Colloquia

Archives: Fall 2017

Department of Electrical and Computer Engineering Colloquia: Tufts University

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.

Organizer: Shuchin Aeron

Location: Halligan Hall, Room 102, Fridays from 1:45pm to 2:45pm (refreshments at 1:35pm), unless otherwise noted.

September 15, 2017
Re-configurable photonic crystals and metamaterials using microplasma
Speaker: Dr. Jeffrey Hopwood, Ph.D., Tufts University

Abstract:
Metamaterials and photonic crystals are synthetic arrays of engineered elements that may exhibit negative permittivity and permeability over narrow regions of the electromagnetic spectrum. In this work, we investigate such materials which are also capable of self-initiating a microscopic region of ionized gas – a microplasma – within the material. The microplasma acts as a dynamic element with variable conductivity or permittivity. In this manner, the transmission properties of the original material are reconfigured by the appearance, disappearance, or modulation of the plasma by incident EM radiation. Experimental measurements of various plasma-modulated systems range over 1-44 GHz and show that intense microplasmas can alter transmission in excess of 20dB with plasma formation times on the order of 200 ns. Future prospects and applications of plasma formation in metamaterials will be discussed.

September 22, 2017
Digitally-Assisted Analog Integrated Circuit Design for EEG Signal Measurement Applications with Dry Electrode-Skin Contact
Speaker: Dr. Marvin Onabajo, Ph.D., Northeastern University

Abstract:
Battery-powered portable or implantable biopotential measurement devices are becoming increasingly widespread in the medical diagnostics field. Due to rising demand in health monitoring applications, the development of dry-contract electrode measurement methodologies is a research challenge that calls for integrated analog front-ends with higher input impedance in addition to a good common-mode rejection ratio. Our research group has developed a Self-Calibrated Analog Front-End for Long Acquisitions of Biosignals (SCAFELAB) system with an on-chip optimization scheme to enable more reliable biosignal measurements with low-power single-chip devices fabricated in complementary metal-oxide semiconductor (CMOS) technology. The main application for the SCAFELAB system is electroencephalography (EEG) signal acquisition involving voltage measurements down to a few microvolts. Long-term brain signal monitoring applications are expected to directly benefit from the analog front-end circuit design approach to be discussed in this talk. For example, the integrated circuit design methods are applicable in systems for drowsiness detection, epilepsy diagnosis, and intent recognition to allow communication or to control

objects/robots. EEG signals are conventionally acquired using electrodes covered with electrolyte gels or solutions to decrease the contact impedance at the skin interface. However, such wet-contact measurements require time to prepare the skin surface. More importantly, they cause discomfort (or even allergic reactions) and dry out in long-term monitoring applications such as in brain-computer interfaces where EEG signals are acquired and analyzed over hours, days, or longer. In general, dry electrodes are better suited for monitoring over long time durations, but their use is associated with increased contact resistances. This characteristic complicates the measurement of small biopotentials by requiring very high input impedance at the analog front-end amplifier. In this talk, the focus is on the design of such an amplifier and the associated on-chip test signal generation circuits that serve during a digitally-controlled self-calibration mode at start-up. It will conclude with the discussion of measurement results from a prototype chip consisting of an instrumentation amplifier, lowpass-notch filter and variable gain amplifier in the signal path, which was fabricated in 0.13μm CMOS technology together with the on-chip test signal generation and digital calibration control circuits.

September 29, 2017
Energy-Efficient Approximate Computing
Speaker: Dr. Shereif Reda, Ph.D., Brown University

Abstract:
Minimizing energy consumption is a key objective in modern computing circuits and systems. Approximate computing is an emerging paradigm where circuits are deliberately designed such that their results are approximate. By giving up some arithmetic accuracy, it is possible to design circuits with dramatically lower power dissipation and smaller silicon footprint. Using approximate circuits is attractive for emerging classes of applications that are inherently tolerant to errors, which include signal processing, computer vision, machine learning, and cognitive systems. In this talk, I will first describe new methods to design approximate circuits for basic arithmetic building blocks, such as adders, multipliers and dividers. Our circuits use a novel mechanism to dynamically zoom in on the most relevant bits in input operands and approximate the remaining bits. I will show how our approximate arithmetic circuits can provide dramatic reductions in power consumption with negligible reduction in accuracy. I will then describe new automated methods to synthesize arbitrary approximate circuit accelerators. Our techniques enable designers to automatically discover large number of approximate circuits from their original circuit, by mutating the original circuit in intelligent ways and retaining the most promising mutants. I will focus on the application of approximate accelerators for deep neural networks, which recently emerged as a major success story in machine learning and artificial intelligence. I will describe how our techniques drastically simplify the underlying computation requirements for deep learning accelerators in terms of circuit area cost and power consumption without compromising accuracy. Finally, I will overview future directions for approximate systems.

October 6, 2017
MEMS-enabled photonic metamaterial devices
Speaker: Dr. Xin Zhang, Ph.D., Boston University

Abstract:
Photonic metamaterials, which consists of subwavelength "meta-atoms", have received vast interest due to their extraordinary and unprecedented electromagnetic properties. Particularly, the effective properties can be tailored and modulated to construct metamaterial devices by reconfiguring or actuating the constituting meta-atoms. In the evolvement of metamaterials, microelectromechanical systems (MEMS) play an important role to construct functional photonic devices across the electromagnetic spectrum. In this talk, I will present research on MEMS-enabled metamaterial devices, from the fundamental physics to their applications to bridge the terahertz gap. Multifunctional terahertz devices including metamaterial enhanced biological/chemical sensors, detectors, perfect absorbers, and spatial amplitude and phase modulators, and will be introduced

October 13, 2017
*Ph.D. Research Spotlight
An IQC-based explicit rate bound for Nesterov's optimization scheme
Speaker: Dr. José Bento, Ph.D., Boston College

Abstract:
Over the past few years, there has been a growing interest in improving the design and analysis of various known optimization algorithms. In particular, Lessard et al. (2014), developed a convenient framework to analyze and design iterative first-order optimization algorithms built on the notion of Integral Quadratic Constraints (IQC) from robust control theory. This approach reduces the computation of upper bounds on the convergence rate of optimization algorithms to verifying the stability of a dynamical system, which can be checked by solving small semi-definite programming (SDP) problems. In this talk, we revisit Nesterov's accelerated Gradient method and, using the framework of Lessard et al. (2014), derive a new, tighter, and explicit upper bound on its convergence rate for the family of strongly convex functions. Our analytical solution provides a new rule on how the parameters of the algorithm should be chosen to meet various performance demands.

October 20, 2017
Designing for Physics and Play in Computational Fabrication
Speaker: Dr. Emily Whiting, Ph.D., Boston University

Abstract:
Advancements in rapid prototyping technology are closing the gap between what we can simulate with computers and what we can build. The effect is rippling through industries from aerospace to dentistry to prosthetics where it is now possible to create shapes of astounding complexity. Despite innovations in hardware, however, costly bottlenecks still exist in the design phase. Today's computational tools for design are largely unaware of the fundamental laws that govern how materials and structures behave in the real world. Creating customized products that perform a specific function depends on a wealth of physical properties. 3D modeling software typically gives no indication of support, gravity, or other properties of mechanics, and common shape representations make it tedious to exploit new degrees of freedom such as the internal structure of the object. In this talk I will present recent work in an interdisciplinary field of mechanics-based geometry processing: a cross-pollination of digital geometry processing, engineering mechanics, and rapid prototyping. The aim is to infuse principles of mechanics into all stages of manufacturing, from interactive design to feasibility optimization and novel fabrication processes. This work has been featured in numerous media sources including TEDx, MIT Technology Review, and Make magazine.

October 27, 2017
*Undergraduate Research Spotlight
Graph Clustering using Non-backtracking Random Walk
Speakers: Anuththari Gamage and Brian Rappaport, EE 2018, Tufts University

Abstract:
Graphs are used for representing interactions between entities in disciplines as varied as natural language processing, computational biology, and community detection in social networks. Clustering graphs provides insights into the structure of the data being analyzed and allows us to predict missing links between data. Classical graph clustering algorithms generally use spectral factorization methods which are computationally expensive and show reduced performance on sparse graphs. We introduce Vec-NBT, which uses the deep-learning model word2vec along with non-backtracking random walks on a graph to predict clusters. We show experimentally that this algorithm has better performance on sparse graphs compared to the state-of-the-art methods and explore applications in protein functionality prediction using pairwise protein interaction networks.

November 3, 2017
First-Photon Imaging and Other Imaging with Few Photons
Speaker: Dr. Vivek Goyal, Ph.D., Boston University

Abstract:
LIDAR systems use single-photon detectors to enable long-range reflectivity and depth imaging. By exploiting an inhomoheneous Poisson process observation model and the typical structure of natural scenes, first-photon imaging demonstrates the possibility of accurate LIDAR with only 1 detected photon per pixel, where half of the detections are due to (uninformative) ambient light. I will explain the simple ideas behind first-photon imaging. Then I will touch upon related subsequent works that mitigate the limitations of detector arrays, withstand 25-times more ambient light, allow for unknown ambient light levels, and capture multiple depths per pixel.

Related paper DOIs:
10.1126/science.1246775
10.1109/TSP.2015.2453093
10.1109/LSP.2015.2475274
10.1364/OE.24.001873
10.1038/ncomms12046
10.1109/TSP.2017.2706028

November 7, 2017 *Tuesday
Speaker: Dr. Akshay Rajhans, Ph.D., MathWorks
Heterogeneous Model-Based Design of Tomorrow's Cyber-Physical Systems

Abstract:
Cyber-physical systems (CPS) are complex systems where interconnected computational or cyber elements are deeply embedded in physical environments. Next generation CPS, such as self-driving cars, autonomous quadrotors, and the smart grid leverage the addition of 'smarts' by deploying new cyber elements to sense and communicate real-time data about various network parameters, while still being subject to the same underlying laws of physics that govern electric grid. In this talk we will look at some challenges and opportunities for the model-based design of such systems at a high level, before diving into a specific research and development challenges pertaining to heterogeneity of modeling formalisms.

November 17, 2017
Speaker: Dr. Ehsan Elhamifar, Ph.D., Northeastern University

December 1, 2017
Speaker: Dr. Darrell Schlom, Ph.D., Cornell University

December 8, 2017
Speaker: Dr. Gu-Yeon Wei, Ph.D., Harvard University