Colloquia

Archives: Fall 2016

Department of Electrical and Computer Engineering Colloquia: Tufts University

Halligan Hall, Fridays from 1:45pm to 2:45pm (refreshments at 1:35pm), unless otherwise noted.

All seminars are open to the public. Our seminars are a great opportunity to see the results of exciting new research by faculty, students, or other institutions, or just to get a sense of what the ECE Department is all about. For comments or questions, or if you would like to receive email notifications of upcoming colloquia, please send us an email.

Organizers: Shuchin Aeron and Tom Vandervelde

September 2, 2016

September 9, 2016
Halligan 102
High-Dimensional Analysis of Stochastic Iterative Methods for Convex and Nonconvex Optimization: Dynamics, Mean-Field Limits and Phase Transitions
Speaker: Dr. Yue M. Lu, Ph.D., Harvard University

Abstract:
We consider efficient iterative methods (e.g., stochastic gradient descent, randomized Kaczmarz algorithms, iterative coordinate descent) for solving large-scale optimization problems, whether convex or nonconvex. A flurry of recent work has focused on establishing their theoretical performance guarantees. This intense interest is spurred on by the remarkably impressive empirical performance achieved by these low-complexity and memory-efficient methods.

In this talk, we will present a framework for analyzing the exact dynamics of these methods in the high-dimensional limit. For concreteness, we consider two prototypical problems: regularized linear regression (e.g. LASSO) and sparse principal component analysis. For each case, we show that the time-varying estimates given by the algorithms will converge weakly to a deterministic "limiting process" in the high-dimensional (scaling and mean-field) limit. Moreover, this limiting process can be characterized as the unique solution of a nonlinear PDE, and it provides exact information regarding the asymptotic performance of the algorithms. For example, performance metrics such as the MSE, the cosine similarity and the misclassification rate in sparse support recovery can all be obtained by examining the deterministic limiting process. A steady-state analysis of the nonlinear PDE also reveals interesting phase transition phenomenons related to the performance of the algorithms. Although our analysis is asymptotic in nature, numerical simulations show that the theoretical predictions are accurate for moderate signal dimensions.

What makes our analysis tractable is the notion of exchangeability, a fundamental property of symmetry that is inherent in many of the optimization problems encountered in signal processing and machine learning.

September 30, 2016
Halligan 102
3D Electroluminescent Living Cellular Devices (ELICD) for Multicellular Systems Biology Research
Speaker: Dr. Nurdan Ozkucar, Ph.D., Tufts University

Abstract:
Abstract: In this talk, I will describe 3D Electroluminescent Living Cellular Devices (ELICD) for Multicellular Systems Biology Research. Multicellular systems as described here are the systems that consist of more than one cell type and represent an intact biological processes. I will talk about how ELICD will enable multicellular systems biology research and fill the gap between basic and clinical studies. Current methods used for measuring biological electrical activity provide valuable information at single cell or tissue level. However, their limitations on durability, biocompatibility or overall anatomy prevent them to be biologically relevant platforms to study the multicellular systems. Biological, electrical and anatomical relevance of ELICD system will be highlighted.

October 7, 2016
Halligan 102
The Search for Energy Efficiency: From Hardware to Software And Back
Speaker: Dr. Martha Kim, Ph.D., Columbia University

Abstract:
In this talk, I will describe 3D Electroluminescent Living Cellular Devices (ELICD) for Multicellular Systems Biology Research. Multicellular systems as described here are the systems that consist of more than one cell type and represent an intact biological processes. I will talk about how ELICD will enable multicellular systems biology research and fill the gap between basic and clinical studies. Current methods used for measuring biological electrical activity provide valuable information at single cell or tissue level. However, their limitations on durability, biocompatibility or overall anatomy prevent them to be biologically relevant platforms to study the multicellular systems. Biological, electrical and anatomical relevance of ELICD system will be highlighted.

October 14, 2016
Halligan 102
Emerging SiGeSn Integrated-Photonics Technology
Speaker: Richard Soref, Ph.D., University of Massachusetts, formerly of the Air Force Research Laboratory

Abstract:
SiGeSn heterostructure photonics is motivated by sensing, communications, night vision and other potential applications in the 1.55- to 5.0-micron wavelength band. Commercial products are anticipated from the real possibility of manufacturing photonic-and-optoelectronic integrated circuits in a high-volume CMOS or BiCMOS foundry using entirely group-IV components.

October 21, 2016
Halligan 102
Micro- and nano-rectenna arrays for infrared power conversion and detection
Speaker: Richard M. Osgood III, US Army NSRDEC

Abstract:
Nanoscale antenna arrays coupled vertically to rectifying diodes form metal-insulator-metal ("MIM") diodes that can exhibit optical rectification and direct current output, when illuminated with visible or infrared light at resonance having the correct polarization direction. Planar asymmetric metasurfaces, composed of horizontal (Al, Au or Ag) antenna arrays on thin barrier layers (Al_2O_3 and NbO_x produced by Atomic Layer Deposition and large-area anodization, respectively) on ground planes (Al or Au and Nb, respectively), may be used as nonlinear frequency "microrectenna array" detectors, and have responded to visible continuous-wave laser illumination with significant output power, characterized by a short-circuit current and open-circuit voltage [1, 2].

Using our design rules that maximize asymmetry (and therefore the component of the electric field pointed into the substrate, analogous to Second Harmonic Generation), we designed, fabricated, and analyzed these metasurfaces, with teeth lying, parallel to the x-axis, on one side only of horizontal stripes, thus breaking left-right symmetry. These stripe arrays lay parallel to the y-axis, exhibited a cross-stripe resonance at a wavelength of approximately 1.15 mm (with polarization along the x-axis), and extracted the observed direct current. These microrectenna arrays are similar to planar large-area wide-angle spectrally selective plasmonic absorbers, investigated in Ref. 3, except that "teeth" have been added to rectify the high-frequency voltage generated by the incident light and produce a direct current.

We varied the y-pitch of the teeth on both Au/NbOx/Nb and Al/Al_2O_3/Al microrectenna arrays and found good agreement between simulation and FTIR-measured reflectivity. For example, y-pitches of 500 nm, 750 nm, and 1000 nm exhibited resonances at 2 mm, 1.5 and 2.1 mm, and 1.7, 2, and 2.6 mm, respectively (for polarization along the x-axis), in addition to the cross-stripe resonance. We have designed new broadband arrays by chirping the y-pitch along the x-direction in the arrays at a spatial rate of 5 nm per 10 columns. Current-voltage measurements were carried out, showing that the Al/Al_2O_3/Al MIM diodes have very large barrier heights and > 5V breakdown voltage, while the Nb-based diodes had greater responsivity near zero voltage. These results were compared to our MIM diode model which included a novel treatment of the image potential using the pseudobarrier ("effective action") technique, and effective mass. The measured response to visible lasers was compared to predictions by classical and quantum [4, 5] rectification models.

[1] R. M. Osgood III, et. al., J. Vac. Sci. Tech. A 34 (2016) 051514.
[2] M.Y. Kang, et. al., private communication (2013).
[3] C. Wu, et. al., Phys. Rev. B 84 (2011) 075102.
[4] A. Sanchez, et. al., J. Appl. Phys. 49 (1978) 5270.
[5] J. R. Tucker and M. J. Feldman, Rev. of Mod. Phys. 57, (1985) 1055.

October 28, 2016
Halligan 102
Towards an Algebraic Network Information Theory
Speaker: Dr. Bobak Nazer, Ph.D., Boston University

Abstract:
Network information theory explores the fundamental limits of reliable communication and compression across a network. The classical approach to this theory uses random i.i.d. codebook constructions to obtain rate regions, which can in turn be evaluated and optimized to obtain performance limits. For example, Gaussian specializations of the multiple-access and broadcast rate regions have shaped the design of modern cellular networks.

Recent efforts have demonstrated that, in certain topologies, it is possible to outperform random i.i.d. codebooks by employing codebooks with algebraic structure. This algebraic structure may emerge either from the fact that the receivers only want a function of the transmitted messages (e.g., physical-layer network coding) or from the structure of the channel itself (e.g., interference alignment). Although there are now many examples highlighting the potential gains of codebooks with algebraic structure, it remains unclear if these examples can be captured as part of an accessible framework, i.e., an algebraic network information theory. In this talk, I will discuss, through a series of examples, recent progress towards such a theory and its implications for distributed source and channel coding.

November 4, 2016
Halligan 102
Network coding - a personal account of combining theory and practice
Speaker: Dr. Muriel Medard, Ph.D., MIT

Abstract:
This talk seeks to illustrate the interplay between theoretical development and engineering implementation, with a personal slant. It centers on Network Coding (NC), a modern information theoretic development that leverages algebraic data manipulation during transport through a network to enhance resource usage. The addition of data manipulation to network modeling went beyond traditional graph theoretic considerations, allowing a significant relaxation of constraints that had original been treated as essential and, consequently, to the circumvention of impasses. The new model afforded opportunities for improved resource usage in existing networks through developments such as our Random Linear Network Coding (RLNC). While RLNC provided provably optimal throughput within standard theoretical frameworks, introducing it into the most common Internet transport protocol, Transmission Control Protocol (TCP), required an inventive reinterpretation of TCP's control signals. Our recent theoretical results in Equivalence Theory show there is no benefit, in terms of throughput, in combining NC with the type of coding commonly used to palliate mistransmissions in error-prone media such as wireless links. These results confirm the sense behind current operational practice, but contradict long-standing folk-theorems regarding the benefit of joint coding. However, when other performance metrics such as energy consumption are taken into account, in practice we have shown that combining NC with coding for wireless links leads to marked, cumulative gains. We shall conclude the talk with open challenges and research directions driven by the coming convergence of data storage and networking. No background knowledge will be assumed.

November 8, 2016 *Tuesday
Halligan 102
Bio-Electronic Interfaces at Nano-Scale
Speaker: Dr. Xiaocheng Jiang, Ph.D., Tufts University

Abstract:
Rapidly advancing nano/micro technologies have been blurring the distinction between man-made and biotic systems, providing tremendous opportunities in both fundamental research and bio-related applications. In this talk, I will discuss our recent efforts on the design and development of nanoelectronic materials and devices that can seamlessly integrated with living systems for probing, interrogating and directing biologically significant processes. In particular, I will present selected examples to address the challenges to: (1) effectively couple and transduce bio-derived signals with nanoscale field effect transistors that have comparable dimension to biomolecules; (2) quantitatively probe and facilitate biological charge transport from cell metabolism through rationally designed nanostructured interfaces; and (3) establish soft, biocompatible cell-/tissue-interfaces with bio-derived electroactive materials/devices. We hope the unconventional design and construction of these small-scale platforms could fill the gap between living and artificial systems, and open up new opportunities in biomedical sensing, cell/tissue engineering, and bioenergy conversion.

November 18, 2016
Halligan 102
Improved Methods for Monitoring Cardiovascular Risk Factors
Speaker: Dr. Barton Gao, Ph.D., Philips Connected Sensing Venture

Abstract:
Cardiovascular diseases are the top 1 natural death cause in the world. High Blood Pressure (BP) is a major cardiovascular risk factor that is treatable, but hypertension detection and control rates are too low. BP monitoring is vital for improving hypertension management, but existing cuff devices are inconvenient. Pulse Transit Time (PTT) is a potential approach for cuffless BP monitoring, because it's easy to measure and highly correlated with BP. But, several challenges (e.g., calibration) must be overcome to realize this approach. Meanwhile PTT as an arterial stiffness marker and central BP permit cardiovascular risk stratification independent of brachial BP. But, wave reflection makes measurement of these cardiovascular risk factors Challenging.

Progress of improving monitoring cardiovascular risk factors in terms of convenience, accuracy, and otherwise was reported. To be specific, a. one PTT estimation technique for robust arterial stiffness monitoring; b. one technique of estimating PTT as a function of BP for both cuffless BP monitoring and more informative arterial stiffness monitoring; c. one investigation on non-invasive PTT estimates as markers of BP for cuffless BP monitoring; d. one simple adaptive transfer function technique of estimating central BP for more accurate and non-invasive central BP monitoring.

December 2, 2016
Halligan 102
Making Parallelism Pervasive with the Swarm Architecture
Speaker: Dr. Daniel Sanchez, PhD., MIT

Abstract:
We present a new parallel architecture that exploits fine-grained irregular parallelism, which is abundant but hard to mine with current software and hardware techniques. In this architecture, called Swarm, programs consist of short tasks, as small as tens of instructions each, with programmer-specified order constraints. Swarm executes tasks speculatively and out of order, and efficiently speculates thousands of tasks ahead of the earliest active task to uncover enough parallelism. Furthermore, Swarm sends tasks to run close to their data, reducing data movement. We contribute several new techniques that allow Swarm to scale to large core counts and speculation windows, including a new execution model, speculation-aware hardware task management, selective aborts, and scalable ordered task commits.

We evaluate Swarm on graph analytics, simulation, and database benchmarks. At 64 cores, Swarm is 51-122x faster than a single-core system, and outperforms state-of-the-art software-only parallel algorithms by 3-18x. Besides achieving near-linear scalability, the resulting Swarm programs are almost as simple as their sequential counterparts, as they do not use explicit synchronization.

December 9, 2016