2017 SOCAMS Abstract

Time and Room:

9:00 - 9:45, RH 101

Name:

Natalia Komarova

Institution:

UC Irvine

Title:

Near equilibrium calculus of stem cells

Abstract:

Stem cells are an important component of tissue architecture. Identifying the exact regulatory circuits that can stably maintain tissue homeostasis (that is, approximately constant size) is critical for our basic understanding of multicellular organisms. It is equally critical for figuring out how tumors circumvent this regulation, thus providing targets for treatment. Despite great strides in the understanding of the molecular components of stem-cell regulation, the overall mechanisms orchestrating tissue homeostasis are still far from being understood. Typically, tissue contains the stem cells, transit amplifying cells, and terminally differentiated cells. Each of these cell types can potentially secrete regulatory factors and/or respond to factors secreted by other types. The feedback can be positive or negative in nature. This gives rise to a bewildering array of possible mechanisms that drive tissue regulation. In this talk I describe a novel stochastic method of studying stem cell lineage regulation, which is based on population dynamics and ecological approaches. The method allows to identify possible numbers, types, and directions of control loops that are compatible with stability, keep the variance low, and possess a certain degree of robustness. I will also discuss evolutionary optimization and cancer-delaying role of stem cells.

Enter the names of your co-authors

Pauline van den Driessche, Jay Yang, Zheng Sun, Maksim Plikus, David Axelrod

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Time and Room:

9:45 - 10:30, RH 101

Name:

Mark Huber

Institution:

Claremont McKenna College

Title:

Monte Carlo methods for high dimensional integration

Abstract:

A Monte Carlo algorithm utilizes random choices in order to approximate a target value. For my work, this is usually the value of a high dimensional integral that cannot be evaluated analytically. Such problems arise in the context of #P complete problems, model selection for Bayesian inference, and maximum likelihood values for frequentist inference. In this talk, I'll discuss the latest methods for generating random values from such distributions, and estimates that use Monte Carlo data that are provably robust in the sense that the probability that the relative error rises above a certain amount can be strictly bounded.

Time and Room:

11:00 - 11:20, NS 1201

Name:

Xiyang Luo

Institution:

UC Los Angeles

Title:

Uncertainty Quantification in Graph Semi-supervised Learning

Abstract:

Classification of high dimensional data finds wide-ranging applications. In many of these applications equipping the resulting classification with a measure of uncertainty may be as important as the classification itself. In this paper we introduce, develop algorithms for, and investigate the properties of, a variety of Bayesian models for the task of binary classification; via the posterior distribution on the classification labels, these methods automatically give measures of uncertainty. The methods are all based around the graph formulation of semi-supervised learning. We provide a unified framework which brings together a variety of methods which have been introduced in different communities within the mathematical sciences. We study probit classification, generalize the level-set method for Bayesian inverse problems to the classification setting, and generalize the Ginzburg-Landau optimization-based classifier to a Bayesian setting; we also show that the probit and level set approaches are natural relaxations of the harmonic function approach introduced in Zhu et al. We introduce efficient numerical methods, suited to large data-sets, for both MCMC-based sampling as well as gradient-based MAP estimation. Through numerical experiments we study classification accuracy and uncertainty quantification for our models; these experiments showcase a suite of datasets commonly used to evaluate graph-based semi-supervised learning algorithms.

Enter the names of your co-authors

Andrea Bertozzi, Andrew Stuart, Konstatinos Zygalakis

Time and Room:

11:20 - 11:40, NS 1201

Name:

Xiaohan Wei

Institution:

University of Southern California

Title:

Structured signal recovery from non-linear and heavy-tailed measurements

Abstract:

We study high-dimensional signal recovery from non-linear measurements with design vectors having elliptically symmetric distribution. Special attention is devoted to the situation when the unknown signal belongs to a set of low statistical complexity, while both the measurements and the design vectors are heavy-tailed. We propose and analyze a new estimator that adapts to the structure of the problem, while being robust both to the possible model misspecification characterized by arbitrary non-linearity of the measurements as well as to data corruption modeled by the heavy-tailed distributions. Moreover, this estimator has low computational complexity. Our results are expressed in the form of exponential concentration inequalities for the error of the proposed estimator. On the technical side, our proofs rely on the generic chaining methods, and illustrate the power of this approach for statistical applications. Theory is supported by numerical experiments demonstrating that our estimator outperforms existing alternatives when data is heavy-tailed.

Enter the names of your co-authors

Larry Goldstein, Stanislav Minsker

Time and Room:

11:40 - 12:00, NS 1201

Name:

Wuchen Li

Institution:

UC Los Angeles

Title:

Optimal transport on graphs with Fisher information regularization.

Abstract:

Optimal transport in continuous spaces provides powerful tools in applications, such as image processing, modeling and game theory. In this talk, we consider similar matters on finite graphs. Various recent developments related to Fokker-Planck equations, Shannon-Boltzmann entropy, Fisher information, as well as Wasserstein metric on graphs will be presented. Some applications are presented, including computation of the metric between images, evolutionary games, numerics schemes and "geometry" of finite graphs.

Enter the names of your co-authors

Penghang Yin; Stanley Osher

Time and Room:

12:00 - 12:20, NS 1201

Name:

Ka Chun Lam

Institution:

Caltech

Title:

Energy Decomposition With Applications to Matrix Compression And Multiresolution Decomposition

Abstract:

In this paper, we introduce the notion of {\bf Energy decomposition} for self-adjoint, positive

definite matrix A using the representation of {\bf energy elements}. The interaction between these energy elements depicts the underlying topological structure of the operator. This concept of decomposition naturally reflects the hidden geometric structure of the operator which inherits the localities of the structure. By utilizing the intrinsic geometric information under this Energy framework, we propose a systematic operator compression scheme for the inverse operator A^{-1}. In particular, with an {\it appropriate partitioning} of the underlying geometric structure, we can construct localized basis by using the concept of {\bf interior} and
{\bf closed energy}. Meanwhile, two important localized quantities are introduced, namely the {\bf error factor} and the {\bf condition factor}. Our error analysis results show that these two factors will be the guidelines for finding the appropriate partition of the basis functions such that prescribed compression error and acceptable condition number can be achieved. By virtue of this insight, we proposed the {\bf Patch Pairing} algorithm to realize our energy partition framework for operator compression with controllable compression error and condition number. From the perspective of linear system solver, we also extend our compression scheme into a multi-resolution matrix factorization algorithm which achieves nearly optimal performance on both complexity and well-posedness.

Enter the names of your co-authors

Yizhao Hou, De Huang

Time and Room:

11:00 - 11:20, NS 2201

Name:

Guher Camliyurt

Institution:

University of Southern California

Title:

A Lagrangian analyticity result for the Euler equations

Abstract:

We revisit preservation of analyticity and Gevrey regularity for the Euler equation. We provide a result on preservation of Gevrey norm and analyticity in Lagrangian formulation and discuss the validity of the result in the Eulerian variables.

Enter the names of your co-authors

Igor Kukavica

Time and Room:

11:20 - 11:40, NS 2201

Name:

Paul Plucinsky

Institution:

Caltech

Title:

Microstructure induced suppression of wrinkling in thin nematic elastomer sheets

Abstract:

Nematic elastomers are rubbery solids which have liquid crystals incorporated into their polymer chains. These materials display many unusual mechanical properties, one such being the ability to form fine-scale microstructure. In this work, we explore the response of taut and appreciably stressed sheets made of nematic elastomer. Such sheets feature two potential instabilities – the formation of fine-scale material microstructure and the formation of fine-scale wrinkles. We develop a theoretical framework to study these sheets that accounts for both instabilities, and we implement this framework numerically. Specifically, we show that these instabilities occur for distinct mesoscale stretches, and observe that microstructure is finer than wrinkles for physically relevant parameters. Therefore, we relax (i.e., implicitly but rigorously account for) the microstructure while we regularize (i.e., compute the details explicitly) the wrinkles. Using both analytical and numerical studies, we show that nematic elastomer sheets can suppress wrinkling by modifying the expected state of stress through the formation of microstructure.

Enter the names of your co-authors

Kaushik Bhattacharya

Time and Room:

11:40 - 12:00, NS 2201

Name:

Chuntian Wang

Institution:

UC Los Angeles

Title:

A Partially Hyperbolic Model for Plasma Physics: Deterministic and Stochastic Zakharov-Kuznetsov Equation

Abstract:

Zakharov-Kuznetsov (ZK) equation is the long-wave small-amplitude limit of the Euler-Poisson system for cold plasma uniformly magnetized along one space direction. It is also a multi-dimensional extension of the Korteweg-de Vries (KdV) equation and a special case of the partially hyperbolic equations.

The talk will focus on the well-posedness and regularity of both the deterministic and Stochastic ZK equation, subjected to a rectangular domain in space dimensions two and three. Particularly, in the deterministic case, we obtain the global existence of strong solutions in 3D, which, for similar equations in fluid dynamics, is still open. For the stochastic ZK equation driven by a white noise, in 3D the existence of martingale solutions, and in 2D the uniqueness and existence of the pathwise solution are established, an analogy to the results of the weak solutions (in the PDE sense) in the deterministic case.

In terms of methodology, the focus is on the handling of the mixed features consisting of the partial hyperbolicity, nonlinearity, anisotropicity and stochasticity of the system, which, sitting at the interface among probability and analysis of the parabolic and hyperbolic PDEs, provides interesting and challenging mathematical complications.

Enter the names of your co-authors

Jean-Claude Saut, Roger Temam

Time and Room:

12:00 - 12:20, NS 2201

Name:

Ran Zhao

Institution:

Claremont Graduate University

Title:

Pointwise Hölder Exponent Estimation on Function of Multifractional Brownian Motion

Abstract:

We provide an estimator of the pointwise Hölder exponent of a general continuous stochastic process driven by a multifractional Brownian motion (mBm), by improving the ordinary generalized quadratic variation (GQV) method. The consistency and the optimal rate of convergence of the estimator have been discussed. This algorithm extends the applications of GQV method to a much wider range of multifractional processes, that can be unknown functions of mBm. Simulation results show that our extended estimator has better accuracy and convergence speed than commonly used alternative methods, such as ordinary GQV method and oscillation method. We also prove that our method can apply to the case where only the local average values of the process are observed. As an application to finance, we successfully compare trading information contained in stock prices from multiple markets, based on the extended GQV estimator of pointwise Hölder exponent.

Enter the names of your co-authors

Qidi Peng

Time and Room:

2:00 - 2:45, RH 101

Name:

Andrej Zlatos

Institution:

UC San Diego

Title:

Stochastic homogenization for reaction-diffusion equations

Abstract:

We study spreading of reactions in random media and prove that homogenization takes place under suitable hypotheses. That is, the medium becomes effectively homogeneous in the large-scale limit of the dynamics of solutions to the PDE. Hypotheses that guarantee this include fairly general stationary ergodic KPP reactions, as well as homogeneous ignition reactions in up to three dimensions perturbed by radially symmetric impurities distributed according to a Poisson point process.

In contrast to the original (second-order) reaction-diffusion equations, the limiting "homogenized" PDE for this model are (first-order) Hamilton-Jacobi equations, and the limiting solutions are discontinuous functions that solve these in a weak sense. A key ingredient is a new relationship between spreading speeds and front speeds for these models (as well as a new method to prove existence of these speeds). This can be thought of as the inverse of a well-known formula in the case of periodic media, but we are able to establish it even for more general stationary ergodic media.

Time and Room:

2:45 - 3:30, RH 101

Name:

Joseph Teran

Institution:

UC Los Angeles

Title:

Snow Business: Scientific Computing in the Movies and Beyond

Abstract:

New applications of scientific computing for solid and fluid mechanics problems include simulation of virtual materials in movie special effects and virtual surgery. Both disciplines demand physically realistic dynamics for materials like water, smoke, fire, and soft tissues. New algorithms are required for each area. Teran will speak about the simulation techniques required in these fields and will share some recent results including: simulated surgical repair of biomechanical soft tissues; extreme deformation of elastic objects with contact; high resolution incompressible flow; and clothing and hair dynamics. He will also discuss a new algorithm used for simulating the dynamics of snow in Disney's animated feature film, "Frozen".

Time and Room:

4:00 - 4:20, NS 1201

Name:

Jiancheng Lyu

Institution:

UC Irvine

Title:

Computing Residual Diffusivity by Adaptive Basis Learning via Spectral Method

Abstract:

We study the residual diffusion phenomenon in chaotic advection computationally via adaptive orthogonal basis. The chaotic advection is generated by a class of time periodic cellular flows arising in modeling transition to turbulence in Rayleigh-Benard experiments. The residual diffusion refers to the non-zero effective (homogenized) diffusion in the limit of zero molecular diffusion as a result of chaotic mixing of the streamlines. In this limit, the solutions of the advection-diffusion equation develop sharp gradients, and demand a large number of Fourier modes to resolve, rendering computation expensive. We construct adaptive orthogonal basis (training) with built-in sharp gradient structures from fully resolved spectral solutions at few sampled molecular diffusivities. We make use of the Poincar\'e map of the advection-diffusion equation to bypass long time simulation and gain accuracy in computing effective diffusivity and learning adaptive basis. We observe a non-monotone relationship between residual diffusivity and the amount of chaos in the advection, though the overall trend is that sufficient chaos leads to higher residual diffusivity.

Enter the names of your co-authors

Jack Xin, Yifeng Yu

Time and Room:

4:20 - 4:40, NS 1201

Name:

Huiwen Wu

Institution:

UC Irvine

Title:

A Randomized Multigrid Method for Solving Least Squares Problems

Abstract:

We introduce a randomized multigrid method for overdetermined linear least squares problems. Given an arbitrary full rank m times n matrix A, with m greater or equal to n, any m times 1 vector b, we combine the sampling techniques and multigrid method to solve the normal equation of linear system Ax = b in this method. The algorithm requires O(kmn+n^3log(n)) floating point operations where k is the number of iteration steps. This cost is less than O(mn^2) required by the classification schemes such QR decomposition and SVD decomposition. It also converges in less steps compared to PCG. We present several numerical examples illustrating the performance of the algorithm.

Enter the names of your co-authors

Long Chen

Time and Room:

4:40 - 5:00, NS 1201

Name:

Melike Sirlanci

Institution:

University of Southern California

Title:

Estimating Blood Alcohol Concentration / Breath Alcohol Concentration from Transdermal Alcohol Concentration Based on a Diffusion Equation with Random Coefficients

Abstract:

Estimating Blood Alcohol Concentration / Breath Alcohol Concentration from Transdermal Alcohol Concentration Based on a Diffusion Equation with Random Coefficients

We develop an abstract approximation and convergence framework for the estimation of random parameters in infinite dimensional dynamical systems governed by regularly dissipative operators in a Gelfand triple setting. Our results are motivated by a problem involving the development of a data analysis system for a transdermal alcohol biosensor. Our approach combines some recent results for random abstract parabolic systems with ideas contained in a treatment of Prohorov metric convergence of approximations in the estimation of random parameters in abstract dynamical systems based on aggregate or population data. Our approach differs in that we found it necessary to require that the distributions of our random parameters be described by probability density functions. Based on the data sampled from the population we aim to estimate the joint probability distribution function of the random parameters. Our convergence results rely on the well-known Trotter-Kato approximation theorem from linear semigroup theory.

Enter the names of your co-authors

I. G. Rosen, Susan Luczak

Time and Room:

5:00 - 5:20, NS 1201

Name:

Stas Minsker

Institution:

University of Southern California

Title:

Distributed Statistical Estimation and Rates of Convergence in Normal Approximation

Abstract:

In this talk, we will present new algorithms for distributed statistical estimation that can take advantage of the divide-and-conquer approach. We show that one of the key benefits attained by an appropriate divide-and-conquer strategy is robustness, an important characteristic of large distributed systems. Moreover, we introduce a class of algorithms that are based on the properties of the geometric median, establish connections between performance of these distributed algorithms and rates of convergence in normal approximation, and provide tight deviations guarantees for resulting estimators in the form of exponential concentration inequalities. Techniques are illustrated with several examples; in particular, we obtain new results for the median-of-means estimator, as well as provide performance guarantees for robust distributed maximum likelihood estimation.

The talk is based on a joint work with Nate Strawn.

Time and Room:

4:00 - 4:20, NS 2201

Name:

Fei Yu

Institution:

UC Irvine

Title:

High Order Diffuse Domain Methods for Partial Differential Equations with Dirichlet Boundary Conditions in Complex Geometries

Abstract:

Previously, Li et al. (Comm. Math. Sci., 7:81-107, 2009) developed a diffuse domain method (DDM) in order to solve partial differential equations (PDE) in complex geometries. In this approach the complex geometry was embedded into a larger, regular domain. The original PDE was reformulated with a phase field function, which smoothly approximates the characteristic function of the original domain, plus additional source terms that approximate the boundary conditions. Later Lervåg and Lowengrub (Comm. Math. Sci., 2014) performed a matched asymptotic analysis of general diffuse domain methods for Neumann and Robin boundary conditions and showed that for certain choices of boundary condition approximations the DDM is second-order accurate in epsilon, which characterizes the width of the region over which the characteristic function is smoothed. We extend this analysis to PDEs with Dirichlet boundary conditions and show that by perturbing the reformulated equation in a certain way, we are able to achieve second-order accuracy in epsilon. Our analytic results are confirmed numerically in both the L^2 and L^∞ norm for selected test cases.

Enter the names of your co-authors

John Lowengrub

Time and Room:

4:20 - 4:40, NS 2201

Name:

Hailong Guo

Institution:

UC Santa Barbara

Title:

Gradient Recovery For Elliptic Interface Problem

Abstract:

In this talk, we present two types of novel gradient recovery methods for elliptic interface problem: 1. Finite element methods based on body-fitted mesh; 2. Immersed finite element methods. Due to the lack of regularity of solution at interface, standard gradient recovery methods fail to give superconvergent results, and thus will lead to over-refinement when served as a posteriori error estimator. This drawback is overcome by designing an immersed gradient recovery operator in our methods. We analyze the superconvergence of these methods, and provide several numerical examples to verify the superconvergence and its robustness as a posteriori error estimator.

Enter the names of your co-authors

Xu Yang

Time and Room:

4:40 - 5:00, NS 2201

Name:

Lihui Chai

Institution:

UC Santa Barbara

Title:

Seismic tomography using Frozen Gaussian approximation

Abstract:

We propose a wave-equation based seismic tomography method using the Frozen Gaussian approximation (FGA). Seismic tomography is one
of the core methodologies for imaging the structural heterogeneity of the Earth's interior at a variety of scales. Usually, two main tasks in seismic imaging are: 1) to get an efficient and accurate forward model, and 2) to solve the inverse problem. In this project, for the forward modeling, we use the FGA as an efficient asymptotic solver to the wave equations. In order to compute high-frequency seismic wave propagation in high contrast media, we incorporate the Snell's law into the FGA formulation, and asymptotically derive reflection, transmission and free surface conditions for FGA. For the inversion, we use the adjoint tomography method and minimize the seismic misfit in the least-square sense. Numerical results demonstrate that the high efficiency and embarrassingly parallelizability make the FGA

based adjoint tomography
method very promising in 3D seismic imaging.

Enter the names of your co-authors

Ping Tong and Xu Yang

Time and Room:

5:00 - 5:20, NS 2201

Name:

James Hateley

Institution:

UC Santa Barbara

Title:

Frozen Gaussian Approximation for the Elastic Wave Equation in Isotropic Media

Abstract:

In recent works the frozen Gaussian approximation (FGA) has been proven analytically and verified empirically to be an efficient solver high frequency wave propagation. I will give motivation using geometric optics and go through derivation the FGA for the elastic wave equation in an isotropic medium assuming high frequency wave propagation. Because of the nature of the equation, this will be done in an atypical fashion using a projection instead of the eigenfunctions. With this method there is a natural split of the wavefield into p/s waves, with each being decomposed into fixed-width Gaussian wavelets that propagate along ray paths. The accuracy is given by the short wavelength over large domain size. As The FGA overcomes the problems from many well known methods. As it is based on the asymptotic analysis of the phase plane, it does not require the high mesh resolution. It over comes the problem from geometric optics of caustics and as the Gaussians are of fixed width, there is no beam spreading as opposed to the Gaussian beam method. The algorithm outlined is embarrassingly parallel. It is an efficient solver for high frequency wave propagation. Furthermore the splitting of the wavefield does not require any extra computational work.

Enter the names of your co-authors

Lihui Chai, Xu Yang
