongoing field of research in theoretical ecology. One of such mechanisms is competitor-mediated coexistence, in which coexistence of two competing species is made possible by a third species invading the ecosystem from outside. The simplest model for this phenomenon is a three-species competition-diffusion system of Lotka-Volterra type. For some choices of the parameters, such system admits two different stable one-dimensional traveling wave solutions. Depending on their relative velocity, such waves interact in several different ways and the study of such interaction offers insight about whether or not coexistence occurs in two-dimensional domains.

Special Short Session III
16:35-16:50 on February 12

Machine-learning inference of variables of a chaotic fluid flow from data using reservoir computing

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Abstract

We infer macroscopic behaviors of a three-dimensional fluid flow with chaotic behaviors using reservoir computing. A reservoir is a recurrent neural network whose internal parameters are not adjusted to fit the data in the training process. What is done is to train the reservoir by feeding it an input time-series and fitting a linear function of the reservoir state variables to a desired output time-series. Due to this approach of reservoir computing we can save a great amount of computational costs, which enables us to deal with a complex deterministic behavior.

Recently it is reported that the reservoir computing is effective in the inference of time-series and some characteristics using the Lorenz system, Rossler system and Kuramoto-Sivashinsky system. We apply the same method to a chaotic fluid flow.

In our procedure of the inference, we assume no prior knowledge of a physical process of a fluid flow except that its behavior is complex but deterministic. We present an inference of the complex behavior, which requires only past time-series data as training data.

We show that the reservoir dynamics constructed from only past data of energy functions can infer the future behavior of energy functions and reproduce the energy spectrum. It is also shown that we can infer a time-series data from only one measurement by using the delay coordinates. These imply that the obtained two reservoir systems constructed without the knowledge of microscopic data are equivalent to the dynamical systems describing macroscopic behavior of energy functions. It should be remarked that such dynamical systems describing macroscopic behaviors cannot be derived from the Navier-Stokes equation.

Special Short Session III
16:50-17:05 on February 12

Application of Hamiltonian Monte Carlo Method to Bayesian Estimation of Sika Deer Population Dynamics for Effective Wildlife Management.

Tomoro Kimura[1] and Kazuyuki Nakamura[1,2,3]

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Abstract

For the past several decades, overabundant deer have caused problems across Japan. In Hokkaido prefecture, agricultural damage exceeded five billion yen in 1996. For ecosystem management, it is necessary to estimate population and to lead them to desirable state artificially. To estimate deer population dynamics temporally and spatially, state-space models integrating multiple observation data are suitable. These models often include high dimensional parameters and complex distributions. Markov chain Monte Carlo (MCMC) method is generally adopted for the parameter estimation. Especially, many previous researches have applied Gibbs sampling which is one of an algorithm of MCMC method. However, this algorithm requires too much time for calculation in the case of large parameter size.

In this study, we adopted Hamiltonian Monte Carlo (HMC) method instead of Gibbs sampling. HMC method is also one of a MCMC algorithm. We can obtain samples from target distribution quickly with this algorithm. To verify its efficiency, we conducted numerical experiment. We estimated deer population using simulation data with the two algorithms respectively, and compared those results. As a result, it was confirmed that the number of samples which must be abandoned as burn-in period and thinning interval is very small in HMC method. Deer population model applied in this research includes more than 200 parameters and complex distributions such as Gaussian CAR model which express spatial correlations. We conclude that HMC method is efficient algorithm for estimation of deer population dynamics. This method enables us to expand models with higher dimensional parameters. Through such expansion, HMC method will promote beneficial discovery of new ecological knowledge for sustainable ecosystem management.

Special Short Session III
17:05-17:20 on February 12

Nonparametric inference for Lévy models

Kengo Kato, Cornell University
Daisuke Kurisu*, Tokyo Institute of Technology

1 Abstract

This paper develops bootstrap methods to construct uniform confidence bands for nonparametric spectral estimation of Lévy densities under high-frequency observations. We assume that we observe n discrete observations at frequency $1/\Delta > 0$, and work with the high-frequency setup where $\Delta = \Delta_n \to 0$ and $n\Delta \to \infty$ as $n \to \infty$. We employ a spectral (or Fourier-based) estimator of the Lévy density, and develop novel implementations of Gaussian multiplier (or wild) and empirical (or Efron's) bootstraps to construct confidence bands for the spectral estimator on a compact set that does not intersect the origin. We provide conditions under which the proposed confidence bands are asymptotically valid. Our confidence bands are shown to be asymptotically valid for a wide class of Lévy processes. We also develop a practical method for bandwidth selection (inspired by the idea in Bissantz et al. (2007)), conduct simulation studies to investigate the finite sample performance of the proposed confidence bands, and apply the proposed method to the Lévy density of the 15 minute bars data of log-GBP/AUD exchange rate.

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Special Short Session III
17:20-17:35 on February 12

On the Error of Realized Measures of Volatility in Finance

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Abstract

For estimating daily volatility with high-frequency data in financial markets, several realized measures of volatility have been introduced such as the two-scale (TS) estimator, the realized kernel (RK) estimator, the pre-averaging (PA) estimator and the separating information maximum likelihood (SIML) estimator. Even though they are all consistent estimators of true volatility, actual estimates do not coincide among them in empirical analysis. Therefore, it is worth making a comparison on these estimators.

First, we investigate the finite sample properties of the estimators of the integrated volatility based on a set of simulations. The SIML estimator seems to have robustness to the forms of noise, even though it is not the best in respect to the convergence rate in a standard case. Second, empirical analysis is conducted with these estimators. We assess the fitting to some time series models such as heterogeneous autoregressive (HAR) model and the accuracy of prediction of value-at-risk (VaR) among the competing estimates. Third, our discussion is extended to multivariate case, in which the major interest is to estimate realized covolatility and correlation for the purpose of hedging and portfolio management.

In addition, we incorporate the realized measurement error, which is defined as the difference between estimates of realized measures and true (latent) volatility, by state space modeling and filtering.

Invited Session 6: Data Science II
10:00-10:30 on February 13

Nonlinear independent component analysis: A principled framework for unsupervised deep learning

Aapo Hyvärinen

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Dept of Computer Science,
University of Helsinki, Finland

Abstract

Unsupervised learning, in particular learning general nonlinear representations, is one of the deepest problems in machine learning. Estimating latent quantities in a generative model provides a principled framework, and has been successfully used in the linear case, e.g. with independent component analysis (ICA) and sparse coding. However, extending ICA to the nonlinear case has proven to be extremely difficult: A straightforward extension is unidentifiable, i.e. it is not possible to recover those latent components that actually generated the data. Here, we show that this problem can be solved by using additional information either in the form of temporal structure or an additional, auxiliary variable. We start by formulating two generative models in which the data is an arbitrary but invertible nonlinear transformation of time series (components) which are statistically independent of each other. Drawing from the theory of linear ICA, we formulate two distinct classes of temporal structure of the components which enable identification, i.e. recovery of the original independent components. We show that in both cases, the actual learning can be performed by ordinary neural network training where only the input is defined in an unconventional manner, making software implementations. We further generalize the framework to the case where instead of temporal structure, an additional auxiliary variable is observed (e.g. audio in addition to video). Our methods are closely related to "self-supervised" methods heuristically proposed in computer vision, and further provide a theoretical foundation for such methods.

The talk is based on the following papers:
`http://www.cs.helsinki.fi/u/ahyvarin/papers/NIPS16.pdf`
`http://www.cs.helsinki.fi/u/ahyvarin/papers/AISTATS17.pdf`
`https://arxiv.org/pdf/1805.08651`

Invited Session 6: Data Science II
10:30-11:00 on February 13

Nonsmooth Convex Optimization and Sparse Regularization in Signal and Information Processing

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Abstract

In this talk, we give an introductory overview of nonsmooth convex optimization and sparse regularization techniques with applications to signal and information processing. Specifically, we start by introducing L1 regularized sparse estimation as a typical example of nonsmooth convex optimization. Then, we move on to various application examples, including signal reconstruction and decomposition, image restoration, remote sensing, and graph signal processing, which illustrate the power of sparse regularization techniques via convex optimization.

Invited Session 6: Data Science II
11:00-11:30 on February 13

A semi-parametric spatiotemporal Hawkes-type point process model with periodic background for crime data

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Jorge Mateu *University Jaume I of Castellón, Castellón, Spain*

Past studies have shown that crime events are often clustered[1]. Different from past studies, where the excitation effect has been emphasized, we focus on disentangling the periodic components from the long-term trend in the background rate. The reason for such a separation is straightforward: crime behavior is influenced by the criminal's biological clock and the rhythms of our social life. This study proposes a new spatiotemporal Hawkes-type point process model which has a conditional intensity in the form of:

$$\lambda(t,x,y) = \mu_0\,\mu_{\rm t}(t)\,\mu_{\rm d}(t)\,\mu_{\rm w}(t)\,\mu_{\rm b}(x,y) + A\int_{-\infty}^{t_-}\iint_S g(t-s)\,h(x-u,y-v)\,N({\rm d}u\times{\rm d}v\times{\rm d}s), \quad (1)$$

where the $\mu_{\rm t}(t)$, $\mu_{\rm d}(t)$, and $\mu_{\rm w}(t)$ represent the trend term, the daily periodicity, and the weekly periodicity in the temporal components of the background rate, respectively, $\mu_{\rm b}(x,y)$ represents the spatial homogeneity of the background rate, and $g(t-s,x-u,y-v)$ represents the subprocess triggered by an event previously occurring at location (u,v) and time s. average values of the trend term $\mu_{\rm t}(t)$, the daily periodicity $\mu_{\rm d}(t)$, $\mu_{\rm w}(t)$, and the weekly periodicity $\mu_{\rm b}(x,y)$ are all normalized to 1, the temporal response g and spatial response h are p.d.f.s for the clustering component, and two relaxation coefficients,A and μ_0, are introduced to stabilize and fasten the estimation process. Consequently, we generalize the stochastic reconstruction technique,[2,3] which has been used to estimate Hawkes-type models with a simple background rate, to extract and to estimate different periodic components from the background rate. We introduce an E-M type iterative algorithm to estimate the two relaxation parameters by using MLE and all the functions in the conditional intensity simultaneously.

This model is used to analyze the robbery-related violence data in Castellon city, Spain, during the years of 2012 and 2013. The results show that the robbery crime is highly influenced by the daily life rhythms, revealed by its daily and weekly periodicity, and that about 3% of such crimes can be explained by clustering. Further diagnostic analysis show that the model could be improved by considering the following ingredients: (1) The daily occurrence patterns are different between weekends and working days; (2) in the city center, robbery activity shows different temporal patterns, in both weekly periodicity and long-term trend, from other suburb areas.

References

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[3] J. Zhuang, Y. Ogata, and D. Vere-Jones. Analyzing earthquake clustering features by using stochastic reconstruction. *Journal of Geophysical Research*, 109(3):B05301, 2004.

Invited Session 7: Financial Time Series Modeling
13:00-13:30 on February 13

Dynamics of Commercial Real Estate Market in Tokyo

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The subprime problem 10 years ago triggered the global economic crisis, which was the manifestation of the potentially risks in the securitized financial products in the US real estate market (eg. mortgage backed securities). The development of securitization technology has made the correlation between the financial markets and real estate markets increasing, so that the risk of the economic crisis due to the collapse of the market is increasing. In U.S., the Case-Shiller house price index (Case and Shiller (1987)) widely used in practice. Meanwhile, domestically house price indices based on transaction data has been made by the Ministry of Land, Infrastructure and Transport (Shimizu et al. (2010)). However, the indices that adequately indicate price trends in the commercial real estate market have not fully developed since the access to the transaction records in real estate market has been restricted generally. Therefore, in order to accurately express the dynamics of the commercial real estate market, we have firstly developed not only price indices but also rent and investment return indices in Tokyo, base on hedonic approach. These indices can be beneficial to investors in the real estate markets. Secondly, we have extracted trends of the real estate to adequately understand the market, based on a seasonal adjustment model proposed by Gersch and Kitagawa (1983) and Kitagawa and Gersch (1984). The specific characteristics in the commercial real estate market in Tokyo will be discussed.

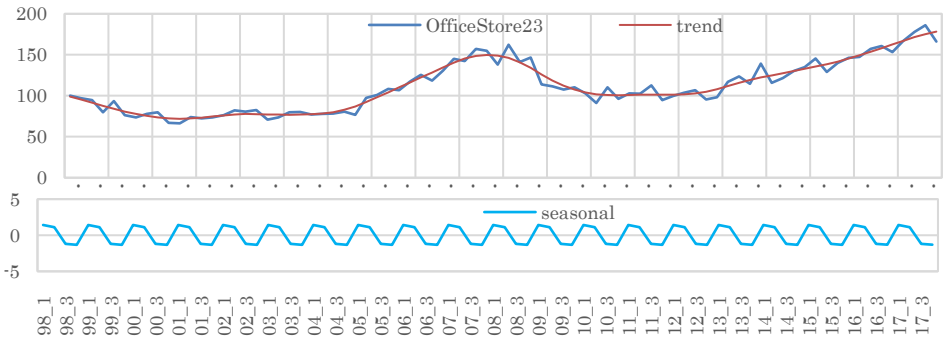

Fig. Market Trend in Commercial Real Estate

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Invited Session 7: Financial Time Series Modeling
13:30-14:00 on February 13

On Trend Change Factors of Financial Markets

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Seisho Sato, Graduate School of Economics, The University of Tokyo
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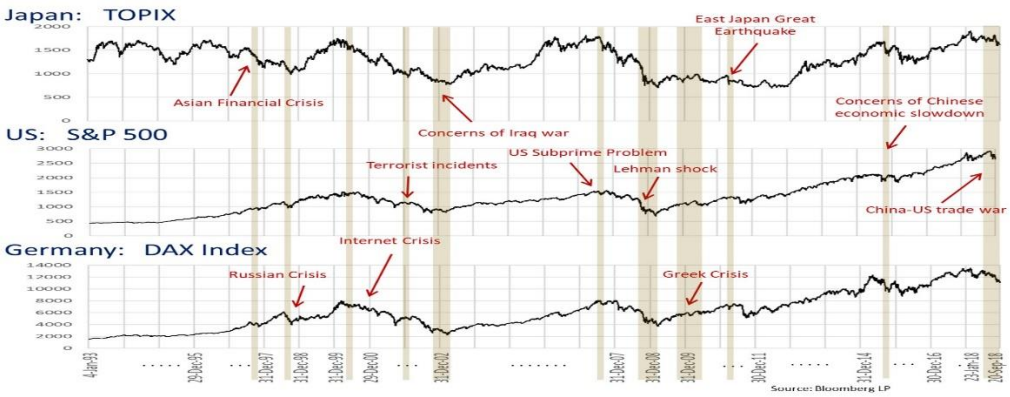
Political events and economic problems in one country have increasingly influenced the economies and financial markets worldwide. For example, the global economic crisis occurred at the end of 2008 was first triggered by the US subprime mortgage problem in the summer of 2007. In a financial market, a trend of the asset price can be regarded as the gradually changing long-term fluctuations caused by characteristics specific to the asset. On the other hand, the short-term cyclical fluctuations around the trend can sensitively be influenced by those of any other asset prices, and they may behave as only a price adjustment or may lead to a future change in the trend direction. Aiming to analyze factors causing changes of the trend, we extract the trend component from a financial market index, based on a seasonal adjustment model proposed by Gersch and Kitagawa (1983) and Kitagawa and Gersch (1984). Then, we investigate the fluctuation structures of the return series of the TOPIX (Japan), S&P 500 (USA) and the DAX (Germany), focusing on the mutual relationship of their trend component fluctuations for about 25 years, by conducting generalized power contribution analysis (Tanokura and Kitagawa 2015). This talk will report the characteristics of these fluctuations.



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