Workshop in Honor of Yury Kutoyants’ 70th Birthday

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Delphine Blanke

Global smoothness estimation of a Gaussian process

Thursday, 16:00 – 16:30

We consider a real Gaussian process \( X \) with global unknown smoothness \((r_0, \beta_0)\): more precisely \( X^{(r_0)} \) is supposed to be locally stationary with Hölder exponent \( \beta_0, \beta_0 \in [0, 1] \). For \( X \) observed at a finite set of points, we derive estimators of \( r_0 \) and \( \beta_0 \) based on the quadratic variations for the divided differences of \( X \). Under mild conditions, we obtain an exponential bound for estimating \( r_0 \), as well as sharp rates of convergence for the estimation of \( \beta_0 \). A simulation study illustrates the finite-sample properties of both estimators for different types of processes.

Joint work with Céline Vial (University of Lyon 1)

Denis Bosq

Detecting jumps in the context of \( p \) derivatives and for Poisson processes

Friday, 9:00 – 9:35

In this talk, we consider the PARD\(^{(p)}(1)\) process, where \( D \) is the space of cadlag function and the \( p \)th derivative has a possible jump. One envisages to detect position and intensity of jump in the context of \( p \) observed derivatives with continuous or discrete data. We also detect jumps for the estimated \((p + 1)\) derivative. In the second part, we consider Poisson process with detection of fixed jump. Asymptotic consistency of our estimators are obtained.
Marat Burnashev

*On Detection of Gaussian Stochastic Signals in White Gaussian Noise*

Friday, 14:00 – 14:35

Some problems of detection of Gaussian Stochastic Signals with partially unknown covariance in White Gaussian Noise are considered.

Igor Cialenco

*Trajectory Fitting Estimator for linear SPDE*

Thursday, 10:45 – 11:20

While the theory of statistical inference for stochastic ordinary differential equations (SODEs) represents a mature field, its counterpart for stochastic evolution equations in infinite dimension is still in its earlier stage of development. Traditionally, the parameter estimation problem for stochastic partial differential equations (SPDEs) is mainly studied by means of maximum likelihood estimators. In this talk we propose a new type of estimators for the drift parameter of a large class of SPDEs, called the Trajectory Fitting Estimator (TFE). This estimators can be viewed as an analog to the TFE for SODEs or to the least square estimator from the time series analysis. We will discuss consistency and asymptotic normality of such estimators for linear evolution equations driven by additive space-time noise (possible colored in space). One of the key difference between SPDEs and SODEs, from statistical inference point of view, is the possibility to study asymptotics in large number of spatial points (or large number of Fourier modes), besides large times or small noises, and this is the asymptotic regime we focus our study on. We will conclude the talk with several illustrative examples.

*Joint work with Ruoting Gong (Illinois Institute of Technology), and Yicong Huang (Illinois Institute of Technology)*
In this work we consider the estimation problems for a diffusion process following the model:

\[ d\xi_t = f(\theta, t)\xi_t dt + dB_t \]

where \( f : \mathbb{R} \times \Theta \rightarrow \mathbb{R} \) is a continuous function, periodic in \( t \) with a known period \( P > 0 \) and \( \Theta \subset \mathbb{R} \).

When the process is observed in continuous time \([0, T]\) and \( T \rightarrow \infty \), the maximum likelihood estimator of \( \theta \) is consistent and we point out its efficiency. The results comply with those obtained in [1] for the particular case \( f(\theta, t) = \theta f(t) \).

When the process is discretely observed at times \( t_j = j\Delta_n \) in the interval \([0, n\Delta_n]\), with \( \Delta_n \rightarrow 0 \) and \( n\Delta_n \rightarrow \infty \) as \( n \rightarrow \infty \), we study maximum contrast estimators of \( \theta \). Following [2], these estimators are consistent. Here we investigate the asymptotic law and the efficiency of these estimators of \( \theta \).

References:


The talk deals with recovering an unknown random process \( f(t) \), \( t \in [0, 1] \), from the noisy observations

\[
dY_\epsilon(t) = f(t)dt + \epsilon dW(t), \quad t \in [0, 1],
\]

where \( W(\cdot) \) is a standard Wiener process. It is assumed that \( f(\cdot) \) is a smooth function, i.e.

\[
\sqrt{\mathbb{E}[f^{(m)}(t)]^2} = Q(t),
\]

where \( f^{(m)}(t) \) stands for the derivative of order \( m \) of \( f(t) \). It is well known that if \( Q(t) \) is known one can construct easily an estimate \( \hat{f}_Q(t, Y_\epsilon) \) linear in \( Y_\epsilon(\cdot) \) such that

\[
\mathbb{E} \int_0^1 \left| \hat{f}_Q(t, Y_\epsilon) - f(t) \right|^p dt \simeq \epsilon^p \int_0^1 \left[ \frac{Q(t)}{\epsilon} \right]^{p/(2m+1)} dt, \quad \text{as} \quad \epsilon \to 0.
\]

Our main goal is to construct an estimate of \( f(t) \) such that, on the one hand, it does not depend on \( Q(t) \) and, on the other hand, it has \( L_p \)-risk similar to the one of \( \hat{f}_Q(t, Y_\epsilon) \).

The proposed estimate called Nonparametric Smoothing Spline is computed in two steps:

1. Cascade compression of the data \( Y_\epsilon(t) \), \( t \in [0, 1] \).
2. Reconstruction the underlying process from the compressed data with the help of the convex programming algorithm proposed by A. Nemirovski in 1985.
The joint law of the terminal values of a nonnegative submartingale and its compensator

Friday, 15:40 – 16:15

Let $X$ be a nonnegative submartingale of class $(D)$ starting from 0 with the Doob–Meyer decomposition $X = M + A$. Our main result is a characterization of the set of all possible joint distributions $\text{Law}(X_\infty, A_\infty)$. We prove, in particular, that, for every integrable law $\mu$ on the positive half-line, there exists an integrable increasing process $B$, $B_0 = 0$, with the compensator $C$, such that (1) $\text{Law}(B_\infty) = \mu$; (2) for every $X$ with $\text{Law}(X_\infty) = \text{Law}(B_\infty)$, $\text{Law}(A_\infty)$ is smaller than or equal to $\text{Law}(C_\infty)$ with respect to convex order; (3) for every $X$ with $\text{Law}(A_\infty) = \text{Law}(C_\infty)$, $\text{Law}(X_\infty)$ is greater than or equal to $\text{Law}(B_\infty)$ with respect to convex order. This fact has important consequences for the theory of martingale inequalities. The extreme cases in (1) and (2) correspond to the class of “remarkable” nonnegative submartingales introduced by Ashkan Nikeghbali (2006).

The work is supported by the Russian Science Foundation under grant 14-21-00162 and performed in Steklov Mathematical Institute of Russian Academy of Sciences

Dynamic Functional Principal Components

Wednesday, 10:50 – 11:25

In this paper, we address the problem of dimension reduction for functional time series. Such time series arise frequently, e.g., when a continuous time process is segmented into some smaller natural units, such as days, each observation representing one intraday curve. We argue that functional principal component analysis (FPCA), which is a key technique in the field, does not provide an adequate dimension reduction in a time series context. FPCA is a static procedure which ignores the essential serial dependence features of the data. Therefore, inspired by Brillinger’s theory of dynamic principal components, we propose a dynamic version of FPCA which is based on a frequency domain approach, and show that it provides the optimal dimension reduction. By means of a simulation study and an empirical illustration, we show the considerable improvement our method entails when compared to the usual (static) procedure.

Based on joint work with Siegfried Hörmann and Łukasz Kidzinski
Reconstructing particle identities in discretely observed branching diffusions with immigration, and an application to nonparametric estimation of diffusions coefficient

Wednesday, 14:35 – 15:10

We consider ergodic branching diffusions with immigration (BDI). In view of inference about the diffusion coefficient of the one-particle motion based on discrete observation of a BDI process at step size $\Delta$, we address the problem of reconstruction of particle identities (note that information about particle trajectories is lost under time-discrete observation of the BDI process). We present an algorithm which allows—using mainly a heat kernel bound assumption on the one-particle motion with position-dependent killing—to reconstruct asymptotically as $\Delta \downarrow 0$ correctly particle identities whenever the number of particles present in the BDI process is non-zero.

We can give conditions under which the invariant occupation measure of the BDI process admits a continuous density. Thus, fixing compact intervals on which this density is strictly positive, and exploiting ergodicity, we can fill regression schemes with ‘reconstructed’ squared increments. This allows to estimate nonparametrically an unknown diffusion coefficient of the one-particle motion from discrete observations of a BDI process.

Joint work with Matthias Hammer, TU Berlin, and Tobias Berg, Universität Mainz

Some results on Lasso-model selection for dynamical systems with small noise and discretely observed ergodic diffusion processes

Friday, 10:45 – 11:20

We will present some results for model selection using Lasso method for dynamical systems with small noise observed in continuous time as well as for ergodic diffusion processes observed at discrete time. In the first case, we consider general $L^p$ constrained method of the moments which allows to perform simultaneous adaptive estimation and model selection of the dynamical system. For multidimensional ergodic diffusion processes we will focus only on $L^1$ constraint quasi-maximum likelihood estimation method under high frequency sampling.
Estimation of infinite-dimensional parameter in $l_p$ spaces

Tuesday, 10:15 – 10:50

1. U. Grenander in his book “Abstract Inferences” (J. Wiley, 1981) has considered the following non-parametric estimation problem. We are observing a sample

$$X_1, X_2, \ldots X_n$$

where the random variables $X_j$ take integer values $1, 2, \ldots$ with the probabilities $\theta(k) = P\{X_j = k\}$. The problem is to estimate the (infinite-dimensional) parameter $\theta = (\theta(1), \theta(2), \ldots)$. In particular U. Grenander proved the following result

**Theorem 1.** If $\sum_{j=1}^{\infty} \sqrt{\theta(j)} < \infty$, then the maximum likelihood estimates (MLE) satisfy the following limit relation

$$\lim_{n \to \infty} \sqrt{n}||\hat{\theta}_n - \theta||_1 = \lim_{n \to \infty} \sum_{j=1}^{\infty} \sqrt{n}||\hat{\theta}_n(j) - \theta(j)|| = \sqrt{\frac{2}{\pi}} \sum_{j=1}^{\infty} \sqrt{\theta(j)(1-\theta(j))}.$$

Here we continue the investigation of U. Grenander.

2. The MLE $\hat{\theta}_n = (\hat{\theta}_n(1), \ldots)$ where $\hat{\theta}_n(k) = \{j, 1 \leq j \leq n : X_j = k\}$. It follows that with probability one $\sqrt{n}(\hat{\theta}_n - \theta) \in l_p$, $1 \leq p \leq \infty$. Denote $l_p$, $0 < p < 1$ the metric space of $x = (x_1, \ldots)$, $\sum_{j=1}^{\infty} |x_j|^p < \infty$ with the metric $\rho(x, y) = \sum_{j=1}^{\infty} |x_j - y_j|^p$; if $\sum_{j=1}^{\infty} (\theta(j))^p < \infty$, then $\sqrt{n}(\hat{\theta}_n - \theta) \in l_p$ with probability one.

Denote $Q_n(p, \theta)$ the distribution of the normed MLE $\sqrt{n}(\hat{\theta}_n - \theta)$ in the space $l_p$. Denote $Q(p, \theta)$ the distribution in $l_p$ of the Gaussian random sequence

$$\eta = (\eta_1, \ldots) = (\xi_1 \sqrt{\theta(1)(1-\theta(1))}, \ldots \xi_k \sqrt{\theta(k)(1-\theta(k)), \ldots})$$

where $\xi_1, \xi_2, \ldots$ are Gaussian random variables such that

$$E\xi_k = 0, E\xi_k^2 = 1, E\xi_k \xi_l = -\sqrt{\frac{\theta(k)\theta(l)}{(1-\theta(k))(1-\theta(l))}}.$$

**Theorem 2.** Let $0 < p \leq \infty$. If $\sum_{k=1}^{\infty} (\theta(k))^{p/2} < \infty$, then the distributions $Q_n(p, \theta)$ converge to the distribution $Q(p, \theta)$, $n \to \infty$. In other words for any real valued bounded continuous in $l_p$ function $\varphi(x)$

$$E_\theta \varphi(\sqrt{n}(\hat{\theta}_n - \theta)) = E_\varphi(\eta).$$
Theorem 3. Let \( l(x) \uparrow x \in [0, \infty) \). There exists a constant \( a > 0 \) such that if \( l(x) \leq \text{const} \cdot e^{ax^2} \), then under the conditions of the previous theorem

\[
\lim_{n} E_{\theta} l\left( \sqrt{n} (\hat{\theta}_n - \theta) \right)_{p} = E l(||\eta||_p), 1 \leq p \leq \infty.
\]

In particular ((cf (1))

\[
\lim_{n} E_{\theta} ||\sqrt{n} (\hat{\theta}_n - \theta) ||^p_p = \frac{1}{\sqrt{2\pi}^p} 2^{p+1} \Gamma\left( \frac{p+1}{2} \right) \sum_{j=1}^{\infty} (\theta(j)(1 - \theta(j)))^{p/2}.
\]

The last equality is valid for all \( p > 0 \).


4. We consider also some analogues of this problem with the observations in continuous time

Partly joint work with V. Ershov
Starting in the late eighties several authors from Berlin in cooperation with colleagues studied stochastic delay differential equations of the type

\[ dX(t) = \int_{-r}^{0} X(t + s)a(ds)dt + dW(t), \quad t \geq 0, \]

where \( a(ds) \) is an arbitrary signed finite measure on \([-r,0]\), \( 0 < r \leq \infty \) and \((W(t), t \geq 0)\) is a Wiener process (Autoregressive Schemas with continuous time). If the measure \( a(ds) \) depends on a parameter \( \vartheta : a(ds) = a_\vartheta(ds), \vartheta \in \Theta \), statistical questions arise. For different families of measures \( a_\vartheta(ds) \) maximum-likelihood-estimators of \( \vartheta \) based on continuous or discrete observations of \( X(t) \) up to some finite time \( T \) are considered. Local asymptotic properties were obtained and sequential estimators were constructed. Numerical procedures to solve the above equation for special classes of measures \( a(ds) \) are mentioned.

The talk is based on work with A.A.Gushchin, Y.Kutoyants, M.Sørensen, V.A.Vasiliev and members of the Berlin SDDE-Team.
Nikolaos Limnios

An Empirical Processes Approach for Semi-Markov Processes Estimators and Applications
Wednesday, 15:10 – 15:45

We are concerned here by the uniform central limit theorem for empirical estimators of semi-Markov processes indexed by functions under the uniformly integrable entropy condition via the martingale difference method for empirical processes. This is a new direction for semi-Markov processes limit theorems which generalize our previous results. This generalization offers a good framework for applications which are given for kernel estimation, copula estimation and bootstrap method.

Joint work with Salim Bouzebda (UTC, LMAC).

Eva Löcherbach

Estimating the interaction graph of stochastic neural dynamics

Thursday, 16:50 – 17:25

We address the question of statistical model selection for a class of stochastic models of biological neural nets. Models in this class are systems of interacting chains with memory of variable length. Each chain describes the activity of a neuron, indicating whether it has a spike or not at a given time. For each neuron, the probability of having a spike depends on the entire time evolution of its presynaptic neurons since the last spike time of the neuron. When the neuron spikes, its potential is reset to a resting level, and all of its postsynaptic neurons receive an additional amount of potential. The relationship between a neuron and its pre- and postsynaptic neurons defines an oriented graph, the interaction graph of the model. We show how to estimate this graph of interactions, based on an observation of the process up to time \( n \), within a growing sequence of observation windows. We prove the consistency of this estimator and obtain explicit error bounds for the probability of wrong estimation of the graph of interactions.

Joint work with Aline Duarte, Antonio Galves and Guilherme Ost.
Hiroki Masuda

On regularized estimation of ergodic diffusion process

Thursday, 15:10 – 15:45

We are concerned here with how to deduce the uniform integrability of a regularized, possibly sparse type quasi-likelihood estimator of an ergodic diffusion process observed at high frequency. For this purpose, we will make use of the general machinery for proving polynomial type uniform tail-probability estimate of a scaled M-estimator, showing how it can carry over to cases of multiple and mixed-rates asymptotics where associated statistical random fields not only may be non-differentiable, but also may fail to be locally asymptotically quadratic.


Joint work with Yusuke Shimizu (Kyushu University).

Tahar Mourid

LAN Condition For Functional Autoregressive Processes

Friday, 11:20 – 11:55

We establish Local Asymptotic Normality and Uniform Local Asymptotic Normality conditions for a class of function space valued autoregressive processes when the correlation operator depends on an unknown one-dimensional parameter. We then derive Hajek minimax bound, consistency, asymptotic normality and efficiency of the conditional maximum likelihood estimator yielding their optimality. A simulation studies illustrate the performance of the estimators.

A joint work with Nesrine Kara Terki
Ilia Negri

**Moment convergence of Z-estimators**

Wednesday, 17:25 – 18:00

The problem to establish the asymptotic distribution of statistical estimators as well as the moment convergence of such estimators has been recognized as an important issue in advanced theories of statistics. This problem has been deeply studied for $M$-estimators for a wide range of models by many authors. The purpose of this paper is to present an alternative and apparently simple theory to derive the moment convergence of $Z$-estimators. In the proposed approach the cases of parameters with different rate of convergence can be treated easily and smoothly and any large deviation type inequalities necessary for the same result for $M$-estimators do not appear in this approach. Applications to the model of i.i.d. observation, Cox’s regression model as well as some diffusion process are discussed.

*Joint work with Yoichi Nishiyama, Waseda University.*

Mark Podolskij

**Edgeworth expansion for Euler approximation of continuous diffusion processes**

Thursday, 9:35 – 10:10

In this talk we present the Edgeworth expansion for the Euler approximation scheme of a continuous diffusion process driven by a Brownian motion. Our methodology is based upon a recent work of Yoshida, which establishes Edgeworth expansions associated with asymptotic mixed normality using elements of Malliavin calculus. Potential applications of our theoretical results include higher order expansions for weak and strong approximation errors associated to the Euler scheme, and for studentized version of the error process.

*Joint work with B. Veliyev and N. Yoshida*
**Large deviations for the Ornstein-Uhlenbeck process without tears**

Wednesday, 16:15 – 16:50

The goal of this talk is to investigate large deviations for the maximum likelihood estimator of the drift parameter of the Ornstein–Uhlenbeck process without tears. We propose a new strategy to establish large deviation results which allows us, via a suitable transformation, to circumvent the classical difficulty of non-steepness. Our approach holds in the stable case where the process is positive recurrent as well as in the unstable and explosive cases where the process is respectively null recurrent and transient. We also extend our approach to the Ornstein–Uhlenbeck process with shift, as well as to the Cox–Ingersoll–Ross process.

*Joint work with Bernard Bercu, Université de Bordeaux.*

**Rough Volatility and Leverage Effect: From Microstructural Foundations to Smile**

Thursday, 14:00 – 14:35

It has been recently shown that rough volatility models reproduce very well the statistical properties of low frequency financial data. In such models, the volatility process is driven by a fractional Brownian motion with Hurst parameter of order 0.1. Furthermore, it is very well-known that volatility and price movements are correlated, through the so-called leverage effect phenomenon. The goal of this talk is first to explain how fractional dynamics and leverage effect can be obtained from the behaviour of market participants at the microstructural scales. Using Hawkes processes, we show that these features naturally arise in the presence of high frequency trading under no arbitrage condition. Then we will demonstrate that such result enables us to derive an efficient pricing method for rough volatility models.

*This is joint work with Omar El Euch, Masaaki Fukasawa, Jim Gatheral and Thibault Jaisson.*
Valentin Solev

*On a problem of adaptive estimation in stationary noise*

Friday, 14:35 – 15:10

We study the nonparametric estimation of unknown function in stationary noise as the unknown function belongs to a given convex subset of the Stepanov class of pseudo-periodic functions. We construct simple nonlinear estimators which are adaptive with respect to the unknown spectral density of noise. The asymptotic properties of the adaptive estimators are obtained.

Michael Sørensen

*Efficient estimation for high frequency data*

Thursday, 9:00 – 9:35

Estimation for high frequency observations of stochastic differential equation models by means of approximate martingale estimating functions is discussed with particular focus on rate optimality and efficiency. This approach covers most estimators proposed in the literature. We discuss the effect of a bounded observation interval and the effect of jumps on the efficiency of the estimators. For models without jumps Godambe-Heyde optimal estimating functions are efficient, but this is rarely the case in the presence of jumps.

References:


*The lecture is based on joint work with Nina Munkholt Jakobsen*
Masayuki Uchida

Bayes type estimators and hybrid estimators for diffusion processes based on reduced data
Thursday, 11:20 – 11:55

We consider parametric estimation for both drift and diffusion coefficient parameters of ergodic diffusion processes based on high frequency data. By means of the Bayes type estimation with reduced high frequency data, we obtain an initial estimator with a non-optimal rate of convergence. A hybrid estimator is defined by using the adaptive maximum likelihood (ML) type method with the initial Bayes type estimator. We apply the Ibragimov-Has’minskii-Kutoyants program and the polynomial type large deviation inequality for the statistical random field to the Bayes type estimation and the hybrid estimation, and prove that the hybrid estimator has asymptotic normality and convergence of moments. We give an example and simulation results on the finite sample behavior of the hybrid estimators.

Joint work with Yuto Yoshida

Nakahiro Yoshida

Recent developments in asymptotic expansion for non-ergodic systems
Wednesday, 14:00 – 14:35

We discuss applications of the martingale expansion for a martingale with a mixed normal limit. With the aid of the quasi likelihood analysis (QLA), we derive asymptotic expansions of the quasi maximum likelihood estimator (QMLE), the quasi Bayesian estimator (QBE) and the hybrid one-step estimator in the volatility parametric estimation.
Assume that we observe a process \( X = (X_t, 0 \leq t \leq T) \) satisfying the following system of stochastic differential equations:

\[
\begin{align*}
    dX_t &= h_t Y_t \, dt + \varepsilon \, dW_t, \quad X_0 = 0, \\
    dY_t &= g_t Y_t \, dt + \varepsilon \, dV_t, \quad Y_0 = y_0 \neq 0, \quad 0 \leq t \leq T,
\end{align*}
\]

where \( W_t \) and \( V_t, 0 \leq t \leq T, \) are two independent Wiener processes. The process \( Y = (Y_t, 0 \leq t \leq T) \) is not observed directly, but it is the one that should be controlled.

The problem of asymptotically efficient estimation of different functions on \( 0 \leq t \leq T \) under a small noise, i.e., as \( \varepsilon \to 0, \) is considered. Kutoyants' ideas on handling this type of problems lead to constructing kernel-type estimators for the functions \( f_t := h_t y_t, h_t, y_t, g_t, 0 \leq t \leq T. \)

Here \( y_t, 0 \leq t \leq T, \) stands for the solution of the above model with both noise terms dropped. Lower bounds on the rate of convergence of asymptotically efficient estimators are obtained. The estimators at which these lower bounds are attained are constructed explicitly.

Joint work with Yu. Kutoyants (Université du Maine)

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Workshop in Honor of Yury Kutoyants’ 70th Birthday

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