Quasi-Stationary Distributions for the Voter Model on Complete Bipartite Graphs

Iddo Ben-Ari

Department of Mathematics, University of Connecticut

In this talk I will discuss the discrete-time voter model for opinion dynamics and its quasi-stationary distribution (QSD). The focus will be on the sequence of QSDs corresponding to the model on complete bipartite graphs with a "large" partition whose size tends to infinity and a "small" partition of constant size. In this case, the QSDs converge to a nontrivial limit featuring a consensus, except for a random number of dissenting vertices in the large partition which follows the heavy-tailed Sibuya distribution. The results rely on duality between the voter model and coalescing random walks through time-reversal. Time permitting, I'll expand the discussion on the duality and its application to a broader class of processes. The research presented in this talk was mostly performed in the Markov Chains REU and is joint work with Hugo Panzo and student participants Philip Speegle and R. Oliver VandenBerg.

Periodic homogenization of discontinuous Markov processes

Zhen-Qing Chen

Department of Mathematics, University of Washington

In this talk, I will present some recent results on homogenization of discontinuous Markov processes with Lévy type generators in periodic media. Under a proper scaling, the scaled Markov process is shown to converge weakly to a Lévy process. Different phenomena occur depending on the tails of the jumping kernel of the discontinuous Markov process. These results can be viewed as the non-local counterparts of the celebrated work of Bensoussan-Lions-Papanicoaou and Bhattacharya for diffusions. Based on joint work with Xin Chen, Takashi Kumagai and Jian Wang.

Quickest real-time detection of a Brownian coordinate drift, with applications to Markovian drifts

Philip Ernst

Department of Statistics, Rice University

This talk concerns two recent papers. In the first paper, we consider the motion of a Brownian particle in two or more dimensions, whose coordinate processes are standard Brownian motions with zero drift initially, and then at some random/unobservable time, one of the coordinate processes gets a (known) non-zero drift permanently. Given that the position of the Brownian particle is being observed in real time, the problem is to detect the time at which a coordinate process gets the drift as accurately as possible. We solve this problem in the most uncertain scenario when the random/unobservable time is (i) exponentially distributed and (ii) independent from the initial motion without drift. The solution is expressed in terms of a stopping time that minimizes the probability of a false early detection and the expected delay of a missed late detection. This paper is joint work with Goran Peskir (The University of Manchester) and is currently in press at *The Annals of Applied Probability*. The second paper considers the above problem in the random switching environment setting; one of the coordinate processes gets a (known) non-zero drift permanently depending on an underlying continuous time Markov chain with finite state space. This paper is joint work with Hongwei Mei (Rice University) and can be found at `https://arxiv.org/pdf/2107.14441.pdf`.

Ergodicity for Langevin dynamics with singular potentials

Maria Gordina
Department of Mathematics, University of Connecticut

We will discuss Langevin dynamics of N particles on $\mathbb{R}^d$ interacting via a singular repulsive potential, such as the Lennard-Jones potential, and show that the system converges to the unique invariant Gibbs measure exponentially fast in a weighted Sobolev norm. The proof relies on an explicit construction of a Lyapunov function using geometric methods. In contrast to previous results for such systems, our results imply geometric convergence to equilibrium starting from an essentially optimal family of initial distributions. This is based on the joint work with F. Baudoin and D. Herzog published in the Archive for Rational Mechanics and Analysis, as well as a paper with E. Camrud, D. Herzog and G. Stoltz. If time permits, we will mention related open problems.

Generative Adversarial Networks (GANs): Game and Control Perspectives

Xin Guo
Department of IEOR, University of California, Berkeley

Generative Adversarial Network (GANs) have enjoyed great successes in computer vision and image generation, and more recently in mathematical finance for its capability of financial data generation and computing solutions for high dimensional mean-field games.

Despite these empirical successes of GANs, GANs training, usually via the stochastic gradient approach, has been challenging, especially in terms of its stability and convergence. In this talk, we discuss the game structure of GANs in a stochastic differential equation framework, and present our latest work using the control approach to analyze the stability of GANs training. Based on joint work with Haoyang Cao of Alan Turing Institute and Othmane Mounjid of UC Berkeley.

Inverse Reinforcement Learning

Vikram Krishnamurthy
Department of Electrical & Computer Engineering, Cornell University

Inverse reinforcement learning aims to estimate the utility function of a decision maker by observing its decisions. This talk presents three approaches to inverse reinforcement learning. The first approach uses Afriat's theorem and Bayesian generalizations of revealed-preferences to reconstruct the utility function of a constrained Bayesian utility maximizer as a convex feasibility problem. The second approach uses passive Langevin dynamics to reconstruct utility functions given noisy gradient information. The third approach discusses inverse filtering problems - reconstructing the posterior given noisy information.

Stability of Coupled Jump Diffusions and Applications

Hai-Dang Nguyen
Department of Mathematics, University of Alabama

This work develops stability and stabilization results for systems of fully coupled jump diffusions. Such systems frequently arise in numerous applications where each subsystem (component)

is operated under the influence of other subsystems (components). We derive sufficient conditions under which the underlying coupled jump diffusion is stable. The results are then applied to investigate the stability of linearizable jump diffusions, fast-slow coupled jump diffusions. Moreover, weak stabilization of interacting systems and consensus of leader-following systems are examined.

A Stochastic Maximum Principle for Forward-Backward Stochastic Control Systems with General Conditional Mean-Fields

Son Luu Nguyen

Department of Mathematics, University of Puerto Rico

In this talk, we investigate a recursive optimal control problem with regime-switching. The main feature is that general conditional mean-fields are used in the controlled forward-backward systems. Analysis of variational equations are carried out and the second-order expansions for both forward and backward equations are obtained using a new L_p estimate of conditional mean-field backward equations driven by discontinuous martingales and derivatives with respect to the measure. A necessary condition for the optimal control problem is proved without assuming the convexity of the control domain.

Stochastic domination of various orders and its applications in stochastic control

Oleksii Mostovyi

Department of Mathematics, University of Connecticut

In this talk, we will start by discussing the stochastic domination of various orders and provide its characterizations in terms of the appropriate class of test functions. The motivation for this work comes from the regularity analysis of the value function in Mayer's formulation of the optimal investment problem in general incomplete semimartingale settings. Here, we show that stochastic domination of the infinite order in the dual domain and complete monotonicity of the inverse marginals in the utility function allows for the analyticity of the value function. Two counterexamples of independent interest illustrate that analyticity fails if either of the conditions above is not satisfied. Finally, we show that for the dual domain of the optimal investment problem in Mayer's formulation, stochastic domination of infinite order is equivalent to the apparently stronger domination of the second order. This talk is based on the joint work with Mihai Sîrbu and Thaleia Zariphopoulou.

Hydrodynamic Limits of non-Markovian Interacting Particle Systems on Sparse Graphs

Kavita Ramanan

Division of Applied Mathematics, Brown University

We study empirical measures of a large system of (possibly non-Markovian) interacting jump processes in which the infinitesimal evolution of each particle depends on the states of neighboring particles with respect to a sparse underlying interaction graph. Such systems model a variety of applications in statistical physics, neuroscience and engineering. We show that when the sequence of graphs converges in a suitable sense to a limit graph, the corresponding sequence of empirical

measures also converges weakly to a deterministic limit. We also provide counterexamples to show when this convergence could fail. These results can be seen as complementary to mean-field limits for interacting particles on complete (or sufficiently dense) graphs. This is based on joint work with A. Ganguly.

Coexistence and competitive exclusion in serial passage experiments

Sebastian J. Schreiber

Department of Evolution and Ecology, University of California, Davis

Serial passage is the successive transfer of a bacterial or viral populations through a series of cultures or experimental animals. This method was employed by Louis Pasteur to produce a rabies vaccine in the late 1800s. During serial passage, the population is grown in one environment, and then a portion of that population is removed and put into a new environment. Recently, these serial passage experiments have been used to understand the maintenance of genetic diversity due to fluctuating environments. In this talk, I will present preliminary results about a mathematical framework for understanding coexistence and extinction for stochastic, hybrid system models of serial passage experiments. Applications to two types of serial passage experiments will be given.

Time-triggered stochastic hybrid systems with two timer-dependent resets

Abhyudai Singh

Department of Electrical & Computer Engineering, University of Delaware

In this talk, I will present a class of time-triggered stochastic hybrid systems where the state-space evolves as per a linear time-invariant dynamical system. This continuous-time evolution is interspersed with two kinds of stochastic resets. The first reset occurs based on an internal timer that measures the time elapsed since it last occurred. Whenever the first reset occurs the states-space undergoes a random jump and the timer is reset to zero. The second reset occurs based on an arbitrary timer-depended rate, and whenever this reset fires, the state-space is changed based on a given random map. For this class of systems, we provide exact conditions that lead to finite statistic moments, and the corresponding exact analytical expressions for the first two moments. This framework is applied to study random fluctuations in the concentration of a protein in a growing cell. Our analysis provides closed-form formulas for the noise in the protein concentration and leads to a striking result-the noise in the protein concentration is invariant of the noise in the cell-cycle time.

Regime Switching Mean Field Games with Quadratic Costs

Qingshuo Song

Department of Mathematical Sciences, Worcester Polytechnic Institute

This paper studies Mean Field Games with a common noise given by a continuous time Markov chain under a Quadratic cost structure. The theory implies that the optimal path under the equilibrium is a Gaussian process conditional on the common noise. Interestingly, it reveals the Markovian structure of the random equilibrium measure flow, which can be characterized via a deterministic finite dimensional system

Optimal Fee Structure of Variable Annuities

Gu Wang

Department of Mathematical Sciences, Worcester Polytechnic Institute

We study the design of fee structures of variable annuities as a stochastic control problem, in which an insurer is allowed to choose the fee structure in any form that satisfies the budget constraint, and seeks an optimal one to maximize its business objective. Under the no surrender assumption, we show that the optimal fee structure is of barrier type with a time-dependent free boundary. The insurer's optimal strategy is to charge fees if and only if the account value of variable annuities hits the free boundary from below.

Stochastic Observability and State Estimation of Randomly Switched Unobservable Linear Systems

Le Yi Wang

Electrical & Computer Engineering, Wayne State University

This talk will present some recent results on observability and observer design for randomly switched linear systems in which subsystems may not be observable. We introduce switching speed conditions under which off-line collectively observable systems can support stochastic observability in real-time operation. Asymptotic observability of randomly switched linear systems is presented. Observer design for unobservable subsystems and their coordination algorithms are introduced. Convergence properties are established, including strong convergence and exponential convergence rate. Estimation error probabilities under finite data are derived by using large deviation principles.

Time-Inconsistent Optimal Control Problems with Equilibrium Recursive Cost Functionals

Jiongmin Yong

Department of Mathematics, University of Central Florida

This talk is concerned with a class of stochastic optimal control problems for stochastic differential equations with the cost functionals determined by backward stochastic Volterra integral equations. Such kind of problems are time-inconsistent, which means that an optimal control selected at given initial pair might not stay optimal afterwards. Therefore, instead of finding optimal controls for a given initial pair, one should find an equilibrium strategy which is time-consistent and locally optimal. Such a strategy can be determined by an equilibrium HJB equation. This is a joint work with Hanxiao Wang.

Stochastic Damping Hamiltonian Systems with State-Dependent Switching

Chao Zhu

Department of Mathematical Sciences, University of Wisconsin-Milwaukee

This work focuses on a class of stochastic damping Hamiltonian systems with state-dependent switching, where the switching process has a countably infinite state space. After establishing the existence and uniqueness of a global weak solution via the martingale approach under very mild

conditions, we next establish the strong Feller property for regime-switching stochastic damping Hamiltonian systems by the killing technique together with some resolvent and transition probability identities. The commonly used continuity assumption for the switching rates $q_{kl}(\cdot)$ in the literature is relaxed to measurability in this work. Finally we provide sufficient conditions for exponential ergodicity and large deviations principle for regime-switching stochastic damping Hamiltonian systems. Several examples on regime-switching van der Pol and (overdamped) Langevin systems are studied for illustration.

Monotone Mean-Variance Portfolio Selection

Bin Zou

Department of Mathematics, University of Connecticut

We study a portfolio optimization problem for a representative investor with the monotone mean-variance preference in an incomplete financial market. The price processes of the risky assets are given by non-Markovian regime-switching models. We employ the theories of stochastic Hamilton-Jacobi-Bellman equations and backward stochastic differential equations (BSDEs) to solve the problem. We obtain the optimal investment strategy and the value function in semi-explicit forms, subject to the unique solution of a regime-switching BSDE. Moreover, we derive a continuous-time version of the efficient frontier and the capital asset pricing model under the monotone mean-variance preference. We show that the optimal strategy to the monotone mean-variance problem is the same as the pre-commitment strategy to the classical mean-variance problem from time zero, and vice versa. To illustrate our result, we obtain closed-form solutions in special path-dependent regime-switching models.