Deutsche Forschungsgemeinschaft
Priority Program 1324

Extraction of quantifiable information from complex systems

Final Conference 2014
Marburg, Welcome Hotel

DFG SPP 1324

Philipps Universität Marburg

DFG Deutsche Forschungsgemeinschaft

Information

Organization. This conference is organized by Stephan Dahlke and Frank Eckhardt. For organisational question please ask Frank Eckhardt.

Registration. The registration will be open on Sunday, November 23 from 19:00 to 21:00 in the Welcome Hotel (Pilgrimstein 29, 35037 Marburg). From Monday, Novemver 24 to Thursday, November 27 the registration will be open at the conference venue at these times:

Monday	09:00-18:00
Tuesday	09:00-18:00
Wednesday	09:00-12:00
Thursday	09:00-18:00

Special Events.

Welcome Reception:	Sunday	November 24,	19:00-21:00,	Welcome Hotel
Conference Dinner:	Tuesday	November 25,	19:00-22:00,	Welcome Hotel
Guided City Tour:	Wednesday	November 26,	15:00-17:00	

Orientation and local transport. The Welcome Hotel (Pilgrimstein 29, 35037 Marburg) is located in the center of Marburg and are easily accessible from other parts of the city.

You can reach the Welcome Hotel from Marburg main train station (Hauptbahnhof) by taking
Bus 1,2,3,4,5 : direction “Innenstadt” (city centre)
Bus 7 : direction “Innenstadt, Südbahnhof”
and getting off at the stop “Stadthalle”.

A daily pass (Tageskarte) within Marburg costs 4,10 EUR, and a weekly pass (Wochenkarte) 12,40 EUR. You can purchase tickets from the driver. Please check www.rmv.de for more details.

Places to eat dinner. Plenty of (budget & upscale) places to eat are in the city center at Rudolphsplatz and in the old city center (Oberstadt) which are very close to the Welcome Hotel, for instance:

- Barfüsserstraße, market place, Oberstadt: various options
- Bus stop ’Gutenbergstraße’: Bottega (exquisite)

- Bus stop 'Volkshochschule': Colosseo (italian style), Tandoori (indian style)
- Elisabethkirche: Elisabethbräu (german style), Mexicali (mexican style)
- Steinweg: Gartenlaube (german style)

Webpage. The conference web page can be found here:

`http://www.dfg-spp1324.de/nuhagtools/event_NEW/make.php?event=SPP-JT14`

After the conference we will provide the slides of the talks on this web page.

Keynote Speakers

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Program

Monday, November 24

Time	Speaker	*Title of Talk*
09:15-09:30	S. Dahlke (Univ. Marburg)	*Opening*
09:30-10:30	C. Le Bris (ENPC)	*Some recent progress in numerical approaches for nonperiodic homogenization*
10:30-11:00		*–Coffee Break–*
11:00-11:30	R. Schneider (TU Berlin)	*Hard and soft thresholding for approximation in hierachical tensor formats*
11:30-12:00	M. Bachmayr (RWTH Aachen)	*Adaptive Low-Rank Methods for High-Dimensional Second-Order Elliptic Problems*
12:00-14:00		*–Lunch Break–*
14:00-15:00	H. Woźniakowski (Columbia University)	*Exponential Convergence and Tractability for Analytic Multivariate Problems*
15:00-15:30	D. Rudolf (Univ. Jena)	*Algorithms for the approximation of rank one tensors*
15:30-16:00	B. Brumm (Univ. Tübingen)	*Efficient computations of matrix-vector products for high-dimensional Galerkin approximations*
16:00-17:00		*-Coffee Break-*
17:00-17:30	J. Garcke (Univ. Bonn)	*Solving optimal feedback control problems for partial differential equations using adaptive sparse grids*
17:30-18:00	T. Volkmer (TU Chemnitz)	*Approximation of multivariate periodic functions by trigonometric polynomials based on rank-1 lattice sampling*
18:00-18:30	S. Kunis (Univ. Osnabrück)	*Fast Fourier and Laplace transforms*
19:00		*–Dinner–*

Tuesday, November 25

Time	Speaker	*Title of Talk*
09:30-10:30	F. Bornemann (TU München)	*Random Matrix Distributions, Operator Determinants, and Numerical Noise*
10:30-11:00		*-Coffee Break-*
11:00-11:30	C. Bender (Saarland Univ.)	*Primal-Dual Methods for Nonlinear Pricing Problems*
11:30-12:00	F. Dickmann (Univ. Duisburg-Essen)	*Multilevel Monte Carlo approach for Nonlinear Pricing Problems*
12:00-14:00		*–Lunch Break–*
14:00-15:00	D. Higham (University of Strathclyde)	*The Computational Complexity of Simulating Continuous Time Markov Chains*
15:00-15:30	S. Steck (Univ. Ulm)	*Reduced Basis Method for Hamilton-Jacobi-Bellman equations*
15:30-16:00	S. Glas (Univ. Duisburg-Essen)	*Reduced Basis Approximation of Non-Coercive Variational Inequalities*
16:00-17:00		*–Coffee Break–*
17:00-17:30	G. Plonka-Hoch (Univ. Göttingen)	*Stable Sparse FFT for Nonnegative Vectors*
17:30-18:00	G. Teschke (Hochschule Neubrandenburg)	*Sparse Recovery in Inverse Problems*
19:00		*–Conference dinner–*

Wednesday, November 26

Time	Speaker	*Title of Talk*
09:30-10:30	J. Buhmann (ETH Zürich)	*Information theory of algorithms*
10:30-11:00		*–Coffee Break–*
11:00-11:30	L. Yaroslavtseva (Univ. Passau)	*Deterministic quadrature rules for marginals of SDEs based on weak Ito-Taylor steps*
11:30-12:00	S. Li (WWU Münster)	*Multilevel Monte Carlo for Lé vy-driven SDEs: Implementation*
12:00-12:30	M. Altmayer (Univ. Mannheim)	*Weak convergence rates for non-smooth payoffs in the Heston model*
12:30-14:00		*–Lunch–*

Thursday, November 27

Time	Speaker	*Title of Talk*
09:30-10:30	S. Larsson (Chalmers University of Technology and University of Gothenburg)	*Duality in refined Sobolev-Malliavin spaces and weak approximation of SPDE*
10:30-11:00		*–Coffee Break–*
11:00-12:00	K. Lee (Ajou University)	*Temporal random noises in stochastic parabolic equations*
12:00-14:00		*–Lunch Break–*
14:00-15:00	K. Kim (Korea University)	*Stochastic PDEs with non-local time and space operators*
15:00-16:00	P. A. Cioica (Univ. Marburg)	*On the Besov Regularity of Stochastic Partial Differential Equations on Bounded Lipschitz Domains*
16:00-17:00		*–Coffee Break–*
17:00-17:30	W. Stannat (TU Berlin)	*Linear stochastic partial differential equations: a rough path view*
17:30-18:30	M. Kovács (University of Otago)	*Weak convergence of finite element approximations of linear stochastic evolution equations with additive Lévy noise*
19:00		*–Dinner–*

Friday, November 28

Time	Speaker	*Title of Talk*
09:30-10:30	H.-G. Feichtinger (Univ. Wien)	*Function Spaces - State of the Art and Recent Developments*
10:30-11:00		*-Coffee Break-*
11:00-11:30	M. Hansen (TU München)	*New embedding results for Kondratiev spaces*
11:30-12:00	B. Sprungk (TU Chemnitz)	*Metropolis-Hastings MCMC in Function Space for Bayesian Inverse Problems*
12:00		*–Lunch–*

Abstracts in Alphabetical Order

Weak convergence rates for non-smooth payoffs in the Heston model

Martin Altmayer

In this talk, we will study the weak approximation of the Heston price process for payoff functions, which are only measurable and bounded. The main tool for the analysis will be the explicit knowledge of the characteristic function of the Heston price process, since we can not rely on the seminal work of Bally and Talay (1995). The latter work requires smooth coefficients and Gaussian tails for the underlying SDE, which is not fulfilled for the Heston model.

Adaptive Low-Rank Methods for High-Dimensional Second-Order Elliptic Problems

Markus Bachmayr

We consider the application of subspace-based tensor formats to high-dimensional operator equations on Hilbert spaces, and combine such tensor representations with adaptive basis expansions of the arising lower-dimensional components. This leads to a highly nonlinear type of approximation. In this talk, we focus on problems posed on function spaces for which the inner products do not induce a cross norm, e.g., problems on Sobolev spaces such as second-order elliptic PDEs on product domains. We discuss the particular issues, related to general spectral properties of such elliptic operators, that arise in treating such problems using low-rank tensor expansions. In the particular case of wavelet representations that we are considering, preconditioning reduces to diagonal scaling, which, however, still turns out to be problematic for low-rank representations. We present an approximate diagonal scaling operation suitable for tensor expansions and an iterative method - not tied to a fixed background discretization - that under standard assumptions can be guaranteed to converge to the solution of the continuous problem. Furthermore, under additional low-rank representation sparsity assumptions, the scheme constructs an approximate solution using a number of arithmetic operations that is optimal up to logarithmic terms. Here, the major difficulty lies in obtaining meaningful bounds for the tensor ranks of iterates. The practical efficiency of the method is demonstrated in numerical experiments.

The presented results are joint work with Wolfgang Dahmen.

Primal-Dual Methods for Nonlinear Pricing Problems

Christian Bender

We study a class of stochastic dynamic programming problems which arise in nonlinear option pricing problems (e.g. due to early exercise features, credit value adjustment, or model risk). This class of problems also appears in time discretization schemes for (reflected) backward stochastic differential equations and fully nonlinear second order parabolic PDEs. Generalizing the primal-dual methodology, which is popular in Bermudan option pricing, we design several Monte-Carlo algorithms for the construction of confidence intervals for the value of the dynamic program.

Random Matrix Distributions, Operator Determinants, and Numerical Noise

Folkmar Bornemann

Because of universal scaling laws, distributions and correlation functions of classical random matrix ensembles and combinatorial growth processes in the large size limits have become increasingly important in physics and statistics. Their effective numerical computation has been made possible by evaluating higher derivatives of operator determinants. We review the underlying mathematical ideas and demonstrate how numerical explorations have led to new formulae, to new numerical algorithms, and finally allowed to exhibit universal scaling in some concrete physical experiments. Special attention is given to the sharp assessment of numerical errors: we relate them to a robust statistics of numerical noise in the tail of Chebyshev expansions.

Efficient computations of matrix-vector products for high-dimensional Galerkin approximations

Bernd Brumm

In the below reference, we considered Galerkin methods for the high-dimensional Schrödinger equation. We presented a fast algorithm to compute the product of the Galerkin potential matrix times a vector and gave a convergence analysis. Neither does the fast algorithm require assembly of the matrix nor do we need to employ quadrature. This talk presents some generalizations and further applications of the underlying ideas.

Reference: B. Brumm, A fast matrix-free algorithm for spectral approximations to the Schrödinger equation, November 2013, update August 2014.
See
`http://na.uni-tuebingen.de/pub/brumm/fastalgorithm_Brumm_Aug14.pdf`

Information theory of algorithms

Joachim M. Buhmann

Algorithms as selection procedures for mathematical structures are often exposed to randomness in the input or noise during computation. This uncertainty reduces the attainable resolution in the output space. Therefore, the performance of an algorithm should be characterized by its robustness to stochastic influences, i.e., input noise and randomness during execution, in addition to its runtime and its memory consumption. I will present an information theoretic framework for algorithm analysis where an algorithm is considered to be a contracting posterior distribution. The tradeoff between informativeness and stability is controled by a generalization capacity (GC). GC objectively ranks different algorithms for the same data processing task based on the bit rate of their respective capacities. Information theoretic algorithm selection is rigorously demonstrated for minimum spanning tree algorithms and for greedy MaxCut algorithms. The method also allows us to rank centroid based and spectral clustering methods, e.g. k-means, pairwise clustering, normalized cut, adaptive ratio cut and dominant set clustering.

On the Besov Regularity of Stochastic Partial Differential Equations on Bounded Lipschitz Domains

Petru A. Cioica

We present results obtained within the project 'Adaptive Wavelet Methods for SPDEs'. After a short overview over the goals and achievements of this project, we discuss one topic in detail: The analysis of the regularity of SPDEs, using special scales of Besov spaces to measure the regularity of the solution with respect to the space variable. The regularity in these Besov spaces determines the convergence rate of adaptive wavelet methods. Our investigations are needed in order to underpin the use of spatially adaptive wavelet methods instead of classical uniform alternatives.

This is joint work with: Stephan Dahlke (Marburg), Nicolas Döhring (Kaiserslautern), Kyeong-Hun Kim (Seoul), Stefan Kinzel (Marburg), Kijung Lee (Suwon), Felix Lindner (Kaiserslautern), Thorsten Raasch (Mainz), Klaus Ritter (Kaiserslautern), and RenÃl' L. Schilling (Dresden).

Multilevel Monte Carlo approach for Nonlinear Pricing Problems

Fabian Dickmann

Primal-dual simulation methods for constructing confidence intervals on option prices have recently been extended from Bermudan option pricing to a quite general class of nonlinear pricing problems (see the talk by C. Bender). Such methods can be enhanced via the multilevel approach. If measured in terms of the root-mean-squared error ε, the complexity of Andersen-Broadie type algorithms for upper confidence bounds (dual problem) can be reduced to the order ε^{-2}, while the plain Monte Carlo implementation of these type of algorithms typically leads to a complexity between ε^{-3} or even ε^{-4}.

Function Spaces - State of the Art and Recent Developments

Hans Georg Feichtinger

Although Function Spaces play an important role already for a long time, be it the family of L^p-spaces in classical Fourier analysis, the Hardy-spaces for the treatment of Calderon-Zygmund operators or (anisotropic) Besov spaces in micro-local analysis, there is still only a small family (usually L^p-spaces and Besov spaces) which are really in regular use by the majority of mathematicians working in analysis.

The talk will try to outline some genera construction principles for function spaces (rather than concrete, multi-parameter spaces), meaning typically Banach spaces of distributions, the role of the theory of Banach frames, description by atomic decompositions and corresponding invariance properties. Group representation theory is playing an important role in the description (and analysis) of these function spaces, in particular if one takes the approach via coorbit spaces.

The talk will be more in the spirit of motivation, the discussion of general principles and the transfer of ideas in one setting rather than the detailed technical presentation of a few special cases.

Solving optimal feedback control problems for partial differential equations using adaptive sparse grids

Jochen Garcke

An approach to solve finite time horizon optimal feedback control problems for partial differential equations using adaptive sparse grids is presented. A semi-discrete optimal control problem is introduced and the feedback control is derived from the corresponding value function. The value function can be characterized as the solution of an evolutionary Hamilton-Jacobi Bellman (HJB) equation which is defined over a state space whose dimension is equal to the dimension of the underlying semi-discrete system. Besides a low dimensional semi-discretization it is important to solve the HJB equation efficiently to address the curse of dimensionality. We apply a semi-Lagrangian scheme using spatially adaptive sparse grids. Sparse grids allow the discretization of the high(er) dimensional value functions arising in the numerical scheme since the curse of dimensionality of full grid methods arises to a much smaller extent. For additional efficiency an adaptive grid refinement procedure is explored. We present several numerical examples studying the effect of the parameters characterizing the sparse grid on the accuracy of the value function and optimal trajectories. Furthermore we analyze the behaviour of the trajectories in case of noise.

Reduced Basis Approximation of Non-Coercive Variational Inequalities

Silke Glas

We consider variational inequalities with different trial and test spaces and a possibly non- coercive bilinear form. Well-posedness could be achieved under general conditions that are e.g. valid for the space-time formulation of parabolic variational inequalities. As an example for a parabolic variational inequality, we may think about time-dependent obstacle problems or option pricing, e.g. for American Options or Swing Options. Fine discretizations that are needed for such problems resolve in high dimensional problems and thus in long computing times. To reduce the dimensionality of these problems, we use the Reduced Basis Method. In our work, error estimators in terms of the residual could be obtained by combining the Reduced Basis Method with a space-time formulation of the variational inequality. We provide numerical results for a heat inequality model focusing on rigorosity and efficiency of the error estimator.

New embedding results for Kondratiev spaces

Markus Hansen

We consider embeddings between weighted Sobolev spaces (Kondratiev spaces) relevant for the regularity theory for such elliptic problems, and Triebel-Lizorkin spaces, which are known to be closely related to approximation spaces for nonlinear n-term wavelet approximation. We provide matching necessary and sufficient conditions for such embeddings.

As a further application we discuss the relation of these embedding results with results by Gaspoz and Morin for approximation classes for adaptive Finite element approximation.

The Computational Complexity of Simulating Continuous Time Markov Chains

Des Higham

I will analyze and compare the computational complexity of different simulation strategies for continuous time Markov chains. I consider the task of approximating the expected value of some functional of the state of the system over a compact time interval. This task is the computational bottleneck in many large scale computations arising in biochemical kinetics and cell biology. In this context, the terms 'Gillespie's method', 'The Stochastic Simulation Algorithm' and 'The Next Reaction Method' are widely used to describe exact simulation methods. I will look at the use of standard Monte Carlo when samples are produced by exact simulation and by approximation with tau-leaping or an Euler-Maruyama discretization of a diffusion approximation. Appropriate modifications of recently proposed multi-level Monte Carlo algorithms will also be studied for the tau-leaping and Euler-Maruyama approaches. I will pay particular attention to a parameterization of the problem that, in the mass action chemical kinetics setting, corresponds to the classical system size scaling.

This is joint work with David Anderson and Yu Sun at Wisconsin.

Stochastic PDEs with non-local time and space operators

Kyeong-Hun Kim

Non-local operators in the time variable are used to model anomalous diffusion, where a particle plume spreads at a rate that is inconsistent with the classical model. And, non-local space operators describe long-range jumps and interactions of the given diffusion. Compared to PDE theory, which is relatively well-developed for a wide class of non-local operators, Stochastic PDE theory has been successful only for non-local space operators of few special types. Hence for the description of various complex phenomena, it becomes essential to develop the theory of SPDEs with general non-local operators. In this talk, we present the uniqueness, existsnce and regularity theory for stochastic PDEs with such nonlocal operators.

Weak convergence of finite element approximations of linear stochastic evolution equations with additive Lévy noise

Mihály Kovács

We present an abstract framework to study weak convergence of numerical approximations of linear stochastic partial differential equations driven by additive Lévy noise. We first derive a representation formula for the error which we then apply to study space-time discretizations of the stochastic heat and wave equations. We use the standard discontinuous finite element method as spatial discretization and the backward Euler method respectively I-stable rational approximations to the exponential function as time-stepping for the heat and wave equations. For twice continuously differentiable test functions with bounded first and second derivatives, with some extra condition on the second derivative for the wave equation, the weak rate is found to be twice that of the strong rate. The results extend the earlier work by the Lindner and Schilling as we consider general square-integrable infinite dimensional Lévy processes with no additional assumptions on the jump intensity measure. Furthermore, the present framework is applicable to hyperbolic equations as well.

This is a joint work with Felix Lindner (TU Kaiserslautern) and René Schilling (TU Dresden).

Fast Fourier and Laplace transforms

Stefan Kunis

Recently, the butterfly approximation scheme and hierarchical approximations have been proposed for the efficient computation of integral transforms with oscillatory and with asymptotically smooth kernels. Combining both apporaches, we propose a certain fast Fourier-Laplace transform, which in particular allows for an efficient evaluation of polynomials at nodes in the complex unit disk.

The talk is based on joint papers with J. Dick, F. Kuo, P. Kritzer G. Larcher, F. Pillichshammer, and I. Sloan.

Duality in refined Sobolev-Malliavin spaces and weak approximation of SPDE

Stig Larsson

We introduce a new method for proving weak convergence for stochastic evolution problems. The proof is based on refined Sobolev-Malliavin spaces from the Malliavin calculus. It does not rely on the use of the Kolmogorov equation or the Ito formula and is therefore applicable also to non-Markovian equations, where these are not available. We use it to prove weak convergence of fully discrete approximations of the solution of the semilinear stochastic parabolic evolution equation with additive noise as well as a semilinear stochastic Volterra integro-differential equation.

This is joint work with Adam Andersson, Mihály Kovács, and Raphael Kruse.

Some recent progress in numerical approaches for nonperiodic homogenization

Claude Le Bris

We will review some recent mathematical and numerical contributions related to nonperiodic multiscale problems. A typical setting is that of an elliptic equation with a highly oscillatory coefficient, modeling a structure with a set of embedded localized defects, or a structure that, although not periodic, enjoys nice geometrical features. The purpose is then to construct theoretical settings, and next numerical approaches providing an efficient and accurate approximation of the solution in several possible cases of practical interest.

This is joint work with Xavier Blanc (Paris 7), Pierre Louis Lions (College de France), Frederic Legoll (Ecole des Ponts) and several other collaborators.

Temporal random noises in stochastic parabolic equations

Kijung Lee

Stochastic parabolic equations are different from deterministic ones in many angles and the ways of approaching them are to be different. In this talk we discuss such differences with emphasis on the regularity of solutions. A stochastic parabolic equation describes diffusion with random noises. In the first part of the talk we briefly discuss a modeling of temporal noises. In the second part we focus on the Sobolev regularity of the solution with white noises. Unlike the case with deterministic convection, the stochastic convection reduces diffusion. Moreover, the way that the stochastic inhomogeneous term affects the regularity of the solution is different from the one by deterministic inhomogeneous term. By the nature of the problem, in particular by the bad contribution of the white noises in the inhomogeneous part, the second derivatives of the solution may blow up on the boundary even with $\mathcal{C}^1$ space domain. This makes us need help of appropriate weights near the boundary to describe the regularity of solutions. Also, in the case of systems, the theory of stochastic ones sometimes fails. We discuss this with an example.

Multilevel Monte Carlo for Lévy-driven SDEs: Implementation

Sangmeng Li

In this talk we present an implementation of a fast multilevel Monte Carlo scheme for Lévy-driven SDEs introduced and analysed in the previous research. The scheme is based on direct simulation of Lévy increments. We give an efficient implementation of the algorithm. In particular, we explain direct simulation techniques for Lévy increments. Further, we optimise over the involved parameters and, in particular, the refinement multiplier. We stress that we focus on the case where the frequency of small jumps is particularly high, meaning that the Blumenthal-Getoor index is larger than one.

Stable Sparse FFT for Nonnegative Vectors

Gerlind Plonka-Hoch

We propose a deterministic stable FFT algorithm to compute a sparse vector x from its Fourier transformed vector. In case of nonnegative vectors being M-sparse, we need at most $\min\{M\log(N), N\}$ Fourier values in order to recover x and at most $\mathcal{O}(M^2 \log N)$ arithmetical operations. The algorithm works iteratively and does not incorporate any a priori knowledge on the sparsity M of x. Each iteration step only involves the solution of a linear system of size at most M. We develop an adaptive strategy to ensure that the coefficient matrix in the linear system is well-conditioned. For this purpose, we have to study Vandermonde matrices with knots on the unit circle. The talk is based on joint work with Katrin Wannenwetsch.

Algorithms for the approximation of rank one tensors

Daniel Rudolf

We study the approximation of high-dimensional rank one tensors. We prove that for certain parameters (smoothness and norm of the rth derivative) this problem is intractable while for other parameters the problem is tractable and the complexity is only polynomial in the dimension.

Hard and soft thresholding for approximation in hierachical tensor formats

Reinhold Schneider

In tensor product approximation, Hierarchical Tucker tensor format (Hackbusch) and Tensor Trains (TT) (Tyrtyshnikov) have been introduced recently, during period of the DFG SPP priority program 1324. It offers stable and robust approximation of highdimensional problems by a low order cost. The talk reports on joint work with Prof. Hackbusch and his group at MPI Leipzig. The corresponding ranks required for an approximation up to agiven error depend on bilinear approximation rates and corresponding trace class norms. For numerical computations, the computation of an approximate solution can be casted into an optimization framework constraint by the restriction to tensors of prescribed multi-linear ranks r or low rank tensors. Beside the Dirac Frenkel variational principle which exploits the differential geometric structure of the hierarchical tensor formats, thressholding techniques based on an heorarchical SVD (HSVD) can be applied to provide convergence. Beside the quasi-best approximation by hard thressholding, we discuss iterative soft thressholding techniques, developed jointly together with M. Bachmayr (IGPM RWTH Aachen). Soft thressholding iteration applies convex optimization techniques to tensor product approximation.

Metropolis-Hastings MCMC in Function Space for Bayesian Inverse Problems

Björn Sprungk

We consider Markov Chain Monte Carlo methods adapted to a Hilbert space setting. Such algorithms occur in Bayesian inverse problems where the solution is a probability measure on a function space according to which one would like to integrate or sample. We focus on Metropolis-Hastings algorithms and, in particular, we introduce and analyze a generalization of the existing pCN-proposal. This new proposal allows to exploit the geometry or anisotropy of the target measure which in turn might improve the statistical efficiency of the corresponding MCMC method. Numerical experiments for a real-world problem confirm the improvement.

Linear stochastic partial differential equations: a rough path view

Wilhelm Stannat

Existence and uniqueness of (analytically weak) linear rough partial differential equations with possibly degenerate second order linear differential operator in the drift term and first order linear differential operators in the dispersion term are proven, both forward and backward in time.

Plugging in the path lift of Brownian motion, we obtain in particular robust pathwise solutions of the corresponding linear stochastic partial differential equations. As an application Wong-Zakai approximation results to linear stochastic partial differential equations are obtained.

The talk is based on joint work with J. Diehl and P. Friz.

Reduced Basis Method for Hamilton-Jacobi-Bellman equations

Sebastian Steck

We aim to model the European Emission Trading System in order to gain insight how different regulatory actions affect the emission permit market and the behaviour of its participants. This information can be used to learn how an emission trading system should be regulated best.

The spot price of the emission permits can be characterized by the solution of the Hamilton-Jacobi-Bellman (HJB) equation. Since it has to be solved for numerous different regulatory parameters, we wish to save computational effort by applying the Reduced Basis Method.

For the determination of an error estimator, we use a space-time formulation of these equations and apply the Brezzi-Rappaz-Raviart theory. Thus, we have to restrict to quadratic non-linearities.

Sparse Recovery in Inverse Problems

Gerd Teschke

This talk is concerned with two important topics in the context of sparse recovery in inverse and ill-posed problems. The focus is on the incomplete data scenario. We discuss extensions of compressed sensing for specific infinite dimensional ill-posed measurement regimes. We are able to establish recovery error estimates when adequately relating the isometry constant of the sensing operator, the ill-posedness of the underlying model operator and the regularization parameter. Finally, we very briefly sketch how projected steepest descent iterations can be applied to retrieve the sparse solution.

Approximation of multivariate periodic functions by trigonometric polynomials based on rank-1 lattice sampling

Toni Volkmer

We consider the approximation of periodic functions belonging to Sobolev spaces of isotropic and dominating mixed smoothness. For the approximation of such a function f, a trigonometric polynomial with frequencies supported on an index set I is used. In general, this approximation causes an unavoidable error, the so-called truncation error. Based on sampling values of the function f along a rank-1 lattice, we obtain such an approximation by a trigonometric polynomial p. Due to using sampling values, we observe an additional error in general. Our method constructs a suitable rank-1 lattice for a given frequency index set I using a component-by-component method and then performs a fast Fourier transform on the sampling values. The main advantage of our method is that it is based mainly on a single one-dimensional fast Fourier transform, and that the arithmetic complexity of computing the Fourier coefficients of the trigonometric polynomial p, which is used as approximation for the function f, depends only on the cardinality of the support of the trigonometric polynomial p in the frequency domain. Namely, the arithmetic complexity of the algorithm is $\mathcal{O}(|I|^2 \log |I| + d|I|)$.

Exponential Convergence and Tractability for Analytic Multivariate Problems

Henryk Woźniakowski

For analytic d-variate multivariate problems it is natural to expect an exponential convergence and complexity bounds as a function of d and $1 + \log \varepsilon 1$, where Îţ is an error threshold. We study necessary and sufficient conditions on exponential convergence and uniform exponential convergence. The latter holds when the exponent of exponential convergence is independent of d. We also study necessary and sufficient conditions when complexity bounds are polynomial in d and $1 + \log \varepsilon 1$, and when they are not exponential in d and $1 + \log \varepsilon 1$.

Deterministic quadrature rules for marginals of SDEs based on weak Ito-Taylor steps

Larisa Yaroslavtseva

We consider the problem of approximating the expectation $Ef(X(1))$ of a function f of the solution X of a d-dimensional system of stochastic differential equations (SDE) at time point 1 based on finitely many evaluations of the coefficients of the SDE, the integrand f and their derivatives. We present a deterministic algorithm, which produces a quadrature rule by iteratively applying simplified weak Ito-Taylor steps together with strategies to reduce the diameter and the size of the support of a discrete measure.

We essentially assume that the coefficients of the SDE are s-times continuously differentiable and that the integrand f is r-times continuously differentiable. In the case $r \leq (s-2)d/(d+2)$ we almost achieve an error of order $\min(r, s)/d$ in terms of the computational cost, which is optimal in a worst case sense.

List of Participants

Ali	Mazen	Universität Ulm *mazen.ali@uni-ulm.de*
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