

Manisha Bhardwaj

Optimal Bayesian Inference in Social Networks

Understanding how information propagates in a social network has been an active area of research over the last few decades. Early mathematical models were developed to understand how consensus is reached in simple networks. With the advent of social media which can connect millions of users, there has been resurgent interest in the problem. For instance, Frongillo et al.[2], have examined how individuals in a social network can optimally exchange information about a dynamically changing parameter.

It is frequently assumed that discussion improves the decisions of individuals. However, such exchanges can correlate the beliefs of different individuals in a social network, and negatively impact a collective decision. Indeed, even individual decisions may suffer after an exchange of information. Bahrami group [1] observed that discussion can have a positive impact on decision making only if the observers have approximately equal competence. Redundancies are likely to be present in social networks, specifically in large networks with many edges. In such situations, how should observers integrate incoming information to achieve the best possible estimate and reach the best decisions?

We study a simple graphical Bayesian model of interacting observers who try to estimate a value in the outside world with their own observations and their local neighborhood information. We study in detail feed forward and recurrent network and establish a general result on how the individuals can achieve optimal Bayesian inference in the presence of redundancies. Such redundancies impact the performance of even optimal observers. We also consider the propagation of individuals biases and priors in making decisions and show how certain network structures impact an individuals' maximum-likelihood (ML) estimate.

Apart from our theoretical studies, we also design a lab-based psychophysical experiment to be conducted on human observers to test their potential of making optimal decisions in presence of redundant information.

Parisa Fatheddin

Large and Moderate Deviations for Some Measure-Valued Processes

Here we derive the Large and Moderate Deviation Principles for two important population models: super-Brownian motion and Fleming-Viot Process. We do so by considering an Stochastic Differential Equation (SPDE) with non-lipschitz coefficient.

Jun Eun Kim

Mutually Inhibiting Two Cluster Model for Sleep Wake Transition Mechanism

Sleep-wake dynamics change across postnatal development: sleep bout durations exhibit exponential distributions at all ages, but wake bout durations exhibit exponential distributions at the younger ages in contrast to the older ages at which a power-law distribution emerges. We modeled sleep and wake neuronal networks as two mutually-inhibiting Erdos-Renyi type random graphs in which each neuron can be in an excited, basal or inhibited state with corresponding distinct spiking rates. We investigated the dynamics of the stochastic mean field equations for the number of neurons in each state, finding that the network size and mean degree of the graphs contribute to the change in bout distributions.

Lu Lu

On the integrated mean squared error of the wavelet density estimators

Wavelet density estimators (WDE) are wavelet projections of the empirical measure based on i.i.d data. We'll discuss the law of the iterated logarithm (LIL) and a Berry-Esseen type theorem. Under certain assumptions, WDE can be written in a form similar to that of KDE. While the tools such as U-statistics and approximation by a Gaussian chaos are still useful for WDE, more assumptions on the density are needed to compute the asymptotic variance, which gives the scaling constant in LIL. To study the Berry-Esseen type theorem, a rate of convergence result in the martingale CLT is used.

ShiShi Luo

Measure-valued processes and multilevel selection

Natural selection can act at multiple biological levels, often in opposing directions. This is particularly the case for host-pathogen systems, where pathogen evolution occurs both within the host it infects and via transmission between hosts. In mathematical terms, this is a multiscale problem characterized by stochasticity at each scale. A minimal model for this system can be formulated as a measure-valued process. As well as providing biological insight, this model has interesting mathematical properties, namely, under different parameter scalings, it admits either a propagation of chaos result or a Fleming-Viot process in the infinite population limit.

Elizabeth Makrides

Understanding Microbial Community Structure via Metagenomic Analysis"

Just as different human communities may grow up depending on the type of jobs available (think Silicon Valley), microbial community structures depend on the resources available. One question researchers have asked is whether the response to resource availability is primarily reflected in shifting species, or if there is a "lottery" system, in which any species that satisfies a certain functional niche can enter and remain. The lottery hypothesis suggests that different environments will primarily change the functional composition of the communities (i.e., what traits are present) rather than the taxonomic composition (i.e., what species are present). Our project examines the functional and taxonomic structure of microbial communities along Greenwood Creek in the Plum Island Estuary Long Term Ecological Research (LTER) site. Due to the presence of a sewage outfall at the top of the creek, a strong gradient of nitrogen and other compounds has existed in Greenwood Creek for many years which could have substantial effects on community structure. Since this nitrogen gradient co-occurs with a strong salinity gradient, we also took sediment samples from a nearby creek with a similar salinity gradient to put our findings in context. Following sampling, we extracted DNA from the soil and used "next-generation" sequencing technology to sequence millions of random DNA fragments from the community of microbes in the sediment. We will compare these sequences to DNA sequences in existing databases to determine the presence and abundance of different functional genes and taxonomic groups along the two creeks. This combination of field ecology, environmental biology, high-throughput sequencing and bioinformatics allows us to get a full picture of the otherwise invisible structure and function of microbial communities and address basic hypotheses regarding microbial ecology.

Mavs Pararai

Underreporting in the generalized Poisson regression model

When count data is analyzed, the assumption is that the counts were correctly reported. However, underreporting can be a problem. We use the generalized Poisson regression model to analyze data on underreported number of sexual partners.

Jelena Ryvkina

Fractional Brownian motion with variable Hurst parameter

A new class of Gaussian processes generalizing the usual fractional Brownian motion (fBM) for Hurst indices in $(1/2, 1)$ is presented. The parameter can now be chosen to be any measurable function assuming values in this interval. These new processes allow for modeling of phenomena where the regularity properties can change with time. The presentation shows how the fBMvH is obtained from an appropriate class of covariance functions as well as addresses some properties of the process, including long-range dependence and local Hölder continuity of the paths under regularity assumptions on the parameter function. It should be noted that fBMvH is distinct from the multifractional Brownian motion, which is another known generalization of fBM.

Xiaoming Song

Admission Control for Multidimensional Workload with Heavy Tails and Fractional Ornstein-Uhlenbeck Process

Abstract: The infinite source Poisson arrival model with heavy-tailed workload distributions has attracted much attention, especially in the modeling of data packet traffic in communication networks. In particular, it is well known that under suitable assumptions on the source arrival rate, the centered and scaled cumulative workload process for the underlying processing system can be approximated by fractional Brownian motion. In many applications one is interested in the stabilization of the work inflow to the system by modifying the net input rate, using an appropriate admission control policy. In this work we study a natural family of admission control policies which keep the associated scaled cumulative workload asymptotically close to a pre-specified linear trajectory, uniformly over time. Under such admission control policies and with natural assumptions on arrival distributions, suitably scaled and centered cumulative workload processes are shown to converge weakly in the path space to the solution of a d -dimensional stochastic differential equation (SDE) driven by a Gaussian process. It is shown that the admission control policy achieves moment stabilization in that the second moment of the solution to the "station average" SDE is bounded uniformly for all times. In one special case of control policies, as time approaches infinity, we obtain a fractional version of a stationary Ornstein-Uhlenbeck process that is driven by fractional Brownian motion with Hurst parameter $H > 1/2$.

Cristina Tone

Limit Theorems for Random Fields Satisfying Strong Mixing Conditions

We introduce some limit theorems for strictly stationary random fields satisfying an interlaced mixing condition. We proceed by first introducing a common technique in proving limit theorems for dependent random sequences, followed by two extensions, including the case of an Hilbert space-valued random field satisfying the same strong mixing condition, and a functional central limit theorem for empirical processes.

Ngoc Tran

Size-biased permutation of a finite sequence with i.i.d terms

This work reviews and complements results on the exact and asymptotic distribution of the size-biased permutation of finitely many independent and identically distributed positive terms. Our main theorem is a coupling between the asymptotic distribution of the last few terms of the aforementioned size-biased permutation and its few smallest order statistics.

Zhixin Wang

Stability of Nonlinear Regime-switching Jump Diffusions

Motivated by networked systems, stochastic control, optimization, and a wide variety of applications, this work is devoted to systems of switching jump diffusions. Treating such nonlinear systems, we focus on stability issues. One of the distinct features considered here is that the switching process depends on the jump diffusions.

Hong Zhu

Testing and association measure for bivariate survival data with interval sampling via Kendall's tau

We propose a nonparametric test of quasi-independence based on a coordinatewise conditional Kendall's tau for bivariate survival data with interval sampling. To quantify dependence between bivariate failure times given quasi-independence, a nonparametric estimator of an unconditional Kendall's tau that uses inverse probability weights is developed. Asymptotic properties are established through U-statistics Theory. Simulation studies demonstrate that the test procedure and association estimator perform well with moderate sample sizes.