Wednesday morning, 22.05.2024

8:30–9:00	*Registration*
9:00–9:30	**Frank van der Meulen** (VU Amsterdam) *Simulating conditioned diffusions on manifolds*
9:30–10:00	**Ruben Seyer** (Chalmers & University of Gothenburg) *Differentiating MCMC algorithms with parallel universes*
10:00–10:30	**Moritz Schauer** (Chalmers & University of Gothenburg) *Guided smoothing and control for diffusion processes*
10:30–11:00	*Coffee break*
10:50–11:20	**John Schoenmakers** (WIAS Berlin) *Optimal stopping with randomly arriving opportunities to stop*
11:20–11:50	**Niklas Dexheimer** (Aarhus University) *Data-driven optimal stopping: a pure exploration analysis*
11:50–12:20	**Asbjørn Holk Thomsen** (Aarhus University) *Shape optimization for reflected SDE's*
12:20–14:00	*Lunch break*

Wednesday afternoon, 22.05.2024

14:00–14:30 **Junichiro Yoshida** (University of Tokyo)
Quasi-maximum likelihood estimation and penalized estimation under non-standard conditions

14:30–15:00 **Sascha Gaudlitz** (HU Berlin)
Statistical inference in semi-linear SPDEs with spatial ergodicity

15:00–15:30 **Teppei Ogihara** (University of Tokyo)
Malliavin calculus techniques for local asymptotic mixed normality and their application to hypoelliptic diffusions

15:30–16:00 *Coffee break*

16:00–16:30 **Jan Albrecht** (University of Potsdam)
Approximate likelihood for heterogeneity estimation in integrated diffusion processes

16:30–17:00 **Francesco Iafrate** (Sapienza University of Rome)
Adaptive elastic-net estimation for ergodic diffusion processes

Thursday morning, 23.05.2024

9:00–9:30	**Orimar Sauri** (Aalborg University) *Asymptotic error distribution of the Euler Scheme for fractional stochastic delay differential equations with additive noise*
9:30–10:00	**Johannes Brutsche** (University of Freiburg) *Pathwise stability for change-point estimation in the volatility of (fractional) Brownian motion*
10:00–10:30	**Fabian Mies** (TU Delft) *Likelihood asymptotics for stationary Gaussian arrays*
10:30–11:00	*Coffee break*
10:50–11:20	**Francisco Pina** (University of Luxembourg) *Drift parameter estimation of discretely observed high-dimensional diffusion processes*
11:20–11:50	**Bastian Schroeter** (Kiel University) *Nonparametric change-point analysis of multidimensional volatility*
11:50–12:20	**Nicolas Lengert** (University of Luxembourg) *Limit theorem for functionals of local time of Brownian motion*
12:20–14:00	*Lunch break*

Thursday afternoon, 23.05.2024

14:00–14:30	**Markus Bibinger** (University of Würzburg) *Statistical analysis of a stochastic boundary model for high-frequency data from a limit order book*
14:30–15:00	**Sven Karbach** (University of Amsterdam) *Continuous-time autoregressive moving average processes on cones*
15:00–15:30	**Angelika Silbernagel** (University of Siegen) *Testing for dependence between time series using multivariate extensions of ordinal patterns*
15:30–16:00	*Coffee break*
16:00–16:30	**Kasper Bågmark** (Chalmers, Gothenburg) *An energy-based deep splitting method for the nonlinear filtering problem*
16:30–17:00	**Nilton Ávido** (University of Porto) *Parameter estimation in a partially observed hypoelliptic linear stochastic differential equation: a simulation study*
17:00–17:15	*DYNSTOCH matters*
19:00	*Conference Dinner, Forstbaumschule*

Friday morning, 24.05.2024

8:30–9:00	*Registration*
9:00–9:30	**Eric Ziebell** (HU Berlin) *Non-parametric estimation for the stochastic wave equation*
9:30–10:00	**Anton Tiepner** (Aarhus University) *Parameter estimation in hyperbolic linear SPDEs from multiple local measurements*
10:00–10:30	**Masayuki Uchida** (Osaka University) *Statistical parametric estimation for a linear parabolic SPDE in two space dimensions based on temporal and spatial increments*
10:30–11:00	*Coffee break*
10:50–11:20	**Gregor Pasemann** (HU Berlin) *Diffusivity estimation for a stochastic heat equation from noisy observations: nonparametric theory and semigroup approximation*
11:20–11:50	**Ivo Richert** (Kiel University) *Quasi-maximum likelihood estimation of partially observed affine and polynomial processes*
11:50–12:20	**Randolf Altmeyer** (University of Cambridge) *Polynomial time guarantees for sampling based posterior inference*

Jan Albrecht (University of Potsdam)

Approximate likelihood for heterogeneity estimation in integrated diffusion processes

Joint with Manfred Opper, Robert Großmann

We consider a discretely observed integrated diffusion model with mixed effects. Such models describe, for example, the motility of heterogeneous populations of microorganisms, when their velocity is modeled by a diffusion process. The second-order nature of the model makes the observations non-Markovian, and the two layers of stochasticity introduce additional challenges for inference. In such setups, the likelihood of the parameters is generally not tractable. For models with additive noise, we propose an approximate maximum likelihood approach to estimate the mixed effects. To this end we derive an approxi- mate SDE with colored noise for the observed displacements and approximate their joint probability with a Gaussian. Combining this with a stochastic EM-algorithm leads to an estimate for the heterogeneity parameters. We validate the approach for models with different drift terms using simulated data. Additionally, we show how the approximated likelihood simplifies to an effective Markov description in the fast sampling limit.

Randolf Altmeyer (University of Cambridge)

Polynomial time guarantees for sampling based posterior inference

The Bayesian approach provides a flexible framework for a wide range of nonparametric inference problems. It relies crucially on computing functionals with respect to the posterior distribution, such as the posterior mean or posterior quantiles for uncertainty quantification. Since the posterior is rarely available in closed form, this is based on Markov chain Monte Carlo (MCMC) sampling algorithms. The runtime of these algorithms until a given target precision is achieved typically scales exponentially in the model dimension and the sample size. In contrast, in this talk we will see that sampling based posterior inference in a general high-dimensional setup is feasible, even without global structural assumptions such as strong log-concavity of the posterior. Given a sufficiently good initialiser, we present polynomial-time convergence guarantees for a widely used gradient based MCMC sampling scheme. The key idea is to combine posterior contraction with the local curvature induced by the Fisher information of the statistical model near the data generating truth. We will discuss applications to high-dimensional logistic and Gaussian regression.

Nilton Ávido (University of Porto)

Parameter estimation in a partially observed hypoelliptic linear stochastic differential equation: a simulation study

Joint with Paula Milheiro–Oliveira

Hypoelliptic stochastic differential equations present some challenges regarding parameter estimation, essentially due to the non-invertibility of the diffusion matrix. In this study, we address the problem of estimating the drift matrix in a linear hypoelliptic stochastic differential equation using partial observations in continuous time. The system under consideration is described by the following 2-dimensional equation:

$$d\begin{bmatrix} X_t^{(1)} \\ X_t^{(2)} \end{bmatrix} = A(\theta)\begin{bmatrix} X_t^{(1)} \\ X_t^{(2)} \end{bmatrix} dt + B\,dW_t\,, \tag{1}$$

with $B = \begin{bmatrix} 0 \\ \sigma \end{bmatrix}$ and σ known, representing the state of the system and the equation

$$dY_t = H\begin{bmatrix} X_t^{(1)} \\ X_t^{(2)} \end{bmatrix} dt + \varepsilon\, d\tilde{B}_t \tag{2}$$

represents the observation process, with $t \in [0, T]$ and $H \neq 0$. The drift matrix A depends on the vector of unknown parameters, denoted by $\theta = (\theta_1, \theta_2)$. Here W_t and $\tilde{B}_t$ are independent standard Wiener processes, and ε is a positive number that approaches zero, $\varepsilon \to 0$.

The maximum likelihood estimator for θ was studied by Koncz (1987) for degenerate n-dimensional systems under complete observation. In the present study, we adapted this estimator to our problem by combining it with the Kalman-Bucy filter. This approach made is an approximation to the Expectation Maximisation (EM) algorithm. As far as we know, the properties of such an estimator in the context of partial observations have not been addressed in the literature and deserve further investigation.

The results presented here refer to the numerical simulation of a harmonic oscillator to which both the EM algorithm and the EM approximation algorithm are applied and compared. The harmonic oscillator describes the dynamic behaviour of an elementary engineering structure subjected to random vibrations.

The unknown parameters represent the oscillator's stiffness and damping coefficients. Based on the literature, a considerable deviation in the estimation of the damping coefficient is expected. For $\varepsilon = 0$, the properties of the MLE of θ are studied in (Prior et al., 2017). In the present work, by means of the numerical simulations, the influence of the observation error on the performance of the estimator is analyzed, as the observation error variance vanishes. Resorting to a large number of simulated paths, the error of the estimator, essentially in terms of the bias and mean square error, is studied.

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Kasper Bågmark (Chalmers, Gothenburg)

An energy-based deep splitting method for the nonlinear filtering problem

Joint with Adam Andersson and Stig Larsson

The problem of estimating the probability density of a continuous state given noisy measurements is called the filtering problem. In the case when the system of states and observations is nonlinear the problem cannot be solved analytically (except in a few special cases). Classical methods, namely particle filters, suffer under the curse of dimensionality in the underlying dimension of the state space. Deep learning is a powerful tool in creating scalable approximations for similar problems. The proposed method combines a deep splitting method, previously used for PDEs and SPDEs [1, 2], with an energy-based approach [4], in order to approximate the solution to the Zakai equation. This is a linear SPDE, whose solution is in fact an unnormalized filtering density. This results in a computationally fast filter that takes observations as input and that does not require re-training when new observations are received [3]. The method is tested on four examples, two linear in one and twenty dimensions and two nonlinear in one dimension. The method shows promising performance when benchmarked against the Kalman filter and the bootstrap particle filter.

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Markus Bibinger (University of Würzburg)

Statistical analysis of a stochastic boundary model for high-frequency data from a limit order book

We propose statistical methods to infer characteristics of a semi-martingale efficient log-price process in a boundary model with one-sided microstructure noise for high-frequency prices of limit orders. We focus on volatility estimation and jump detection. We establish asymptotic results in a high-frequency regime. Convergence rates are shown to be faster than under standard market microstructure noise and hinge on a tail index of the imposed noise distribution. For illustration, we shed light on the related asymptotic properties for point estimation of boundary parameters. We address the estimation of the noise tail index and adaptive inference on the semimartingale.

Johannes Brutsche (Universität Freiburg)

Pathwise stability for change-point estimation in the volatility of (fractional) Brownian motion

Joint with Gabriele Bellerino

The starting point is the problem of identifying changes in time within the specification of volatility in Gaussian noise models. We discuss continuity properties of the corresponding change-point estimators as functions of the discretely observed data and their behaviour when applied to data generated by fractional Brownian motion. The asymptotics under consideration are simultaneously in the sample size n and the Hurst parameter H.

Niklas Dexheimer (Aarhus University)

Data-driven optimal stopping: A pure exploration analysis

Joint with Sören Christensen and Claudia Strauch

The standard theory of optimal stopping is based on the idealised assumption that the underlying process is essentially known. In this paper, we drop this restriction and study data-driven optimal stopping for a general diffusion process, focusing on investigating the statistical performance of the proposed estimator of the optimal stopping barrier. More specifically, we derive non-asymptotic upper bounds on the simple regret, along with uniform and non-asymptotic PAC bounds. Minimax optimality is verified by completing the upper bound results with matching lower bounds on the simple regret. All results are shown both under general conditions on the payoff functions and under more refined assumptions that mimic the margin condition used in binary classification, leading to an improved rate of convergence. Additionally, we investigate how our results on the simple regret transfer to the cumulative regret for a specific exploration-exploitation strategy, both with respect to lower bounds and upper bounds.

Sascha Gaudlitz (HU Berlin)

Statistical inference in semi-linear SPDEs with spatial ergodicity

Joint with Randolf Altmeyer

We consider the non-parametric estimation of the reaction term in a semi-linear parabolic SPDE. Consistency is achieved by making use of the spatial ergodicity of the SPDE while the time horizon is fixed. The analysis of the estimation error requires new concentration results for spatial averages of (delta-like) transformation of the SPDE, which are based the combination of the Clark-Ocone formula with bounds on the marginal densities. The general methodology is exemplified in the asymptotic regime, where the diffusivity level and the noise level of the SPDE tend to zero in a realistic coupling. Both frequentist and Bayesian methods are discussed.

Francesco Iafrate (Sapienza University of Rome)

Adaptive elastic-net estimation for ergodic diffusion processes

We introduce the Adaptive Elastic-net estimator for ergodic diffusion processes sampled under a high-frequency observation scheme. Our method combines adaptive ℓ^1 and ℓ^2 regularization leading to improvements in prediction accuracy and interpretability, while retrieving the sparse latent structure of the model. We show that this estimator has oracle properties in an asymptotic regime with mixed rates, ensuring consistent selection of relevant variables and optimal convergence rates. Additionally, an iterative algorithm for parameter estimation is described, which allow to efficiently compute the full solution path as a function of the penalization parameter. We test the performance of our method on both synthetic data and real world applications.

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Sven Karbach (University of Amsterdam)

Continuous-time autoregressive moving average processes on cones

Joint with F.E. Benth

In this presentation, we explore multivariate continuous-time autoregressive moving average (CARMA) processes with values in convex cones. Specifically, we establish explicit conditions ensuring that vector- and matrix-valued CARMA processes assume values in the positive orthant and the cone of positive semi-definite matrices, respectively. Furthermore, we highlight the application of CARMA processes in modeling dynamic aspects of renewable energy markets, where the positivity of the CARMA class plays an important role in the accurate modeling and simulation of key market variables, such as forward electricity prices and wind speeds

Nicolas Lengert (University of Luxembourg)

Limit theorem for functionals of local time of Brownian motion

Joint with Simon Campese, Mark Podolskij

We present the asymptotic theory for integrated functions of increments of Brownian local times in space. We determine their first-order limit as well as the asymptotic distribution of the fluctuations. Our main result establishes that a standardized version of our statistics convergences stably in law towards a mixed normal distribution.

Fabian Mies (TU Delft)

Likelihood asymptotics for stationary Gaussian arrays

Joint with Carsten Chong (HKUST)

Arrays of stationary Gaussian time series can arise naturally in econometric applications, e.g. as the discretization of continuous-time stochastic processes, or be introduced artificially to model persistency via so-called local-to-unity models, i.e. linear time series models with parameters close to a unit root. For the parametric statistical estimation of these stationary models, the spectral density plays a central role. In particular, classical results in time series analysis suggest that the Gaussian likelihood and Fisher information may be approximated in terms of the spectral density, and conditions for efficiency of the MLE have been formulated in the literature. Unfortunately, these general results do not cover arrays of time series. Our contribution is to show in which way the asymptotic likelihood theory needs to be adapted for the array case, and we demonstrate that this yields a straight-forward approach to study a broad class of processes.

As a motivating example, we investigate the estimation of the mixed fractional Brownian motion based on high-frequency observations. Our findings reveal that the achievable rates of convergence depend intricately on the size of the various components, as well as their intertemporal and crosstemporal dependence structure.

Teppei Ogihara (University of Tokyo)

Malliavin calculus techniques for local asymptotic mixed normality and their application to hypoelliptic diffusions

Joint with Masaaki Fukasawa

We study statistical inference for diffusion processes whose diffusion coefficient is degenerate. Such models arise in the Langevin equation which represents molecular dynamics, and is also related to modeling of the stochastic volatility in finance. We show local asymptotic mixed normality (LAMN) of the statistical models. The LAMN property is important in asymptotic statistical theory and enables us to discuss the asymptotic efficiency of estimators. Gobet (Bernoulli 2001) studied the LAMN property for nondegenerate diffusion processes. We extend his result to degenerate diffusion processes by using the scheme with the L^2 regularity condition proposed in Jeganathan (Sankhyā 1982). We also show the LAMN property for partial observations of degenerate diffusion processes. This model is an extension of the LAMN results in Gloter and Gobet (AIHP PS 2008) for one-dimensional integrated diffusion processes to multi-dimensional one.

Gregor Pasemann (HU Berlin)

Diffusivity estimation for a stochastic heat equation from noisy observations: nonparametric theory and semigroup approximation

Joint with Markus Reiß

We estimate the inhomogeneous diffusivity of a stochastic heat equation from one observed trajectory perturbed by additional observation noise, based on a maximum-likelihood type estimator. In order to account for the inhomogeneity of the diffusivity, we accumulate various local averages from the observed trajectory. The asymptotic analysis of resulting estimator reveals the need for precise approximation theory of Trotter-Kato type for the heat flow, which we will discuss.

Francisco Pina (University of Luxembourg)

Drift parameter estimation of discretely observed high-dimensional diffusion processes

Joint with Chiara Amorino and Mark Podolskij

In this talk, we discuss the parametric statistical inference of the drift function of a high-dimensional diffusion process. In particular, we present an Oracle inequality for the Lasso estimator when the path of the process is observed discretely and under sparsity conditions on the parameter. We will provide error bounds for the estimator and compare it with the case of continuously observed paths. Moreover, we will discuss in detail the contribu- tion of discretization error, understanding its impact on the results.

Ivo Richert (Kiel University)

Quasi-maximum likelihood estimation of partially observed affine and polynomial processes

Joint with Jan Kallsen

In spite of their computational tractability and versatility in modelling real-world phenomena, existing theory on the statistical estimation of parameterised affine or polynomial processes is surprisingly sparse and has yet only focused on specific examples of polynomial diffusions in the past. Moreover, many practical applications such as stochastic volatility or other latent-factor models from financial mathematics lack a full observability of the components of the employed polynomial process, vitiating many classic statistical estimation methodologies.

The present work closes this gap by developing a general framework for estimating affine and polynomial processes partially observed at discrete points in time. This is achieved by developing a canonical discrete-time representation of polynomial processes in the form of a vector-autoregressive model of order one, and then approximating the transition dynamics of this model by those of a Gaussian process with matched first and second moments using the popular Kalman filter. We establish weak consistency and asymptotic normality of the resulting *Quasi-Maximum Likelihood estimators* and derive several easily computable explicit approximations of the asymptotic estimator covariance matrix. In addition, we illustrate our results by using the example of the popular Heston stochastic volatility model from financial mathematics as well as by the example of multivariate Lévy-driven Ornstein–Uhlenbeck processes.

Orimar Sauri (Aalborg University)

Asymptotic error distribution of the Euler scheme for fractional stochastic delay differential equations with additive noise

In this talk we consider the Euler scheme for a class of stochastic delay differential equations driven by a linear fractional α-stable Lévy motion with index $H \in (0,1)$. We stablish the consistency of the scheme and study the limit distribution of the normalized error process. We show that in the rough case, i.e. when $H < 1/\alpha$, the rate of convergence of the simulation error is of order $\Delta_n^{H+1-1/\alpha}$ (Δ_n is the step-size of the scheme) and that the limit process is once again the solution of an (semi-linear) SDDE.

Moritz Schauer (Chalmers & University of Gothenburg)

Guided smoothing and control for diffusion processes

Joint with Oskar Eklund and Annika Lang

The smoothing distribution is the conditional distribution of the process in the space of trajectories given noisy observations made continuously in time. It is generally difficult to sample from this distribution. Motivated by an application of the Bellman principle from optimal control, we use the theory of enlargement of filtrations to show that the conditional process has an additional drift term derived from the backward filtering distribution that is moving or guiding the process towards the observations. This term is intractable, but its effect can be equally introduced by replacing it with a heuristic, with importance correcting for the discrepancy. We derive from this Markov Chain Monte Carlo and sequential Monte Carlo algorithms to sample from the smoothing distribution. The choice of the guiding heuristic is discussed and evaluated.

John Schoenmakers (WIAS Berlin)

Optimal stopping with randomly arriving opportunities to stop

Joint with Josha Dekker, Roger Laeven, Michel Vellekoop

We develop methods to solve general optimal stopping problems with opportunities to stop that arrive randomly. Such problems occur naturally in applications with market frictions. Pivotal to our approach is that our methods operate on random rather than deterministic time scales. More specifically, we convert the original problem, which is essentially defined on a finite time horizon, into an equivalent discrete-time optimal stopping problem with $\mathbb{N}_0$-valued stopping times and an infinite horizon. To numerically solve this problem, we revisit the dual martingale approach, design a random times least squares Monte Carlo method, and analyze an iterative policy improvement procedure in an infinite horizon setting. We illustrate the efficiency of our methods by some numerical case studies.

Bastian Schroeter (Kiel University)

Nonparametric change-point analysis of multidimensional volatility

Joint with Mathias Vetter

This talk highlights the challenges in applying some established change-point methods for statistics of high-frequency data to multidimensional data. The main interest is in the volatility of a continuous d-dimensional Itô semi-martingale the latter of which is discretely observed over a fixed time horizon on increasingly finer grids. We construct a non-parametric statistic to discriminate continuous paths from paths with volatility jumps and show its convergence to a non-parametric statistic. Subsequently, we determine the approximate distribution of this non-parametric statistic. Finally, we outline how this statistic can be used to construct an estimator for the jumps points in the volatility.

Ruben Seyer (Chalmers & University of Gothenburg)

Differentiating MCMC algorithms with parallel universes

Joint with Gaurav Arya, Frank Schäfer, Kartik Chandra, Alexander K. Lew, Mathieu Huot, Vikash K. Mansinghka, Jonathan Ragan-Kelley, Christopher Rackauckas, Moritz Schauer

Analysing the sensitivity of MCMC with respect to design choices of algorithm, prior, or likelihood is difficult due to the discrete nature of the underlying Markov process dynamics. In this talk, we present an algorithm for consistent automatic differentiation of Metropolis-Hastings samplers, viewing the estimator as a functional of a stochastic process. We combine stochastic process gradient estimators, consisting of multiple alternative chains used for unbiased estimation of the gradient in stationarity, with classical Markov chain couplings, yielding a computable random horizon estimator where we otherwise lack convergence guarantees. In fact, using a likelihood ratio method even leads to increasing error with the length of the Metropolis-Hastings chain. Under weak model assumptions our estimator process inherits the convergence properties of the Metropolis-Hastings chain. This provides a general framework that applies to a wide range of research questions about sensitivity and inference; we demonstrate the algorithm on a series of vignettes, including optimization over an Ising model simulation, prior sensitivity analysis in a hierarchical model, and tuning of the Metropolis-Hastings proposal kernel.

Angelika Silbernagel (University of Siegen)

Testing for dependence between time series using multivariate extensions of ordinal patterns

Joint with Christian Weiß and Alexander Schnurr

Since their introduction by Bandt and Pompe in 2002 [1], ordinal patterns have become a popular tool for data analysis. As the name may already suggest, ordinal patterns capture the ordinal structure of the underlying data. In particular, ordinal patterns are able to capture possibly non-linear dependence.

Recently, there has been a growing interest in extending ordinal patterns to multivariate time series in a way that takes potential correlations between the movement of the variables into account. With regard to these extensions, we introduce a general framework for dependence tests between time series under the assumption of serial independence. This also includes ordinal pattern dependence (as considered in [2]) as it can be embedded into the context of multivariate ordinal patterns.

To this end, we prove general limit theorems of multivariate pattern distributions. These encompass some existing results. Then, the performances of the tests are analyzed and compared to classical Pearson's correlation and Spearman's rho by simulations, considering various data-generating processes.

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Asbjørn Holk Thomsen (Aarhus University)

Shape optimization for reflected SDE's

Joint with Sören Christensen (Christian-Albrecht University of Kiel) and Lukas Trottner (Aarhus University)

Stochastic differential equations are ubiquitous in modelling real world phenomena, both in natural sciences, finance and other fields. However, control of such processes has so far been limited to the scalar case. In this talk, we expand this by considering reflection type control of certain reversible diffusion processes in higher dimensions. We consider the long-run average cost as a functional of the domain of reflection, and derive an explicit expression for this. This reduces the problem of optimal control to one of shape optimization, and we propose a gradient based approach to solve this when the optimal shape is assumed to be strongly star-shaped. Finally, we discuss data-driven methods of solving this problem when the underlying dynamics are unknown.

Anton Tiepner (Aarhus University)

Parameter estimation in hyperbolic linear SPDEs from multiple local measurements

Joint with Eric Ziebell

The coefficients of elastic and dissipative operators in a linear hyperbolic SPDE are jointly estimated by means of multiple spatially localised measurements. Given that the spatial resolution level tends to zero, asymptotic normality is established. Under a maximal number of observations, the convergence rates for the coefficients coincide with those from the spectral approach, thus they depend both on the dimension and the differential order of the parameterised elasticity and damping operators. Applications to physical models such as wave or vibrating plate equations are discussed.

Masayuki Uchida (Osaka University)

Statistical parametric estimation for a linear parabolic SPDE in two space dimensions based on temporal and spatial increments

Joint with Yozo Tonaki and Yusuke Kaino

We aim to estimate unknown coefficient parameters of a linear parabolic second-order stochastic partial differential equation (SPDE) in two space dimensions driven by a Q-Wiener process using high-frequency data with respect to time and space. Bibinger and Trabs (2020, SPA) and Hildebrandt and Trabs (2021, EJS) focused on minimum contrast estimators (MCEs) for unknown coefficient parameters of a linear parabolic second-order SPDE in one space dimension driven by a cylindrical Wiener process from high-frequency spatio-temporal data. Their studies successfully proved asymptotic normality of the MCEs. Applying the methodology of Hildebrandt and Trabs (2021) to the SPDE in two space dimensions, we obtain MCEs of the coefficient parameters of the SPDE in two space dimensions based on temporal and spatial increments. Furthermore we develop adaptive estimators of the coefficient parameters based on an approximate coordinate process. It is proved that the adaptive estimators are asymptotically normal under certain regularity conditions. Simulation results of the proposed estimators are also provided.

Frank van der Meulen (VU Amsterdam)

Simulating conditioned diffusions on manifolds

Joint with Marc Corstanje (Vrije Universiteit Amsterdam), Moritz Schauer (University of Gothenburg and Chalmers Technical University), Stefan Sommer (University of Copenhagen)

To date, most methods for simulating conditioned diffusions are limited to the Euclidean setting. The conditioned process can be constructed using a change of measure known as Doob's h-transform. The specific type of conditioning depends on a function h which is typically unknown in closed form. To resolve this, we extend the notion of guided processes to a manifold M, where one replaces h by a function based on the heat kernel on M. We consider the case of a Brownian motion with drift, constructed using the frame bundle of M, conditioned to hit a point x_T at time T. We prove equivalence of the laws of the conditioned process and the guided process with a tractable Radon-Nikodym derivative. Subsequently, we show how one can obtain guided processes on any manifold N that is diffeomorphic to M without assuming knowledge of the heat kernel on N. We illustrate our results with numerical simulations and an example of parameter estimation where a diffusion process on the torus is observed discretely in time.

The paper is at `https://arxiv.org/abs/2403.05409`.

Junichiro Yoshida (University of Tokyo)

Quasi-maximum likelihood estimation and penalized estimation under non-standard conditions

Joint with Nakahiro Yoshida

We develop a general parametric estimation theory that allows the derivation of the limit distribution of estimators under the following two non-standard conditions: (i) The true parameter value may lie on the boundary of the parameter space and (ii) even identifiability fails. For Singularity (i), we seek the form of the parameter space around the true value when the limit is taken, in the framework of the local asymptotic theory established by Ibragimov and Khas'minskii. This approach can handle some complex example previous studies cannot, under penalized estimation as well as quasi-maximum likelihood estimation (in the ergodic or non-ergodic statistics).

For Singularity (ii), we consider penalized estimation to stabilize the asymptotic behavior of the estimator by forcing it to converge to the most parsimonious of all the true values. This estimator can show the oracle property even in singular models where other estimation methods for model selection, such as likelihood ratio tests, seem complicated. An example is a superposition of parametric proportional hazard models.

Eric Ziebell (HU Berlin)

Non-parametric estimation for the stochastic wave equation

The spatially dependent wave speed of a stochastic wave equation driven by space-time white noise is estimated using the local observation scheme. Given a fixed time horizon, we prove asymptotic normality for an augmented maximum likelihood estimator as the resolution level of the observations tends to zero. We show that the expectation and variance of the observed Fisher information are intrinsically related to the energy within the associated deterministic wave equation and prove an asymptotic equipartition of energy principle using the notion of asymptotic Riemann-Lebesgue operators.