CONFERENCE PROGRAM

Women's **I**ntellectual **N**etwork **R**esearch **S**ymposium

A Meeting of Math Minds

BROWN UNIVERSITY

PROVIDENCE, RI

MARCH 4, 2017

This conference is organized in cooperation with the Association for Women in Mathematics (AWM) and supports the Non-Discrimination Statement of the Association for Women in Mathematics.

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Contents

1 Conference Objectives

The conference objectives are to introduce students and faculty, in particular women, to ongoing research in New England and bridge gaps between universities. We aim to connect women in similar mathematical fields, as well as promote collaboration and share strategies for addressing issues facing women and other underrepresented groups in math. The conference is open to everyone, regardless of gender identity.

2 Acknowledgments

The organizers would like to thank Stephanie Han for her invaluable assistance in creating graphics and printed materials for the conference, and Carly Hansen-Decelles and Lyubov Niemann for their careful assistance with administrative details.

3 Schedule

9:15 - 10:00	Sign In	170 Hope Lobby	
9:45 - 10:00	Introduction & Welcome	B&H 168	Stephanie Dodson
10:00 - 11:00	Plenary Lecture	B&H 168	Prof. Mary Lou Zeeman
11:10 - 11:50	Contributed Talks, A-E	B&H	
12:00 - 1:00	LUNCH*	170 Hope, 182 George	
1:00 - 1:10	Introduction	B&H 168	Prof. Kavita Ramanan
1:10 - 2:10	Plenary Lecture	B&H 168	Prof. Moon Duchin
2:20 - 2:50	Contributed Talks, F-J	B&H	
3:00 - 4:00	Tutorials	B&H 168	Prof. Linda Ness
		B&H 161	Dan Nichols
		B&H 190	Dr. Nicolás Trillos
4:00 - 4:30	Poster Session**	170 Hope	
4:30 - 5:00	Math Corners	170 Hope	
5:00 - 5:45	Panel	B&H 168	

B&H = Barus & Holley
*AWM chapter members are invited to share their lunch in 182 George St on the main floor and discuss ideas for chapter events and programs. Lunch stations will also be set up in 170 Hope St on the first and third floors, with additional seating available on the second floor. Vegan and gluten-free lunches will be provided in 170 Hope St, room 207 for those who requested them.
** Snacks and coffee will be served in 170 Hope St concurrently with the Poster Session and Math Corners discussion period, from 4 pm to 5 pm.

4 Plenary Lectures

10:00 am - 11:00 am **Barus & Holley 168**

Mathematical modeling: from the menstrual cycle to resilience

Professor Mary Lou Zeeman, *Bowdoin College*

How do we find the problems we work on? Sometimes we choose them, and sometimes it feels like they choose us. I'll describe some of the modeling questions that I find captivating, and how they have guided my career.

1:10 pm - 2:10 pm **Barus & Holley 168**

How Things Spread Out

Professor Moon Duchin, *Tufts University*

Hyperbolicity captures a bunch of equivalent metric phenomena having to do with what you might call "rapid spreading out." I will survey a variety of interrelated spreading-out theorems, with applications.

5 Contributed Talks

5.1 Morning Sessions: Time Tables

Session A Chair: Weijie Pang B&H 168	• 11:10-11:25 Weijie Pang • 11:25-11:40 Yanqi Zhang • 11:40-11:55 Yaohua Zhang
Session B Chair: Veronica Ciocanel B&H 190	• 11:10-11:25 Veronica Ciocanel • 11:25-11:40 Konstandinos Kotsiopoulos • 11:40-11:55 Hwayeon Ryu
Session C Chair: F. Patricia Medina B&H 157	• 11:10-11:25 F. Patricia Medina • 11:25-11:40 David Miller
Session D Chair: Victoria Day B&H 159	• 11:10-11:25 Heather Fang • 11:25-11:40 Robin Koytcheff • 11:40-11:55 Melissa Zhang
Session E Chair: Pooja Agarwal B&H 161	• 11:10-11:25 Sarah Rebekah Childs • 11:25-11:40 Nina Holden • 11:40-11:55 Sahinde Dogruer Akgul

5.2 Morning Sessions: Abstracts

5.2.1 Session A

11:10 am - 11:25 am **Barus & Holley 168**

Sensitivity Analysis of Financial Network

Weijie Pang, *Worcester Polytechnic Institute*

The financial system is increasingly interconnected. Cyclical interdependencies among corporations may cause that the default of one firm seriously affects other firms and even the whole financial network. To describe financial networks, L. Eisenberg and T. Noe introduced network models that became popular among researchers and practitioners. To describe the connections between firms, they use the liabilities between two firms to construct relative liability matrices. Based on this description, they compute the payouts of firms to their counterparts. However, in practice, there is no accurate record of the liabilities and researchers have to resort to estimation processes. Thus it is very important to understand possible errors of payouts due to the estimation errors. In our research, we describe estimation errors via sizes and directions of perturbations in the relative liability matrices. We quantify the effect of estimation errors to payouts using directional directives and derive its formula in the regular financial network. For a given relative liability matrix, we compute the effect to the payout of different estimation errors.

11:25 am - 11:40 am **Barus & Holley 168**

Modeling financial durations using estimating functions

Yaohua Zhang, *University of Connecticut*

Accurate modeling of patterns in inter-event durations is of considerable interest in high-frequency financial data analysis. The class of logarithmic autoregressive conditional duration (Log ACD) models provides a rich framework for analyzing durations, and recent research is focused on developing fast and accurate methods for fitting these models to long time series of durations under least restrictive assumptions. This article describes an optimal semi-parametric modeling approach using martingale estimating functions. This approach only requires assumptions on the first few conditional moments of the durations and does not require specification of the probability distribution of the process. We introduce three approaches for parameter estimation in our methodology, including solution of nonlinear estimating equations, recursive formulas for the vector-valued parameter estimates, and iterated component-wise scalar recursions. All three estimation methods are compared via extensive numerical studies. Effective starting values from an approximating time series model increase the accuracy of the final estimates. We demonstrate our approach via a simulation study and a real data illustration based on high-frequency transaction level data on several stocks.

5.2.2 Session B

11:10 am - 11:25 am **Barus & Holley 190**

The superhighway in frog eggs: modeling insights

Veronica Ciocanel, *Brown University*

Messenger RNA transport to certain cell locations is essential for the development of the egg cell and embryo in certain frogs. This accumulation of RNA molecules at the cell edge is not well understood, but is thought to depend on diffusion, bidirectional movement on a highway of microtubules, and anchoring mechanisms. We test these proposed mechanisms using differential equations models and analysis, informed by parameter estimation. Our results for the dynamics of RNA suggest different behavior in various regions of the healthy egg cell, and propose directions for new experiments.

11:25 am - 11:40 am **Barus & Holley 190**

Asymptotic behavior of the random logistic model

Konstandinos Kotsiopoulos, *University of Massachusetts, Amherst*

For t a nonnegative integer we construct a Markov chain $x(r,t)$ by perturbing the well-known logistic map $f(x) = rx(1-x)$, $r \in (0,4]$ by a truncated Gaussian noise. The truncated noise restricts the process to the interval $[0,1]$, where the logistic map exhibits interesting behavior. It can be shown that an invariant measure for the Markov chain exists. The main focus of the talk is on the asymptotic behavior of the Markov chain and on how this behavior reflects the underlying deterministic dynamics. The asymptotic behavior can be studied via two different approaches. The first approach is to consider the vanishing-noise limit followed by the ergodic limit, whereas the second is to consider the ergodic limit first. In each case we derive a number of limit theorems for $x(r,t)$. The work discussed in this talk is joint research with Professor Richard S. Ellis.

11:40 am - 11:55 am **Barus & Holley 190**

Synchronization of tubular pressure oscillations in coupled nephrons

Hwayeon Ryu, *University of Hartford*

The kidney plays an essential role in regulating the blood pressure and a number of its functions operate at the functional unit of the kidney, the nephron. To understand the impacts of internephron coupling on the overall nephrons' dynamics, we develop a mathematical model of a tubuloglomerular feedback (TGF) system, a negative feedback mechanism for nephron's fluid capacity. Specifically, each model nephron represents a rigid thick ascending limb only and is assumed to interact with nearby nephrons through vascular and hemodynamic coupling along the pre-glomerular vasculature. We conduct a bifurcation analysis by deriving a characteristic equation obtained via a linearization of the model equations.

5.2.3 Session C

11:10 am - 11:25 am **Barus & Holley 157**

Numerical approximations for methane hydrate models

F. Patricia Medina, *Worcester Polytechnic Institute*

The computational simulation of Methane Hydrates (MH), an ice-like substance abundant in permafrost regions and in subsea sediments, is useful for the understanding of their impact on climate change as well as a possible energy source. We consider a simplified model of MH evolution which is a scalar nonlinear parabolic PDE with two unknowns, solubility, and saturation, bound by an inequality constraint. This constraint comes from thermodynamics and expresses maximum solubility of methane component in the liquid phase; when the amount of methane exceeds this solubility, methane hydrate forms. The problem can be seen as a free boundary problem somewhat similar to the Stefan model of ice-water phase transition. Mathematically, the solubility constraint is modeled by a nonlinear complementarity constraint and we extend the theory of monotone operators to the present case of a spatially variable constraint. Part of our posterior work extended the computational model and analysis to include more variables such as salinity, pressure, temperature, and gas phase saturation, as well as in considering realistic scenarios such as those that may occur in ocean observatories along Hydrate Ridge and Cascadia Margin.

11:25 am - 11:40 am **Barus & Holley 157**

Laurent polynomials and a fast inversion algorithm for structured matrices

David Miller, *University of Hartford*

The Vandermonde matrix is classical and is encountered in polynomial interpolation computation. The structure of the Vandermonde matrix leads to fast inversion algorithms and system solvers. We look to extend these properties to other structured matrices, focusing on a fast inversion algorithm for the Laurent-Vandermonde matrix, which is defined using Laurent polynomials.

5.2.4 Session D

11:10 am - 11:25 am **Barus & Holley 159**

Knot colorings with no colors

Heather Fang, *Wheaton College*

In this talk I will discuss recent work on n-colorings, a kind invariant among knots. An n-coloring assigns an integer to each arc so that at each crossing there would be some relationship preserved under addition mod n. I will present results on the colorabilities of some simple knots using linear algebra under modular arithmetic.

11:25 am - 11:40 am **Barus & Holley 159**

Linking numbers and generalizations

Robin Koytcheff, *University of Massachusetts Amherst*

The linking number is arguably the simplest nontrivial invariant of knots and links. It detects whether two closed curves in space are linked and can be defined in elementary terms by counting crossings. I will begin with this elementary definition and then describe this invariant as the degree of a map of surfaces. I will further reinterpret it in terms of homotopy classes of maps of configuration spaces. This perspective leads to a more general invariant which, by recent joint work with F. Cohen, Komendarczyk, and Shonkwiler, separates link homotopy classes of string links, proving an analogue of a conjecture of Koschorke from the 1990s.

11:40 am - 11:55 am **Barus & Holley 159**

Smith theory, knot theory, and braids

Melissa Zhang, *Boston College*

The original goal of Smith theory was to understand the actions of finite p-groups on topological spaces. In the late '50s, Borel introduced the notion of equivariant cohomology, which broadened the scope of objects we could apply Smith-theoretic methods to. In this talk, we apply Borel's construction to doubly-periodic links to prove a Smith-type inequality for annular Khovanov homology, a knot-theoretic invariant which is particularly well-suited for studying the braid group.

5.2.5 Session E

11:10 am - 11:25 am **Barus & Holley 161**

Torsion points on elliptic curves

Sarah Rebekah Childs, *Northeastern University*

The goal of this project is to be able to understand how Elliptic Curves work over any field. We will study the Group Law of the Elliptic Curve. Through this process, we will be able to algebraically describe the points and the relationship between rational points on an elliptic curve. We will study the properties of torsion points of order two and three on the elliptic curve. In the end, we will be able to prove important characteristics of these torsion points on Elliptic Curves.

11:25 am - 11:40 am **Barus & Holley 161**

Schramm-Loewner evolutions

Nina Holden, *Massachusetts Institute of Technology*

The Schramm-Loewner evolution (SLE) is a family of random fractal curves, which have been proven or conjectured to be the scaling limit of a variety of two-dimensional lattice models in statistical mechanics. First I will give a short introduction to SLE with many pictures/simulations. Then I will mention a recent convergence result obtained with Xin Sun.

11:40 am - 11:55 am **Barus & Holley 161**

Lipschitz stability of -FOCS and RC canonical Jordan bases of real H-selfadjoing matrices under small perturbations

Sahinde Dogruer Akgul, *University of Connecticut*

Bella, Prasad and Olshevsky proved the stability of flipped orthogonal Jordan bases of complex H-selfadjoint matrices under small perturbations. Specifically, let $A0$ be an $H0$-selfadjoint matrix, and A be H- selfadjoint. It was shown that if (A, H) is a small perturbation of $(A0, H0)$ and if A is similar to $A0$, then there exists an invertible matrix S such that $\|I - S\| \leq K(\|A - A0\| + \|H - H0\|)$ with some $K > 0$ depending only on $(A0, H0)$ and $S - 1AS = A0$, $S * HS = H0$.

We answer the question by L. Rodman and prove the real version of above result. Specifically, if $(A0, H0)$ and (A, H) are real, then the matrix S can also be chosen to be real. To prove this result we introduce a new concept, the flipped-orthogonal conjugate-symmetric Jordan basis of real H-selfadjoint matrices. Finally, we prove that the real Jordan canonical form of $(A0, H0)$ is also Lipschitz stable.

5.3 Afternoon Sessions: Time Tables

Session F	Chair: Karen Larson	B&H 168	2:20-2:35 Angela Vierling-Claassen 2:35-2:50 Nadejda Drenska
Session G	Chair: Patrick Rebeschini	B&H 190	2:20-2:35 Patrick Rebeschini 2:35-2:50 Patricia Alonso Ruiz
Session H	Chair: Aslihan Demirkaya	B&H 157	2:20-2:35 Aslihan Demirkaya 2:35-2:50 Aden Forrow
Session J	Chair: Alexandria Volkening	B&H 161	2:20-2:35 Alexandria Volkening 2:35-2:50 Yixuan He

5.4 Afternoon Sessions: Abstracts

5.4.1 Session F

2:20 pm - 2:35 pm **Barus & Holley 168**

Scrape my professor

Angela Vierling-Claassen, *Lesley University*

What can be learned from scraping a large portion of the 1.6 million reviews in Rate My Professor's database of user-submitted reviews of college professors? In this talk I discuss what can be learned about gender in these ratings, particularly differences in how reviewers describe male and female professors, and how these reviews can be used to develop a "Sexism Index" for a school. I will also talk briefly about the process of scraping the data.

2:35 pm - 2:50 pm **Barus & Holley 168**

A PDE approach to prediction with expert advice

Nadejda Drenska, *Courant Institute, NYU*

In the machine learning literature one approach to prediction assumes the existence of two or more 'experts'; the best prediction in this setting is one that 'minimizes regret', i.e. tries to perform as close as possible to the best-performing expert. This talk focuses on a model problem of the prediction of a binary sequence (or a stock whose price goes up or down one unit every time step) in the case of two time-dependent experts with publicly available algorithms. I will discuss a continuum limit in which the optimal prediction is an approximation algorithm to the original problem. The optimal prediction in the limit is a solution to a second order parabolic PDE, with surprising connections to motion by curvature. This is joint work with Robert Kohn.

5.4.2 Session G

2:20 pm - 2:35 pm **Barus & Holley 190**

Message passing in convex optimization

Patrick Rebeschini, *Yale University*

We present a general framework to analyze the convergence behavior of message-passing in convex optimization, potentially with constraints. We discuss applications in solving systems of linear equations in graph Laplacians, computing network flows, and calculating distributed average consensus over a network. (joint work with Sekhar Tatikonda)

2:35 pm - 2:50 pm **Barus & Holley 190**

Entropy-based inhomogeneity detection

Patricia Alonso Ruiz, *University of Connecticut*

Glass fiber reinforced polymers constitute a type of plastics characterized by their light weight, versatility and strength. For instance, they are present in many automotive components: the lower a vehicle's weight, the less fuel it uses and the fewer carbon dioxide it emits.

When constructing pieces of this material with different parts that have complicated shapes, inhomogeneities may occur and engineers are very interested in detecting them. Due to the composition of these materials, the direction of the fibers becomes of special relevance in order to approach this problem. In this talk, we present an inhomogeneity-detection method that relies on the stochastic model provided by marked Poisson point processes combined with the concept of entropy as a measure of changes in the directional distribution of fibers.

This talk is based on joint work with E. Spodarev.

5.4.3 Session H

2:20 pm - 2:35 pm **Barus & Holley 157**

Kink dynamics in a parametric ϕ^6 system: A model with controllably many internal modes

Aslihan Demirkaya, *University of Hartford*

In the present work, we intend to explore a variant of the ϕ^6 model originally proposed in Phys. Rev. D **12**, 1606 (1975) as a prototypical, so-called, "bag" model where domain walls play the role of quarks within hadrons. We examine the prototypical steady state of the model, namely an apparent bound state of two kink structures. We explore its linearization and find that as a function of a prototypical parameter controlling the curvature of the potential an effectively arbitrary number of internal modes may arise in the point spectrum of the linearized analysis. We intend to use Evans function analysis to predict the bifurcation points of the relevant internal modes and confirm these theoretical predictions numerically. Finally, given the remarkable flexibility of the model in possessing different numbers of internal modes we once again intend to explore the dynamics of multi-bound-state collisions to identify the role of the additional internal modes in enhancing the complexity of the observed scattering scenarios.

2:35 pm - 2:50 pm **Barus & Holley 157**

State selection in active flow networks

Aden Forrow, *Massachusetts Institute of Technology*

Coherent, large scale dynamics in many nonequilibrium physical, biological, or information transport networks are driven by small-scale local energy input. We introduce and explore a new Toner-Tu type model for compressible active flows on tree networks. In contrast to thermally-driven systems, our active friction selects discrete states with only a small number of oscillation modes activated at distinct fixed amplitudes. This state selection interacts with graph topology to produce different localized dynamical time scales in separate regions of large networks. Using perturbation theory, we systematically predict the stationary states of noisy networks and find good agreement with a Bayesian state estimation based on a hidden Markov model applied to simulated time series data on binary trees. Our results, inspired by bacterial systems, suggest that the macroscopic response of a broader range of active networks, from actomyosin force networks in cells to cytoplasmic flows, could be dominated by a significantly reduced number of modes, in stark contrast to energy equipartition in thermal equilibrium systems.

5.4.4 Session J

2:20 pm - 2:35 pm **Barus & Holley 161**

How the zebrafish got its stripes

Alexandria Volkening, *Brown University*

Zebrafish (Danio rerio) is a small fish with distinctive black and yellow stripes that form on its body and fins due to the interactions of different pigment cells. Working closely with the biological data, we present an agent-based model for these stripes that accounts for the migration, differentiation, an death of three types of pigment cells on the zebrafish body. We also explore stripe formation on the caudal fin, where bone rays and fin growth seem to help direct pigment cell placement. The development of both wild-type and mutated patterns will be discussed, as well as the non-local continuum limit associated with the model. This is joint work with Bjorn Sandstede.

2:35 pm - 2:50 pm **Barus & Holley 161**

Determining optimal cancer treatment protocol via a simple mathematical model

Yixuan He, *Dartmouth College*

To facilitate and expedite drug synthesis for cancer treatment, we designed a simple mathematical model for cancer growth in vitro in order to better study the effects of anti-cancer drugs on tumor growth. Our model uses a system of ordinary differential equations to model qualitative results observed in a cell whether grown in monolayer, 3D spheroid, or xenograft culture. The model also accounts for growing vasculature, presence of signaling compounds, and drug treatments. Using our model, we were able to successfully characterize the growth of a neuroblastoma, the leading type of cancer in infants, with and without the treatment of anti-cancer drugs to determine optimal treatment protocol.

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6 Tutorials

3:00 pm - 4:00 pm **Barus & Holley 168**

The Product Formula Representation for Measures on Dyadic Sets and Applications to Data

Professor Linda Ness, *Rutgers University*

Pre-processing is one of the most time consuming and least transparent phases in analysis of a data set. The lack of transparency often makes reproducibility and replicability of the data analysis significantly more difficult. Pre-processing methods which output instances of canonical representations with a theoretical foundation begin to address this issue. Such representations permit comparison of different pre-processing methods for the same data set and provide a data structure instance which can be input into a general purpose data analysis algorithm.

This tutorial will present a canonical representation – the Dyadic Product Formula Representation - which can be applied to data “sampled” from any universe set which has an ordered binary tree structure. This representation can be used to pre-process a data set into an instance of a measure in the very large family of Dyadic Measures. (Measures differ from probability distributions only in that the “total volume” can be any positive number, not just 1.) The pre-processing explicitly computes the parameters of the measure from the data set itself. Thus the data set (i.e. data sample) is represented as one particular measure, i.e. as a point on a statistical manifold. It enables statistical analysis of a very broad class of data sets since the universe of the data set need only have a structure of repeated division into two parts. The parameters simply characterize the “skewness” of the data sample at multiple dyadic scales and localities of the universe, as determined by the binary tree structure.

The tutorial will be accessible to a broad audience because the approach can be explained using the elementary concepts of dyadic histograms (for multiple scales) and binary tree structures. The representation results can be visualized easily in two dimensions (e.g. using daywheel illustrations). The method will be illustrated on a variety of examples, including time series data sets and binary feature data sets. Several statistical, machine learning and mathematical analysis methods exploiting the representation will be briefly illustrated. Relations to other statistical and mathematical concepts (e.g. Bayesian analysis and topology) will be mentioned as time permits.

3:00 pm - 4:00 pm **Barus & Holley 161**

Public-key Cryptography with Elliptic Curves

Dan Nichols, *University of Massachusetts, Amherst*

In the last several decades, public-key encryption algorithms based on number theoretic concepts have become essential for secure digital communications. I will give a brief overview of public-key cryptography and describe how messages can be securely encrypted and decrypted using elliptic curves over finite fields.

3:00 pm - 4:00 pm **Barus & Holley 190**

PDEs and Machine Learning: How one mathematician survives the age of data analysis

Dr. Nicolás Trillos, *Brown University*

The boom of machine learning and data analysis in recent years has created opportunities for computer scientists, statisticians and people from a large variety of disciplines. As someone with a more pure mathematical background, how can one take advantage of these opportunities? In this tutorial I will share my own story: modern analytical tools from PDE theory, calculus of variations, geometric measure theory, optimal transport and random geometric graphs can be put together to shed light on the behavior of machine learning procedures. Conversely, modern statistical techniques can be used for better modeling of physical phenomena described by PDEs of different kinds.

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7 Poster Session

7.1 Electronic Posters

4:00 pm - 4:30 pm **170 Hope St**

Patterns in Dynamical Systems

Katherine Moore, *Dartmouth College*

Given a map $f : [0,1] \to [0,1]$, we may consider finite sequences of iterates $x, f(x), f(f(x)), \ldots, f^{n-1}(x)$. If these n values are different, we associate a permutation $\pi \in S_n$ to this sequence by replacing the smallest value with a 1, the second smallest with a 2, and so on. If π arises in this way, we say that it is an allowed pattern of f. It is known that if f is a piecewise monotone map, then there are permutations that are never realized by f. This surprising observation gives rise an important tool for distinguishing random from deterministic time series and for estimating the complexity of a time-series. The poster contains a few interesting applications of this perspective to time-series analysis, combinatorics and dynamical systems.

4:00 pm - 4:30 pm **170 Hope St**

Offline-Enhanced Reduced Basis Method through adaptive construction of the Surrogate Parameter Domain

Jiahua Jiang, *University of Massachusetts, Amherst*

Classical Reduced Basis Method (RBM) is a popular certified model reduction approach for solving parametrized partial differential equations. However, the large size or high dimension of the parameter domain leads to prohibitively high computational costs in the offline stage. In this work we propose and test effective strategies to mitigate this difficulty by performing greedy algorithms on surrogate parameter domains that are adaptively constructed. These domains are much smaller in size yet accurate enough to induce the solution manifold of interest at the current step. In fact, we propose two ways to construct the surrogate parameter domain, one through an Inverse Cumulative Distribution Function (ICDF) and the other based on the Cholesky Decomposition of an error correlation matrix. The algorithm is capable of speeding up RBM by effectively alleviating the computational burden in offline stage without degrading accuracy, assuming that the solution manifold has low Kolmogorov width. We demonstrate the algorithm?s effectiveness through numerical experiments.

4:00 pm - 4:30 pm **170 Hope St**

Nonparametric Inference of Neural Response with Exact Simultaneous Confidence Bands

Ivana Petrovic, *Brown University*

Nonparametric statistical methods for estimating neural firing rates as a function of other variables sometimes come with a notion of statistical confidence. However, they tend to perform poorly in realistic simulations, since confidence estimates are often based on large sample or dense data assumptions, rarely satisfied in practice.

We propose a procedure for nonparametrically estimating neural firing rate, which allows for fast and exact construction of frequentist confidence intervals, and works even in cases with sparse data. The key idea behind the procedure is our reformulation of the neural firing rate estimation in terms of simultaneous confidence bands for multiple binomial proportions problem.

We investigate the performance of the procedure on simulated datasets, and illustrate its use on two real datasets- for assessing changes in hippocampal place fields of rats across experimental conditions, and for assessing changes in the communication between prefrontal cortex and caudate nucleus of monkeys across experimental conditions.

7.2 Traditional Posters

4:00 pm - 4:30 pm **170 Hope St**

Filtering and Optimizing Financial Data Using Wavelets Transforms and Monte Carlo Simulations

Abdul Hasib Rahimyar & Hieu Nguyen, *Western Connecticut State University*

Due to the complexity of the financial world, any advantage in organizing data is of huge value. The research in this paper will be focusing on options trading, and properly pricing options through various data analysis techniques. By reducing noise through the Wavelet Transform, we can further reduce variance by following it up with Monte Carlo Simulations. Through this paper we hope to transform financial data, namely historical stock data, into a more straightforward and filtered form to maximize profits and minimize losses associated with options trading.

4:00 pm - 4:30 pm **170 Hope St**

A Mathematical Model for the Effects of Fertilization on Nitrogen Concentrations in Unsaturated Soil on Blueberry Farms

Ashley Crane, *Roger Williams University*

Nitrogen compounds are commonly used as fertilizers in agricultural crop growth. Despite their wide-spread use, the uptake and utilization of these compounds by crops, and their subsequent leaching into the surrounding environment, are not well understood. Of particular interest are blueberry plants, which do not efficiently ingurgitate the most commonly used nitrate (NO3) and ammonium (NH4) fertilizers. Thus, unknown quantities of these fertilizers will infiltrate the neighboring soil and groundwater. To address this issue, we have constructed a biogeochemical mathematical model to predict the concentrations of nitrate and ammonium in the unsaturated soil of blueberry plants. The model utilizes a system of ordinary and partial differential equations, and incorporates (i) region-based types of soil, (ii) nitrate uptake of the plant specie, (iii) water content in the roots region, (iv) pressure heads in the soil pores, and (v) the application rates of nitrate and ammonium. We then demonstrate the utility of the model through a case study that examines blueberry production in southern New Jersey. Simulations demonstrate that the model accurately accounts for natural processes, and results show that higher application rates of nitrate and ammonium cause unnecessarily high concentrations of each in the unsaturated soil level.

4:00 pm - 4:30 pm **170 Hope St**

Teaching dimension, VC dimension, and critical sets in Latin squares

Yingjie Qian, *McGill University*

A critical set in an $n \times n$ Latin square is a minimal set of entries that uniquely identifies it among all Latin squares of the same size. It is conjectured by Nelder in 1979, and later independently by Mahmoodian, and Bate and van Rees that the size of the smallest critical set is $\lfloor n^2/4 \rfloor$. We prove a lower-bound of $n^2/10^4$ for sufficiently large n, and thus confirm the quadratic order predicted by the conjecture. We prove a lower-bound of $n^2/10^4$ for sufficiently large n, and thus confirm the quadratic order predicted by the conjecture. This improves a recent lower-bound of $\Omega(n^{3/2})$ due to Cavenagh and Ramadurai. From the point of view of computational learning theory, the size of the smallest critical set corresponds to the minimum teaching dimension of the set of Latin squares. We study two related notions of dimension from learning theory. We prove a lower-bound of $n^2?(e + o(1))n^{5/3}$ for both of the VC-dimension and the recursive teaching dimension.

4:00 pm - 4:30 pm **170 Hope St**

Use of GAP programming for 2×2 matrices over rings and fields

Frida Randen, *University of Bridgeport*

The GAP programming tool is a system specifically for computational algebra. The group of all invertible 2×2 matrices over a finite field is built in to the GAP system. We wrote a GAP program to compute the group of all invertible 2×2 matrices over the integers mod n. The poster shows how this function works. The main theorem used for the program says that a 2×2 matrix over the integers mod n is invertible if and only if its determinant is in the group of units of the integers mod n. We calculated the size of the group of all the invertible 2×2 matrices over the integers mod n for different values of n. When n is a prime, the integers mod n is a field, and the size of the group of the invertible 2×2 matrices over a field of order p is known to be $(p^2 - 1)(p^2 - p)$. We found a formula for the size of the group of invertible 2×2 matrices over the integers mod n, when n is a power of a prime.

4:00 pm - 4:30 pm **170 Hope St**

Topography and Vegetation Patterns in the Horn of Africa

Sarah Iams, *Harvard University*

In the context of semi-arid ecosystems, where water is considered a limiting resource for vegetation growth, models can be designed to form self-organized spatial patterns that resemble vegetation patterns observed in these ecosystems. These models are often analyzed in the context of a uniformly sloped landscape with homogeneous water availability. Remote sensing imagery makes it possible to identify the correspondence between pattern characteristics and local slope. This correspondence is weak, perhaps because topography has a strong influence on water availability. We add topography to simple models, which yields results that include vegetation arcing, and which may give insight into observed patterns.

4:00 pm - 4:30 pm **170 Hope St**

An Interdisciplinary Approach to Computational Neurostimulation

Madison Guitard, *Roger Williams University*

Transcranial direct current stimulation (tDCS) is a noninvasive neurological treatment that applies low doses of electrical current directly to a patient's head surface using scalp electrodes. This treatment has shown great promise as a medical intervention for neurodegenerative diseases such as Parkinson?s disease and Alzheimer?s disease. The central focus of this project is to determine and quantify the influence that individualized cranial tissue conductivities have on delivering an electric field from electrotherapies, such as tDCS, to a targeted region of the brain. Existing simulations of tDCS, as well as other modes of neurostimulation, typically choose average values for the conductivities of the scalp, skull, cerebrospinal fluid, and gray and white matter tissues, and so these simulations do not incorporate patient specific electrical conductivity variability. Therefore, it is currently unclear whether these standard values are appropriate and most effective for simulations for all patients. The goal of this research is to determine how variability in conductivity impacts tDCS simulation predictions. To achieve this goal, we are working to create a stochastic partial differential equation based mathematical model of tDCS, and assess the impact that differences in conductivities have on simulation efficacy.

4:00 pm - 4:30 pm **170 Hope St**

Equilibrium behavior of randxomized load balancing algorithms

Pooja Agarwal, *Brown University*

Randomized load balancing algorithms play an important role in large-scale networks. Many such algorithms have been extensively analyzed in the case of exponential service times. In contrast, the practically relevant case of general service times has received less attention. Under fairly general conditions on the service distribution, recently a hydrodynamic limit was established for the join-the-shortest-of-d-queues routing algorithm that describes the system dynamics as the number of servers goes to infinity, in terms of a system of coupled measure-valued processes. We prove existence of a unique equilibrium point for these hydrodynamic equations. We also discuss some properties of these equilibrium points, and their implications for the performance.

4:00 pm - 4:30 pm **170 Hope St**

Continuous Time Opinion Formation on Directed Weighted Graphs

Harjasleen Malvai, *Brown University*

Ideas that challenge the status quo either evaporate or dominate. The literature that mathematically studies the evolution of ideas treats space as uniform and considers individuals in an isolated community, using an ODE model. We extend these models to include multiple communities and their interaction by using a directed weighted graph. We study in detail some special cases, state general properties, and indicate pathways for further research.

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8 Math Corners

The organizers invite all attendees to enjoy a snack and coffee in 170 Hope St from 4:00 pm - 5:00 pm. At 4:30 pm, after the poster session, we will have designated areas of the building by mathematical topic to encourage those interested in a given topic to meet and discuss. The topic areas will be marked with signage throughout the building, and include the following.

Topic	Location
Mathematical Biology	Second Floor
Machine Learning	Second Floor
Financial Mathematics	Third Floor
Analysis	Third Floor
PDE & Dynamical Systems	Third Floor
Topology	Room 108
Geometry	Room 108
Group Theory	Room 118
Number Theory	Room 118
Statistics & Probability	Room 207

9 Panel Discussion: *Conversations on Mentoring*

Panelists

- **Melody Chan**, *Brown University* Melody Chan works in combinatorial algebraic geometry, tropical geometry, and combinatorics. She was an undergraduate at Yale and spent time at Cambridge, Berkeley, and Harvard before starting as an assistant professor in the math department at Brown University in 2015.

- **Ruth Charney**, *Brandeis University* Ruth Charney is the Theodore and Evelyn Berenson Professor of Mathematics at Brandeis University. She received her PhD from Princeton University in 1977 and held postdoctoral positions at UC Berkeley, and Yale University. She then spent nearly 20 years on the Ohio State University faculty before returning to Brandeis, her undergraduate alma mater, in 2003.

- **Katherine M. Kinnaird**, *Brown University* Katherine M. Kinnaird researches the dimension reduction problem, representing high-dimensional and noisy sequential data as a low-dimensional object that encodes relevant information. She applies her work to tasks from the interdisciplinary field of Music Information Retrieval (MIR), such as locating the chorus of a given musical song or finding all copies of a particular recording of a song. Katherine earned her Ph.D. at Dartmouth College from the Department of Mathematics in 2014. Currently, Katherine is a Data Sciences Postdoctoral Fellow at Brown University, affiliated with the Division of Applied Mathematics, and previously she was a Visiting Assistant Professor in the Department of Mathematics, Statistics, and Computer Science at Macalester College, where she was the founder and Principal Investigator for the Data Science TRAIn Lab. Katherine serves as the President of the Executive Board of the annual Women In Machine Learning Workshop, co-located with Neural Information Processing Systems, a top machine learning conference.

- **Siddhi Krishna**, *Boston College* Siddhi Krishna is a 3rd year PhD student at Boston College. As an undergraduate at Brandeis University, she studied math and economics, with the intention of pursuing further studies in behavioral economics. After graduating with her Bachelor's degree, however, she realized there was so much more math to learn, and returned to Brandeis to advance her math background. Now, at Boston College, Siddhi studies low-dimensional topology and knot theory. Siddhi strongly believes that mentorship has played a key role in her academic and personal development, and tries to "pay it forward" by engaging in mentoring opportunities herself. This summer, she will be a returning faculty member at the Bridge to Enter Advanced Mathematics program in New York, which exposes middle schoolers from low-income communities to high school and college level mathematics.

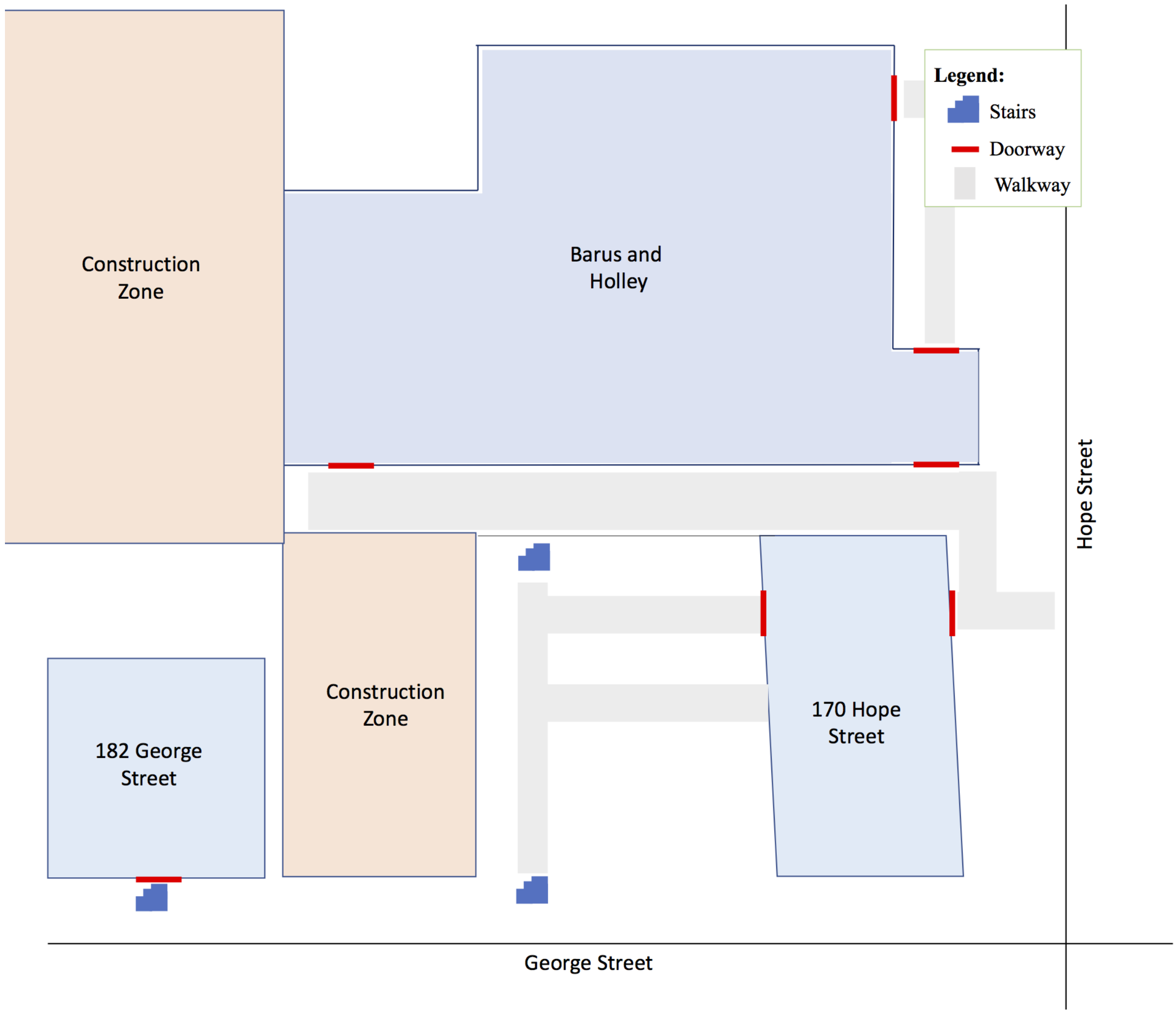
- **Vikram Sundar**, *Harvard University* Vikram Sundar is a junior at Harvard University, majoring in math and physics and planning on pursuing an MD/PhD post-graduation. While at Harvard, he co-founded Harvard's Gender Inclusivity in Math, an organization dedicated to reducing the gender gap in Harvard's math department. His research interests currently lie in computational chemistry, specifically in the development of force fields to model small molecules in computational simulations.

- **Lalitha Venkataramanan**, *Schlumberger Doll Research* Lalitha Venkataramanan is a Scientific Advisor at Schlumberger Doll Research and is based in Cambridge, MA. She has worked in the field of measurement inversion and interpretation for over 18 years. She has managed a research program on inversion of multiple measurements to estimate rock and fluid properties. Her research interests include forward modeling and inversion of nuclear magnetic resonance, dielectric and optical measurements obtained from downhole and laboratory data as well as optimization, optimal experimental design and probability and stochastic processes. Trained as an Electrical Engineer, she obtained her M.S and Ph.D. degrees from Yale University in 1998. She has over 10 granted patents and 15 pending patent applications, over 25 refereed Journal papers. She has given several invited presentations about her work at Universities and organized panel discussions and workshops for careers outside academia. She is a board member of SIAM industry committee.

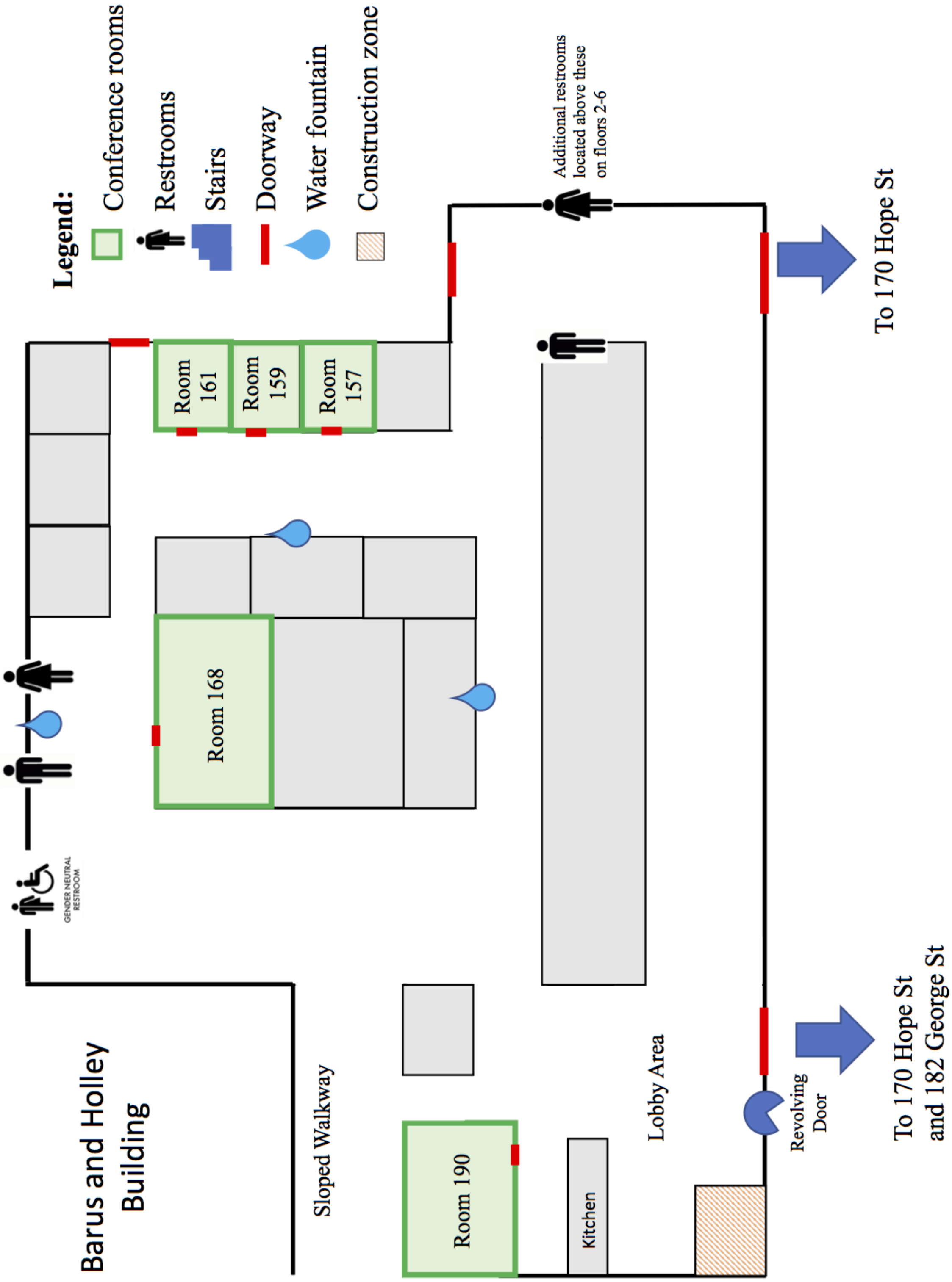
- **Ulrica Wilson**, *Morehouse College and ICERM* Ulrica Wilson is an Associate Professor of Mathematics at Morehouse College. She is ICERM's Associate Director of Diversity and Outreach. In this role, Ulrica provides leadership in meeting institutional diversity goals: ensuring diversity throughout ICERM's programs, assisting in the development of policies and procedures, participating in national meetings and conferences, and helping to identify and obtain funding for programs and activities.

10 Navigating the Conference

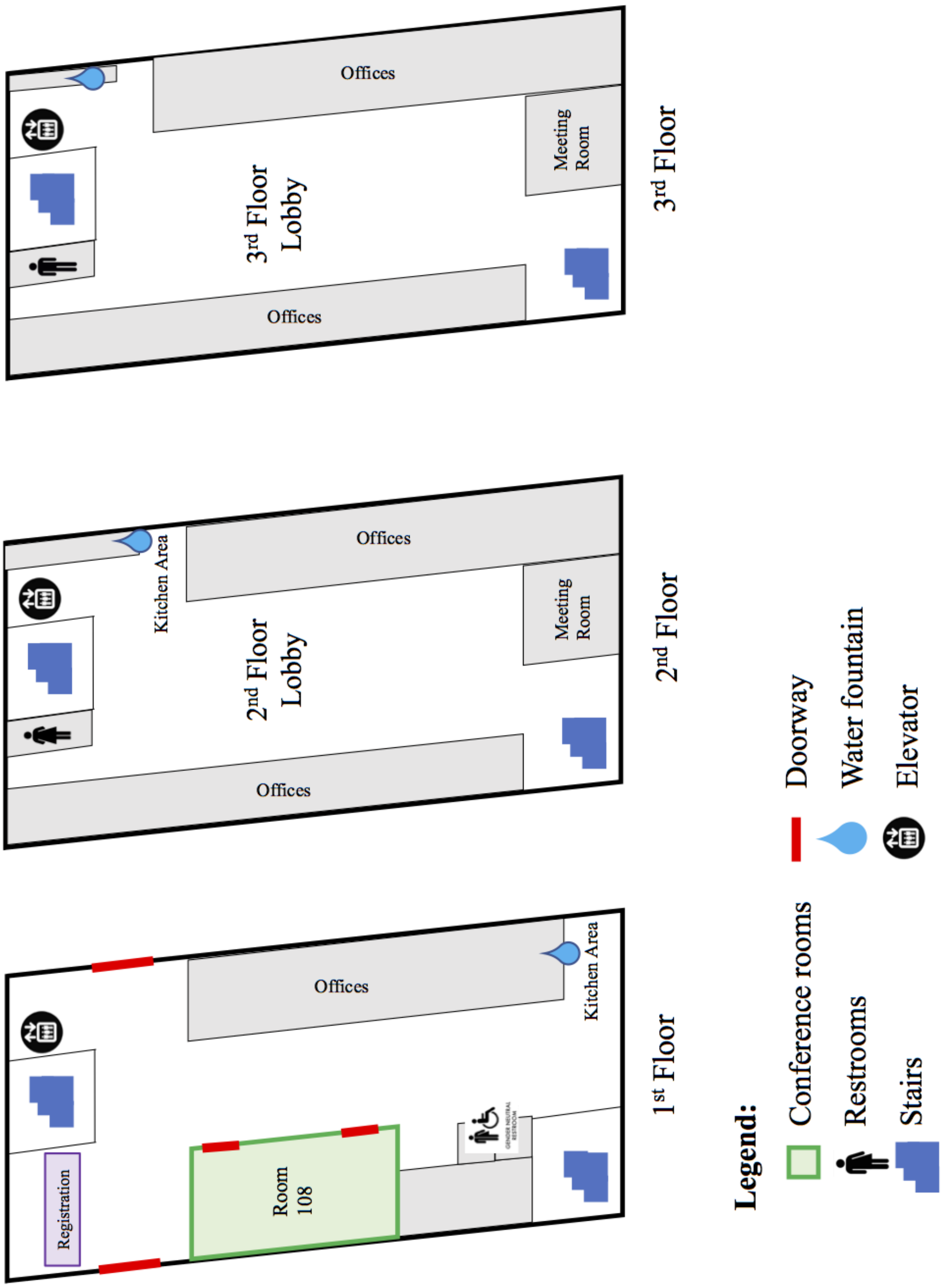
10.1 Conference Map



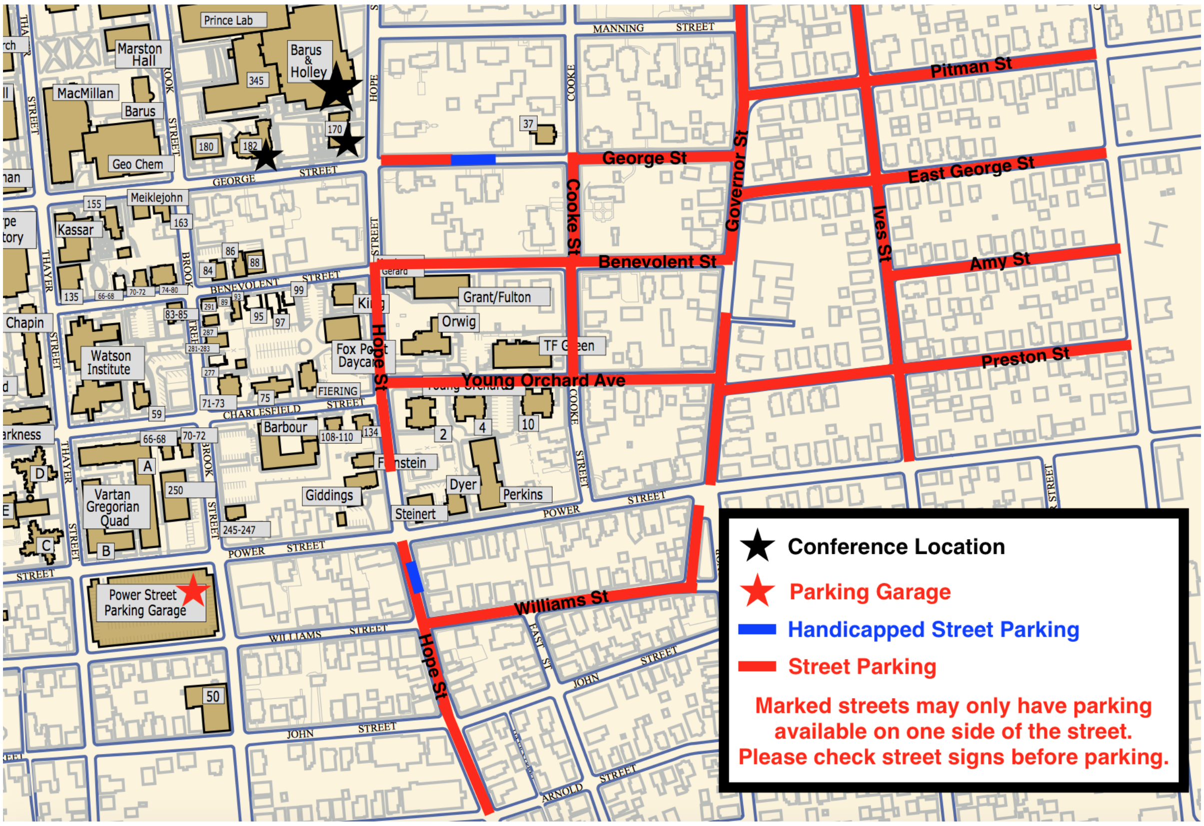
10.2 Map of Barus & Holley



10.3 Map of 170 Hope St



10.4 Parking Options



11 Organizing Committee and Contact Information

Local Organizing Committee

- Stephanie Dodson
- Karen Larson
- Amanda Howard
- Anna Lischke

Scientific Committee

- Stephanie Dodson (Brown University)
- Karen Larson (Brown University)
- Amanda Howard (Brown University)
- Anna Lischke (Brown University)
- Victoria Day (University of Massachusetts, Amherst)
- Siddhi Krishna (Boston College)
- Professor Kavita Ramanan (Brown University)

Please contact `winrs.ne@gmail.com` or `awm@brown.edu` with questions.