Colloquia

Archives: Spring 2017

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

January 20, 2017
Halligan 102
Topological insulators and 2D materials as candidates for optoelectronics and spin-based applications
Speaker: Dr. Parijat Sengupta, Ph.D., Boston University

Abstract:
The advent of topological ideas in condensed matter is a new paradigm where the traditional notions of Fermi-liquid theory and order parameter do not explain experimentally observed phenomena, for instance, the integer and fractional quantum Hall effect and the more recently discovered topological insulators (TI). In this presentation, I will focus on topological insulators and go over some of the key facts that typically characterize these materials. I will begin with analytic results on band structure of topological insulators derived using a simple Dirac Hamiltonian and connect them to more elaborate semi-empirical tight binding, continuum k.p, and first principles calculations. A noteworthy feature of a TI (3D) band structure is the helical dispersion where the spin is locked perpendicular to momentum giving rise to 1) spin-polarized photocurrents when the surface is illuminated with circularly-polarized light and 2) spin dependent optical transition from valence to conduction surface bands. Using the phenomenon of circular dichroism (preferential absorption of right- or left-circularly polarized light), I will emphasize on light absorption on the surface of C3v group symmetric 3D TIs such as Bi_2Se_3 and contrast them with their C2v group symmetric counterparts. I will explicitly show how the band structure in presence of Rashba- and Dresselhaus-like terms (in a C2v topological insulator) can give rise to a dual-valued circular dichroism, drawing a parallel between the emerging field of valleytronics in transition metal dichalcogenides such as MoS_2. In addition, the helical dispersion through the Edelstein effect gives a tunable non-equilibrium spin density that manifests as a spin current and spin orbit torque. I will express these quantities of current technological interest especially in design of magnetic RAMs within the paradigm of the topological Berry curvature. In the last part of the talk, I will present how the idea of topological invariants such as the quantized Chern number can be extended in explaining electronic behavior of several emerging 2D material systems, for example, the transition metal dichalcogenides (TMDCs) and black Phosphorus (BP). I will use 1) mono-layer TMDCs as a representative example to show valley and spin-current calculations and their possible optical modulation and 2) topological phase transitions and implications thereof in semi-Dirac multi-layered BP and induced magnetic moment in its mono-layer counterpart, phosphorene. Throughout the talk, I will highlight on the practical utility of these ideas (and current bottlenecks) for improved device performance and their seamless integration with current manufacturing technologies.

February 3, 2017
Halligan 102
Tisch Library for Electrical and Computer Engineers: Introduction to Services for Graduate Students
Speaker: Erica Schattle, Tufts University

Abstract:
Discover ways you can make the most of library services for your coursework and research. We'll cover graduate student essentials, including key research databases, access to technical standards, patent searching, citation management software, and consultation services. Bring your questions!

February 10, 2017
Halligan 102
Sensor and Software Fault-Monitoring for Automated Aircraft
Speaker: Dr. Jason Rife, Ph.D., Tufts University

Abstract:
As aircraft automation becomes increasingly sophisticated, new challenges arise in maintaining our national air transportation system's exceptional safety record. This talk discusses current research on detecting and responding to rare faults in two areas of aircraft automation. A first topic will be monitoring for GPS faults should they occur during automated landing of commercial aircraft. Error analysis methods will be discussed with application to the Ground Based Augmentation System (GBAS), a new GPS-based landing system under development by the FAA. A second topic will be monitoring for bugs in the flight management system (FMS) for autonomous drones. Recent work in using machine learning for FMS bug detection will be discussed, with an emphasis on the potential applications for streamlining the increasingly costly and time consuming activity of proving safety for drone systems.

February 17, 2017
Halligan 102
Building Alexa
Speaker: Dr. Shiv Vitaladevuni, Ph.D., Amazon

Abstract:
Amazon launched Echo, a household conversational device, which allows users to interact via voice with Alexa, including asking questions and issuing commands to play music, control home appliances, etc. A key tenet is to enable hands free, eyes free interaction. Over the last two years, Alexa has gained increasing popularity and expanded capabilities. We will describe some of the speech, language and machine learning research that went into building Alexa and how we are expanding her capabilities.

March 10, 2017
Halligan 102
Group-IV semiconductor optoelectronics based on strain-engineered nanomembranes
Speaker: Dr. Roberto Paiella, Ph.D., Boston University

Abstract:
The development of practical light sources based on group-IV semiconductors is a major outstanding goal of optoelectronics research, as a way to enable the continued integration of electronic and photonic functionalities on a CMOS compatible platform. However, this goal is severely complicated by the indirect energy bandgap of silicon, germanium, and related alloys. Here I will present two related approaches to address this issue using semiconductor nanomembranes (NMs), i.e., single-crystal sheets with nanoscale thicknesses that are completely released from their native substrates. By virtue of their extreme aspect ratios, NMs combine the unsurpassed electronic and optical properties of crystalline semiconductors with the mechanical flexibility of soft materials, and offer new opportunities to tailor material properties via strain engineering. In one approach, mechanically stressed Ge NMs are developed that can sustain high enough tensile strain to convert Ge into a direct-bandgap semiconductor, as needed to enable interband laser action with practical threshold currents and output powers. In the second approach, spontaneous elastic strain sharing in highly lattice-mismatched NMs is used to prepare complex SiGe multiple-quantum-well structures potentially free of plastic deformation, as a means to overcome the key materials problems that have so far hindered the development of group-IV quantum cascade lasers.

March 17, 2017
Halligan 102
Algorithms for Geometrically-Structured Optimization
Speaker: Dr. Justin Solomon, Ph.D., MIT

Abstract:
Many problems in geometry processing, graph theory, and machine learning involve optimizations whose variables are defined over a geometric domain. The geometry of the domain gives rise to geometric structure in the optimization problem itself. In this talk, I will show how leveraging geometric structure in the optimization problem gives rise to efficient and stable algorithms applicable to a variety of application domains. In particular, I will describe new methods for problems arising in shape analysis/correspondence, flows on graphs, and surface parameterization.

March 31, 2017
Halligan 102
Fast Processing of Large Graph Applications Using Asynchronous Architecture
Speaker: Dr. Michel A. Kinsy, Ph.D., Boston University

Abstract:
Graph algorithms and techniques are increasingly being used in scientific and commercial applications to express relations and explore large data sets. Although conventional or commodity computer architectures, like CPU or GPU, can compute fairly well dense graph algorithms, they are often inadequate in processing large sparse graph applications. Memory access patterns, memory bandwidth requirements and on-chip network communications in these applications do not fit in the conventional program execution flow. In this work, we propose and design a new architecture for fast processing of large graph applications. To leverage the lack of the spatial and temporal localities in these applications and to support scalable computational models, we design the architecture around two key concepts. (1) The architecture is a multicore processor of independently clocked processing elements. These elements communicate in a self-timed manner and use handshaking to perform synchronization, communication, and sequencing of operations. By being asynchronous, the operating speed at each processing element is determined by actual local latencies rather than global worst-case latencies. We create a specialized ISA to support these operations. (2) The application compilation and mapping process uses a graph clustering algorithm to optimize parallel computing of graph operations and load balancing. Through the clustering process, we make scalability an inherent property of the architecture where task-to-element mapping can be done at the graph node level or at node cluster level. A prototyped version of the architecture outperforms a comparable CPU by 10~20x across all benchmarks and provides 2~5x better power efficiency when compared to a GPU.