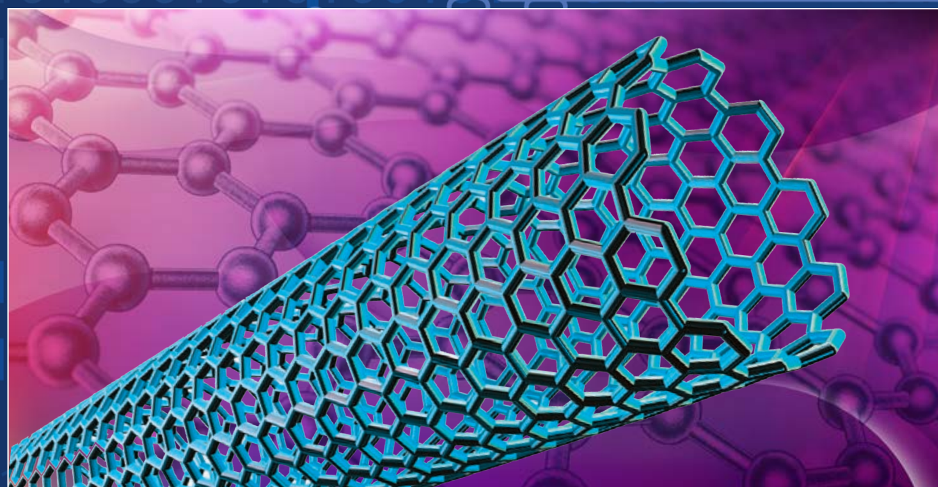
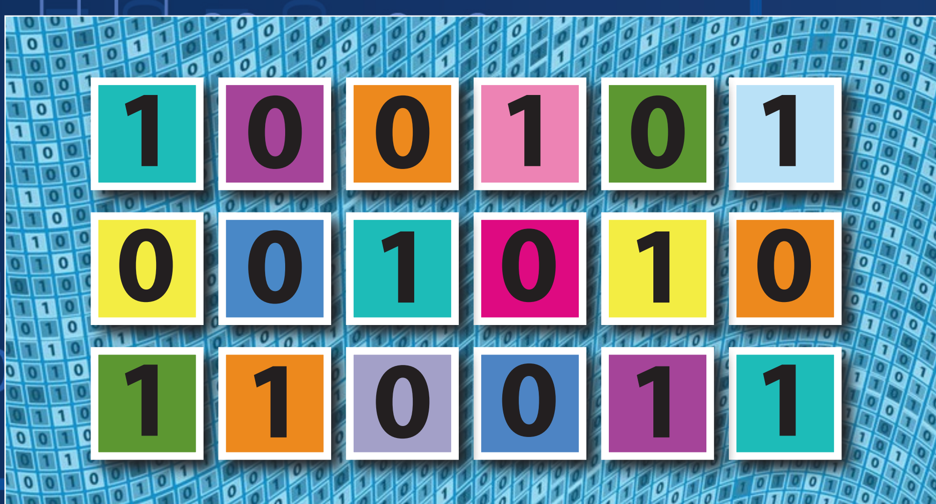
EECS News

Department of Electrical Engineering and Computer Science 2013



Nanotechnology and Progress: A Quantum Entanglement



Big Data Explorations

UNIVERSITY OF MICHIGAN

In This Issue

Electrical Engineering and Computer Science

Electrical and Computer Engineering
1301 Beal Avenue
Ann Arbor, MI 48109-2122

Computer Science and Engineering
2260 Hayward Street
Ann Arbor, MI 48109-2121

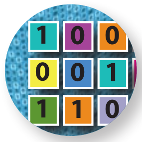
EDITORS:
Catharine June
Communications, ECE

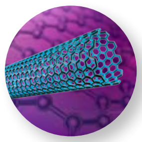
Steven Crang
Communications, CSE

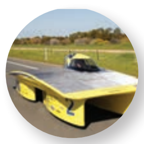
GRAPHIC DESIGNER:
Rose Anderson, EECS

PHOTOGRAPHERS:
Steven Crang, Catharine June, Anthony Absi, Hyoving Won Baac, Blake Livingston, Joseph Xu

Thanks also to the anonymous and unknown photographers who contributed to this issue.







Welcome to EECS News 2013

Khalil Najafi, Chair
Electrical and Computer Engineering Division

Marios Papaefthymiou, Chair
Computer Science and Engineering Division

Welcome to the 2013 edition of *EECS News*! Each year this publication seems to expand because there's so much we want to share. Yet this is still just a glimpse into the many educational and research activities that take place in EECS.

This year, *EECS News* casts a spotlight on two far-reaching research areas in our department: Big Data and Nanotechnology. We're all aware of how information and its use are rapidly changing our lives, and in a research focus article on Big Data, we look at how those massive sets of data are generated – through deliberate research programs or organically as a byproduct of our digital lives – and the potential discoveries buried within that information. EECS faculty are at the forefront of research in collecting, filtering, analyzing, and leveraging this data to enable new advances and understandings in fields ranging from medical science to political science and economics.

Nanotechnology is a buzzword that seems to be heard everywhere, especially for those tuned to the right frequency. Research in this area holds both the reality and promise of radically new approaches to medicine, electronics, energy, and computing. It takes tremendous infrastructure to pursue this area of research, and we are fortunate to be able to provide that to our faculty and students at Michigan. As you'll discover in the featured research article, Michigan has a long-standing and successful history in nanotechnology research, and our younger faculty are continuing that legacy.

We are pleased to announce the establishment of the Center for Future Architectures Research (C-FAR). Prof. Todd Austin, Director, will lead the five-year, $28M Center in its mission to create future generation scalable computing systems. In other research activities, EECS researchers are engaged in projects such as recording massive neural activities, studying the security risks found in cardiac and other medical devices, facilitating research into context-aware systems and applications, and improving imaging techniques for health, homeland security, transportation safety, as well as fast, low-power image detection.

In a department the size of EECS, there exist opportunities for enrichment virtually every day: distinguished lectures, seminars, workshops, symposiums, student defenses, and much more. We are recording more of these events, as well as offering webinars for live participation. We have included some QR codes to recorded materials in this issue of *EECS News*, and invite you to explore our website for current and upcoming opportunities.

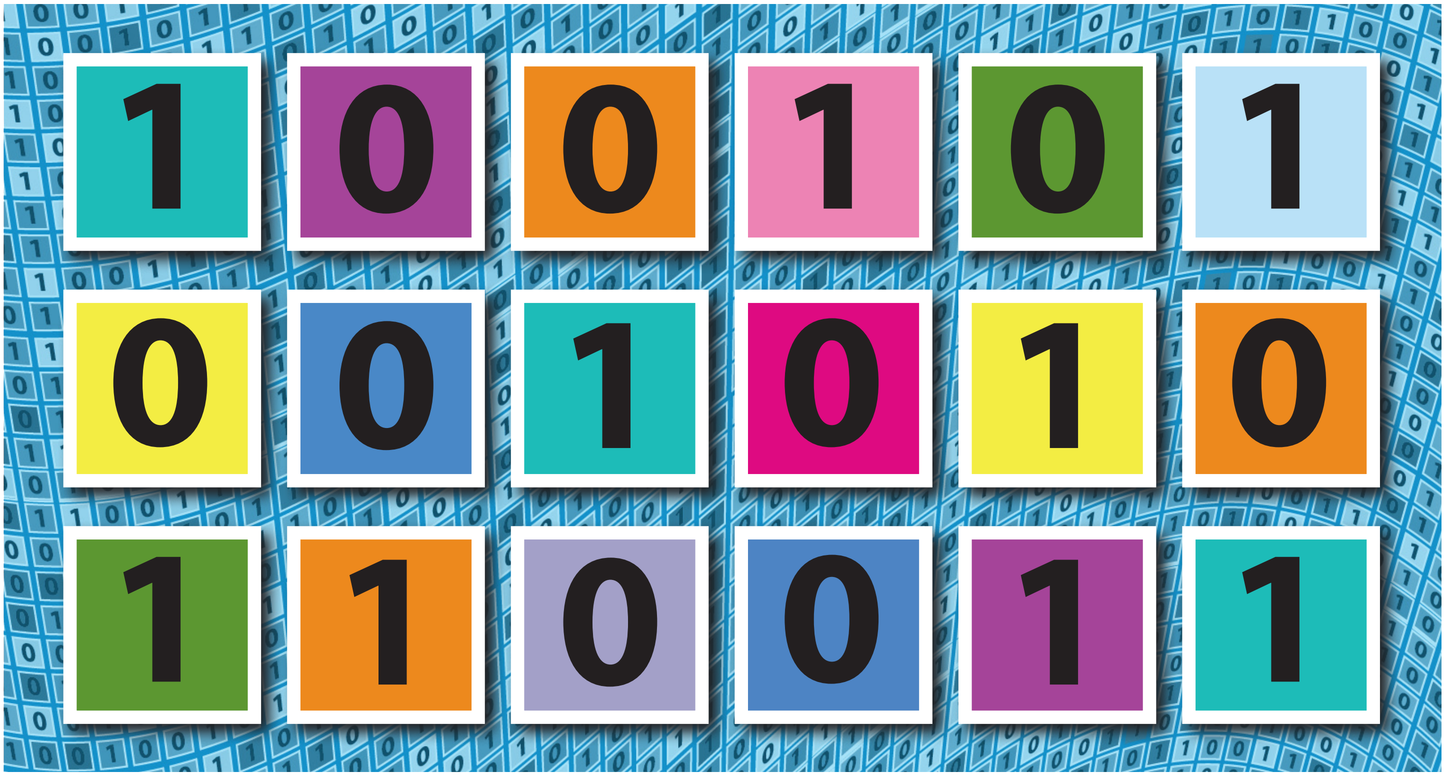
Perhaps the biggest news for our department is the hiring of ten new faculty. Their research expands our existing research areas in nanotechnology, sustainability, control systems, big data, and large-scale cloud and data center systems. We were fortunate to find such outstanding individuals to join our team and look forward to all they have to offer.

EECS students continue to amaze us in so many ways. Our students have just pulled off MHacks 2013, the largest collegiate hackathon to date, which brought over 1,200 students from around the country to compete in Michigan Stadium. Two of our students groups are celebrating milestone anniversaries this year: 75 years for Eta Kappa Nu and 100 years for the Amateur Radio Club. To provide a flavor of what our students are accomplishing, we have numerous other updates on various student teams, contests, and individual accomplishments.

We appreciate the contributions of our alumni to society and are thankful for all they do to elevate our department. We highlight four alums in this issue: Dick Costolo, now CEO of Twitter, who followed a path that began with a career in improvisational comedy; Andrew Farah, who led the development of the revolutionary Chevy Volt; Nancy Benovich Gilby, a serial entrepreneur who has started an incredible 10 companies; and Hannah Goldberg, our youngest featured alumnus, who left NASA's Jet propulsion Laboratory to join a startup company that's preparing for their first mission in space. We enjoyed welcoming all returning alumni to this year's Homecoming, as well as our 2013 Merit Award winners, Stephen Mollenkopf (President and COO of Qualcomm, Inc.) and Alan Steremberg (President of Weather Underground). We have also highlighted Prof. Charlotte Froese Fischer, whose gift has made possible a professorship in theoretical computer science in the name of U-M alumnus Patrick C. Fischer, a new position that will help Michigan to lead in this important area.

We are starting a new tradition with *EECS News*, providing a list of our faculty with their photos in each annual newsletter. Now in its 10th year, *EECS News* is becoming a historical document of life in the department. We hope you enjoy this year's snapshot.

Big Data Explorations



Data is pervasive – and we generate more every day. We live in the era of big data, in which we produce and collect digital information on an unprecedented scale. This data is generated by the terabyte through social media interactions, commerce and banking, business operations, healthcare activities, and scientific exploration. By developing tools and techniques to comb through and make sense of big data, decisions that previously were based on guesswork, intuition, or on painstakingly constructed models of reality can now be made based on the data itself.

We're talking about a lot of data, which is increasingly being gathered by the ubiquitous information-sensing mobile devices, remote sensing technologies, software logs, cameras, microphones, radio-frequency identification readers, and wireless sensor networks around us. In 2010, enterprises and users stored more than 13 exabytes of new data; this is over 50,000 times the data in the Library of Congress. As of 2012, 2.5 quintillion (2.5×10^{18}) bytes of new data were created every day.

Big data analysis now drives nearly every aspect of modern society, from manufacturing and retail, through mobile and financial services, through the life sciences and physical sciences. Big data is transforming how research is conducted, with giant repositories of specialized research data, such as biological or astronomical data, collected and shared on a massive scale. There is an entire discipline of bioinformatics that is devoted to the curation and analysis of such data.

Big data holds great promise for reducing healthcare cost and improving quality, for transforming the way education is delivered, and for use in assembling and acting on societal data. The ability to continue to use big data to make new connections and discoveries will help to drive the breakthroughs of tomorrow.

Researchers in EECS are amongst those developing the tools and techniques that are stretching the bounds of exploration in big data, and in this article we'll provide some examples to illustrate the breadth of those efforts.

The Big Data Processing Pipeline

Big data doesn't simply mean capturing more data with a bigger net. Big data is unstructured and complex, and probing it requires the use of special techniques in order to derive and verify meaning from it.

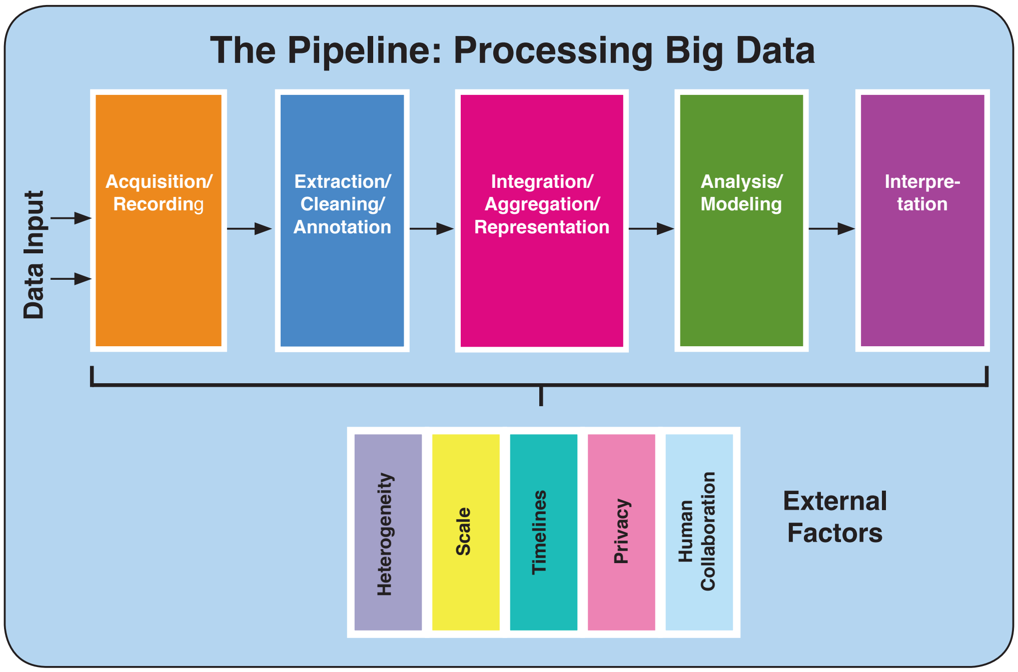
Big data researchers will point out that large quantities of the data that they encounter and record during **acquisition** are essentially "noise" which must be intelligently filtered out or compressed without losing relevant data. Furthermore, this task must be completed in real-time as data is collected since it would be highly inefficient or perhaps impossible to store and then reduce data. As data is filtered, it is important to generate metadata that will adequately describe the captured data and provide a basis for experimental use.

In a second step, information must often be **extracted** from the data itself and placed into a form that is suitable for analysis. For example, image data is not necessarily useful in its original state, but data such as pixel values can be extracted for manipulation. Along with extraction, data must be **cleaned** to account for erroneous inputs or experimental constraints.

Data analysis is considerably more challenging than simply locating, identifying, understanding, and citing data. For effective large-scale analysis, this must happen in a completely automated fashion. For data to be **integrated**, **aggregated**, and **represented** automatically, differences in data structure and semantics must be expressed in computer understandable form.

Methods for **querying**, **modeling**, and **analyzing** big data are fundamentally different from traditional statistical analyses on small samples. Interconnected big data forms large heterogeneous information networks, with which information redundancy can be explored to compensate for missing data, to crosscheck conflicting cases, to validate trustworthy relationships, to disclose inherent clusters, and to uncover hidden relationships and models.

Once data has been analyzed, it must be **interpreted,** which usually involves examining assumptions and searching for error. This is a human activity, essentially a due-diligence stage in which results are placed into context. A properly constructed big data project will enable this final step by building in the tools to make the data accessible and understandable from the outset.



This big data analysis pipeline shows the major steps in manipulating big data. At the bottom are big data needs that make these tasks challenging.

Big data research is further impacted by **external factors** not always found in traditional data collection and manipulation efforts, which can include the heterogeneity and scale of the data, timeliness for collecting and processing data, privacy concerns, and the need for collaboration across data sets. These added dimensions place an additional burden on big data researchers.

Enabling Big Data Acquisition and Extraction Through Database Design

H.V. Jagadish, the Bernard A. Galler Professor of Electrical Engineering and Computer Science, has for many years sought to develop large-scale databases that are not only more capable in terms of performance and functionality, but that are also easier to use. His current research is centered around the usability of big data, particularly when that data comes from multiple heterogeneous sources and has undergone many manipulations.

His research has been instrumental in the development of projects such as the Michigan Molecular Interactions Database, which is a repository of biological research data collected through the National Center for Integrative Biomedical Informatics, one of seven national centers for Biomedical IT set up by the National Institutes of Health (NIH). He previously led database research to build a native XML store, which is a hierarchical database from the ground up for storing and querying XML data.

Prof. Jagadish has recently received an NSF Big Data grant for his project, Choosing a Needle in a Big Data Haystack. This project develops tools and algorithms to support users in the task of choosing one, or a few, objects from a very large set, particularly when there is a great deal of complex data on which to base this choice.

Prof. Jagadish summarizes this project as follows: "Imagine the case of a traveler looking at hotel booking options in a major city on a travel site. There are likely to be hundreds, perhaps thousands, of options to choose from. While there are some criteria that can be expressed as simple functions of attribute values, such as the price for a hotel room, other considerations, such as how stylish a hotel is, can be much harder to determine as a function of known attributes. The task is to help minimize the number of options to be examined, and to optimize the order in which they are examined." Techniques that Prof. Jagadish will explore include supporting human specification of information need against a variety of big data sources, and machine presentation of relevant results with the volume of big data.

How Fast Do You Need That Data?

Prof. Barzan Mozafari's work is aimed at building data-intensive systems that are more scalable, more robust, and more predictable, with a particular interest in database-as-a-service clouds, distributed systems, and crowdsourcing. In his BlinkDB project, Prof. Mozafari and his collaborators have developed a massively parallel query engine for big data that will allow analysts working with terrabytes of distributed data to receive results dramatically faster. The query time for 7.5TB of data partitioned across 100 Amazon EC2 machines using Hadoop is typically around 1.5 hours. BlinkDB eliminates this wait by building a set of carefully chosen samples of original data and running the query on those samples only. In doing so, BlinkDB leverages sophisticated sub-sampling and re-sampling techniques to optimize the query execution and guarantee the user-requested accuracy. BlinkDB enables answers that are 99% accurate within seconds, enabling analysts to experience interactive analysis of their data in real-time.

In another project, Prof. Mozafari notes that crowdsourcing has become a popular means of performing tasks that have been difficult for computers, such as image annotation and audio transcription, but that even crowds of humans cannot feasibly annotate big data, say millions of images or tweets. He has developed an algorithm that will determine which queries in a crowdsourcing task can be posed to a machine learning algorithm that will make the correct annotation, and which should be posted to the human crowd. The algorithm also estimates an optimal time and/or dollar budget to acquire data from the crowd.

Natural Language Processing – Drawing Insight From Written Lanugage

Profs. Dragomir Radev and Rada Mihalcea seek to draw extended meaning from large written data sets. They work in the area of Natural Language Processing (NLP), which leverages techniques from artificial intelligence, machine learning, and linguistics to derive meaning from natural language input. NLP allows large collections of written works or comments to be collected, categorized, summarized and shared; it enables study of the use and effectiveness of language; and it can measure the sentiment or emotion behind communications. Profs. Radev's and Mihalcea's work involves the creation of algortihms, tools, and techniques that can be employed for these inquiries.

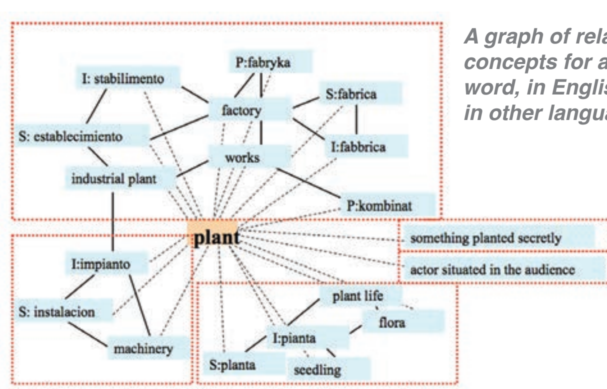
Prof. Dragomir Radev leads the CLAIR (Computational Linguistics And Information Retrieval) research group, which focuses on text analysis, natural language processing, information retrieval, and network analysis. His group has compiled the CLAIRLib library, which contains more than 300 modules for use by researchers performing NLP tasks.

His current research in big data is directed toward analyzing large sets of online discussions to identify leaders, influencers, and subgroups; mining scientific papers and citation and collaboration networks to predict the future impact of new technologies; automatic generation of summaries and surveys on scientific topics; and analyzing the diversity in online content written by large groups of contributors. In a recent project, Prof. Radev developed a method of summarizing scientific papers by collecting comments on papers and producing a consensus summary on the work that may or may not agree with the authors', enabling a new means of evaluating and indexing work.

The impact from Prof. Radev's work is broad. By exploiting records of historical and current political debates from around the world, he has led projects to measure and quantify elements of political influence and attraction, and the direction of political discourse. He has also led efforts that have extracted biomedical events from the literature in order to advance research in that realm.

Prof. Rada Mihalcea's work has focused on improving language processing by mining extremely large bodies of text. In much of her work, she has used Wikipedia as source material, since the on-line information repository is huge (over 4 million articles in English and over 31 million total wiki pages) and is interconnected through multiple keywords.

One line of inquiry has been to analyze text to learn what terms in language are important. This is done by looking at the links, annotations, and key phrases in Wikipedia to identify important terms, and then by applying that understanding to other texts. In an NSF-funded project she led entitled *Using Multilingual Wikipedia for Natural Language Processing*, it was shown that language processing can be improved further through the use of multilingual source information, since word meanings and representations differ across languages in ways that can provide informative context.



A graph of related concepts for an input word, in English and in other languages.

Prof. Mihalcea is also interested in using NLP to understand whether people are expressing opinions or facts. This is a growing field that has importance in terms of product reviews and of companies' desires to understand what people are saying about them. She points out that again, processing multiple languages will help since languages lexicalize words differently. "We've found from several projects that if you mine information from several languages at once you can do better at identifying opinions in any individual language by leveraging the different conventions in languages for expressing opinions."

In a project just funded under the NSF INSPIRE program entitled *Language-Based Computational Methods for Analyzing Worldviews*, Prof. Mihalcea will utilize large datasets of differences in perception for thousands of concepts, by several cultures representing hundreds of thousands of people. The project will inform applications in communication, tracking of cultural values, and others. The large multicultural dataset that will be created as part of this project, along with the tools to process it, will be made publicly available.

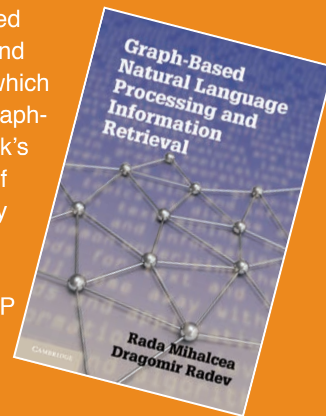
Nowcasting Mines the Social Web for Societal Trends

As a graduate student in 2003, Prof. Michael Cafarella helped to design an open-source multimachine search and index engine called Nutch. That tool was the direct predecessor to Hadoop, which is today a widely-used data mining tool that is unique in providing a means for distributing both the storage and processing of an enormous amount of data over lots of relatively inexpensive computers for big data projects. Open-source tools such as Nutch and Hadoop have provided the foundation that has helped to make the collection of petabytes of data possible.

Today, one focus of Prof. Cafarella's research is monitoring and extracting information from huge volumes of on-line user activity and using it to predict ongoing real-world social phenomena, a process which has been labeled "nowcasting." In a series of recent projects, he and his collaborators have developed mechanisms that will analyze and interpret what people are saying on line and in social media about statistics such as unemployment in an effort to reproduce or add on to those statistics in a way that is more efficient than current techniques.

In pursuing this work, he has identified a major obstacle to widespread nowcasting adoption in feature selection. Typical nowcasting systems require the user to choose a set of relevant social media objects, which is difficult, time-consuming, and can imply a statistical background that users may not have. Prof. Cafarella and his collaborators have proposed a tool called Ringtail, which takes a single user input string and yields a number of relevant signals that can be used to build a nowcasting model. The researchers evaluated Ringtail on six different topics using a corpus of almost 6 billion tweets, showing that features chosen by Ringtail in a wholly-automated way are better or as good as those from a human and substantially better if Ringtail receives some human assistance. Work such as Prof. Cafarella's helps to set the stage for a substantially more efficient and responsive set of processes for measuring societal signals.

Profs. Mihalcea and Radev collaborated to publish the book "Graph-Based Natural Language Processing and Information Retrieval" in 2011, which was the first of its kind on the graph-based method for NLP. The book's first part is a general overview of graph theory and network theory as applied to text processing, and its second part is a detailed description of techniques for NLP in graphs, including semantics, syntax, discourse analysis, and text summarization.

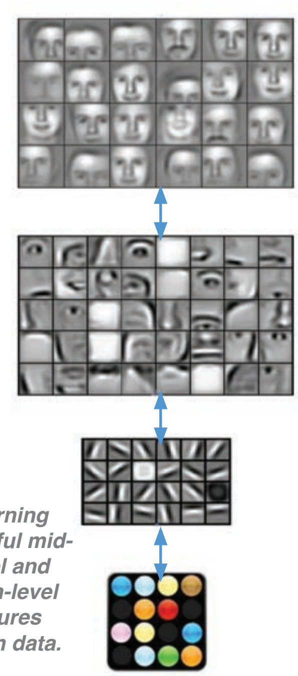


What Can You See With Big Data?

How can systems be taught to identify and select relevant features in order to create representations of real-world objects from image, audio, and other rich media data? Big data is not limited to text and numbers, and the variety and quantity of data types available provide fertile ground for explorations.

Prof. Honglak Lee's research is in developing algorithms for learning useful feature representations automatically from data – a concept called representation learning – which can enable applications such as computer systems that can identify and respond to image data. The machine learning algorithms he has developed can "decompose" input into a hierarchy in which simple features are learned first and are then used to learn higher-level features.

These algorithms use a combination of unsupervised and supervised learning techniques. Prof. Lee uses the example of face recognition illustrate these techniques: "In unsupervised learning, if you have lots of images that contain some common structures then potentially the algorithm can discover those features automatically without you telling it that these images are faces. In supervised learning, when the system is told that a structure is a face or that portions of the face are specific features, then it can associate some of these learned mid-level features and make the connection to the label of face."



Learning useful mid-level and high-level features from data.

A picture of a face is quite recognizable to a human, but to a computer system it is merely a collection of pixel intensity values. To facilitate the recognition process, Prof. Lee employs a hierarchy of features, from pixels, through edges, to mid-level features (facial features), to be able to identify objects (faces). These mid-level features are useful because they can be shared across other tasks as well. For example, in the case of faces the features can also be used for tasks such as classifying by gender or classifying facial expressions. These learning algorithms are very powerful since they can be flexibly adopted across diverse datasets and domains, including heterogeneous multiple input modalities.

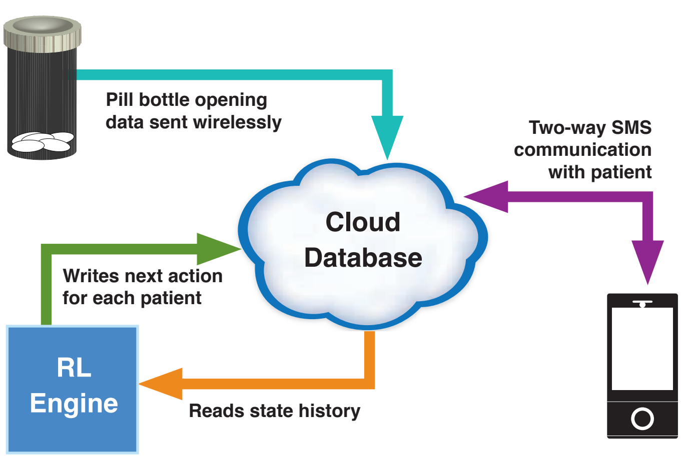
Potential outgrowths from Prof. Lee's work could be an artificial vision system or an assistive medical tool that could help a physician with remote medical procedures or risk prediction by visually identifying and recognizing task-relevant sub-structures and/or abstractions from medical imaging data. The techniques that he has developed also have applicability to processing other types of data, such as video and audio.

Prof. Jia Deng's research is also in the area of computer vision. He is particularly interested in tackling large-scale computer vision challenges using big visual data — the massive amount of images and videos made available by digital cameras, mobile devices, and the Internet. Prof. Deng develops statistical models, learning algorithms, and systems with humans in the loop to harvest, understand, and harness big visual data. His ultimate goal is to build intelligent machines that can perceive and reason about the complex visual world as humans do.

Personalized Medicine Aims for Massive Scale

Prof. Satinder Singh Baveja's major contributions are in the area of reinforcement learning, and he is increasingly putting those techniques to use in projects that fall at the intersection of personalized health and big data. In a pilot-project underway with collaborators from Pharmacy and Internal Medicine, he is developing a system to motivate patients who suffer from high blood pressure, and who have a history of not taking medication regularly, to take their medications on time. These patients may not be taking their medications for a variety of reasons, from being forgetful to concerns about side effects, or because the patient does not experience ill-effects on a daily basis.

The system makes use of a novel pill bottle that records when it has been opened for dosing and which sends data to the cloud to indicate that doses have been taken. In response, messages are sent to the patient via SMS. These messages are of several types that address different potential underlying causes of lack of medication taking. As the system continues to collect data, it will learn what types of message provide the best compliance from the patient. Because the system is envisioned to scale to millions of users, it will learn and employ strategies based on aggregate successes, but always tailored to individual response. Prof. Baveja notes that this model is extensible and that with the right wearable or environmental sensors to provide input, the system could encourage a number of other long-term personalized health behaviors. "Through this loop, we can measure behavior, analyze the data in the cloud at large scale, and learn from that to provide increasingly actionable, personalized health-content for the user."



Hidden Health Data Brought to Light

Prof. Zeeshan Syed has a focus on analyzing and interpreting medical data to unearth "invisible" signals that were previously unknown and "lost in the noise." The goal of Prof. Syed's research is the development of a computational framework that allows for the structured discovery of novel, highly-discriminative risk markers from terabytes and even potentially petabytes of physiological data routinely collected in clinical medical settings that would otherwise be overlooked.

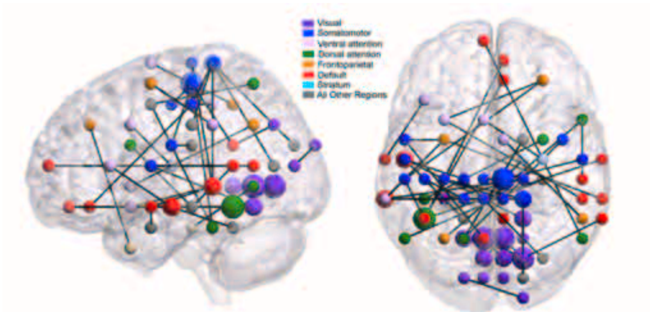
In recent work that included collaborations with the Brigham Young Women's Hospital, the University of Michigan Cardiovascular Center, and the Henry Ford Hospital, Prof. Syed studied the ECG data that is collected routinely from patients when they are admitted for heart attacks. By closely analyzing large numbers of these data sets, Prof. Syed was able to identify previously unknown biomarkers that have been able to indicate which patients are at elevated risk for a repeat cardiac incident over the next year so that they can be treated accordingly.

These techniques are extensible and may also be applicable to research into mental health by studying electrical signals of the brain in order to determine if markers might exist that could indicate epilepsy and the likelihood of seizures, or could be applicable in better understanding psychiatric conditions such as depression, bipolar disorder, and schizophrenia.

Building Algorithms for Classification and Learning

Prof. Clayton Scott studies patterns in large, complex data sets in order to make quantitative predictions and inferences about those patterns and to develop new algorithms. He has undertaken a number of projects as vehicles for creating and validating these algorithms, from nuclear particle classification through carbon dioxide monitoring.

In a project with Psychiatry and Philosophy, he is seeking to quantify the neural mechanisms that distinguish patients with various mental health disorders from healthy patients, and to characterize the effects of various psychoactive drugs by applying machine learning methodology to functional neuroimaging (fMRI) data across a variety of mental health disorders. For each mental health disorder or drug analyzed, the goal is to infer a connectome, which is a network of pairs of brain regions whose functional correlation differs for the given treatment/condition relative to baseline. A single study may involve data from several scanners, with multiple subjects per scanner, while a single subject's brain scan involves millions of voxels.



Functional neuroimaging for connectomic analysis in mental health.

Applying the Tools of Signal Processing to Big Data – Everywhere

Alfred Hero, the R. Jamison and Betty Williams Professor of Engineering, has made fundamental contributions to both the theory and application of signal and image processing with broad applicability to big data. He has conducted work in the area of medical informatics that is leading to better diagnoses and prognoses for patients with serious blood borne diseases by using data to improve diagnoses for a condition that often leads to anemia and in acute cases, leukemia.

In work with wireless sensor networks, he has addressed the importance of knowing where massive networks of sensors are located once they've been deployed, which is relevant for applications such as building and bridge sensors; agriculture; equipment maintenance; traffic monitoring systems; and environmental monitoring of air, water, and soil.

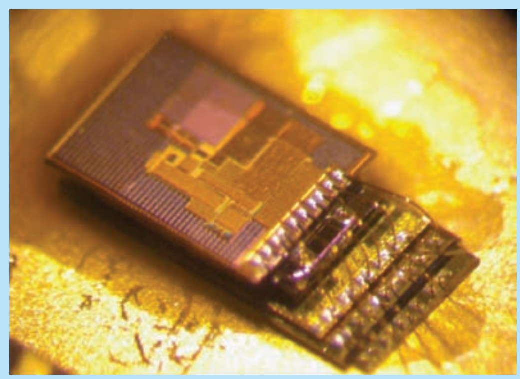
Another domain that Prof. Hero and his students have been investigating for several years is that of mining for correlations between objects in massive databases. Along with Stanford Prof. Bala Rajaratnam, Prof. Hero and his students have established a general theory for controlling the avalanche of false positive correlations that can occur when correlating large numbers of variables. Under this theory, the structure of correlation networks has been used to reveal hidden patterns in databases including multiple gene interaction data, historical financial data, human social-behavioral data, and sensor network data.

For example, in collaboration with computer vision faculty Silvio Savarese, Hero applied correlation network theory to identify groups of videos containing common or similar activities. He has also collaborated with medical clinicians to discriminate between complex patterns of gene interaction that differentiate a healthy from a compromised human immune response to pathogens. Prof. Hero has applied correlation mining to social network data as well, including for community detection in email spammer networks and for improvement of music recommendation systems by using information from each user's network of friends.

Where Does All This Data Come From Anyway?

The ocean of big data that we swim in is increasingly fed by the various sensors that are all around us. Prof. Prabal Dutta is pioneering practical, low-power platforms and wireless protocols for deploying more robust and pervasive sensing, computing, and communications networks. His work is in support of a future "Internet of Things," in which a trillion sensors interact with a billion smart devices and a million servers.

Projects that Prof. Dutta and his students are working on include small sensors that will operate autonomously, communicate wirelessly, and harvest energy from their environments, which will enable them to be deployed in great numbers without overwhelming their owners. In addition, he has recently joined Profs. David Blaauw, Dennis Sylvester, and David Wentzloff on the Michigan Micro Mote Project, which is a complete millimeter-scale computing system that could be used for distributed monitoring (see related story, page 27).

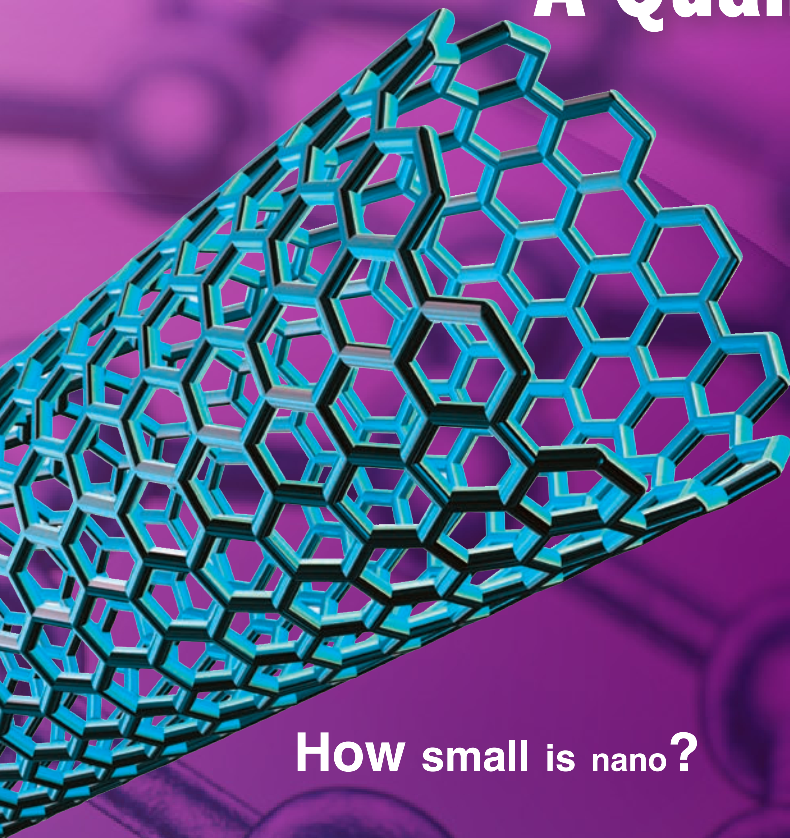


A cubic millimeter Michigan Micro Mote sensor.

Vast sensor deployments are exciting for what we might learn from the data, but a critical challenge is validation and assurance of data quality. Prof. Laura Balzano has begun a two-year study into signal processing theory and methods for blindly calibrating sensors on a massive scale, after they are deployed, and as their calibrations change over time. Her study will be supported with air quality data collected in Michigan by the EPA and the Michigan DEQ.

According to Prof. Balzano, if we hope to deploy even a hundred sensors, it immediately becomes infeasible to calibrate each one by hand regularly enough to maintain a high-quality estimate of those calibration parameters. Consequently, we are interested in ways to automatically calibrate a collection of sensor devices after they are deployed, without dependence on controlled stimuli or high-fidelity groundtruth data.

Nanotechnology and Progress: A Quantum Entanglement



Nanotechnology is a world where materials that behave one way at one size, begin to do their own thing when they get really small. It's where something as hard as a diamond can also be flexible. It's where even Einstein didn't believe his own theory suggesting quantum entanglement – because surely no process that "spooky" could exist in the physical world.

Yet because some particles act differently in the nanoworld, they open up seemingly miraculous improvements in systems that might otherwise be reaching the wall in terms of overall performance. Sometimes just being smaller opens possibilities for new materials and devices.

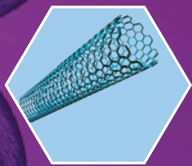
In this brief overview of nanotechnology research in ECE, we'll look at how research at the nanoscale is impacting lighting, medicine, displays, electronics, information security and the far-out world of quantum computing. Our faculty are also looking into how to manufacture these devices.

How small is nano?

"nano" = one billionth

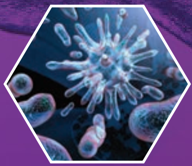
A nanometer (nm) is one billionth of a meter

A single atom is ~0.1-0.3 nm



A carbon nanotube is ~ 1 nm in diameter

DNA is 2.5 nm



A virus is 30-50 nm

A strand of hair is ~ 100,000 nm wide

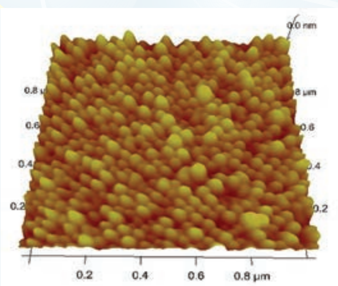
Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. [National Nanotechnology Initiative]

Dots, Waves, and Light – Particles and Quasiparticles

It Starts With a Dot, a Quantum Dot

Quantum dots are the cornerstone of a broad spectrum of research at the nanoscale. A quantum dot is a 2-10 nanometer particle made of some semiconductor material. Like many nanoscale particles, they display characteristics distinct from the same material in bulk – which make them a fascinating source for new technologies, including lighting sources, lasers, solar cells, medical imaging, and quantum computing.

Quantum dots were first discovered in the early 1980's. Just a few years later, a team of researchers that included Pallab Bhattacharya, Charles M. Vest Distinguished University Professor, and Prof. Jasprit Singh, showed that under certain circumstances, quantum dots organized themselves into unique three-dimensional structures. The scientific community didn't pay much attention when they published their findings in 1988 – the results seemed too far-fetched.



Atomic force microscopy of InAs quantum dots, grown on indium phosphide (InP).

This changed in 1996 when Bhattacharya came out with the world's first room temperature Indium Gallium Arsenide (InGaAs)/GaAs quantum dot laser based on self-organized quantum dots. Contributing to this groundbreaking device were Ted Norris, Gérard A. Mourou Professor of EECS, who used ultrafast spectroscopy to better understand the material as well as anticipate its performance in lasers and photodetectors, and Prof. Jamie Phillips, who was involved with the experimental work as a graduate student. Prof. Bhattacharya has continued to be a worldwide leader exploring the capabilities of quantum dots for new devices.

Are Plasmons the Key to Entirely New Devices?

We may know the answer to that question once Prof. Norris is done investigating their properties. "Plasmons may be the route to very sensitive biosensors, improved solar cells, photodetectors, light emitters, and even optical communications in a chip," stated Prof. Norris, who has been using a process called Electron Energy Loss Spectroscopy (EELS) to understand plasmons.

Plasmons are tiny quasiparticles that correspond to the oscillation of electrons in a metal. Plasmons in individual metallic nanoparticles are difficult to study optically, since nanoscale particles are many times smaller than the wavelength of light. EELS opens up the possibility of mapping out the plasmons in nanostructures directly, although it's important to be careful in relating the EELS measurement to the optical properties of the material. The ultra-high resolution of EELS may enable the study of objects smaller than 10 nanometers.

Prof. Norris is working with Prof. Bhattacharya to use EELS to study nanostructures made of semiconductors, relatively unexplored territory. They started with simple structures such as gold and silver nanowires, and are now moving to more complicated systems. Prof. Norris says the research has been extremely promising.

Polaritons Enable Groundbreaking Lasers

Polaritons are manmade quantum phenomena that come about under specific conditions involving photons and excitons (electron-hole pairs). These part light and part matter particles, once created, take on unique properties of their own.

Stephen Forrest, William Gould Dow Professor of Electrical Engineering and U-M Vice President for Research, and his group were the first to demonstrate room-temperature polariton lasing in an organic semiconductor material in 2010. By doing so, they achieved a long sought-after optics phenomenon that could lead to more efficient and flexible lasers for telecommunications and quantum computing applications, among other uses. The next step is to use polaritons to do electrical rather than optical pumping of organic semiconductors.

Using inorganic material, Prof. Bhattacharya developed the first electrically injected polariton laser in 2012, a feat that researchers around the world had been trying to demonstrate since it was first proposed in 1996. The experimental results were published in 2013, in *Physical Review Letters*. A typical laser generates light through Light Amplification by Stimulated Emission of Radiation, hence its name. This new device generates light through Light Amplification by Stimulated Scattering of Polaritons – thereby creating an entirely new laser paradigm.

This laser takes about 1,000 times less energy to operate than a conventional laser, and can be potentially used in any application where a laser is used today, such as consumer electronics, optical communications and the Internet, laser surgery and other medical applications, and displays. First however, the laser needs to operate closer to room temperature, which means raising its operating temperature from 30K to at least 200K. Proving the viability of this laser at room temperature is the next holy grail for Prof. Bhattacharya, and now for many other researchers worldwide.

Nanotechnology for Quantum Computing and Cryptography

Quantum Research for Quantum Computing

One of the most mysterious nanoscale phenomena is quantum entanglement. Even Albert Einstein, who alluded to this effect in a 1935 paper, called it “spooky” and refused to believe it was scientifically accurate. At the risk of oversimplification – quantum entanglement happens when the smallest of particles (such as photons, electrons, or molecules) interact and separate – yet somehow remain linked such that when the state of one of the particles changes, the other particle will change in exactly the same way – no matter their distance apart.

50 years after Einstein’s spooky theory, quantum entanglement was proven to be a real phenomenon – and became the subject of intense exploration as a means to achieve quantum computing. Because of their ability to represent multiple states simultaneously, quantum computers could theoretically factor numbers dramatically faster and with smaller computers than conventional computers. Factoring numbers is the basis for encryption schemes used to protect computer data.

Duncan Steel, Robert J. Hiller Professor, and a group of collaborators from the Naval Research Laboratory and UC-San Diego recently demonstrated quantum entanglement between an electron spin state and a photon polarization state, both resulting from their association with a quantum dot. A quantum dot acts like a transistor in a conventional computer. Lasers are used to excite the quantum dot, which then emits the photon, while the electron spin state remains with the quantum dot. Because the electron and photon were quantum entangled, the researchers were able to transfer information between the two. “Now we can send that photon to another device and transfer the information back into another electron,” explained Prof. Steel. This was a major accomplishment that was mirrored by two unrelated groups working on the same problem. Though the processes used were slightly different, the results were similar and corroborative.

This was simply the latest of several quantum research milestones accomplished by Prof. Steel. In 1998, his group was the first to demonstrate coherent optical control of a single quantum dot. This work led to the idea that quantum dots could be used to build quantum computers. In 2000, Duncan’s group made the first demonstration of optically-induced quantum entanglement in a single quantum dot, and used this to make the first universal quantum gate in a solid-state device.

In 2008, Prof. Steel and his group took yet another important step toward practical quantum computing when they became the first to control the inherent duality of a qubit, or quantum bit. A quantum bit is analogous to a regular bit in that it is a unit of information. However, a qubit differs dramatically from its classical counterpart in being able to simultaneously hold two states. A bit is either 0 or 1 whereas a qubit can simultaneously hold two states correlating to the 0 and 1 of classical computing. A qubit could be defined by the spin of an electron or other atomic particle. In this groundbreaking work, lasers were used to trap the spin of one electron that was confined in a single self-assembled quantum dot. But they could only trap it for the briefest of time.

In 2009, Prof. Steel and colleagues succeeded in lengthening the stable existence of the qubit by more than 1,000 times. Accomplished with the help of a laser, Prof Steel called this unexpected result “a remarkable piece of physics in nature.” It broke down yet another tall barrier to realizing a quantum computer.

A key aspect of Prof. Steel’s most recent demonstration of quantum entanglement is that it is scalable, which is critical to realizing a scalable quantum dot quantum computer architecture.

Quantum Research for Classical Computing

Prof. Steel is also looking to use the quantum properties that emerge in nanoscale materials and devices for classical computing. “Moore’s Law dictates an end to CMOS,” says Prof. Steel. “As we transition from the classical to the quantum world, can we still make these classic computer systems work in the way we want using quantum technologies?” If so, the payoff will be exponentially smaller, faster machines running on a fraction of the power that can solve problems virtually unsolvable with today’s computers.

As a member of the Center for Photonic and Multiscale Nanomaterials, Prof. Steel is investigating new materials that could make it easier to incorporate quantum features into classical computing systems. For example, some quantum dot materials, such as indium nitride, must be kept at extremely cold temperatures, whereas others, such as gallium nitride, could be kept at room temperature.

His approach is to control quantum devices optically, which does away with the need to bond wires to the devices. It also means it's possible to reconfigure a device simply by changing the laser. About 15 years ago, Prof. Steel and his group built the first solid-state device for quantum information; it was a NOT gate. "It takes a lot of physics to figure out how to build quantum devices," said Duncan, "But solving these kinds of problems will lead to technological breakthroughs that aren't even on anyone's radar."

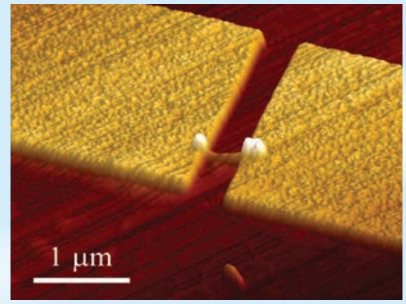
Photons for Quantum Cryptography

In today's computers, private information, such as a credit card number, is encrypted digitally before entering cyberspace. If the information is somehow decrypted and stolen, which happens with alarming regularity, no one would know until bank accounts start to be emptied or secrets leaked. However, if each bit of information sent was equipped with its own nanosized quantum-based photon, it would always be possible to know if a third party was trying to intercept the message. That's because a quantum message being sent as photons will instantaneously change if it's being observed (this is called the wave function collapse) as a byproduct of quantum entanglement.

Prof. Steel's group demonstrated the key quantum requirement (entanglement), and is now demonstrating the link. In related work, faculty are perfecting devices that can generate the photons needed for quantum computing and cryptography.

Prof. Bhattacharya and his team combined quantum dots, GaN nanowires, and electrical injection to create a device that is capable of producing a single photon at a time, while controlling the polarization of the photon. Both attributes are key to accomplishing certain types of quantum cryptography, which require each photon to possess the same degree of linear polarization.

The simplicity of its design and the materials used make it a very attractive improvement over existing technology. It uses the same semiconducting materials commonly used in LEDs and solar cells, and the nanowires are grown on silicon, which is cheap and scalable.



An atomic force microscope image of a nanowire single photon emitter.

In addition to its applicability to quantum cryptography, this single photon emitter is also useful for quantum information processing and metrology applications. Prof. Bhattacharya is currently working on a device that operates closer to room temperature.

Prof. Ku and his group developed a system for generating a "site-controlled" single photon from quantum dots that is based on semiconductor lithography. His system operates at 90 degrees K, which is the highest temperature on record for a single photon source that can generate millions of photons on demand.

"Room-temperature operation is important," said Prof. Ku. "But equally critical for practical applications is the ability to arbitrarily control the output polarization and the ability for the photons to be easily coupled to other optical components such as an optical cavity. The lithographic approach is very promising to these ends." A "deterministic" single photon emitter translates into a marketable product for banks and other institutions that will pay heavily for security.

C-PHOM

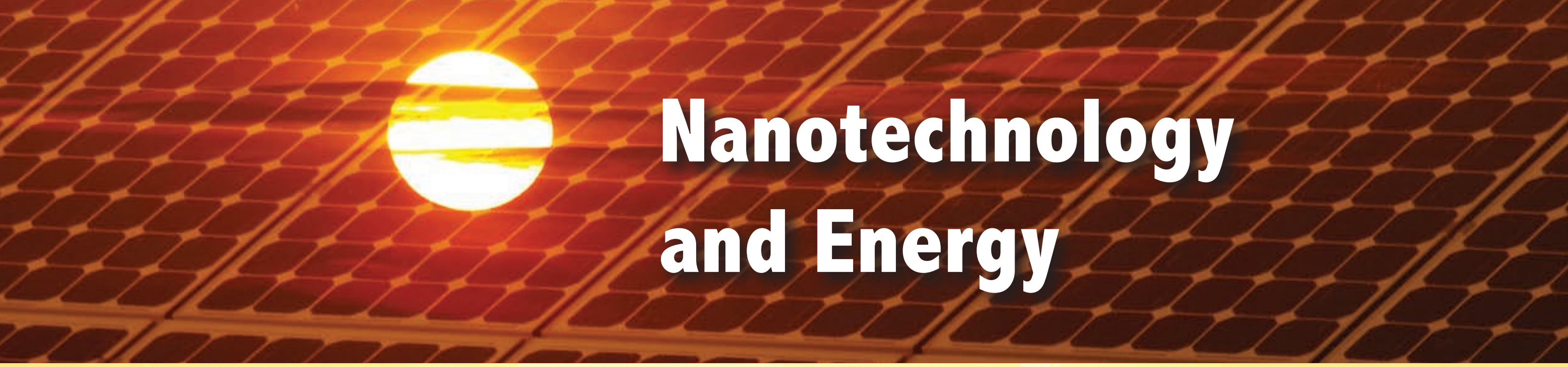
Center for Photonic and Multiscale Nanomaterials

The NSF Center for Photonic and Multiscale Nanomaterials (C-PHOM) was established at Michigan in 2011. Directed by Prof. Ted Norris, research in the Center is focused on controlling how light interacts with matter on all length scales, from nano up to the scale of the wavelength. C-PHOM has two primary research focuses as well as a third area devoted to financially supporting new research directions.

Prof. Bhattacharya leads the area concentrating on wide-bandgap nanostructured materials for quantum light emitters. The research is similar to work he and Prof. Norris accomplished more than a decade ago with the InGaAs/GaAs quantum dot laser, but with an important difference. They are now working with the material Indium Gallium Nitride (InGaN), a completely different animal.

These materials can be used to generate blue, green, and possibly even red light emitters – and contain the promise of new and highly efficient devices. "The material challenges that come with nitrides are enormous," said Prof. Norris, adding that Prof. Bhattacharya's work with nanowires may be a real breakthrough technology for gallium nitride. Also involved in this research from ECE are Rachel Goldman (Materials Science and ECE), P.C. Ku, Jamie Phillips, and Duncan Steel.

Roberto Merlin, Peter A. Franken Professor of Physics and EECS, leads the second research area, which is focused on advanced electromagnetic metamaterials and near-field tools. A metamaterial is an artificial material made up of nano-sized particles that are engineered to take on properties not possible with natural materials. Part of this research involves studying the nonlinear optical properties of the nano building blocks that will create the materials. This research thrust also involves ECE faculty Tony Grbic, who is the Ernest and Betty Kuh Distinguished Faculty Scholar, Jay Guo, and John Schotland (Math and ECE).



Nanotechnology and Energy

Renewable Energy From the Sun

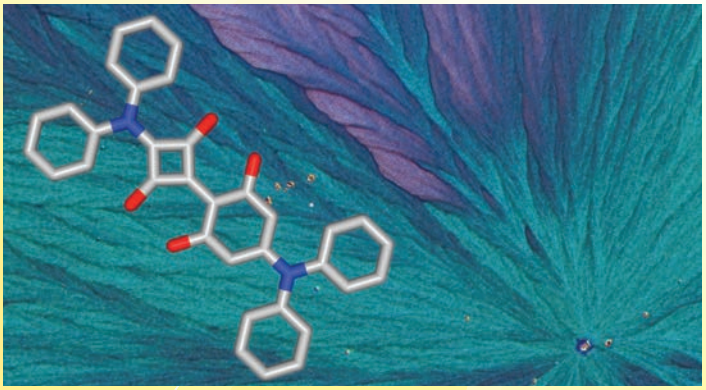
Nanotechnology offers the possibility of new materials built from quantum dot or other nanostructures to convert solar energy into electricity with greater overall efficiency than is possible with silicon. Silicon is the current material of choice for solar cells due to its low cost, but these solar cells are highly inefficient. The solar cell industry doesn't need the thousand-fold improvements that nanotechnology has offered other fields. But it does need further improvements to make solar energy economically competitive with fossil fuel.

Several ECE faculty are working on different aspects of solar cell technology, including Prof. Stephen Forrest, Prof. Jay Guo, Prof. P.C. Ku, Prof. Jamie Phillips, and Prof. Zhaohui Zhong.

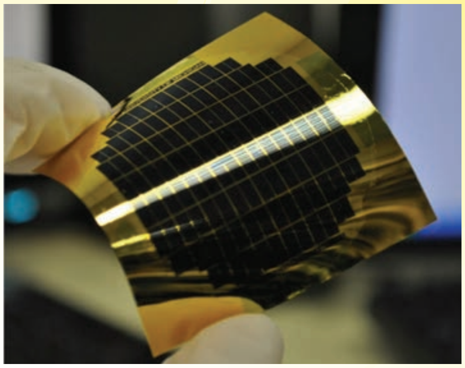
Prof. Forrest is a world leader in organic photovoltaics, which is the study of organic materials to create solar cells. In 2010, along with researchers at Argonne National Laboratory and Northwestern University, he came up with a general theory for organics that was a theoretical corollary to Shockley's well-known diode equation for semiconductors. "Organics have always evaded clear scientific definition," said Prof. Forrest. "This new ideal diode equation will hopefully serve as the theoretical foundation of organic electronics in the future."

In recent work, Prof. Forrest and his team put this theory to the test, and it worked. His group achieved better than a 50% improvement in energy-conversion efficiency by developing techniques to control nanocrystalline order at the active interface in organic photovoltaics. This critical advance provides a fundamental understanding of the process of solar-to-electrical energy conversion in organic thin film solar cells, and the linkage of efficiency to molecular and crystal structure.

Prof. Forrest also discovered a way to build flexible solar cells made from the inorganic material gallium arsenide (GaAs) in a way that opens the door to mass production, which would dramatically lower their cost. He has shown 22% overall efficiency in these solar cells, and is investigating ways to increase that efficiency to 30%. This would put solar cells made from GaAs on a par economically with those made from silicon.



Prof. Forrest and his group used these square-shaped molecules, called squaraines, helped to boost the energy-conversion efficiency in organic photovoltaics.



A flexible GaAs solar cell.

Prof. Jamie Phillips investigates new optoelectronic materials for next-generation solar cells (as well as for infrared detectors and thin film electronics). He has been studying quantum dot intermediate-band solar cells (IBSCs) to see if his group can realize the improved efficiency that researchers believe are inherent in these devices. Working with inorganic materials, he demonstrated the first ZnTe:O IBSC, and more recently has turned his attention to GaSb/GaAs type-II quantum dots. By analyzing what happens in the individual quantum dots, he demonstrated that this form of quantum dot should be a good candidate for efficient IBSCs.

Prof. Norris has been involved with solar cell research from the perspective of defining the fundamental aspects of new materials. Using ultrafast laser technology, he is able to explore the most basic properties of the proposed materials to gauge how effective they will be converting solar energy to electrical power.

Energy-efficient Lighting

Lighting accounts for as much as 25% of all the energy expended in the United States. The U.S. Department of Energy believes that widespread use of white light LEDs could cut the energy expended on lighting in half by 2030.

Light emitting diodes (LEDs) are dramatically more efficient than their incandescent and fluorescent counterparts. There is already a huge consumer market for these devices, including: electronic devices; automotive, household, industrial, and aviation lighting; advertising; traffic lights; and more.

An LED is illuminated by the movement of electronics in a semiconductor material. Researchers continuously investigate different semiconductor materials for making LEDs in search of the combination that will give the best color with the lowest threshold current density, meaning the lowest amount of energy needed to generate light. LEDs can generate red, green, blue, or white light.

Quantum Dots and Nanowires for Better Green and Red LEDs and Lasers

In 2011, Prof. Bhattacharya demonstrated the world's first quantum dot Indium Gallium Nitride (InGaN) laser that could emit the color green. The quantum dot lasers have a threshold current density that is 10 times lower than lasers of other materials used to generate green. Solid-state green lasers are required for full-color mobile projectors, optical data storage, and for medical and military applications; they will eventually find applications in solid-state lighting. Bhattacharya's group also demonstrated blue quantum dot lasers in their stride.

The green InGaN laser was a significant achievement, but not as big as what he's done now, which is to demonstrate red emission from an InGaN-GaN quantum dot laser, a feat considered virtually impossible. This result has also been recently published. A potential major application of such red emitting lasers is heads-up displays in automobile windshields.

Both achievements (red and green emission) were also made possible with InGaN-GaN nanowires. A nanowire is a nanostructure that measures 10s of nanometers in diameter and can be of any length. Quantum mechanical effects come into play with nanowires, making their properties unique from their bulk counterparts.

Lowering the Cost of White Light LEDs

White light LED products are becoming increasingly prevalent on the market as an alternative to incandescent and fluorescent lighting, yet their quality and energy efficiency widely varies, and they are relatively expensive.

Prof. P.C. Ku is investigating an approach to white light LED development that could substantially lower the cost of fabricating the devices. He is growing his own materials, including nanowires, through gallium nitride epitaxy in order to perfect a nonpolar LED substrate. LEDs are typically fabricated on polar substrates because they are far less expensive and simpler to deal with than nonpolar material. However, polar substrates generate an electric field, which make them highly inefficient.

Prof. Ku has achieved good results with his nonpolar substrate, and now is in the process of fabricating LED devices on top of it. "We are trying to bridge the gap between a very expensive non silicon LED lightbulb, and a cheap one," said Prof. Ku.

More Like Real Sunlight

"I want to walk into a room and get the best kind of light – so you'll be healthy, alert, and able to work," says Prof. Ku. That means a light source that provides some of the same benefits as real sunlight. There is scientific evidence that sunlight provides us not only the ability to see, but to feel well and more alert. This effect seems to be related to a receptor in the eye that's linked to our circadian rhythm, or our daily clock. This receptor in the eye senses the blue light from the sun, which in turn regulates how much melatonin is produced by the body; melatonin is directly related to sleep patterns.

Prof. Ku's ideal office light will combine the blue light of the sun with bright, attractive, energy-efficient lighting. To achieve this goal, he's working with Prof. Mojtaba Nawab (Architecture & Urban Planning) and Prof. Kwoon Wong (Ophthalmology & Visual Sciences) to find the right combination of lighting to satisfy both our conscious and subconscious vision.

Prof. Ku formed a company with Prof. Max Shtein (Materials Science and Engineering) called Arborlight, which specializes in LED lighting for retail and office settings.

OLEDs for Displays and Lighting

An organic light emitting diode (OLED) is an LED that contains an organic semiconductor, such as carbon. Unlike LED's, they can be molded into any shape. The first modern OLED was developed by researchers at Eastman Kodak in 1987, but it was highly inefficient. The OLED industry began to really take off when Prof. Forrest built the first phosphorescent OLED with Prof. Mark E. Thompson (Dept. of Chemistry, USC) in 1998. "We used a simple quantum mechanics trick to develop materials that could make them 100% efficient," said Prof. Forrest. Soon after, they were considered the hot new material for displays.

When Samsung developed their super-sharp OLED displays for use in their Galaxy 3 and 4 smart phones, they used many of the same materials and device structures first developed in Prof. Forrest's lab.

OLEDs may one day be used for general lighting. Proponents believe the quality of white light produced by an OLED is superior to an LED, but they lag in overall performance in terms of efficiency, longevity, and cost. Prof. Forrest and his group are working to overcome these deficiencies. For example, they developed a low-index grid (LIG) embedded in the organic layer to redirect the light; when combined with additional methods to extract light, a LIG can lead to a threefold increase in overall efficiency. Improved manufacturing may also lower the cost of white light OLEDs.

Nanotechnology and Health

Ultrasound Becomes "Nanosound"

Ultrasound deals with pressurized sound waves at frequencies higher than audible sound. As the frequency of the sound waves is increased from KHz to MHz levels, they become useful for medical imaging and even non-invasive therapy. For example, highly focused ultrasound has been used to fragment large kidney stones and prostate tumors, without invasive surgery. Being able to focus the ultrasound beam even smaller would open the door to treating tiny cancerous tumors, artery-clogging plaques or even targeting single cells for targeted drug delivery.

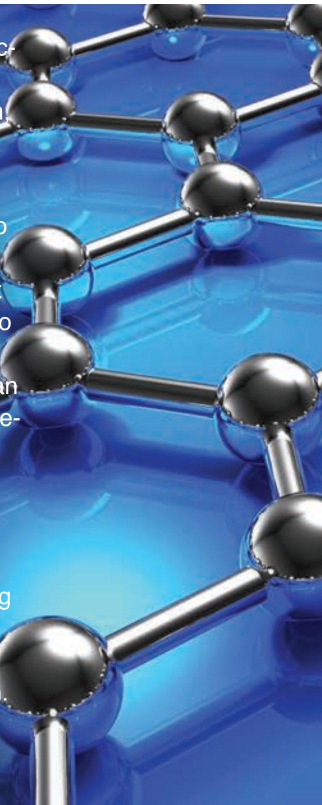
Our faculty were able to accomplish an extremely focused sound beam through the use of an optoacoustic lens that embeds carbon nanotubes in a polymeric film. In experiments, the researchers detached a single ovarian cancer cell from healthy surrounding tissue, and blasted a hole less than 150 micrometers in an artificial kidney stone. With this new technique, doctors could target tumors as small as 75 μm in diameter, much smaller than the 2 mm threshold that is currently possible. This work was accomplished by a team of researchers led by Prof. Jay Guo, Prof. Euisik Yoon, Prof. John Hart (Mechanical Engineering), and Prof. Zhen Xu (Biomedical Engineering).

Improved POC Medical Testing With Nanoelectronics

Point-of-care (POC) medical testing is any diagnostic test done outside a hospital setting. It offers immediate diagnosis and treatment for a variety of medical issues ranging from diabetes and heart problems to pregnancy diagnosis. The U.S. is the leader in POC testing products, recently valued at $3.68B in 2012.

Nanoelectronic sensors are ideally suited to POC devices. Current nanoelectronic sensors are capable of detecting a wide array of molecules in certain solutions. However, they fail in solutions that contain a high percentage of salt due to the bioscreening effect. Many desirable applications have salt, including testing human blood. Prof. Zhong has developed a technique for operating a carbon-based nanoelectronic sensing platform at frequencies high enough to help mitigate the bioscreening effect. He is now developing a graphene-based biosensor to further improve the efficiency of these devices.

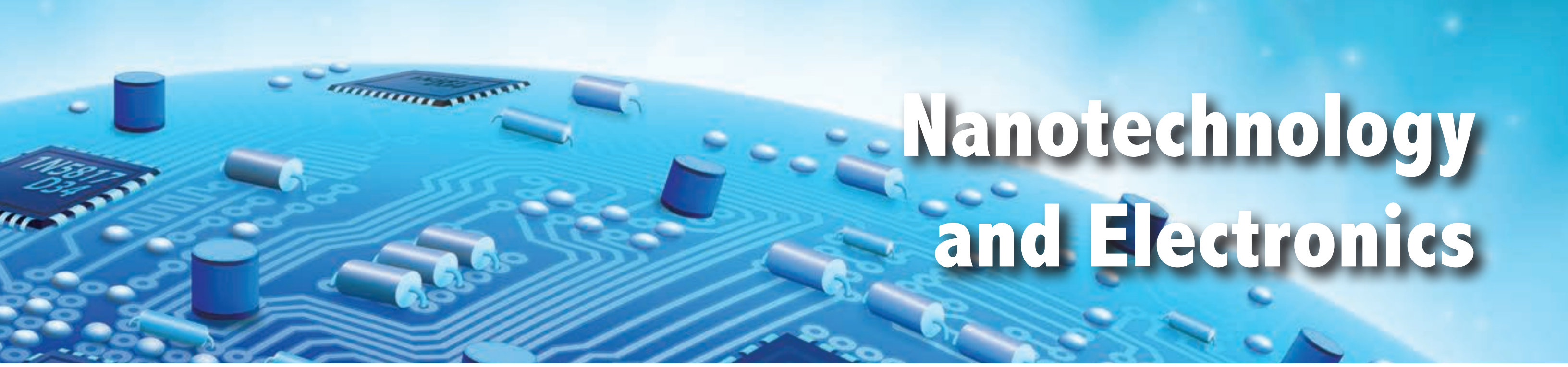
Graphene – The Next Big Thing



Graphene is a material that could bring on a revolution in the electronics world by competing with or even replacing silicon in high-performance computers and electronics. Graphene is comprised of a single layer of carbon atoms arranged in a hexagonal pattern. It is highly conductive (conducting electricity 30 times faster than silicon and heat 10 times faster than copper), flexible yet harder than a diamond, and absorbs only 2.3% of the light it encounters. It is also inexpensive and easily manufactured.

Discovering What Graphene Can Do – Researchers around the world have been hot on the trail for ways to exploit graphene. At Michigan, Prof. Ted Norris has been studying the ultrafast electron dynamics in this material for about six years to lay the groundwork for its use in practical devices. He's been particularly successful at unlocking the secrets of graphene through a coherent control experiment, where short laser pulses were used to inject electrical currents into this material. "Normally when you shine light on a material it'll create electrons and holes," explained Prof. Norris. "But they aren't going anywhere. We can do it in such a way that we can create an electron current, and measure it by the terahertz radiation it emits. We've been able to learn a lot about the material that way."

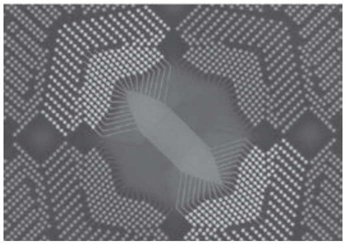
World's First Room Temperature Infrared Photodetector – Building on this information, Prof. Zhaohui Zhong and his team recently succeeded in building the first known room temperature broadband infrared (IR) photodetector. IR detectors are used in a wide array of applications, including optical fiber communications and lasers; imaging in industry, medicine, and science; remote sensing; and detection of humans and animals during the day and night. IR photodetectors offer increased sensitivity and response time compared to their thermal counterparts, but a conventional IR photodetector must operate below 100 K to work at the mid to far infrared region. Prof. Zhong's new IR photodetector changes all that. A paper detailing the device will be published soon.



Nanotechnology and Electronics

Move Over Flash – Memristor Technology is the New Boss

Memristors offer the promise of transforming the semiconductor industry by enabling smaller, faster, cheaper chips and computers. In some areas, such as memory, the improvement over existing technology will be exponential. A memristor is a nanoscale computer component that offers both memory and logic functions in one simple package. More specifically, it is a two-terminal resistive switching device with inherent memory.



Prof. Wei Lu and his team built a specific type of memristor device called resistive random access memory (RRAM), which has fabulous inherent properties for computing. RRAM is capable of extremely high density because it is not made from silicon and can therefore be stacked vertically, yet is still cost effective and scalable. With RRAM it is possible to randomly write and erase bits, and it has very low switching energy.

Prof. Wei Lu and his team are among the leaders in developing this technology to the point where it can be commercialized. "Every major semiconductor company has significant effort in these devices because it is considered the future of next-generation memory," said Prof. Lu. His company, Crossbar, Inc., developed an RRAM prototype and is promising vast improvements in memory capabilities. For example, a smartphone using this technology could store 250 hours of HD video and carry a charge for a week. RRAM has the potential of replacing the flash memory used in tables, digital cameras, and solid-state drives.

Memristor Brainiacs – Memristors for Super-charged Computing and Image Processing

Because memristors combine high density with actions based on past behavior, Prof. Lu has been investigating whether they could work together in ways resembling human neurons. There are about 85 billion neurons in the human brain, each interacting with their neighbors through synapses. Synapses are the gaps between neurons; they are the means by which neurons pass on chemical or electrical signals to neighboring neurons.

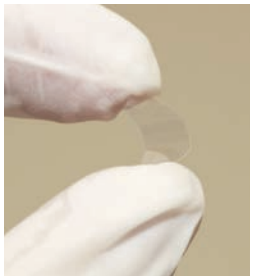
In a groundbreaking 2010 paper, Prof. Lu described how 2 terminal memristor devices can interact with CMOS transistors in a manner very similar to the synapses and neurons in the human brain. He envisions building a computer in which the memristors will act as artificial synapses between conventional circuits, which will act as the artificial neurons.

One specific application of this device is image processing. "With the proliferation of sensors, videos, and images in today's world, we increasingly run into the problem of having much more data than we can process in a timely fashion," said Prof. Lu. "Our approach aims to change that."

He plans to build a system that uses memristors as memory nodes along traditional wired connections between circuits to improve the efficiency of the machine's learning process. "Most data in images or videos are essentially noise," Lu said. "Instead of processing all of it or transmitting it fully and wasting precious bandwidth, adaptive neural networks can extract key features and reconstruct the images with a much smaller amount of data."

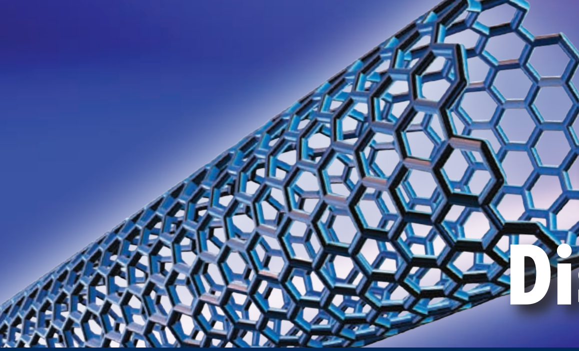
Communicating With Flexible Electronics

Compared to traditional printed circuit boards, flexible printed circuits offer unparalleled design flexibility in addition to increased performance in many areas. They are used in most any industry, including biomedical (devices that rest on the skin for health monitoring, as well as medical implants), energy (flexible solar cells), automotive systems, electronics (cell phones, displays, wearable electronics), and telecommunications.



In terms of advancing the field of flexible circuits, a key concern is to improve the method for receiving and transmitting collected data. "One of the most important elements in communications is modulating the signal," explains Prof. Zhong. "If you want to broadcast music on a radio station, or send information electronically, you have to modulate and encode information into a carrier wave, and that's done by modulators."

Prof. Zhaohui Zhong and his group have developed the first all-graphene flexible, transparent digital modulator for high-speed communications. It is the first time anyone has shown quaternary modulation with a graphene circuit, which doubles the speed of existing binary modulation schemes. It is also ambipolar, which enables a drastic reduction in circuit complexity compared to conventional silicon-based modulators. This technique can be applied to today's multimedia and communication devices for increased performance. His group is also pushing the circuitries to higher frequencies which will expand the range of applications that can benefit from graphene circuitry.

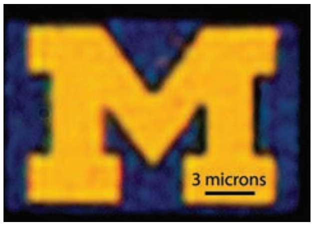


Nanotechnology for Sharper Displays and Disappearing Ink

A carbon nanotube is a cylindrical structure made from carbon sheets that are one atom thick. Quantum effects come into play because of their size, resulting in unusual electrical and mechanical properties.

Nanostructured Color for Sharp, Efficient, Displays

While investigating a way to build more efficient, smaller, and higher-definition display screens, Prof. Guo and his group discovered that nano-thin sheets of metal with precisely spaced gratings could be used to generate different colors. "Amazingly, we found that even a few slits can already produce well-defined color, which shows its potential for extremely high-resolution display and spectral imaging," Guo said. This includes projection displays as well as wearable, bendable, and extremely compact displays.



An optical microscopy image of a 12-by-9-micron U-M logo, where the color is produced by optical resonance rather than absorption.

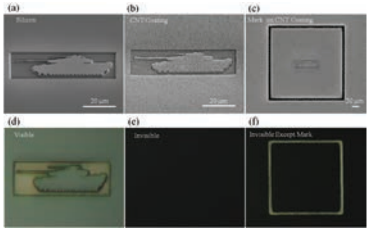
This new technique makes use of optical resonance rather than absorption as in traditional color pigments, and the reflected light can be recycled to improve the display efficiency. His team used this technique to make what they believe is the smallest color U-M logo. At about 12-by-9 microns, it's about 1/6 the width of a human hair. Such color filters can also be integrated into color imaging devices.

In related work, Prof. Guo has taken a lesson from the beautiful colors we see on peacock feathers. The feathers themselves are brown in pigment, but take on their iridescent color due to light interference from the fine structures on the surface of the feathers.

However, for display applications, the fact that the color changed with the viewing angle was problematic.

Prof. Jay Guo and his team discovered that nano-sized cavities etched in glass and covered with a thin metal can be used to generate colors that stay true up to an angle of ±80 degrees. "With this reflective color," said Guo, "you could view the display in direct sunlight. It's very similar to color print."

Surprising Disappearing Nano-ink



Prof. Guo would say the most exciting kind of discoveries are accidental. He and a postdoctoral researcher were investigating cloaking with optical metamaterials, and getting nowhere. Then, a material was dropped onto a dense carbon nanotube "forest" (when carbon nanotubes are closely aligned the individual tubes will stand straight up – creating an effect like a forest of trees) and couldn't be found. It seemed to have just disappeared.

Seeing what was possible, they created a coating made of carbon nanotubes that when "painted" onto a raised 3-D image, made it appear as a 2 dimensional black sheet. The key was to position the carbon nanotubes, which absorb light across a broad band of wavelengths, just right to absorb virtually all the light. When placed on a black background, the image disappears from sight.

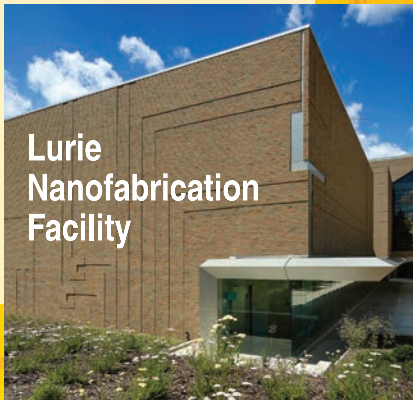
Potential applications include ultra-crisp display screens, solar heating, and even camouflage for stealth aircraft. A Belgium artist interested in the project sent Prof. Guo a work made of titanium to use as a test piece.

How the LNF and NNIN Can Help You With Your Research at the Nanoscale

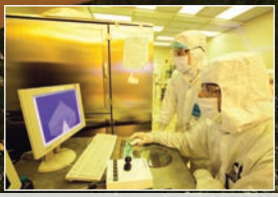
NNIN
Nanoscale Science, Engineering & Technology

The Lurie Nanofabrication Facility ensures Michigan's future as a major player in future micro and nanotechnology. The LNF was a founding member of the National Nanotechnology Infrastructure Network (NNIN), an NSF-funded program initiated in 2004 to make the promise of Nanotechnology accessible to all. The NNIN is an integrated network of premier user facilities across the nation offering 24/7 affordable access to production-level fabrication tools supported by specially trained experts. In addition to fabrication tools, the NNIN also provides expert-supported free computation resources that can help optimize processing and reduce fabrication iterations. With capabilities that would otherwise be cost-prohibitive for smaller organizations or research groups, the LNF and NNIN can enable a wide range of research projects.

For more information and/or to schedule a tour of the LNF, please contact Dr. Khaled Mnaymneh, LNF/NNIN Outreach Coordinator (kmnay@lnf.umich.edu; 734-545-4507).



Nanomanufacturing – Scaling Up



Research in nanotechnology caught fire in the early 1980's thanks in large part to the commercialization of Molecular Beam Epitaxy (MBE) systems and scanning tunneling microscopes. These devices allowed researchers to grow and view molecular and atomic scale structures for the first time.

Some areas of manufacturing, such as the modern computer chip with its nanoscale transistors, has kept pace reasonably well with nanotechnology. One reason for this is the extreme adaptability of silicon to manufacturing processes and different semiconductor materials. However, the semiconductor industry is not currently capable of manufacturing many other forms of technology based on nano-sized components.

Major governmental programs have been initiated to assist in new forms of nanomanufacturing, including the Presidential call for a $1B investment to create a National Network for Manufacturing Innovation (NNMI). Part of this investment will focus on micro and nanoscale manufacturing.

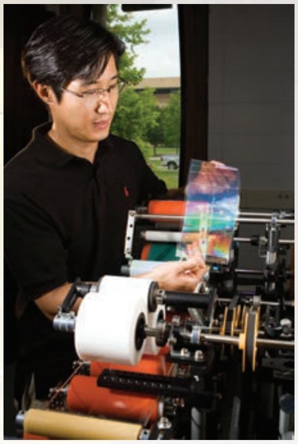
Here at Michigan, the Center for Wireless Integrated Micro-Sensing & Systems (WIMS^2) held a Nano and Micro Manufacturing Workshop to bring together interdisciplinary researchers and manufacturers of nanotechnology (see pg. 35 for more info). Just a few weeks later, NSF held the NSF Workshop on Future Research Needs in Advanced Manufacturing from Industrial Perspective. Both workshops involved leaders from industry and academia discussing how to bring more nanotechnology research to market.

Profs. Guo and Zhong, in collaboration with Prof. Steven Yalisove (MSE) and Prof. John Hart (MIT), have their own program in scalable nanomanufacturing. They are using ultrafast femtosecond lasers to build and scale up carbon-based nanostructures, such as carbon nanotubes and graphene.

Prof. Lu's company, Crossbar, Inc., will manufacture a new class of computer memory based on his work with nanoscale memristors.

Prof. Becky Peterson uses solution-based nanomanufacturing techniques to create nanoscale features via ink-jet printing. By selective surface energy patterning, she can scale down the gate length of printed thin film transistors for high-performance, flexible, large-area, and printable electronics.

During the past decade, Prof. Guo and his group have been perfecting a technique for roll-to-roll nanolithography. Nanoimprint lithography enables large area, low cost fabrication of nanoscale structures. Among the many applications for these structures are transparent electrodes for use in organic photovoltaic devices, liquid crystal displays (LCDs), touch panels, and organic light emitting diodes (OLEDs).



Prof. Guo's group built a prototype device for high-throughput and high-resolution nanoscale patterning. This technique allows for large area printing with a variety of substrates, and includes a method for producing metal mesh patterns as a transparent electrode. His method is being used by major companies in Japan and Korea for commercial applications, and once perfected, could be used to print components for displays and solar cells.

Window to the FUTURE

Research in nanotechnology is the key to future transformative advances in electronics, medicine, computing, and energy. The research described in this article points to applications that may be on the marketplace in a year, or perhaps 10–20 years. It's an exciting area filled with discovery as the research continues to reveal important and even startling results.

If this is a world you'd like to explore further, come visit our labs or contact us. We'll try to respond within a nanosecond.

Research Briefs

C-FAR to Develop Computer Technologies of Tomorrow

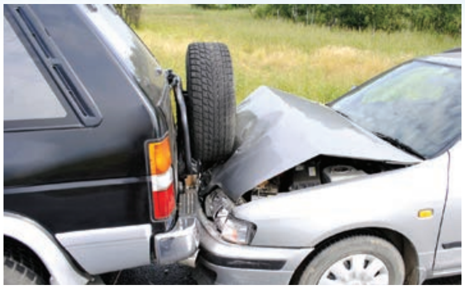
The Center for Future Architectures Research (C-FAR), headed by Prof. Todd Austin, has been established with $28M in funding from the Semiconductor Research Corporation, the world's leading industry/government technology research consortium, to help guide the field through the approaching sunset of Moore's law, which has fueled the semiconductor industry for the past 50 years.

The Center's mission is to harness the power and boost the reliability of the tiniest transistors that will emerge over the next decade. Transistors are the fundamental building blocks of modern electronics, and more than a billion of them compose each integrated circuit in today's cell phones and personal computers. C-FAR will support the design of the next generation of computers that will enable applications such as computer vision, speech recognition, enhanced graphics, and rapid big data analysis.

"It's a challenging time as we approach the end of Moore's law – not tomorrow, but soon," according to Prof. Austin. "The dimensions of transistors today are in the tens of atoms. We have perhaps another decade of squeezing silicon, and that will bring challenges along with opportunities. As nanoscale transistors shrink, they become less reliable. And in some cases, they offer more computational power than other parts of the system are capable of using."

C-FAR researchers will work to overcome these challenges on three fronts. They will design specialized chips tailored for different applications. They'll rethink how to build computers so they're capable of analyzing massive data sets more efficiently, which will be a key application in the next decade. And they'll explore how to integrate tomorrow's technologies into conventional silicon processing techniques to ease the transition for industry. These advanced technologies include three-dimensional stacked chips and phase-change memory, which uses heat to store information in the molecules of a glass-like material.

C-FAR opened in January 2013 and involves 14 other major research institutions. In addition to Austin, EECS co-investigators include Profs. Valeria Bertacco, Kevin Fu, and Scott Mahlke.

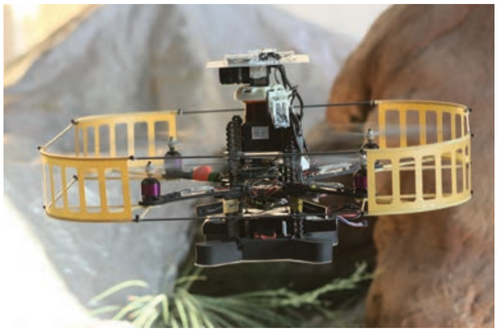


Building Control Software for Engineering Systems

Prof. Jessy Grizzle will lead a new NSF project, *Correct by Design Control Software Synthesis for Highly Dynamic Systems*, to develop sophisticated methods for building control software for engineered systems. The objective is to make it easier to design next-generation systems so that minimal adjustment will be required during subsequent development and implementation processes. This work will have broad applications to many existing systems where fast reactions are critical. Prof. Grizzle sees these software systems being incorporated into the steering and breaking mechanisms in automobiles, robots that are being asked to maneuver different types of environments, and prosthetic devices for human beings.

Providing Sharper Eyes for Flying Robots

As part of a major program based at Michigan (known as COM-BAT) to develop the microelectronics for small autonomous robots, researchers have found a power-efficient way to speed up the processing of images captured by the computer vision system. Traditional methods to extract key features in images require high performance and power-hungry processing, which is not available on a small lightweight flying vehicle. To solve this problem, a team of researchers including Profs. Dennis Sylvester, David Blaauw, and Zhaohui Zhang demonstrated a power-efficient speeded-up robust features (SURF) extraction accelerator targeted primarily for micro air vehicles. The accelerator was fabricated in 28 nm LP CMOS and consumes only 2.7 milliwatts of power.



This quad-rotor aircraft prototype was built to prove the technology in a real-world scenario. The aircraft was built at the University of Pennsylvania.

High-Frequency Trading Tactic Lowers Investor Profits

Research conducted by Prof. Michael Wellman and CSE graduate student Elaine Wah has shown that a lucrative high-frequency trading strategy that exploits today's fragmented equity markets reduces investor profits overall.

Latency arbitrage is a $21B per year tactic made possible by taking advantage of the time it takes for trade price information from various markets to reach a central repository that publishes a public quote, known as the National Best Bid and Offer. High-frequency traders use latency arbitrage tactics to look for price differences between the markets before the public ticker updates, and essentially compute their own versions of the National Best Bid and Offer, which can then be exploited to generate risk-free profit.

Wellman and Wah found that in a fragmented, continuous market modeled after the current system, latency arbitrage diminished profits collectively – not just for regular investors, but also for high-frequency traders, because such systems aggressively match orders across markets at every opportunity, even when it would be more efficient to wait for better matches.

"Discrete trading would be more efficient," Wellman said. "It leads to better trades happening and eliminates the latency arms race, which itself has large costs." Their paper on the subject entitled *Latency Arbitrage, Market Fragmentation, and Efficiency: A Two-Market Model* was presented at the *ACM Conference on Electronic Commerce* in Philadelphia.

GapSense Improves Wireless Network Traffic

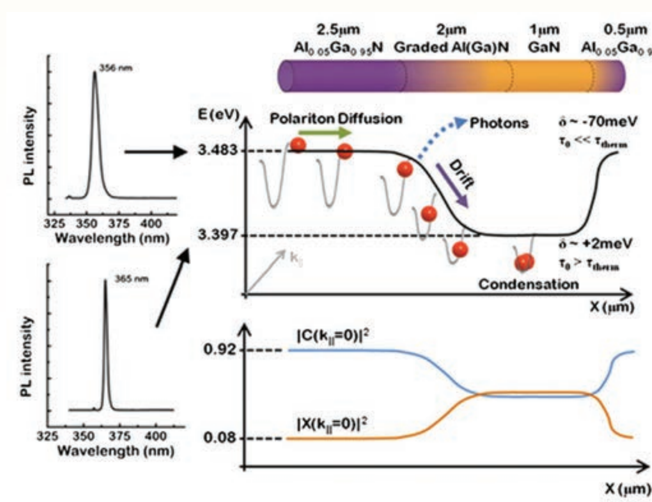
The explosive popularity of wireless devices – from WiFi laptops to Bluetooth headsets to ZigBee sensor nodes – is increasingly clogging the airwaves, resulting in dropped calls, wasted bandwidth, and botched connections. Researchers led by Kang Shin, Kevin and Nancy O'Connor Professor of Computer Science, have developed new software that works like a stoplight to control the traffic and dramatically reduce interference.

GapSense lets devices that can't normally talk to one another exchange simple stop and warning messages by use of a common preamble of energy pulses and gaps. The length of the gaps conveys the stop or warning message. Devices could send them at the start of a communication or in between information packets to let other gadgets in the vicinity know about their plans.

GapSense has been shown to reduce interference by more than 88 percent on some networks with diverse devices. The researchers presented their findings in the paper, *GapSense: Lightweight Coordination of Heterogeneous Wireless Devices*, at the *IEEE International Conference on Computer Communications.*

Scientific Milestone: A Room Temperature Bose-Einstein Condensate

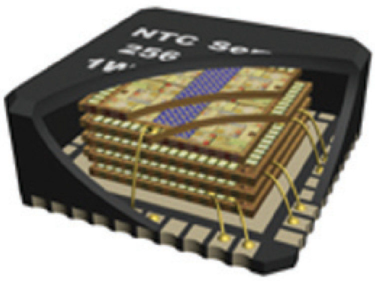
Prof. Pallab Bhattacharya and a team of researchers have created and directly observed what they believe to be a near-equilibrium room temperature Bose-Einstein condensate (BEC). A BEC is an unusual state of matter in which a group of boson particles can exist in a single quantum state, giving scientists the rare opportunity to directly observe novel quantum phenomena. Prof. Bhattacharya believes that because the polariton BEC is a coherent state of matter, it is possible that the light emitted can one day be controlled and used for sensitive instrumentation and measurements.



Schematic of the Al(Ga)N nanowire showing the variation of the exciton energy as a function of position.

Researchers Funded to Develop Massively Parallel and High Performance Architectures

EECS researchers have been awarded a contract for research and development of hardware and software techniques that directly support and make practical a new generation of energy efficient, high performance multi-layer processor systems for use in embedded computing systems. The grant is under DARPA's Power Efficiency Revolution for Embedded Computing Technology (PERFECT) program. Led by Trevor Mudge, Bredt Family Professor of Engineering and Director of the ARM Research Center at Michigan, the investigators include Profs. David Blaauw, Scott Mahlke, Dennis Sylvester, Zhengya Zhang, and Research Scientist Ronald Dreslinski.



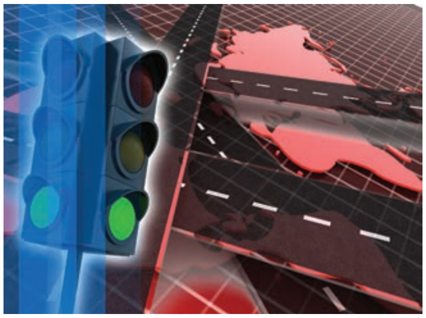
The team aims to improve the power efficiency of embedded computing devices from today's 1 giga floating point operation per second per watt (GFLOPS/w) to 75 GFLOPS/w by bringing together and augmenting their previous projects in this area, including a 128-core parallel 3-D near-threshold computing (NTC) system, known as Centip3De; a circuit technique that allows robust operation at very low voltages in processor pipelines by monitoring timing violations, known as Razor; the development of near-threshold circuit and memory technologies; open-source simulator development; and new parallel compiler systems. Potential outcomes from the work include a revolution in medical device technology, such as a handheld 3-D ultrasound system.

urMus

urMus – A Platform for Creativity on Mobile Devices

Prof. Georg Essl has released new beta versions of urMus, his meta-environment for live and interactive application design and programming on mobile smartphones and tablets. urMus allows for design-by-modification, enabling rapid prototype mobile interactions for user studies. By emphasizing liveness and real-time interactions, the platform seeks to enable the use of mobile smartphones and tablets in live performances and interactive art. urMus has been in development and used in the classroom for four years, including in Prof. Essl's course on mobile musical instrument design. urMus is open-source and supports both the iOS and Android platforms. A release of the platform on Google Play is planned for this fall.

Improving the Interconnected World of Cyber-physical Systems



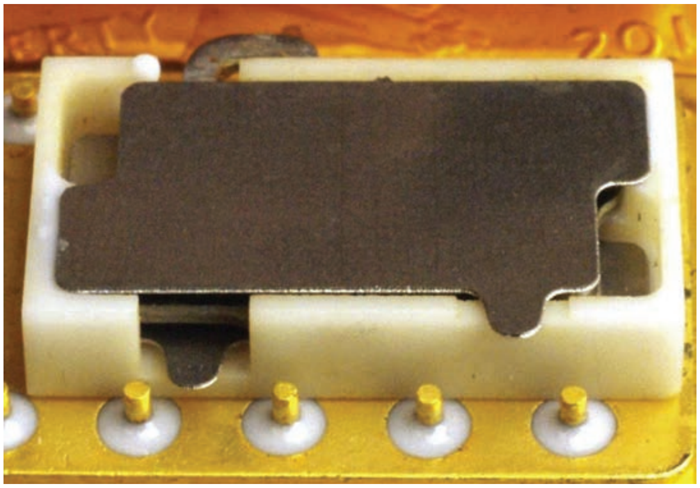
Profs. Demos Teneketzis and Ian Hiskens are members of a new five-year $9M NSF project, *Foundations of Resilient Cyber-Physical Systems (FORCES)*, led by UC-Berkeley, which will test different theories to determine the most efficient approach to designing and operating cyber-physical systems. A cyber-physical system employs sensors, processors, and actuators to enable computers to perform dynamically in the physical world. They enable real-time devices such as cruise control, auto-pilot in aircraft, and robotic activities, and are used in medical devices, energy-efficient devices, advanced manufacturing and agriculture. Among other applications, our faculty will explore applications in transportation through the evaluation of economic incentives that encourage good driving behavior. They will also explore applications in energy through electric power generation and distribution in response to real-time consumer demand. "Even a marginal improvement in the design of these man-made technological systems could translate into a tremendous boon for the economy," said Prof. Teneketzis. "We're talking about billions of dollars."

MARLO Takes Over So MABEL Can Tour With the Chicago Field Museum

The bipedal robot MABEL is headed to the Chicago Field Museum, where she will be part of the exhibit, *The Machine Inside: Biomechanics*. The exhibit will debut March 12, 2014 and remain at the museum until January 4, 2015. For the next 5 years, she will travel around North America to museums and science centers. Prof. Jessy Grizzle and his team are now teaching MARLO, MABEL's successor, to take her first steps. MARLO will one day walk on her own, whereas MABEL was always attached to a horizontal boom (she didn't have hip sockets to stabilize her left and right balance).

Miniaturized Vacuum Pumps for Electronics and Sensors

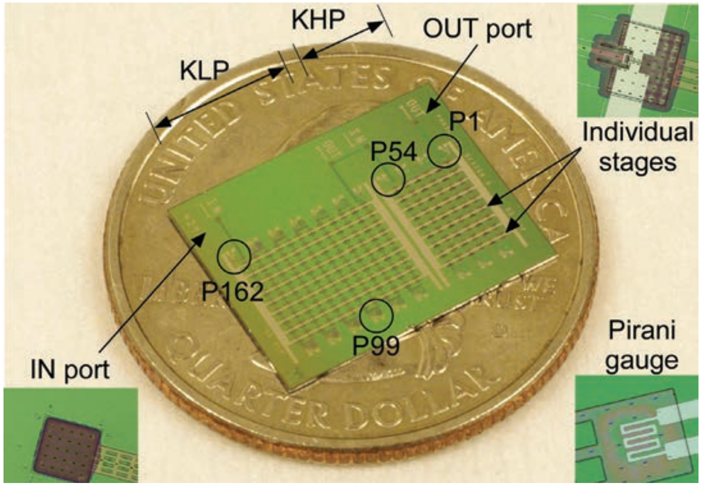
ECE researchers have built three different types of record-breaking micro scale vacuum pumps that could greatly extend the capabilities of electronics and sensing devices that use these devices, such as gas analyzers for homeland security, healthcare, search and rescue, and other applications.



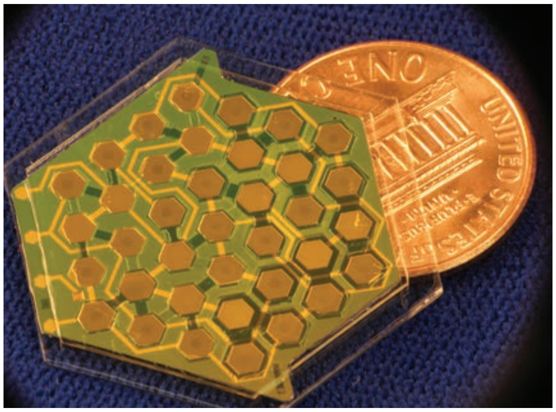
The Penning cell array is housed in a 2.5 cm^3 package.

Sputter-ion pumps (SIPs) are vacuum pumps that operate by ionizing gases within the pump. They are particularly suited for use in microsystems that require long-term or precise control over package pressure, such as portable mass spectrometry systems, resonators, and frequency references. Prof. Yogesh Gianchandani, Dr. Scott Green, and Ravish Malhotra designed a miniaturized, chip-scale Penning cell array for a SIP that is capable of operating at a pressure at least as low as 1.5 μTorr, which is at least 6 orders of magnitude lower than previously reported chip-scale SIPs. The chip-scale Penning cell array was specially designed to overcome some of the inefficiencies caused during the ionizing process at very low pressure levels.

Knudsen pumps operate by thermal transpiration to control gas flow. Like SIP's, they have no moving parts which allows the vacuum pumps to be highly reliable as well as miniaturized. They are ideally suited for chemical detection and breath analyzers, among other applications. Prof. Gianchandani, Seungdo An and Dr. Naveen Gupta developed a Si-micromachined 162-stage two-part Knudsen pump for on-chip vacuum. Experimental evaluation shows that, using an input power of ≈0.39 W, the evacuated chamber is reduced from 760 to ≈0.9 Torr, resulting in a compression ratio of ≈844. Measuring 12x15 mm^2, the pump performed reliably for 37 days, which is a record for this type of device.



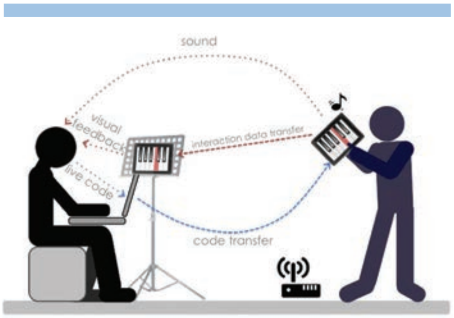
Photograph of an as-fabricated chip.



Microfabricated 12-stage micropump.

The third type of miniaturized vacuum pump recently developed at Michigan is a 24-stage peristaltic microscale rough pump, developed by Prof. Khalil Najafi, Dr. Ali Besharatian, Dr. Karthik Kumar, Prof. Rebecca. L. Peterson, and Prof. Luis P. Bernal. Called the Honeycomb Michigan Pump, it can be mass produced at low cost by the use of high throughput conventional microfabrication techniques, enabling integration of the device with variety of consumer-based microelectronic devices; a feature not available in most of previously reported similar works.

This vacuum pump uses tiny micromachined hexagonal membranes in series configuration. Each element of the array is either a pump or a valve. These ultra-thin electrostatically vibrating hexagonal membranes along with their tiny vacuum chambers form a scalable honeycomb configuration to pressurize or depressurize gases in a few seconds using only few milliwatts of electric power. It is the fastest gas micropump reported to date. The scalable, resonant design produced a large flow rate of 0.36 cc/minute and evacuated a sample chamber to about 97 kPa from the atmospheric pressure of 101.3 kPa. The theoretical limit on the performance of such a pump is to reduce the pressure to around 1.5 kPa.



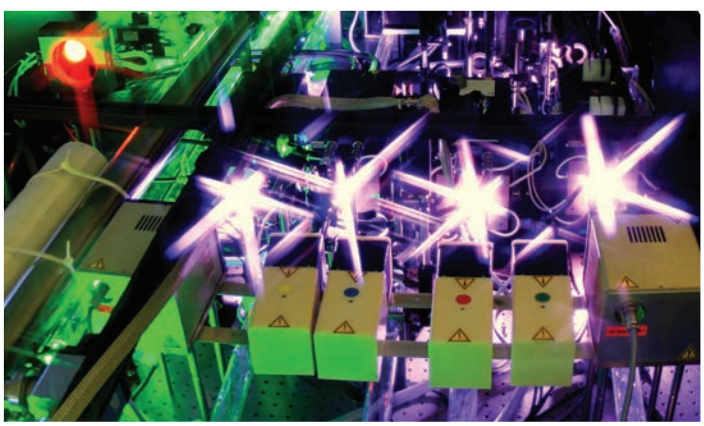
Mobile Collaborative Live Coding

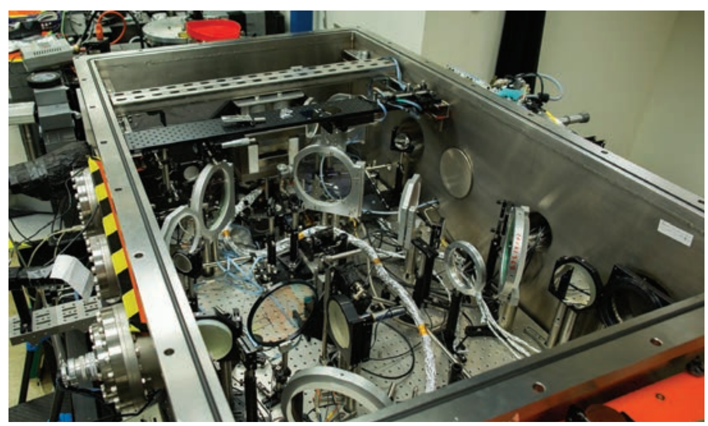
Prof. Gerg Essl and CSE PhD candidate Sang Won Lee are developing support for remote assistive coding on mobile devices. Under this project, a remote stakeholder can have an application built interactively and in collaboration with one or more programmers. Changes to the mobile application occur while the application is running, leading to an immediate form of successive improvement. The work promises to be useful in special-purpose problem solving and application building. It has already been demonstrated as part of a live music performance in concert, in which a musical instrument was programmed on the fly while a musician played it.

Tools Leverage Tweets to Spot Economic Trends

Prof. Michael Cafarella and CSE graduate student Dolan Antenucci have been investigating barriers to the use of social data to reproduce and improve upon the generation of economic data. Their recent work has focused on two areas: feature selection and real-time measures of economic activity. In a study with U-M Economics Profs. Margaret Levenstein and Matthew Shapiro, they proposed a system for choosing a set of relevant social media objects, a task that is otherwise difficult, time-consuming, and can imply a statistical background that some users may not have. The system takes a single user input string (e.g., unemployment) and yields a number of relevant signals the user can use to build a nowcasting model. The authors evaluate their system using a corpus of almost 6 billion tweets, and show that features chosen by the system on average are about 7% better than those from a human and significantly reduce the burden on the user.

In a second study, the same investigators analyze data from individual Twitter postings to estimate labor market flows. They found that the prevalence of tweets with phrases like “got fired” is correlated with official measures of new claims for unemployment insurance and developed real-time measures of economic activity based on these. The Twitter index, because of its real-time nature, carries information about initial claims for unemployment insurance not reflected in the expectations of traditional market analysis prior to the release of the official data.





Using HERCULES to Probe the Interior of Dense Plasmas

For the first time, researchers probed the interior of highly dense plasmas using the world’s most intense tabletop laser called HERCULES, located in the Center for Ultrafast Optical Science (CUOS). William Schumaker, Nuclear Engineering and Radiological Sciences (NERS) graduate student, and an interdisciplinary team of researchers were able to image extremely strong magnetic fields (10,000 times that of the strongest bar magnet) in a surface plasma of only 10s of microns in size that was expanding at close to the speed of light. Scientists are now able to study very dense plasmas, which has important implications for nuclear fusion energy and astrophysical research. ECE faculty involved in the research were Dr. Anatoly Maksimchuk, Dr. Vladimir Chyvkov, Dr. Victor Yanovsky (Director of the HERCULES laser), and Prof. Karl Krushelnik (Director of CUOS and Professor of NERS and ECE).

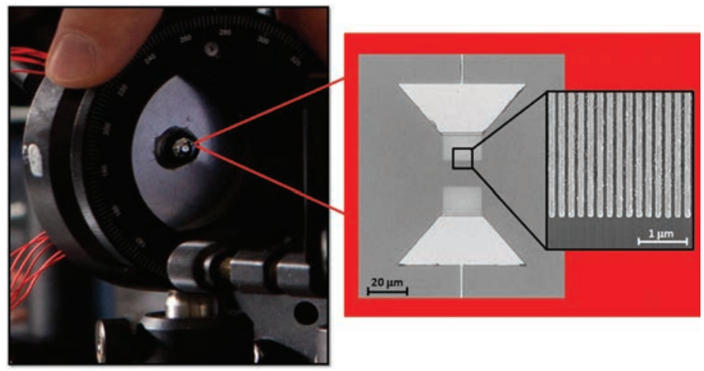
Jerome Zadnik (EOIR Technologies and the National Geospatial Intelligence Agency), Prof. Mohammed Islam, and Bruce Smotherman (SAIC and Air Force Research Labs) conduct experiments with the laser at Wright Patterson Air Force Base.

A New Laser to Identify Targets and What They're Made Of

A new super-continuum laser is able to identify the chemical composition of objects, even in the dark. This broadband infrared laser, developed by Prof. Mohammed Islam, is more powerful than similar current technology. The researchers were able to build the laser using their patented approach that uses off-the-shelf telecom fiber optic technology and takes advantage of the natural physics of the fiber to generate the light. They tested a 5-watt prototype. More recently, they built a 25.7 watt version and are now working on a 50-watt prototype, which is scheduled to be field tested later this year.

Better Than X-rays: A More Powerful Terahertz Imaging System

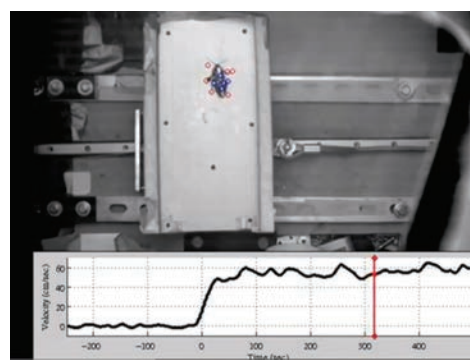
Low-energy terahertz radiation could potentially enable doctors to see deep into tissues without the damaging effects of X-rays, or allow security guards to identify chemicals in a package without opening it. But it's been difficult for engineers to make powerful enough systems to accomplish these promising applications. Now Prof. Mona Jarrahi and her team developed a laser-powered terahertz source and detector system that transmits with 50 times more power and receives with 30 times more sensitivity than existing technologies. This offers 1,500 times more powerful systems to see deeper into tissue or sense small quantities of illegal substances and explosives from a distance.



Microscope image of the plasmonic terahertz source/detector prototype and scanning electron microscope image of the plasmonic electrodes.

Security Risks Found in Sensors for Heart Devices

Prof. Kevin Fu and an international team of researchers have demonstrated security risks of implanted cardiac defibrillators and pacemakers. In controlled laboratory conditions, the researchers were able to forge an erratic heartbeat using radio frequency electromagnetic waves. Theoretically, a false signal like the one they created could inhibit needed pacing or induce unnecessary defibrillation shocks. The study's findings throw light upon new security risks in relatively common analog sensors – sensors that rely on inputs from the human body or the environment to cue particular actions. The team has proposed solutions to help the sensors ensure that the signals they're receiving are authentic, which includes software that could ping the cardiac tissue to determine whether the previous pulse came from the heart or from interference. The findings were presented at the *IEEE Symposium on Security and Privacy*.



Better Robotic Design – Lessons From the Cockroach

In research that has important implications for robotic design, it was shown that running cockroaches start to recover from being shoved sideways before their dawdling nervous system kicks in to tell their legs what to do. "The response time we observed is more than three times longer than you'd expect," said Prof. Shai Revzen, who published the results with colleagues at UC-Berkeley. In experiments, the roaches were able to maintain their footing mechanically – using their momentum and the spring-like architecture of their legs, rather than neurologically, relying on impulses sent from their central nervous system to their muscles. These new insights on how biological systems stabilize could one day help engineers design steadier robots and improve doctors' understanding of human gait abnormalities.

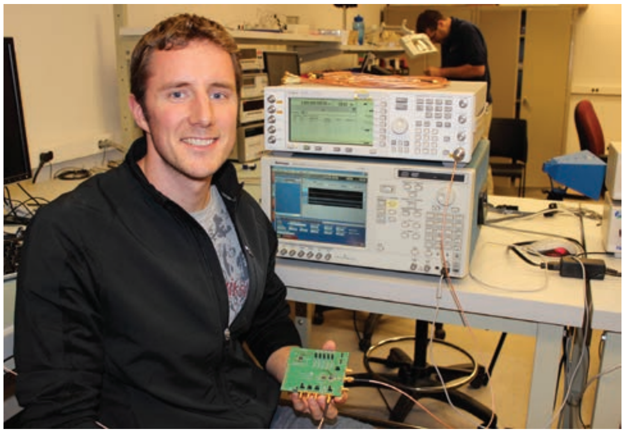
Nano-origami Project Combines Art and Engineering

Industry is highly proficient at patterning flat surfaces down to the nanometer scale, but integrating nanostructures into larger and 3-dimensional materials and devices has proved trickier to master. Prof. P.C. Ku is participating in a new NSF research program that will investigate whether the ancient art of origami could bring nanotechnology into the third dimension. With an origami-like approach, manufacturers could potentially use existing machinery to make high-tech "paper" that can then be folded into the desired device. Prof. Ku is interested in applying this approach to sheets of solar cells, such that the solar cells will be oriented in the direction of the sun no matter how the solar cells are placed.

Weapons-detecting Radar

In the aftermath of the shooting at Newtown, CT, Prof. Kamal Sarabandi realized that the remote sensing technology he had been working on could be applied to detecting these kinds of threats in the future. Using polarimetric radar to search for weapons being carried on an individual, Prof. Sarabandi stated, "if we see enough signal with a polarization different from what was sent, we know that person is carrying something." They can detect abnormalities 100 ft. away, hopefully in time to take action when necessary. A small early-state system is currently being developed for a robot.

Prof. Kamal Sarabandi approaches a mannequin he uses to test his weapons-detecting radar system in an anechoic chamber.



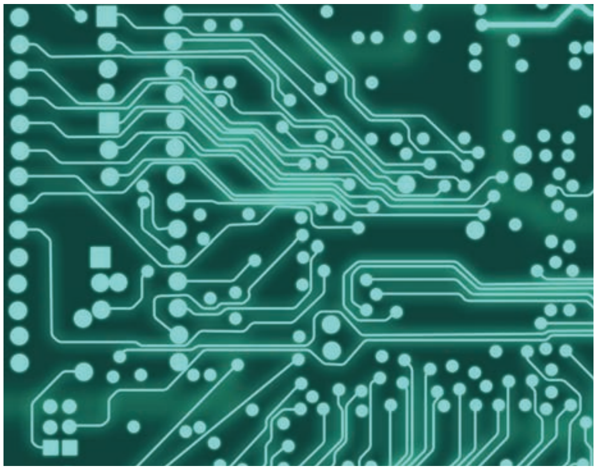
Graduate student Nathan Roberts is testing the receiver on the test board. The receiver, which measures 160 μm by 190 μm, was fabricated on a 1 mm^2 chip using a 130 μm CMOS process. Prof. Wentzloff is in the background.

Patient Monitoring Through Wireless Body Area Networks

To facilitate remote patient monitoring through wireless body area networks (WBAN), Prof. David Wentzloff and his graduate student Nathan Roberts designed an ultra-low power receiver that consumes about 500x less power than other state-of-the-art devices used for short-range wireless communications. This reduction in power is necessary to accommodate body-worn sensor nodes which are very small yet need to operate for long periods of time. These sensor nodes are able to detect various medical conditions and transmit critical information to a central location.

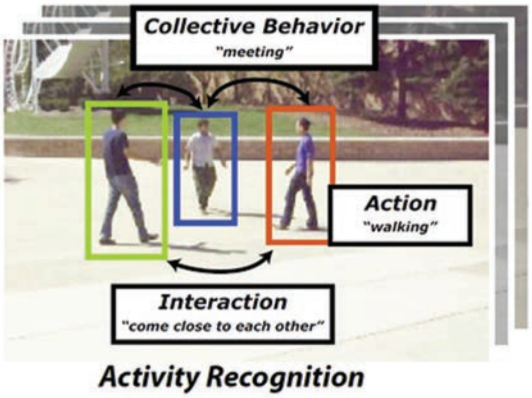
SimPL: An Algorithm for Placing VLSI Circuits

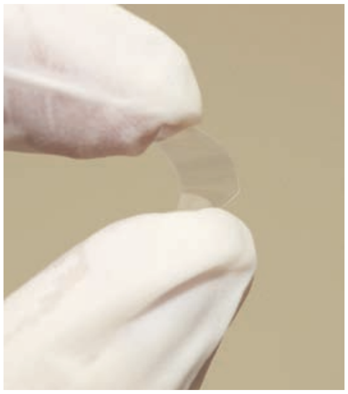
Prof. Igor Markov and his former students Myung-Chul Kim (PhD EE) and Dong-Jin Lee (PhD EE) have published details regarding SimPL, their algorithm for large-scale VLSI placement that outperforms prior art both in runtime and solution quality on standard benchmarks, in the June 2012 *Communications of the ACM*. VLSI placement optimizes locations of circuit components so as to reduce interconnect. Due to its simplicity and superior performance, the SimPL algorithm has been adopted in the industry and was extended by several university groups to multi-objective optimization.



Computer-aided Tracking of Human Activity

The ability to track targets is valuable in many fields, including automobile safety, robotic vision, observing animal herds in the wild, and picking out suspicious activity in a crowd. Prof. Silvio Savarese aims to protect pedestrians with his research by creating a device that will keep an eye on pedestrians and sound an alarm or automatically brake should they take an unexpected step into the street. His research team has found a way to improve a computer's human-tracking accuracy by more than 30 percent by looking not only at where the targets are going, but also at what they're doing. "By creating software that understands which activity a person or a group of people is performing, we can obtain much more robust and stable tracking results," says Prof. Savarese. "This is a new way of solving the tracking problem and can potentially revolutionize the way researchers look at the tracking problem in general."





Combining Flexible, Transparent Electronics With High Speed Communications

The market is burgeoning in the area of flexible and wearable electronics. They are incorporated into a wide array of electronic devices such as displays, solar cells, automotive systems, and cell phones, and have enormous potential in wearable health monitoring devices and medical implants. However, communicating information efficiently from these electronic devices while retaining their flexible and sometimes transparent qualities has been difficult. Thanks to the unique qualities of graphene (it is flexible, transparent, and ambipolar), Prof. Zhaohui Zhong and his team built the first flexible, transparent digital modulator for high speed communications, made solely out of this material. The modulators currently work in the KHz range, though they are working to push it to GHz.

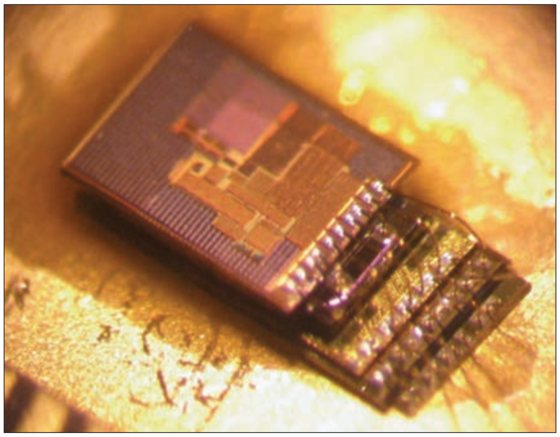
What's New in mm³-scale Computing

Since the first demonstration of a complete millimeter-scale computing system here at Michigan in 2011, our faculty are continuing to advance this technology. These miniature microsystems can be used for a variety of applications including implantable medical devices, security and surveillance systems, structural health monitoring, and environmental sensing. The key challenge, aside from the size, is the limited battery volume; all of the individual components together must consume very little power.

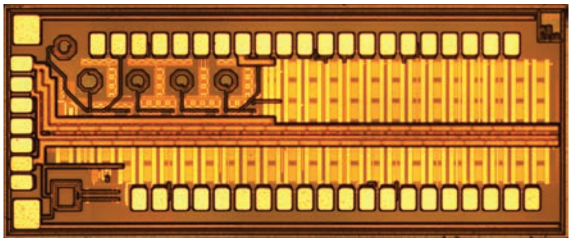
A team of investigators that includes Profs. Dennis Sylvester, David Blaauw, David Wentzloff, Prabal Dutta, and Asst. Research Scientist Yoonmyung Lee recently introduced a prototype micro-sensor system with a heterogeneous multi-layer structure. The system includes two ARM microprocessors, 19 kB memory, a radio transmitter, a power management unit with multi-modal energy harvesting, a thin film lithium battery, a low-power timer, an optical wake-up receiver, a temperature sensor and an image sensor, all in 1.0 mm³ volume.

Having the individual sensor nodes able to communicate with each other is a key to many of the applications we want these sensors to perform. Earlier this year, Prof. Wentzloff succeeded in fabricating an ultra-low power 9.8 GHz crystal-less UWB transceiver, integrated in 0.18 μm BiCMOS, that runs on low enough power to be compatible with millimeter-scale wireless sensor nodes.

The researchers are on track to deliver on their promise to distribute mm³ devices to the research community at large with the goal of spurring further advancements in the field.



1 mm³ fabricated device.



Die photo of a low-power 9.8 GHz UWB transceiver with modem.

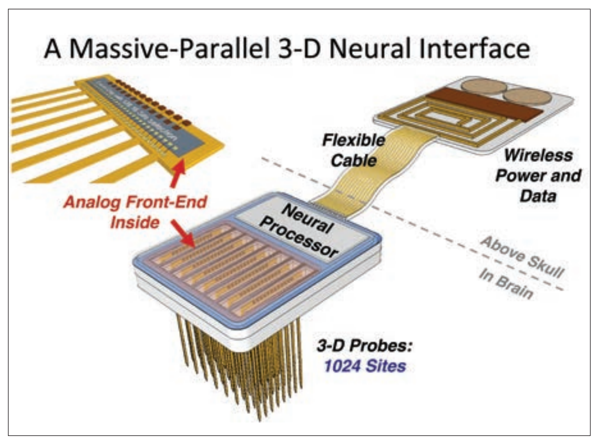
Iranian Internet Censorship Profiled for First Time

Prof. J. Alex Halderman and two anonymous coauthors have published the first peer-reviewed technical study of Iran's national censorship infrastructure, revealing much about the extent and nature of one of the largest and most sophisticated Internet censorship regimes in the world. To conduct their study, the researchers set up a testbed in Iran from which to make network measurements. They analyzed traffic to blocked and non-blocked hosts at the packet level, and used traceroutes to study hops inside the country's infrastructure. The researchers learned that specific sites are heavily blocked through a centralized system, and that additional contextual filtering is employed. A finding of particular interest for censorship resistance was the centralized nature of Iran's censorship system, causing the researchers to speculate that new censorship resistance systems could explore techniques for overwhelming the central monitoring hardware with spoofed traffic, or for tunneling data past it and then further distributing it in a peer-to-peer manner within the country.

Typical screen displayed in place of banned site during Iranian Internet access.

Researchers Funded to Secure Health Networks From Computer Viruses

Prof. Kevin Fu and Research Prof. Michael Bailey will establish methods to scientifically study the extent of malware in hospital networks under the new five-year Trustworthy Health and Wellness project, centered at Dartmouth, that has received $10 million from the National Science Foundation. "Malicious software, or malware, can interrupt the function of medical devices, affecting the quality of patient care. By increasing the quality of the science, we seek to create more meaningful discussions about risks and benefits of adapting hospital networks to the threat of malware," said Prof. Fu. The team will work to establish better authentication and privacy tools; trustworthy control of medical devices; and effective methods to detect malware, compute trust metrics, and audit medical information systems and networks. In the long term, this project will help create health systems that patients can trust to protect their privacy, and that health professionals can rely on to ensure data security.

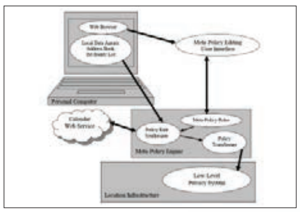


A Better Picture of the Brain With Analog Interface Circuits

The ability to record massive parallel neural activities has been a crucial tool for many complex neuroscientific studies. Improvement in this area is reliant on an increase in the number of simultaneously recorded channels, which in turn requires a similar increase in the number of simultaneously accessible channels, an activity accomplished in part by recording integrated circuits. To meet this need, Prof. Euisik Yoon and his team have built a prototype analog front-end designed in 0.25 μm CMOS process for hybrid integration into neural recording microsystems. The system runs on extremely low power (4 μW), which, along with other modifications, results in a front-end module that shows a reduction in noise-energy-area product that is 25 times that of reported state-of-the-art analog front-end approaches.

EECS Faculty are MCubing to Find Answers – Fast

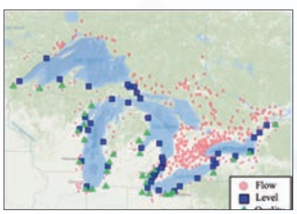
The University of Michigan MCubed program was established to encourage interdisiplinary research and to minimize "the time between idea conception and successful research results by providing immediate startup funds for novel, high-risk and transformative research projects." Thanks to the MCubed program, EECS faculty are teaming up with colleagues across the University to pursue new initiatives deemed to have major societal impact.



Infrastructure for Context-Aware Computing

Mark Ackerman (PI) and Atul Prakash with School of Information

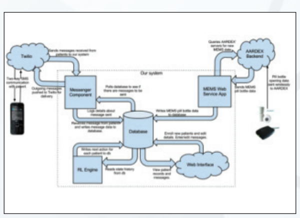
This project will focus on creating an enabling infrastructure to facilitate research into context-aware systems and applications. Base level software components will be built for collecting and managing sensor flows, recognizing user behaviors and contextual states, and delivering contextual events to end-user applications.



A Mathematical, Scientific and Measurement Framework for the Assessment of Water Balance and Water Quality

Laura Balzano with CEE and Graham Sustainability Institute

This project will develop a comprehensive framework to enable the long-term, measurement and analysis of multiple water quality and water quantity stressors across massive regions.



Adaptive Health Communications Over Mobile Devices

Satinder Singh Baveja (PI) with Pharmacy and Internal Medicine

This team plans leverage mobile technology and machine learning to develop tailored/personalized health communication that should be more effective at improving health outcomes.

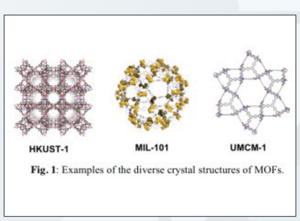


Fig. 1: Examples of the diverse crystal structures of MOFs.

Data-Mining for Optimal Metal-Organic Frameworks

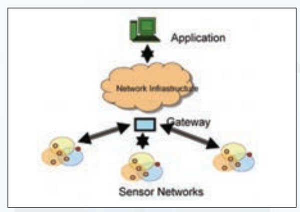
Michael Cafarella with Mechanical Engineering and Natural Sciences

This team proposes to use computation and experimentation to identify new metal-organic frameworks (MOFs) for applications ranging from CO_2 capture to the storage of chemical fuels.

Enabling Patient-Centered Care With Advanced Mobile Monitoring

Robert Dick with Nursing and Pharmacy

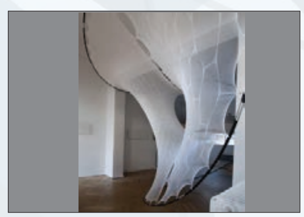
Patients, families, and clinicians must work together to maintain optimal health status levels, intervening at the earliest possible moment when warranted. This team is developing a novel system for outpatient monitoring and early intervention.



National Infrastructure for Sensor Networking

Prabal Dutta and Mingyan Liu with School of Information

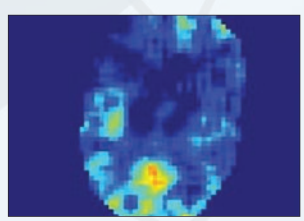
Sensor networks are increasingly critical to research in many disciplines. This project will explore the feasibility of building a national infrastructure to support sensor networking.



Mechanical Properties and Computational Methods for Composites Formed of Pre-stressed Knitted Textiles

Georg Essl with Architecture and Urban Planning and Aerospace Engineering

Proposed is the utilization of pre-stressed knitted textiles for reinforcements in structural composites, as tailored materials for tissue engineering scaffolds, examining manufacturing methods, testing their mechanical properties, and developing computational methods for simulating their performance.



Imaging Fleeting Thoughts

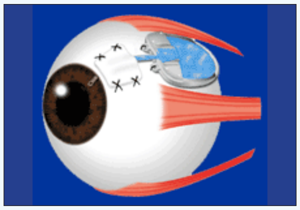
Jeffrey Fessler with Biomedical Eng. and Math

This project will investigate mapping of temporal relationships between brain regions using a new class of ultrafast functional brain MRI using imaging methods based on sparse random sampling with physiologically relevant models to represent brain signals.

Low Power Electronics for Brain Machine Interface Applications

Michael Flynn with Biomedical Engineering and Neurosurgery

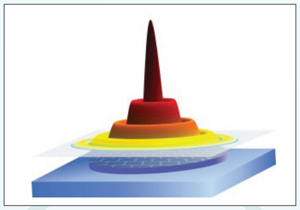
Brain machine interfaces for the treatment of paralysis will require implantable devices that can record hundreds of neural channels simultaneously. The team will attempt to dramatically lower the power consumption of the implant without suffering any measurable drop in signal quality.



A Novel Glaucoma Drainage Device

Yogesh Gianchandani with Ophthalmology and Visual Sciences

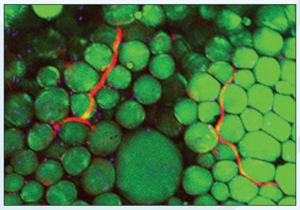
Glaucoma is a sight-threatening condition which affects over 2 million Americans. This collaborative effort hopes to design a novel implant that can effectively lower the eye pressure and prevent worsening of glaucoma.



Reconfigurable Graphene Beams for Microscopy and Micromanipulation

Anthony Grbic (PI) with Physics and Mechanical Eng.

Graphene supports strongly confined surface plasmons at infrared frequencies that can be tuned using a gate voltage. In this work, these surface plasmons will be used to generate reconfigurable, TM-polarized Bessel beams for microscopy applications and micromanipulation.



High-resolution Imaging of Fat Tissue Metabolism

L. Jay Guo with Internal Medicine: Endocrinology, Diabetes and Metabolism and Radiology

This research aims to better understand glucose metabolism by combining cell biology with nanoscale bioengineering and photoacoustic microscopic techniques.

Big Data in Astronomy: U-M Astroinformatics Research Group

Alfred Hero with Astronomy and Physics

This team will attempt to tackle questions about the Universe that can best be answered by combining observations with advances in imaging analysis, non-parametric statistics, inference through machine learning, and high dimensional hypothesis testing and regression statistics.

Electronic Lab Notebook for Physical, Chemical & Engineering Sciences

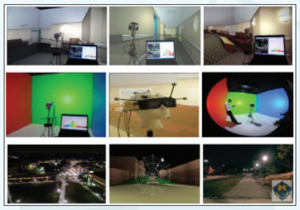
H.V. Jagadish with Materials Science & Engineering and School of Information

This project will develop an automated information management system for optimizing the workflow in research that focuses on materials synthesis, characterization, and modeling. Central to this workflow is electronic lab notebook software that can collect, integrate, and process information for searchable access, reuse, and distribution.

Digital Humanities Approaches to Popular Periodicals: Quantifying Reading Trends With Time Series Analysis

Sugih Jamin with German Studies and Natural Resources and Environment

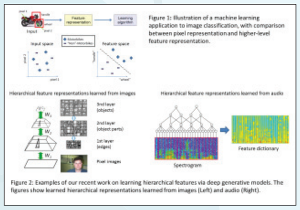
This project uses distant reading and digital humanities techniques to study mainstream German periodicals between 1850 and 1918. Because the bulk of material cannot all be close read, computer-based techniques will index, organize, and present information.



Virtual Reality as a Surrogate Sensory Environment for Evaluation of Human Luminous Environment

P.C. Ku with Architecture and Opthalmology and Visual Sciences

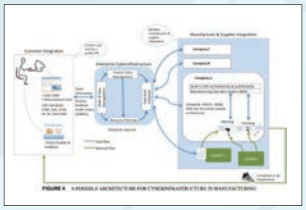
The team will design and fabricate different types of LED-based light sources exhibiting different lighting characteristics and study the effects of these LED light sources within specially designed luminous environments.



Machine Learning for Computational Healthcare

Honglak Lee (PI) and Elliot Soloway with Internal Medicine

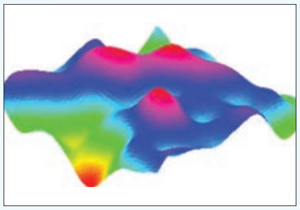
The team will use machine learning to identify important high-level abstractions (e.g., computational biomarkers) from data and improve the performance of computer-aided diagnosis and risk prediction.



Supporting Cyber-enabled Advanced Manufacturing with High-speed Networks

Z. Morley Mao (PI) with Mechanical Engineering and Statistics

The goal of this project is to develop the scientific methodology and analytical and software tools for the design, analysis and verification of virtual fusion for cyber-physical manufacturing systems. The broader impacts of this project include a new way for operators to interact with cyber-physical manufacturing systems.



A Fast Surface Integral Equation Solver for the Radiative Transfer Equation

Eric Michielssen (PI), Kamal Sarabandi, and John Schotland (Math and ECE)

This project will develop a surface integral equation (SIE) formalism for solving radiative transfer equations (RTEs) in piecewise homogeneous media. RTEs find applications in subjects including astrophysics, remote sensing, and optical imaging in biological tissue.

Efficient Electromagnetic Energy Harvesting for Wireless Sensors

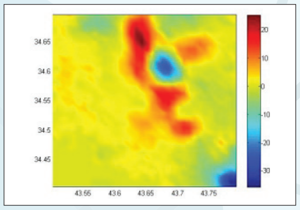
Amir Mortazawi (PI) with Civil and Env. Eng. and U-M Transportation Research Institute

This project focuses on the development of a new approach for designing efficient and wide-band energy harvesters capable of capturing stray electromagnetic energy from the environment. The proposed application is for use in long term autonomous low power wireless sensor nodes, especially to determine the health of civilian infrastructures like bridges and roads.

Using Mobile Technology to Manage Bipolar Disorder

Emily Mower Provost with School of Information

This project aims to leverage recent advances in signal processing and machine learning to use user-centered design process to develop a mobile phone application that leverages passive mood tracking to support self-management in bipolar disorder.



Using Satellite Data to Study How Variation in Energy Access Can Lead to Economic, Political Instability

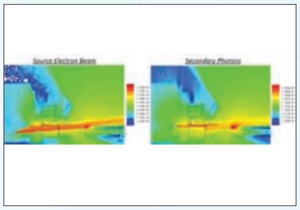
Rajesh Rao Nadakuditi with Political Science

The team will study how variations in energy access at the local level can lead to economic and political instability. The study region spans North Africa, the Middle East, South Asia, and Central Asia.

Building Translation Networks at Michigan

Dragomir Radev with Humanities

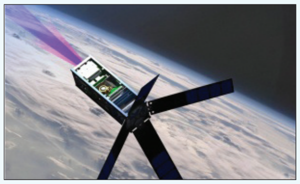
This project will develop a range of innovative applications that could make the interdisciplinary inquiries taking place through Translation at Michigan more engaging and fun.



Neutron Detection for Cancer Therapy

Jamie Phillips with Nuclear Eng. and Rad. Sciences and Physics

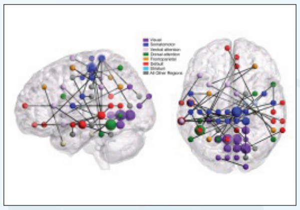
Recent advances in nuclear detection capabilities, including new detection materials and readout electronics, promise to have an impact in the development of new cancer therapy treatments. This project relies on neutron and photon detection techniques to develop new instruments and algorithms that will be applied in cancer treatment facilities.



COOL-Plasma: Efficient Cold-plasma Generation for Applications in Spacecraft Propulsion and Wound Treatment

Juan Manuel Rivas Davila (PI) with Aerospace Eng. and Epidemiology

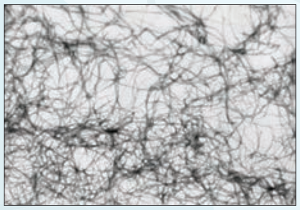
This team plans to develop small and efficient cold plasma source devices for use in spacecraft propulsion systems and topical wound healing in a medical setting.



Pattern Classification for Discovery of Biomarkers of Psychiatric Disease

Clay Scott with Psychiatry

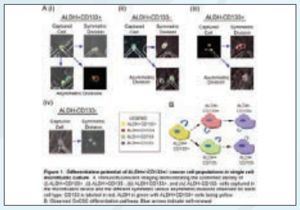
To better diagnose diseases such as ADHD, autism, and schizophrenia, the team will use advanced pattern classification methods derived from statistics and computer science to discover hidden patterns in diseased brains, patterns too subtle and distributed to be detected by human observers.



Biophysical Manipulation of Functional Amyloids

Duncan Steel with Molecular, Cellular and Dev. Biology

This collaboration will foster an understanding of how proteins adopt very ordered aggregates called amyloids. Amyloid formation has a long-standing link to human neurodegenerative diseases like Alzheimer's and Parkinson's.



ALDH Inhibitors as Cancer Differentiation Therapy

Euisik Yoon with Medicine and Medicinal Chemistry

The team has identified novel ALDH inhibitors that deplete ovarian cancer stem cells, and will attempt to determine the mechanism by which this occurs, and the impact of these inhibitors on stem cell survival.

Wustrow, Halderman, and Durumeric.

Download ZMap and Scan the Entire Internet in 45 Minutes

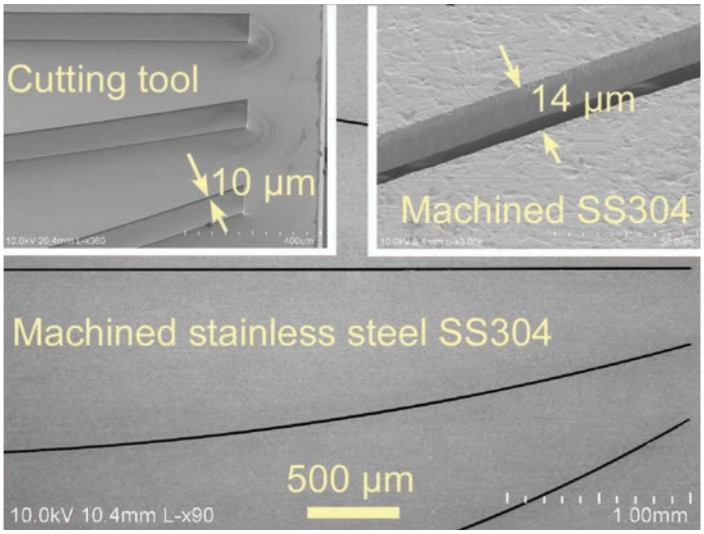
Prof. J. Alex Halderman and CSE PhD candidates Zakir Durumeric and Eric Wustrow have released ZMap, a new open-source tool that can perform a scan of the entire public IPv4 address space on the Internet in less than 45 minutes. For researchers probing the entire public address space, existing tools have required painstaking and time-consuming configuration, as well as either months of data collection or the use of large clusters of computers. ZMap changes that by running on a single computer and producing results over 1,000 times faster, causing the researchers to hope that ZMap will spark a new era of network-based inquiry. Potential applications for ZMap include visibility into distributed systems, tracking of protocol adoption, the ability to enumerate hosts that suffer from a specific vulnerability, discovering unadvertised services, monitoring service availability, and new forms of privacy, anonymous communications, and the monitoring of such.

Technique Uncovers Malware on Embedded Medical Devices

Medical devices based on embedded systems are ubiquitous in clinical settings. Increasingly, they connect to networks and run off-the-shelf operating systems vulnerable to malware. But strict validation requirements make it prohibitively difficult or costly to use anti-virus software or automated operating system updates on these systems. Researchers including Prof. Kevin Fu have developed a monitoring system, called WattsUpDoc, that uses a traditionally undesirable side channel of power consumption to enable run-time malware detection without the need to install and run traditional anti-virus software. In the researchers' experiments, WattsUpDoc detected previously known malware with at least 94% accuracy and previously unknown malware with at least 85% accuracy on several embedded devices – detection rates similar to those of conventional malware-detection systems on PCs.

Better Fabrication Techniques for MEMS Devices

New manufacturing and micromachining processes have been developed by Prof. Yogesh Gianchandani and Dr. Tao Li that expand the range of metals and materials that can be used in the fabrication of harsh-environment sensors and packages. Recent advances in batch mode micro electro-discharge machining (μEDM) have resulted in a minimum feature size of 7 μm and an aspect ratio of ~2.8 on stainless steel, which is attractive for applications such as smart stents and packaging. The researchers also made advancements in batch mode micro ultrasonic machining (μSM) which enables batch fabrication of piezoelectric transducers for structurally complex microresonators and smart biopsy tools.



Department News

New International Research Partnership

The University of Michigan and Ben-Gurion University of the Negev in Israel signed a collaboration agreement in March 2013 to jointly fund collaborative research programs in the area of renewable energy. The specific areas of focus are: 1) Photovoltaics and solar technology; 2) Liquid fuels and engine combustion; and 3) Thermoelectricity, materials and devices. Stephen Forrest, U-M Vice President for Research and William Gould Dow Professor of Electrical Engineering will be one of the Governing Board Members. Prof. Forrest has been visiting Isreal in recent years and is impressed with their entrepreneurial culture, which he hopes will help bring new energy-related technologies to the marketplace.

Karem Sakallah Helps to Launch Ibn Sina School for Computer Science

CSE Associate Chair Prof. Karem Sakallah has participated in the launch of the Ibn Sina School for Computer Science, which aims to prepare undergraduate students in the Middle East and North Africa (MENA) region for successful careers in computer science research. The School is offering its academic program at several locations throughout the MENA region in partnership with local academic host institutions, and was launched in Summer 2012 at Birzeit University in the West Bank of Palestine.

Prof. Sakallah joined with three other scholars from institutions in France, Sweden, and Switzerland to teach at the inaugural session. The students in the program were the top 20 students selected from about 150 applicants from eight West Bank universities. Prof. Sakallah worked with two project teams of students on continuity projects that ran through December, meeting via videoconference and email, and returned and taught a new group of students at the School in the Summer of 2013.

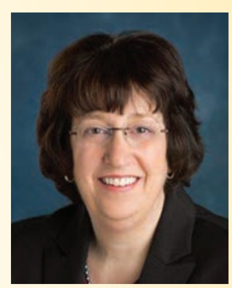
The Ibn Sina School was founded by Prof. Adnan Darwiche of the UCLA Computer Science Department. Its International Advisory Board includes Prof. Michael Wellman, along with other computer scientists from the United States and Europe.

New Administrative Roles for Our Faculty

Jim Freudenberg is the new Director of the Master's Degree Program in Automotive Engineering, part of the Integrative Systems + Design program in the College of Engineering.

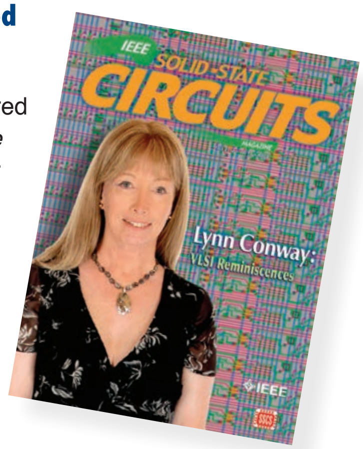
Eric Michielssen was named U-M Associate Vice President for Advanced Research Computing and Director of the Michigan Institute for Computational Discovery and Engineering.

Brian Noble has been selected to serve as Associate Dean for Undergraduate Education at the College of Engineering.



Martha E. Pollack has been selected to serve as Provost and Executive Vice President for Academic Affairs of the University of Michigan.

Lynn Conway's Career Highlighted in IEEE Solid-State Circuits



Prof. Emerita Lynn Conway was featured in a special edition of *IEEE Solid-State Circuits Magazine* in recognition of her groundbreaking contributions to Very Large Scale Integration (VLSI) design. This 24-page memoir recounts her early work at IBM, where she made foundational contributions to superscalar computer architecture in the mid-1960s. At Xerox Palo Alto Research Center, Conway collaborated with Carver Mead of Caltech to innovate scalable MOS design rules and highly simplified methods for silicon chip design. She co-authored *Introduction to VLSI Systems* with Mead, a standard textbook in chip design that was used in more than 100 universities by 1983. Conway also pioneered the Internet-based rapid-chip prototyping infrastructure that was institutionalized as the MOSIS system by DARPA and NSF.

Markov Serves on ACM Classification System Update Project

Prof. Igor Markov has contributed toward a major update to ACM's Computing Classification System (CCS) as the lead for the Hardware tree. The CCS is the de facto standard for classifying computing literature since 1964. The new system, released in late 2012, was developed as a poly-hierarchical ontology that can be utilized in semantic web applications and is being integrated into the search capabilities and visual topic displays of the ACM Digital Library, replacing the previous version that was developed in 1998. The 2012 version of the CCS reflects a year-long team effort that included two review stages and many iterations. The full CCS classification tree is freely available for educational and research purposes in a number of formats from ACM.

Nikola Tesla Bust and Poster

John Wagner next to the Nikola Tesla bust and poster he donated to the University of Michigan.

Thanks to the efforts of Mr. John Wagner, the EECS atrium has been home to a bust of Nikola Tesla since 1989. This summer, he added a poster to educate students about this pioneering inventor. Tesla invented AC current with his "Tesla coil," as well as the four-tuned circuit, the foundation of all radio communication. Michigan was the first of 19 institutions to receive a Tesla bust, at no cost. Mr. Wagner's third grade class raised $114,000 over the course of 10 years to finance the project.

Staff Award

Beth Stalnaker, Graduate Program Coordinator, received the 2013 College of Engineering Judith A. Pitney Staff Service Award, which recognizes the significant contributions of a single CoE staff member with at least 10 years of service.

Holiday Hackers Brighten Beyster Building With a Puzzle of Programmable Lights

Visitors to the Beyster Building on December 6, 2012 were treated to an unexpected and rather unique lighting display. Carefully wound into the building's signature four-story spiral staircase were a series of 100 colorful and blinking holiday lights, which a nearby note revealed to be hackable, individually addressable GE-Color Effects lights driven by a networked Raspberry Pi embedded system. The note added "Check out @bbb_blinken or ask around and surely someone will share the API so that you too can learn how to hack the blinkenlights." The ensuing, ever-changing colors and patterns brightened our season!

News and Events

Fourth Data Mining Workshop Brings Together Close to 200 Researchers

On Wednesday, April 24, 2013, close to 200 researchers from across the University of Michigan and from industry gathered in the Bob and Betty Beyster Building on North Campus for the fourth U-M Workshop on Data Mining. The nearly 100% increase in attendance over the previous year reflects the relevance of data mining across a range of disciplines.

Organized by Profs. Michael Cafarella and Dragomir Radev and sponsored by Yahoo!, CSE, and the Office of Research Cyber-infrastructure, the workshop brought together researchers currently using data mining or interested in the use of data mining to make connections and share experiences and results. The workshop included 12 presentations and concluded with a keynote by Scott Gaffney, Director, Knowledge and User Engagement Science, Yahoo! Labs, entitled *Personalization at Scale*.

Prof. Honglak Lee speaks on Learning and Selecting Features Jointly with Pointwise Gated Boltzmann Machines.

Follow the QR code to see videos from the workshop.

Workshop to Chart the Future of Nano and Micro Manufacturing

The Workshop on Nano and Micro Manufacturing brought together more than 150 nano/microscale device and material manufacturers, researchers, and end users of these technologies to discuss how to rapidly and effectively translate university research into practical products.

The sessions on manufacturing processes covered a vast number of applications and manufacturing technologies. Included in the presentations were roll-to-roll nanofabrication, atomic layer deposition, self-assembly, photolithography and printing technologies. Applications for these technologies range from displays, biomedicine, electronics, automotive, and energy.

Plenary and guest speakers at the workshop included Prof. Sridhar Kota, former Assistant Director for Advanced Manufacturing at the White House Office of Science and Technology Policy and current professor of Mechanical Engineering at Michigan; Kurt Peterson, co-founder of six successful companies in MEMS technology; Ken Wise, William Gould Dow Distinguished University Professor Emeritus; and Lynn Conway, Professor Emerita of Electrical Engineering and Computer Science.

The workshop, chaired by Prof. Yogesh Gianchandani, Director of the Center for Wireless Integrated MicroSensing & Systems (WIMS^2), was co-sponsored by WIMS^2, Freescale Semiconductor, and the Transducers Research Foundation. Additional financial support was provided by the Michigan Economic Development Corporation. The event was held May 22–23, 2013 at the Ford Motor Company Conference and Event Center in Dearborn, MI.

More News and Events

2012–2013 AY Distinguished Lectures in Computer Science and Engineering

PETER NORVIG
Director of Research
Google
The Science and Engineering of Online Learning
April 22, 2013

HAL ABELSON
Class of 1922 Professor of Electrical Engineering and Computer Science
Massachusetts Institute of Technology
From Computational Thinking to Computational Values
February 25, 2013

RICHARD STALLMAN
President and Founder
Free Software Foundation
A Free Digital Society
January 17, 2013

ED LAZOWSKA
Bill & Melinda Gates Chair in Computer Science & Engineering
University of Washington
Computer Science: Past, Present, and Future
October 19, 2012

KRISZTIÁN FLAUTNER
Vice President for Research and Development
ARM, Inc.
Inmates vs Asylum: Overtime
October 12, 2012

Rackham Centennial Lecture

KUNLE OLUKOTUN
Professor, Electrical Engineering and Computer Science
Stanford University
Making Parallelism Easy: A 25 Year Odyssey
October 24, 2012

CSE Colloquium

SRINI DEVADAS
Edwin Sibley Webster Professor of Electrical Engineering and Computer Science
Massachusetts Institute of Technology
EM2, Ascend, and Angstrom: Processor Building at MIT
March 27, 2013

The CSE Distinguished Lecture Series brings top thinkers in the field of computer science to campus. They meet with faculty and students and present their cutting-edge research to the University of Michigan community. Recent CSE Distinguished Lectures are now available to view on the EECS website; use the QR code here to access them.

Distinguished Lectures

William Gould Dow Distinguished Lectureship

This lectureship is the highest honor bestowed on a guest speaker by the Department, and honors William Gould Dow (1895–1999), former faculty member, Department Chair, and pioneer in electronic engineering education. This past year's William Gould Dow lecturer, Prof. Alan S. Willsky, was selected by faculty in the area of Signal Processing.

Prof. Willsky is the leader of MIT's Stochastic Systems Group. His early work on methods for failure detection in dynamic systems is still widely cited and used in practice, and his more recent research on multiresolution methods for large-scale data fusion and assimilation has found application in fields including target tracking, object recognition, oil exploration, oceanographic remote sensing, and groundwater hydrology. He authored the popular textbook, *Signals and Systems*, and has received numerous prestigious awards. He is a member of the National Academy of Engineering.

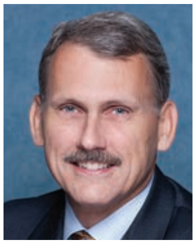
ALAN S. WILLSKY
Edwin Sibley Webster Professor of Electrical Engineering and Computer Science
Director, Laboratory for Information and Decision Systems
Massachusetts Institute of Technology
Learning and Inference for Graphical and Hierarchical Models: A Personal Journey

Khalil Najafi (Schlumberger Professor of Engineering and Chair, Electrical and Computer Engineering), Alfred O. Hero (R. Jamison and Betty Williams Professor of Engineering), Alan Willsky, David C. Munson, Jr. (Dean, College of Engineering)

2012–2013 AY Distinguished Lectures in Electrical Engineering and Computer Science

CAHIT AKIN
Rackham Centennial Lecturer
CEO and Co-founder
Mushroom Networks, Inc.
A Venture Capitalist/Entrepreneur Talks About Starting and Growing Technology Companies
October 11, 2012

CURTIS LING
Rackham Centennial Lecturer
CTO and Co-founder
MaxLinear
Founding to Post-IPO: One Perspective on Technology Entrepreneurship and Fabless Design
October 25, 2012



DANIEL MOLONEY
Past President
Motorola Mobility
Personal Reflections
October 12, 2012

JOHN A. ROGERS
Lee J. Florey-Founder Chair in Engineering
Dept. of Materials Science and Engineering,
University of Illinois, Urbana-Champaign
Materials and Mechanics for Bio-Integrated Electronics
September 20, 2012

Many of these lectures have been videotaped and are available on the EECS website.

ECE Webinars and Videotaped Seminars

Wireless Integrated MicroSensing & Systems: Building and Applying MEMS & Microsystems

WIMS², directed by Prof. Yogesh Gianchandani, is bringing their world to you. Be there in person for seminars, watch online webinars, or catch selected videos at your convenience.

Here are some highlights:

NF Shuttle – Bringing the Fabless Model to the MEMS Industry, by Dr. Mike Daneman, Manager of MEMS Packaging at InvensSense (webinar)

Wireless Implantable Microsystems: Creating a Revolution in Health Care, by Prof. Emeritus Ken Wise (webinar)

Passive MEMS for Communication and Sensing Applications, by Prof. Mina Rais-Zadeh (webinar)

Find these and much more online: wims2.org/media

Catch them all at mipse.umich.edu

Plasma Science Lectures: Transforming Healthcare, Generating Power, and Probing the Solar System

The Michigan Institute for Plasma Science and Engineering, directed by Mark Kushner, George I. Haddad Professor of Electrical Engineering and Computer Science, is now taping their lectures. Here's just a taste:

Laser Inertial Fusion Energy (LIFE), by Dr. Mike Dunne, Lawrence Livermore National Laboratory.

Microplasmas Excited by Microwave Frequencies, by Prof. Jeffrey Hopwood, Tufts University.

Plasma Medicine: Low Temperature Plasma as a Transformational Technology for the Healthcare Field, by Prof. Mounir Laroussi, Old Dominion University

Stars, Disks and Jets: The View From The Telescope, The Computer and The Lab, by Prof. Adam Frank, University of Rochester.

NNIN Computation (NNIN/C) Program at Michigan

The National Nanotechnology Infrastructure Network Computation (NNIN/C) Program offers a webinar series featuring invited guests from industry and academia to present modeling and simulation tools for micro/nano-scale devices. Here are some recent webinars:

An Introduction to Materials Studio, by Dr. Michael Doyle, Principal Scientist, Accelrys

Atomic-scale Modeling of Nanoelectronic Devices with Atomistix ToolKit, by Dr. Anders Blom, Quantumwise

The Ultimate Scaling Limit – A Deterministic Single Atom Transistor, by Prof. Gerhard Klimeck, Electrical and Computer Engineering, Purdue University

Catch them live, or anytime.

Intellectual Property Webinar Available Online

Thomas Lewry and Prof. Mohammed Islam.

Thomas Lewry (BSE CE and J.D.) joined Prof. Mohammed Islam to present a webinar introducing intellectual property issues for engineers. Mr. Lewry is a registered patent attorney and head of Brooks Kushman's litigation group. Mr. Lewry has been a repeat guest lecturer in Prof. Islam's course *EECS 410: Patent Fundamentals for Engineers*. Prof. Islam has spun-out 5 companies. He has either written or participated in more than 120 patents of his own research, and is a registered patent agent with the U.S. Patent and Trademark Office.

Watch the webcast.

More News and Events

CSE Celebrates CSEdWeek

Each December, the CSE Division recognizes Computer Science Education Week with a series of activities and lectures. CSEdWeek was established by the U.S. Congress in recognition of Grace Murray Hopper's birthday, December 9, 1906, and her extraordinary contributions to the field of computer science.

This past December, activities included a series of public project demonstrations by Michigan Hackers, info tables in the Beyster Building atrium manned by peer advisors, a building-wide CS puzzle, the second annual "A Week in the Life at CSE" photo contest, and the first A2CS Tech Mixer – an evening of networking for students with an invited roster of Southeast Michigan-based tech companies, entrepreneurs, and venture capitalists.

The first A2CS Tech Mixer helped build connections between students and the local tech community.

A2CS techmixer
Connecting A2's Tech Community with the U-M Computer Science and Engineering Division

The photo contest winner was CS undergraduate Jill Bender. Her entry was entitled, "His assignment was to write 'I will not throw planes in class, 100 times; he did it he CS way."

David Chesney Talks at TEDxUofM

Dr. David Chesney spoke at *Untapped,* the fourth annual TEDxUofM ideas convention, which took place April 5, 2013 at the Power Center for the Performing Arts. His talk was entitled *Shouts and Whispers: Small Events Leading to Big Changes.* Follow the QR code to see this inspirational talk.

Dr. Chesney spoke about how seemingly insignificant events can have big impacts on the people we become, and how an event from his past led him to weave social context into his courses where possible, specifically in the direction of encouraging his students to develop assistive and therapeutic technologies for children with cognitive and physical disabilities at CS Mott Children's Hospital.

Workshop Unites Industry and Researchers on Medical Device Security Challenges

From the computers that run diagnostic and procedural equipment, to bedside monitors, to implantable medical devices, a range of medical device security issues have now been identified that could potentially impact patient care and well-being. There now exists a search to meaningfully define these challenges such that they become technically solvable, scientifically measurable, humanly acceptable, and economically feasible.

On May 9–10, 2013, professionals from medical device manufacturers and level-I trauma centers and security researchers attended the two-day Archimedes Workshop run by Prof. Kevin Fu through his Archimedes Research Center for Medical Device Security.

Participants included medical device engineers from as far away as Australia, Japan, Korea, Switzerland, and Germany, who visited the closed-door workshop to share effective practices for improving security and privacy in product design and manufacturing.

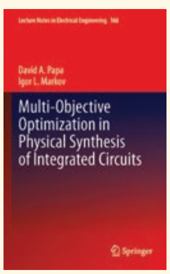
Workshop on Biomedical Electronics and Devices, a Global Partnership

The WIMS² Center and the Biomedical Electronics Translational Research Center (BETRC) from the National Ciao Tung University (NCTU) in Taiwan hosted a public workshop on biomedical microsystems, August 26, 2013 at the Lurie Engineering Center. The workshop laid the groundwork for future collaborations.

Both institutions presented their research in the areas of neural prosthetics, epilepsy control, implantable devices, low power circuits, diagnostic biochips, biomimetic circuits and systems for intelligent prosthesis, biosensors, and other exciting topics.

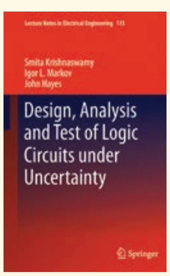
Speakers from Michigan included Prof. Yogesh Gianchandani (Director of WIMS²) and several faculty from ECE and the departments of Mechanical and Biomedical Engineering. Representatives from NCTU included Prof. Chung-Yu Wu, director of BETRC and the National Program on Nano Technology, as well as faculty from the Department of Psychology and the Department of Ophthalmology.

NEW BOOKS



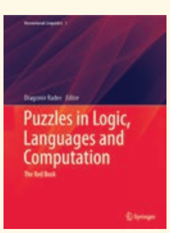
Prof. **Igor Markov** co-authored the book, *Multi-Objective Optimization in Physical Synthesis of Integrated Circuits,* with former student Dr. David Papa. The book introduces techniques that advance the capabilities and strength of modern software tools for physical synthesis, with the ultimate goal to improve the quality of leading-edge semiconductor products.

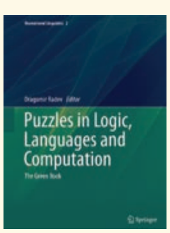
Prof. **Jason Flinn** has authored *Cyber Foraging – Bridging Mobile and Cloud Computing*, which describes how cyber foraging systems dynamically partition data and computation to yield better performance, energy efficiency, and application. The book was published by Morgan & Claypool as a part of their *Synthesis Lectures on Mobile and Pervasive Computing* series.



Prof. **Igor Markov**, **John Hayes**, Claude E. Shannon Professor of Engineering Science, and CSE alumna Dr. Smita Krishnaswamy have authored *Design, Analysis and Test of Logic Circuits under Uncertainty*, which presents a comprehensive overview of logic circuits and provides a multi-discipline approach to the timely topic of uncertainty, with descriptions of methods for analyzing, designing, and testing circuits subject to probabilistic effects.

Prof. **Todd Austin** has joined Andrew S. Tanenbaum of Vrije Universiteit to co-author the sixth edition of *Structured Computer Organization*, which is published by Prentice Hall. The book is a best-selling guide that provides an accessible introduction to computer hardware and architecture for undergraduate students. The new edition is a complete overhaul, and updates all of the examples and instruction sets to modern examples.





Prof. **Dragomir Radev** has edited and compiled, *Puzzles in Logic, Languages and Computation*. This two-volume set includes the best English-language problems created for students competing in the Computational Linguistics Olympiad. These problems are representative of the diverse areas presented in the annual competition, which mimics the skills used by researchers and scholars in the field of computational linguistics.

Curriculum and Education News

Automotive Engineering and EECS

Recent hiring trends have highlighted the importance of our well-trained students to the future of the auto industry. This is old news for Prof. Jim Freudenberg, who has a long-standing relationship with the auto industry. A specialist in control systems and Director of the Systems Laboratory, he is also the new Director of the College of Engineering Master's Degree Program in Automotive Engineering.

"Today's cars are filled with so many electronics, with infotainment centers, automation, and one day soon even networking between automobiles and other safety controls," said Jim, "there's an acute need for EECS students in the industry. The advent of hybrid electric vehicles adds yet another specialization within the field that is ideally suited to our students."

Thanks to the addition of several courses in Power & Energy in recent years, EECS students have several options to strengthen their marketability for the automotive industry by taking senior level courses such as: *Power Electronic Design, Electric Machinery and Drives, Embedded Control Systems, Power System Design and Operation, Grid Integration of Alternative Energy Sources, and Hybrid Systems Control.*

Technology and Wellness

Does technology hurt or help those who want a symbiotic relationship with the world around them? According to Prof. Jasprit Singh, that's up to the individual. He's ready to help students envision for themselves how to use technology to enhance wellness with his new course entitled, *Imagine, Innovate, Act* (ENG 390). Student teams will be comprised of engineers, artists, and others interested in wellness. The end result will be new apps that incorporate multimedia for mental wellness, physical wellness, old age wellness, educational wellness, etc.

Undergraduates Develop Learning Apps for Singapore 3rd Graders

Elliot Soloway, Arthur F. Thurnau Professor, has been at the forefront of utilizing mobile technology in K-12 education for many years. So it was no surprise when he offered *Learning Apps for Primary Education*, an undergraduate class in which students developed a suite of learning applications for smartphones from scratch, and then tested the software in real classrooms. The twist was that the software, called *MyDesk*, was tested by 352 Nan Chiau Primary School third-grade science students in Singapore, who used the app to research and complete assignments. A team of students from Soloway's class made the trip to Singapore for a number of weeks to resolve issues, answer questions, and record how the software was used. The third graders used the software and phones on field trips and for daily classwork. "The students ended up turning in all this stuff teachers didn't expect," says project manager and CSE graduate assistant Cody Bird – such as elephant and monkey sounds to augment a report on animal diversity.

K-12 Outreach

Summer Workshop in Computer Science for High School Teachers

This summer, CSE hosted its fifth annual CS4HS, a two-day workshop for high school teachers that is designed to help them to integrate principles of computing and computational thinking into their classrooms. Organized by Dr. Jeff Ringenberg, CS4HS featured a keynote by U-M Prof. of Education (and CS alumnus) Chris Quintana. Also on the slate were a tour of the local engineering office for security firm Arbor Networks (co-founded by Prof. Farnam Jahanian and CSE alumnus G. Robert Malan), overviews of CS research at U-M, and a demo by the South Lyon High School FIRST Robotics Team, who showed off their Frisbee-throwing robot.

The highlights of the workshop were the lab sessions with Finch Robots, in which the teachers learned to use BlueJ Java and Snap! to program the robots to navigate mazes, draw patterns, and perform other manuevers. “The robots are definitely something I will use in my class. It was the best CS4HS ever,” said Sherri Bryant, a teacher at University High School in Ferndale, MI. The workshop was supported by Google.

A CS4HS team prepares to have their robot enter a maze.

Nanomaterials Training for Advanced Students

C-PHOM students participating in the 2013 Summer Research Symposium in West Hall.

The Center for Photonic and Multiscale Nanomaterials (C-PHOM), established in 2011, offers a High School Research Program for seniors, and a summer Research Experiences for Undergraduates (REU) program for college students. The program is run by Prof. Rachel Goldman (C-PHOM Director of Education) and Akesha Moore (Education Coordinator). Students conduct research in the fields of nanomaterials, nanophotonics, and nanophysics under the guidance of faculty and graduate students.

The High School Research Program is a nearly year-round program that includes an eight week residential component. The students return to campus several times during the year to prepare for local, regional, and national science fair competitions. The REU program is a 10-week residential program for non U-M juniors and seniors. At the completion of the summer residential programs, the C-PHOM students present their research at the U-M Summer Research Symposium.

What’s She Doing Now?

Prof. Jessy Grizzle welcomes many visitors to his robotics lab, as does his bipedal robot MABEL and now younger sister MARLO. This is one of the last times students will be able to catch MABEL, as she will be on loan to the Chicago Field Museum for about 6 years beginning 2014.

As part of a College of Engineering summer camp, high school students visited Prof. Grizzle’s robotics lab in June.

Integrating Microsystems Technology Into STEM Curriculum

Community College science faculty have the opportunity to be trained in Microsystems Technology as well as acquire a complete curriculum that can be integrated into their classes thanks to the combined efforts of staff from the Lurie Nanofabrication Facility (LNF) and The Southwest Center for MicrosysEducation (SCME).

This past summer, the LNF and SCME offered a four-day *Pressure Sensor Workshop* at the LNF. Participants learned how to build and fabricate a MEMS micro-pressure sensor in the LNF. They were also trained on kits provided by SCME that included: *Crystal Rainbow Wafer, Pressure Sensor Model, Lift-off, Pressure Sensor Process, and MEMS: Making Micro Machine*. These kits are available to the general public. All of the participants plan to use the materials in their classrooms.

Interested in the teacher kits, animations and videos? Click here.

More Cleanroom Photos.

ExCAPE to Summer School

Prof. Stéphane Lafortune co-organized a summer school program focused on Program Synthesis this past summer, held on the campus of U-C Berkeley, June 12–15, 2013. The program was sponsored by the NSF Expeditions project called ExCAPE: Expeditions in Computer Augmented Program Engineering. Prof. Lafortune is co-PI on the program, as well as co-lead of the ExCAPE Education and Knowledge Transfer activites. The program attracted 89 participants from 12 countries.

Prof. Lafortune lectured on the Gadara technology, developed at Michigan in collaboration with HP Labs and Georgia Tech to automatically eliminate certain types of software freezes called "deadlocks" from computer programs that run on multicore architectures. Other lecturers at the summer school included Moshe Vardi of Rice University, Ras Bodik of U-C Berkeley, Paulo Tabuaba of UCLA, and ExCAPE Project Director Rajeev Alur of the University of Pennsylvania.

Dragomir Radev Coaches High School Linguists in International Competition

Prof. Dragomir Radev has coached U.S. high school students to successful competition at the *11th International Linguistics Olympiad (IOL)*, which was held in Manchester, UK, from July 22–26, 2013. It is the seventh year that Radev has coached the team.

The IOL, one of twelve international science olympiads, consists of two events. The first is the individual contest, a six-hour test, which this year had problems about the languages Yidini, Tundra Yukaghir, Pirahã, and Muna, as well as a problem on functional magnetic resonance imaging (fMRI). The second event is the team contest, which involved an ancient variant of Georgian, the language of the Republic of Georgia in the Caucasus region of Eurasia. To solve these problems, the student contestants must apply knowledge about the way languages work as well as logic and reasoning skills to decipher unfamiliar languages and writing systems. In the individual contest, the absolute winner among all 137 contestants, with 87 points out of 100, was Alex Wade of the United States. In addition, one of Radev's two U.S. teams won both team competitions.

U.S. and Canadian team members were selected from more than 1,700 students who competed in the North American Computational Linguistics Olympiad, which Prof. Radev co-founded in 2007.

Members and coaches of the U.S. and Canadian Linguistics Olympiad Teams. Prof. Radev is fourth from right.

K-12 Outreach

NANOCAMP

Nanocamp 2013

About 50 middle school and high school students spent a precious Saturday in April 2013 doing hands-on learning exercises before moving into the Lurie Nanofabrication Facility to process their own wafers.

Edwin Olson Talks Robotics at World Science Festival

Prof. Edwin Olson spoke on robotics at the World Science Festival's (WSF) *Cool Jobs* program, which features thought-provoking and inspirational lectures on technical occupations aimed at young people and their families. The WSF took place in June in New York City; follow the QR code to see video of the *Cool Jobs* program; Prof. Olson appears at 56:50.

Prof. Olson talked about his motivation for becoming a roboticist ("It's cool!"), the many activities that robots can perform in order to protect or help humans, and how a robot's form and operation are a result of its intended purpose. He ran a demonstration in which child volunteers came on stage to play a game of hide and seek with a team of searching robots. In addition to his presentation, Prof. Olson and his students participated in workshops and demonstrations of his lab's robots over the course of the science festival weekend.

Graduate students Lauren Hinkle and Rob Goeddel demo robots at the World Science Festival.

Exploring Nanotechnology Workshop for K-12 Educators

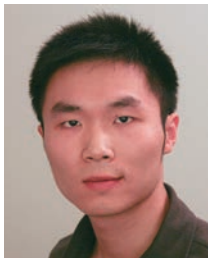
What goes on in those eerily-lit yellow rooms? Nano! Teachers from Metro Detroit and other parts of Michigan came to learn more about why cleanroom lighting is yellow and to demystify the topic of nanotechnology. They left with answers (it's to protect processes like photolithography from UV and blue light), hands-on experience in the LNF cleanroom, and resources that can be used in their classrooms. This all-day event took place March 7, 2013 and was held in conjunction with the Michigan Science Teachers Association annual meeting at nearby Eastern Michigan University.

New Faculty

JACOB ABERNETHY

Assistant Professor
PhD, Computer Science, 2011
University of California Berkeley

Jake Abernethy's research draws from the field of Machine Learning (ML), but he has devoted much attention to a range of areas, including game theory, decision theory, optimization, market mechanism design, and financial applications. He is particularly interested in how algorithms utilized in ML, such as those for discovering patterns in data, are strongly related to methods used in large-scale optimization, as well as strategies for hedging financial derivatives and setting prices in securities markets. Jake aims to explore further collaboration with researchers in Economics, Statistics, Operations Research, and Mathematics. Jake Abernethy joins the faculty from the University of Pennsylvania, where he has been a Simons Postdoctoral Fellow.



JIA DENG

Assistant Professor
PhD, Computer Science, 2012
Princeton University

Jia Deng's research centers around harvesting, understanding, and harnessing big visual data for object recognition, activity recognition, scene understanding, image and video retrieval, and other applications. He has built datasets and tools used by more than 1,000 researchers worldwide and his work has appeared in popular press such as *The New York Times*. He has been the lead student organizer of the ImageNet Large Scale Visual Recognition Challenges since 2010. He was also the lead organizer of the first BigVision workshop at NIPS 2012. He is currently a postdoctoral scholar in the Vision Lab at Stanford University and will be joining the faculty in September 2014.

SOMIN LEE

Assistant Professor
PhD, Bioengineering, 2012
University of California Berkeley

Somin Lee's research is focused on engineering nanophotonic instrumentation to quantitatively analyze complex biological systems and improve cellular therapies. She is specifically interested in the design and implementation of tools enabling enhanced spatial and temporal control for the development of "smart" nano-devices, single-molecule imaging, and tunable nanomedicine. Somin has two U.S. patents. She is currently an NIH Ruth L. Kirschstein Postdoctoral Fellow at Lawrence Berkeley National Laboratory, and will join the faculty January 2014.

JASON MARS

Assistant Professor
PhD, Computer Science, 2012
University of Virginia

Jason Mars has been an active researcher in the areas of computer architecture, system software, and cross-layer system design. His research interests include cross-layer systems architectures for emerging applications, datacenter and warehouse-scale computer architecture, and hardware/software co-design. His work focuses on native application performance, energy efficiency, and system utilization, particularly in the context of the latest innovations in microarchitectural design, runtime systems, and cloud/mobile computing Jason's work has been featured as an IEEE Micro Top Pick, and he recently received Best Paper Awards at HPCA '12 and CGO '12. He received a UVA Research Award in 2012. Jason joins the faculty from the Department of Computer Science and Engineering at University of California San Diego, where he recently held the position of Peggy and Peter Preuss Assistant Professor.

JOHANNA MATHIEU

Assistant Professor
PhD, Mechanical Engineering, 2012
University of California Berkeley

Johanna Mathieu's research focuses on ways to reduce the environmental impact, cost, and inefficiency of electric power systems through new operational and control strategies. She is particularly interested in developing new methods to actively engage distributed flexible resources such as energy storage, electric loads, and distributed renewable resources in power system operation. Johanna has been a U.S. Peace Corps volunteer in Tanzania where she taught applied mathematics and physics to Tanzanian secondary school students. She is currently a postdoctoral researcher at ETH Zurich in the Power Systems Laboratory, and will join the faculty January 2014.

New Faculty

RADA MIHALCEA

Associate Professor

PhD, Linguistics, Oxford University, 2010
PhD, Computer Science & Engineering, 2001
Southern Methodist University,

Rada Mihalcea's research interests are in computational linguistics, with a focus on lexical semantics, graph-based algorithms for natural language processing, and multilingual natural language processing. She is currently involved in a number of research projects, including word sense disambiguation, monolingual and cross-lingual semantic similarity, subjectivity, sentiment, and emotion analysis, multimodal affect analysis, and computational humor. She serves or has served on the editorial boards of the *Journals of Computational Linguistics, Language Resources and Evaluations, Natural Language Engineering,Research in Language in Computation, IEEE Transactions on Affective Computing, and Transactions of the Association for Computational Linguistics*. She was a program co-chair for the two leading conferences in *Computational Linguistics: the Conference of the Association for Computational Linguistics (2011)*, and the *Conference on Empirical Methods in Natural Language Processing (2009)*. She is the recipient of a National Science Foundation CAREER award and a Presidential Early Career Award for Scientists and Engineers. In 2013, she was made a honorary citizen of her hometown of Cluj-Napoca,Romania. Rada joins the faculty from the Department of Computer Science at the University of North Texas.

BARZAN MOZAFARI

Assistant Professor

PhD, Computer Science, 2011
University of California Los Angeles

Barzan Mozafari is passionate about building large-scale data-intensive systems that are more scalable, more robust, and more predictable, with a particular interest in database-as-a-service clouds, distributed systems, and crowdsourcing. In his research, he draws on advanced mathematical models to deliver practical database solutions, adapting concepts and tools from applied statistics, complexity theory, automata theory, and machine learning. He has won several awards and fellowships, including *SIGMOD 2012* and *EuroSys 2013's* best paper awards. Barzan joins the faculty from Massachusetts Institute of Technology, where he has been a Postdoctoral Associate.

NECMIYE OZAY

Assistant Professor

PhD, Electrical Engineering, 2010
Northeastern University

Necmiye Ozay's research interests lie at the broad interface of dynamical systems, control, optimization and formal methods with applications in system identification and validation, autonomy and vision. She is particularly interested in developing novel event detection/information extraction algorithms from sensory data and designing robust cyber-physical systems that can autonomously react to these events and perform complex tasks in dynamic environments. Most recently, Necmiye was a Control and Dynamical Systems postdoctoral scholar at California Institute of Technology.

REBECCA L. PETERSON

Assistant Professor

PhD, Electrical Engineering, 2006
Princeton University

Becky Peterson's research focuses on solution-processed methods for manufacturing inorganic electronic materials, devices, and circuits. She is particularly interested in ink-based approaches to make thin film transistors, transparent conducting oxides, and other functional or electronic materials. Her work encompasses nanoparticle-based electronics and sensors, self-assembled nanopatterning techniques, and electro-mechanical properties of thin films for flexible sensors and electronics, and for their integration in a variety of microsystems. Becky was a Postdoctoral Fellow at the University of Cambridge before coming to Michigan in 2009 as an assistant research scientist.

LINGJIA TANG

Assistant Professor

PhD, Computer Science, 2012
University of Virginia

Lingjia Tang's research focuses on computer architecture and compiler and runtime systems, especially such systems for large scale data centers. Recently, her publication at *Micro '11* was selected for *IEEE Micro* Top Picks. She received a best paper award at *IEEE/ACM International Conference of Code Generation and Optimization (CGO) 2012*. In addition, her publication at *International Symposium of Computer Architecture* was selected as one of the excellence papers of 2011 by Research at Google. Lingjia joins the faculty from the Department of Computer Science and Engineering at University of California San Diego, where she was a research faculty member.

Faculty Honors and Awards

NSF Career and Young Investigator Awards

EDWIN OLSON
DARPA Young Faculty Award

Project Title: *Mutual Modeling for Human/Robot Teaming With Minimal Communications*

Prof. Olson will formulate, develop, and evaluate a novel multi-agent coordination framework in which robots explicitly model the intent of their human and robot teammates, with the intention of simplifying human oversight of teams of cooperating robots and speeding responsiveness.

JUAN M. RIVAS
NSF CAREER Award

Project Title: *Power Converters With Embedded Passive Components*

With traditional methods nearing the end of their ability to improve much beyond their current state, Prof. Rivas will investigate new design techniques to dramatically improve the power density and performance of power electronics.

DAVID WENTZLOFF
NSF CAREER Award

Project Title: *Ultra-Low Power Radios for Energy-Autonomous Systems*

Prof. Wentzloff aims to improve the modeling of wireless channels for a wide range of applications through new wireless communication circuits and architectures, and development of ultra-low power radios for dense wireless environments – such as sensor networks.

ZHAOHUI ZHONG
NSF CAREER Award

Project Title: *Graphene Heterostructures Based Hot Carrier Optoelectronics*

Prof. Zhong will investigate the nonequilibrium hot carrier dynamics in graphene, and explore novel graphene heterostructure devices for hot carrier optoelectronic applications.

Ted Norris

GÉRARD A. MOUROU PROFESSOR OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Ted Norris, internationally renowned leader in the field of ultrafast optics, was named the Gérard A. Mourou Professor of Electrical Engineering and Computer Science. Prof. Norris selected the name of his former mentor and colleague for his professorship.

Prof. Norris conducts research in four primary areas: 1) he applies femtosecond optical techniques to the physics of nanostructures, especially III-V semiconductor optoelectronic devices; 2) he applies ultrafast optics to biomedical imaging, *in vivo* sensing, and cancer therapeutics; 3) he investigates the applications of THz radiation to THz imaging and spectroscopy; 4) and he investigates nanoacoustic imaging with picosecond coherent phonon pulses.

Prof. Norris stepped down as Director of the Center for Ultrafast Optical Science to become Director of the Center for Photonic and Multiscale Nanomaterials (C-PHOM) in 2011. He is also Director of the Optics and Photonics Laboratory and a principle investigator in the Energy Frontier Research Center: Center for Solar & Thermal Energy Conversion (CSTEC). He is a Fellow of the *American Physical Society* and the *Optical Society of America*.

Faculty Honors and Awards

EECS Awards

DAVID BLAAUW
EECS Outstanding Achievement Award for innovative research in variation-tolerant and energy efficient integrated circuit design, and exceptional mentoring and teaching in the area of VLSI circuits.

WEI LU
EECS Outstanding Achievement Award for innovative research in nanoscale electronics and the development of memristor devices.

Z. MORLEY MAO
Outstanding Achievement Award for contributions in monitoring and stabilizing Internet routing behavior, improving Internet security and monitoring smartphones' power consumption.

KURT METZGER
Dr. Metzger, Associate Research Scientist Emeritus, was recognized with a special EECS award in recognition of his extraordinary contributions to the major design course *EECS 452: Digital Signal Processing Laboratory*.

College of Engineering Awards

PETER CHEN
Arthur F. Thurnau Professor

Neil Van Eenam Memorial Undergraduate Teaching Award

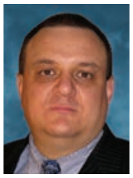
JEFFREY FESSLER
Research Excellence Award

THOMAS WENISCH
Ruth and Joel Spira Teaching Award

ANDREW YAGLE
Service Excellence Award

University Awards

MICHAEL BAILEY
Research Faculty Recognition Award



DRAGOMIR RADEV
Faculty Recognition Award

FAWWAZ ULABY
Emmett Leith Distinguished University Professor of Electrical Engineering and Computer Science, Chen-To Tai Professor of Engineering, and Arthur F. Thurnau Professor

2014 Henry Russel Lectureship

Prof. Ulaby will present the lecture, *Great ideas start very small; the challenge is in how to grow them*, in 2014.

THOMAS WENISCH
Henry Russel Award

HKN Professors of the Year

ANDREW DEORIO

FAWWAZ ULABY

In 2013, the U-M chapter of Eta Kappa Nu selected two recipients as HKN Professor of the Year, one from each division. Based on student input Dr. Andrew DeOrio (CSE) and Prof. Fawwaz Ulaby (ECE) were chosen.

National and Professional Honors and Awards

TODD AUSTIN received the A. Richard Newton GSRC Industrial Impact Award from the Gigascale Systems Research Center in recognition of his work on runtime microprocessor verification.

DAVID BLAAUW and **DENNIS SYLVESTER** were named two of the top contributing authors to the *International Solid-State Circuits Conference (ISSCC)* on the occasion of the 60th Anniversary of ISSCC in 2013.

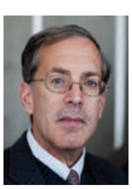
DAVID BLAAUW, **DENNIS SYLVESTER**, and **IGOR MARKOV** were presented with several special awards in celebration of the 50th anniversary of the *Design Automation Conference (DAC)*, including David Blaauw's "DAC Top 10 Cited Author award."

PRABAL DUTTA was selected as a recipient of the Intel Early Career Faculty Honor Program Award. His research has pioneered practical, low-power platforms and wireless protocols for pervasive sensing, computing, and communications.

KEVIN FU received the Federal 100 Award, which recognizes "government, industry, and academic leaders who have played pivotal roles in the federal government IT community."

JESSY GRIZZLE Jerry W. and Carol L. Levin Professor or Engineering, received a *Popular Mechanics'* Breakthrough Award for 2012 for his work with the bipedal robot named MABEL.

BENJAMIN KUIPERS was elected a Fellow of the American Association for the Advancement of Science (AAAS) for his "distinguished contributions to artificial intelligence and robotics, particularly on the representation and effective use of incomplete knowledge of space and of dynamic physical mechanisms."



MARK KUSHNER George I. Haddad Professor of EECS, was appointed to the advisory board for the Princeton Plasma Physics Laboratory (PPPL) for a four-year term.

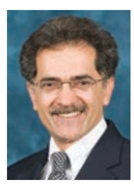
HONGLAK LEE was named to the prestigious list of "AI's 10 to Watch" by IEEE Intelligent Systems for his work in machine learning.

ANATOLY MAKSIMCHUK was named Fellow of the American Physical Society for "major contributions to the understanding of short pulse high intensity laser-plasma interactions, in particular for innovative experimental work in electron and ion acceleration and radiation generation."

IGOR MARKOV was named an IEEE Fellow "for contributions to optimization methods in electronic design automation."

EDWIN OLSON was named one of *Popular Science's* 2012 "Brilliant 10" for his work in developing an autonomous fleet of intelligent and cooperative robots.

KAREM SAKALLAH was named a Fellow of the Association for Computing Machinery (ACM) "for algorithms for Boolean Satisfiability that advanced the state-of-the-art of hardware verification."



KAMAL SARABANDI Rufus S. Teesdale Professor of Engineering, received the 2013 IEEE Geoscience and Remote Sensing Education Award.

SILVIO SAVARESE received the 2013 J. James R. Croes Medal from the American Society of Civil Engineers.

ELLIOT SOLOWAY Arthur F. Thurnau Professor, received a Google App Engine Education Award to support the development of the WeCollabrify Mobile Platform.

ZHENGYA ZHANG received a 2013 Intel Early Career Faculty Honor Program Award.

Faculty and Student Outstanding Paper Awards*

A Low Phase-noise Pierce Oscillator Using a Piezoelectric-on-silica Micromechanical Resonator, by **Zhengzheng Wu**, **Vikram Thakar**, **Adam Peczalski**, and **Prof. Mina Rais-Zadeh**, Best Poster Award, *17th Int. Conference on Solid-State Sensors, Actuators and Microsystems (Transducers '13).*

A Multiphysics Reduced Order Model of Valve Pumping in a 4-Stage Vacuum Micropump, by Karthik Kumar, **Ali Besharatian**, **Prof. Rebecca. L. Peterson**, Prof. Luis P. Bernal, **Prof. Khalil Najafi**, Best Paper Award, *2012 ASME Int. Mechanical Engineering Congress and Exposition (IMECE).*

A Multi-shank Silk-backed Parylene Neural Probe for Reliable Chronic Recording, by **Fan Wu**, Lee Tien, **Fujun Chen**, Prof. David Kaplan (Biomedical Engineering, Tufts University), **Prof. Joshua Berke** (Psychology), and **Prof. Euisik Yoon**, Outstanding Oral Paper Award, *17th Int. Conference on Solid-State Sensors, Actuators and Microsystems (Transducers '13).*

Accelerated Computation of Regularized Field Map Estimates, by **Michael J. Allison** and **Prof. Jeffrey A. Fessler**, Magna Cum Laude Merit Award, *Proceedings of Int. Society of Magnetic Resonance in Medicine*, May 2012.

Combined Dynamic Voltage Scaling and Adaptive Body Biasing for Lower Power Microprocessors Under Dynamic Workloads, by **Steven Martin**, **Krisztian Flautner**, **Prof. Trevor Mudge**, and **Prof. David Blaauw**, 2012 ICCAD Ten Year Retrospective Most Influential Paper Award, *2012 IEEE/ACM Int. Conference on Computer-Aided Design (ICCAD) (originally presented at ICCAD 2002).*

The Computational Complexity of Nash Equilibria in Concisely Represented Games, by **Prof. Grant Schoenebeck** (then a post-doctoral researcher at Princeton) and Salil Vadhan, ACM Notable Article. Originally published in *ACM Transactions on Computation Theory* in 2012.

Computational Sprinting, by Arun Raghavan, **Yixin Luo** (CE undergraduate), **Anuj Chandawalla**, **Prof. Marios Papaefthymiou**, **Prof. Kevin P. Pipe** (professor of Mechanical Engineering and CSE), **Prof. Thomas F. Wenisch**, and Milo M.K. Martin, IEEE Micro Top Pick from the Architecture Conferences of 2012. Originally presented at the *18th Int. Symposium on High Performance Computer Architecture (HPCA).*

Computational Sprinting on a Hardware/Software Testbed, by Arun Raghavan, Laurel Emurian, **Lei Shao** (Mechanical Engineering graduate student), **Prof. Marios Papaefthymiou**, **Prof. Kevin P. Pipe** (professor of Mechanical Engineering and CSE) and **Prof. Thomas F. Wenisch**, Best Paper Award, *18th Int. Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS).*

Dispersion Analysis of Printed-circuit Tensor Impedance Surfaces, by **Amit M. Patel** and **Prof. Anthony Grbic**, Best Student Paper Award (2nd Place), *IEEE Int. Symposium on Antennas and Propagation.*

Distributed Learning of Gaussian Graphical Models via Marginal Likelihoods, by **Zhaoshi Meng**, **Dr. Dennis Wei**, **Dr. Ami Wiesel**, and **Prof. Al Hero**. Notable Paper Award, *Sixteenth Int. Conference on Artificial Intelligence and Statistics (AISTATS).*

End-to-End Sequential Consistency, by **Abhayendra Singh**, **Prof. Satish Narayanasamy**, Daniel Marino, Todd Millstein, and Madanlal Musuvathi, IEEE Micro Top Pick from the Architecture Conferences of 2012. Originally presented at the *Int. Symposium on Computer Architecture (ISCA).*

Graphics Processing Unit-accelerated Implementation of the Plane Wave Time Domain Algorithm, by **Yang Liu**, Vitaliy Lomakin, and **Prof. Eric Michielssen**, Best Paper Award (2nd place), *28th Int. Review of Progress in Applied Computational Electromagnetics.*

High-Frequency Resonant SEPIC Converter with Wide Input and Output Voltage Ranges, by Jingying Hu, Anthony D. Sagneri, **Prof. Juan M. Rivas**, Yehui Han, Seth M. David, and David J. Perreault. Second Prize Paper Award. *IEEE Transactions on Power Electronics*, vol. 27, no. 1, pp. 189-200, January 2012.

"915MHz Ultra Low Power Receiver Using Sub-Vt Active Rectifiers," **Nathan Roberts** and **Prof. David Wentzloff**, Best Student Paper Award, *2012 IEEE Subthreshold Microelectronics Conference.*

Mining Your Ps and Qs, by Nadia Heninger," **Zakir Durumeric**, **Eric Wustrow**, and **Prof. J. Alex Halderman**, ACM Notable Article. Originally presented at the *21st USENIX Security Symposium* in 2012.

Nanoscale Contact Electrodes for Significant Radiation Power Enhancement in Photoconductive Terahertz Emitters, by **Christopher Berry**, **Mohammed R. Hashemi**, **Mehmet Unlu**, and **Prof. Mona Jarrahi**, Best Student Paper Award (3rd place), *2013 Int. Microwave Symposium.*

Plasmonic Photoconductive Antennas for Significant Terahertz Radiation Enhancement, by **Christopher Berry**, **Mohammed R. Hashemi**, **Mehmet Unlu**, and **Prof. Mona Jarrahi**, Best Student Paper Award (2nd Place), *IEEE Int. Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting.*

Predicting Complications of Percutaneous Coronary Intervention Using a Novel Support Vector Method, by **Gyemin Lee**, Hitinder Gurm, and **Prof. Zeeshan Syed**, Best Paper Award, *IEEE Healthcare Informatics and Systems Biology Conference*.

Production Lead Time Problem: Formulation and Solution for Bernoulli Serial Lines, by **Prof. Semyon Meerkov** and **Dr. Chao-Bo Yan**, Best Paper Prize, *Int. Federation of Automatic Control (IFAC) Conference on Manufacturing Modeling, Management and Control.*

Short-term and Long-term Testing of a Vibration Harvesting System for Bridge Health Monitoring, by **James McCullagh**, **Prof. Rebecca L. Peterson**, **Dr. Tzeno Galchev**, **Dr. Robert Gordenker**, **Yilan Zhang**, **Prof. Jerome Lynch** (Professor of Civil and Environmental Engineering and ECE), and **Prof. Khalil Najafi**, Best Student Paper Award, *12th Int. Workshop on Micro and Nanotechnology for Power Generation and Energy Conversion Applications (PowerMEMS 2012).*

Sonic Millip3De: A Massively Parallel 3D-Stacked Accelerator for 3D Ultrasound, by **Richard Sampson**, Ming Yang, Siyuan Wei, Chaitali Chakrabarti, **Prof. Thomas F. Wenisch**, and Milo M.K. Martin, Best Paper Award, *19th Int. Symposium on High Performance Computer Architecture (HPCA).*

X-ray: Automating Root-Cause Diagnosis of Performance Anomalies in Production Software, by **Mona Attariyan**, **Michael Chow**, and **Prof. Jason Flinn**, Best Student Paper, *10th USENIX Symposium on Operating Systems Design and Implementation (OSDI)*.

*Names in **bold** are U-M faculty or graduate students, unless otherwise identified.

Tech Transfer/Commercialization

With a focus on startup companies spun-off from technology developed by faculty and students in the EECS Department.

CSE Spinoff Wins the Linley Group's Analysts' Choice Award

Cyclos Semiconductor, co-founded by CSE Chair Marios Papaefthymiou, has received The Linley Group's Analysts' Choice Award for Best Processor Technology for its achievements in replacing conventional clock-signal trees with a resonant clock mesh and easing the design of high-performance chips. Cyclos has developed a resonant clock mesh packaged as licensable intellectual property. It uses much less power than a traditional clock tree and is already winning converts.

MICHIGAN I-CORPS

i-Corps, Entrepreneurial Support for Advanced Research, Comes to Michigan

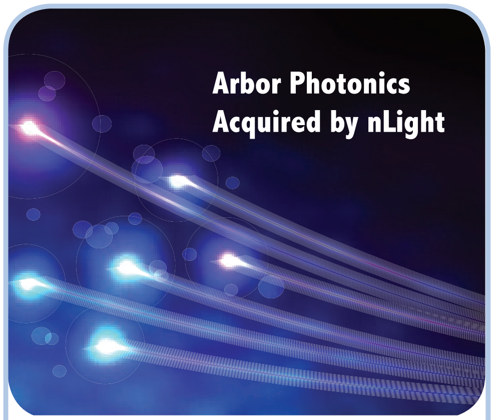
NSF Innovation Corps, or i-Corps, is a program initiated by the National Science Foundation to encourage and support the commercialization of basic research funded by NSF. I-Corps came to Michigan for the first time in 2012, and works with young startups as well as seasoned veterans looking to revamp their companies for the future. It is now a state-wide program between NSF, Michigan Universities, Michigan SmartZones, and venture capital and entrepreneurial communities.

"Usually an entrepreneur identifies a burning need and then goes out to find the solution," said Jonathan Fay, an I-Corps instructor and associate director of entrepreneurial practice. "But this is basic science and they have to go the other way."

The startup company MEMStim, LLC, which is still in the development phase, took advantage of the i-Corps program its first year at Michigan, and learned a thing or two about developing their cochlear implant technology for public consumption. Participating in the program were Ken Wise, William Gould Dow Distinguished University Professor Emeritus, who spent much of his career developing cochlear implants for the profoundly deaf, and his former student and company co-founder Dr. Angelique Johnson (MSE PhD EE '07 '11).

Arborlight, LLC has also participated in the program and like MEMStim, changed the direction of their company in response to what they learned in the program. Arborlight, co-founded by Prof. P.C. Ku and Prof. Max Shtein (Materials Science and Engineering), may one day create artificial skylights that not only appear to be real, but give office dwellers some of the same benefits of real sunlight, such as increased energy.

Arbor Photonics Acquired by nLight



Arbor Photonics, co-founded in 2007 by Prof. Almantas Galvanauskas, was acquired by nLIGHT this past January 2013. nLIGHT specializes in high-performance lasers which enable innovations in advanced materials processing, defense, and medical applications. The company develops and manufactures diode lasers, fiber, and fiber lasers, based on proprietary semiconductor lasers and optical fiber technology. Prof. Galvanauskas pioneered the company's proprietary technology known as Chirally-Coupled Core (3C), which enables their high-power semiconductor fiber lasers. He will remain on the technical board.

Tech Transfer/Commercialization

Driving Microamps to Nanoamps

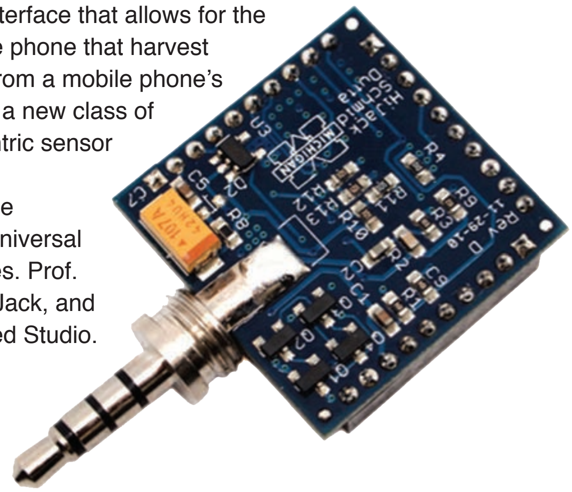
Ambiq Micro, co-founded by Profs. David Blaauw, Dennis Sylvester, and alumnus Dr. Scott Hanson announced that it closed a $10M Series B funding round, August 20, 2013. The company specializes in ultra-low power integrated circuits, and will use the funding to expand their SPOT™ (Subthreshold Power Optimized Technology) design platform, accelerate new product development and expand worldwide market presence.

The SPOT platform technology dramatically reduces energy consumed in standard CMOS chip designs to subthreshold levels – up to orders of magnitude below the power required in today's traditional semiconductor product designs. It can be applied to a wide range of semiconductors used in battery-life critical applications, such as the emerging wearable computing market, smart watches, wireless sensors, smart cards, and low-power medical devices. Battery-powered products that previously lasted a few days on a single charge will be able to run for months or years when designed with Ambiq Micro products, according to the company.

Open Source Corner: HiJack Featured in Electronics Projects Book

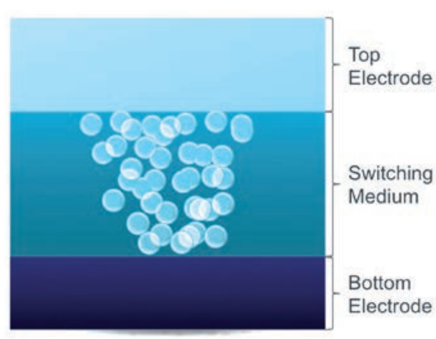
HiJack, the hardware/software platform developed by Prof. Prabal Dutta for use in creating cubic-inch sensor peripherals for the mobile phone, has been featured in the new book, *Building iPhone and iPad Electronic Projects: Real-World Arduino, Sensor, and Bluetooth Low Energy Apps in techBASIC*, by Mike Westerfield, which is aimed at hobbyists, students, professional engineers, industrial designers, and inventors.

HiJack is designed as an interface that allows for the integration of sensors to the phone that harvest power and use bandwidth from a mobile phone's headset interface, enabling a new class of small and cheap phone-centric sensor peripherals that support plug-and-play operation. The headphone jack acts as a universal interface across phone types. Prof. Dutta has open-sourced HiJack, and kits are available from Seeed Studio.



Crossbar, Inc.

Crossbar, Inc., a start-up company pioneering a new category of very high capacity and high-performance non-volatile memory, emerged from stealth mode to announce its Resistive RAM (RRAM) technology. This new generation of non-volatile memory will be capable of storing up to one terabyte of data on a single 200 mm^2 chip. RRAM will enable massive amounts of information, such as 250 hours of HD movies, to be stored and played back from an IC smaller than a postage stamp. It could potentially replace the flash memory commonly used in cell phones, tablets, digital cameras, and solid-state drives. Crossbar has developed a working Crossbar memory array at a commercial fab. Prof. Wei Lu is a co-founder of Crossbar, Inc.



Crossbar RRAM Technology
Simple Implementation for Low-Cost Manufacturability
The resistance switching mechanism of Crossbar's technology is based on the formation of a filament in the silicon-based switching material when a voltage is applied between the two electrodes.

Student News

Largest Student-Run Hackathon Organized and Run at Michigan – in the Big House!

On September 20, 2013 a new record was set at the Big House. Not a sports record – the team was out of town – but a hacking record. 1,214 students from roughly 100 schools across North America participated in the second MHacks, the largest student-run collegiate hackathon to date. The 36-hour long programming competition took place in the luxury boxes at Michigan stadium, and included the opportunity for students to take the field at the Big House. The hackathon concluded with a demo of completed projects and final judging in adjacent Crisler Arena.

This amazing event was conceived and run by EECS-affiliated student group Michigan Hackers in partnership with MPowered Entrepreneurship. To fund the event, the students raised sponsorship dollars from companies across the tech spectrum. It was a follow-up to the groups' first MHacks, which took place in February 2013 and drew about 550 attendees.

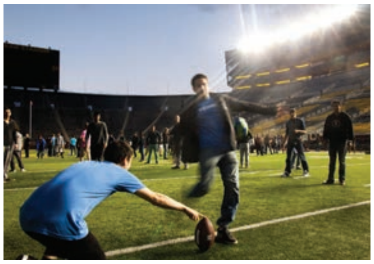
An intelligent trash can that sorts recyclables from garbage won first prize at the 36-hour maker blitz. The team that made *GreenCan* came by bus from the University of Maryland. Second place went to team *Save My Glass*, a "head-up" driving display for Google Glass devised by Mike Huang and Justin Feight, juniors in computer science and engineering at U-M. *Save My Glass* would essentially project a car's dashboard information through Google Glass so the driver wouldn't have to look down to see it. The tool could also use the Glass's blink sensor to determine if the driver had fallen asleep at the wheel, and if so, vibrate to wake him up. Finally, the tool could use the Glass's motion sensors to detect a crash and, if one occurred, dial 911.

"This was one of the most incredible weekends of my life," Thomas Erdman, a junior in computer science at U-M who led the event, told the crowd. "I hope it was one of the most incredible weekends of yours.

"Go home and spread the culture at your schools," he continued. "We saw so many problems solved in 36 hours! Imagine what we can do in a month, or a semester."

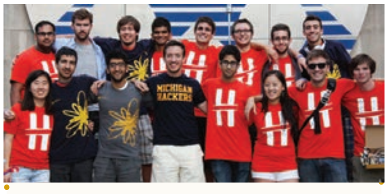
Participants arrived by charter bus from schools across the country.

Hackers filled two levels of the luxury boxes, programming through the night.



Students took a break on Saturday evening to frolic on the field.

The University of Maryland team that was chosen as the event's top hackers.



Hackers Recognized, Inspired at PennApps

Over 20 students associated with Michigan Hackers travelled from Ann Arbor to Philadelphia to compete in the Fall '12 PennApps, then the largest student-run hackathon.

Four U-M students – Brad Bergeron, Cole Kushner, Joe Scherping, and Aaron White – won Best Mobile Hack for their project, *Perimeter*, in which they hacked a power strip and developed a mobile application to control its output. Three other Wolverines – David Fontenot, Shiva Kilaru, and Raj Vir – walked away with the award for Most Viral App with *Hack My Facebook*, an application that contributes comedic posts to one's Facebook account.

Thrilled by the PennApps experience and emboldened by their success, the returning Wolverines were inspired to organize MHacks, the first of which took place five months later and exceeded PennApps in size.

6th Mobile Apps Hackathon: Building More Apps, More Creativity

One of the early faculty proponents of mobile app development is still giving students the space, time, encouragement, and food and drink on a near-continuous basis to make it happen. Elliot Soloway, Arthur F. Thurnau Professor, held his 6th 48-Hour Mobile Apps Hackathon in September 2012. Over the weekend, 60 students nestled into the cozy, techno-cave environment of Design Lab 1 at the Duderstadt Center and worked around the clock in teams to create projects for the iOS and Android platforms, with some camping in the lab and crashing in sleeping bags. At the end of the programming period, 35 of the students demoed an impressive array of 10 complete and functioning mobile apps, including a handheld vision test, a program to read and play sheet music, a guide to bar hopping, and more.

W8UM – Amateur Radio Club @ 100

By Jameson Eisele, EE and Sound Engineering
President of the ARC

The University of Michigan Amateur Radio Club (ARC) is celebrating its 100th anniversary this year, an exciting milestone for an organization founded following the birth of wireless communication.

In the early 1900's, the Electrical Engineering department, as it was then called, used a spark gap transmitter for research. When the U.S. Department of Commerce established a system for licensing radio stations in 1912, the University was awarded the experimental call sign 8XA.

In the decades following, the station was used by the College of Engineering for research, and by the ROTC Signal Corps for radio telegram communications. During the 1920's and 1930's, the station, then licensed as W8AXZ, relayed messages on behalf of the Hobb Greenland and Alberson/Boyd Antarctic expeditions. After the Second World War, amateurs continued activity at Michigan, often with separate stations for each dormitory on campus. In 1967, the Club was relicensed as W8UM, its current call sign, by special request for the University's sesquicentennial.

Today, the University of Michigan Amateur Radio Club continues to operate, now from facilities in the Electrical Engineering and Computer Science building. Here, students, staff, faculty, and community members gather to promote a hobby that continues to serve the entire University community. The Club 'shack' houses high-performance communications equipment and contains resources for members to design, build, and test their own radio projects.

Recently, the station has been used by students to communicate with Michigan's own CubeSats in space! As the ARC club moves into the next century, we look forward to continued collaborations with other departments and student from all programs: electrical engineering, physics, aerospace, computer engineering, and much more.

As part of its centennial celebrations, the ARC hosted a special event station on April 14, 2013 on Central Campus. Amateurs from around the country came to help the Club set up and operate the station, and in total around 86 contacts were made throughout the day.

Jameson Eisele in the Shack.

ECE Poster Session at the Engineering Graduate Symposium

More than 85 ECE graduate students presented their research at the 2012 College of Engineering Graduate Symposium. The Symposium is attended by prospective graduate students as well as current faculty and students. Prizes were awarded in each technical session. The following students earned first place in their sessions:

Azadeh Ansari, *GaN-based Micro-mechanical Resonators for Timing Applications* (MEMS)

Nicholas Asendorf, *The Performance of Deterministic Matched Subspace Detectors: Informative Versus Useful Subspace Components* (Signal Processing and Computer Vision)

Wongun Choi, *A Unified Framework for Multi-target Tracking and Collective Activity Recognition (Computer Science and Software Design)*

Gurkan Gok, *Experimental Verification of Tensor Transmission-line Metamaterials: A Printed Beam-shifting Slab* (RF and Applied Electromagnetics)

Seunghyun Lee, *An All-graphene Flexible and Transparent Circuit for Quaternary Digital Modulation* (Solid State Materials and Physics)

Wei Liang, co-winner, *13.56 MHz High Density dc-dc Converter With PCB Inductors* (Power and Control)

Mahdi Sadeghi, *Micro-hydraulic Structure for High Performance Biomimetic Air Flow Sensor Arrays* (Microfluidics)

Aria G. Sahebi, *An Achievable Rate Region for the 3 User Interference Channel Using Algebraic Codes* (Systems Engineering and Communications)

Andrew Wiggins, *Large-scale Surface Effect Ship Bow Seal Experiments* (Naval Architecture and Marine Engineering)

Kan Zhou, co-winner, *Computationally-efficient Finite-element-based 3D Thermal Models of Electric Machines* (Power and Control)

Photos and Abstracts

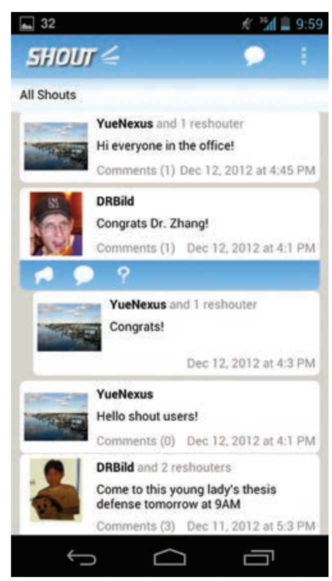
75th Anniversary for HKN

2013 marks the 75th anniversary for Eta Kappa Nu (HKN), the honor society for students in IEEE-designated fields, which includes all areas of specialty in EECS. In 2010, HKN and IEEE merged nationally to form IEEE-HKN, which suits our students just fine. They have been collaborating together for many years at Michigan, most prominently in the jointly-run dB Café.

U-M's HKN Beta Epsilon chapter organizes a wide variety of service projects, such as sewing hats for the homeless, cooking for high-schoolers at Neutral Zone, and cutting down invasive species in the Arb. The members like to have fun, so they organize regular social events, including laser tag, Whirlyball (lacrosse + bumper cars), IM sports, and much more.

Since its founding in 1937, U-M's HKN Beta Epsilon chapter has produced more than 3,000 alumni who are now contributing to society throughout the world.

SHOUT: A Censorship-resistant Microblogging App



A team of student developers created an app called Shout that was designed so that messages can be sent to others in relatively close proximity - even when there is no network infrastructure. It offers an alternative to a centralized service like Twitter that can be disabled or even subject to censorship by an oppressive government, which has happened recently.

The mix of undergraduate and graduate students who developed the program were David Adrian, David R. Bild, Gulshan Singh, and Anthony Tesija. They were advised by Profs. Robert Dick and Z. Morley Mao at U-M, and Prof. Dan Wallach at Rice University.

More Info

Interdisciplinary Teams and Other Student Competitions

BLUELab and Nils Stannik: Working for a Sustainable World

U-M's BLUElab (Better Living Using Engineering Laboratory) is a student-run organization made up primarily of engineering students that works toward sustainable solutions to development problems at home and abroad. Their projects range from providing wind energy and solar heating in Guatemala to providing clean water in Jamaica and Nicaragua, and even equipping a home in Ann Arbor for net-zero water use.

Nils Stannik got involved with BLUElab somewhat through the back door. Nils, who recently graduated with his bachelor's degree in electrical engineering, has a passion for energy research, sustainability, and social justice. During Spring Break of his freshman year, he worked with a local non-profit organization called Appropriate Technology Collaborative (ATC) installing solar panels on a trade school in rural Guatemala. This is now an ongoing project with BLUElab. Next, Nils was drawn into the planning stages by friends of a project to bring electricity to Guatemala using wind energy. This became the BLUElab project called Woven Wind. Nils traveled to Guatemala with the BLUElab team to help build the wind turbines. This particular project was selected as the winner of the 2012 IBM/IEEE Smarter Planet Challenge. Nils was one of the team leaders of a 34-member interdisciplinary team. In addition to the wind turbines, the students educated middle and high schools students in the village about renewable energy.

Nils Stannik (lower left) working on the wind turbine in Guatemala with fellow BLUElab students.

BLUElab student members with Guatemalan women weavers in the Guatemalan village of Nueva Santa Catarina Ixtahuacán.

Solar Car Team

Michigan students build the most efficient electric vehicle in the United States – judging by their success competing in the American Solar Challenge. The Michigan Solar Car team took first place in the last four races and seven times overall, most recently in 2012. There have only been 11 races in North America since 1990.

The team's newest car, which they built from scratch (like all of their solar cars), is called Generation. Unlike recent cars, it has four wheels which was required for their next race – the 2013 World Solar Challenge. The team says their design is straying from the norm by having the driver seated on the left instead of in the middle of the car. Why? It's more aerodynamic that way.

EECS Members of the Solar Car Race Crew in Australia: Tony Fan (Power Electrical Engineer), Cam Herringshaw (Race Strategist), Sarah Spitzer (Micro Electrical Engineer), Matt Goldstein (Head Strategist), Jessi Beck (Race Strategist), Ian Larson (Micro Electrical Engineer).

EECS students have a blast on the Solar Car team, and definitely pull their own weight. Members of the race team currently in Australia are Matt Goldstein, Head Strategist of the team and part of the four member race committee; Sarah Spitzer, Micro Electrical Engineer; Tony Fan, Power Electrical Engineer (responsible for the electrical systems related to power generation and energy storage in the solar array and battery pack); Race Strategists Cam Herringshaw (writes software to model the car and determine the most optimal race strategy) and Jessi Beck (focuses on the user interface of tools to figure out how fast to race the car; and Ian Larson, Micro Electrical Engineer. Ian is responsible for the battery's monitoring and protection system. He will also be checking the car's telemetry data in the chase vehicle.

Sarah Spitzer driving Generation.

These students take a semester off to participate in the race, but for them, it is an honor and well worth the time and effort. All of the students are thrilled to finally get a look at the other cars and put their own car to the test. As Cam stated, "it's going to be a challenge that will test everything I've worked on over the past two years!"

Cheer on the entire team to victory when they race against the best amateur and professional solar car teams in the world. They've reached third place in the World Solar Challenge, a remarkable feat, but still have their eyes on the ultimate prize. The countdown has begun – and the flag falls October 6, 2013 for the 3,000 km race.

2013 Michigan Clean Energy Venture Challenge

Established by U-M and DTE Energy, this annual competition encourages student technologists from colleges and universities across Michigan to transform clean-tech ideas into viable ventures. In 2013, 22 teams from ten Michigan colleges and universities made it to the semifinal round of the competition. Our students earned first and shared second place in this year's competition.

Ryan Moore, Danny Ellis, and Tom Brady.

A company founded by U-M graduate students won the $50,000 top prize in the 2012 Michigan Clean Energy Venture Challenge for their use of unmanned-aerial-vehicle technology in inspecting wind turbines. SkySpecs LLC is developing small, robotic, four-propeller helicopters that is controlled via a touchscreen tablet and that can remotely gather inspection data from hard-to-reach or hazardous places in infrastructure such as bridges and wind turbines.

SkySpecs founders include Sam DeBruin (BSE CE '12 and CSE graduate student) and Ryan Moore (BSE CE '11). Rounding out the team are Danny Ellis, (BSE AERO '12 and dual master's in Aerospace Engineering and Entrepreneurship) and Tom Brady, who recently completed his master's in Aerospace Engineering.

Keith Porter (standing) and Ansgar Strother rode away with second place (tie) and a $15K prize.

These computer engineering alumni came up with the idea of starting a company that would provide affordable access to bicycles for short-distance trips. Their bicycles are significantly less expensive than existing models, and offer flexibility, convenience, and a top notch touchscreen interface on the handlebars. They are now designing and building the software and hardware to create their fleet of shared bicycles.

More Info

10th Game Development Contest Yields Games in 48 Hours

Wolverine Soft, the student group dedicated to designing and building video games, held its 10th annual game development contest in January 2013. The competition, sponsored by Blizzard Entertainment, EA Sports, Zynga, and Pillar Technology encourages groups of students – including those from related disciplines such as art and music – to form and create a working game around a theme in 48 hours.

This year, the theme was "The End?" Winning games were:

1st Place: *Charon's Refusal* by Connor Ullmann

2nd Place: *Temple Redemption* by Charles Lewis, Steven Lebioda, and Audra Hagan

3rd Place: *Perdition* by Helen Lai, James Kotzian, and Julia Sokolow

Armin Alaghi, Zakir Durumeric, Steven Schultz (Northrop Grumman), Prof. Benjamin Kuipers, Clifford Frieler (Northrop Grumman), Hsin-Hao Su, and Amjad Abu Jbara.

CSE Graduate Student Honors Competition Highlights Exceptional Research

CSE concluded its ninth annual CSE Graduate Student Honors Competition on November 12, 2012 when four finalists each gave a summary presentation on their research. Finalists were:

1st Place: Armin Alaghi, Advanced Computer Architecture Lab, *Enhancing Vision via Stochastic Computing*

2nd Place: Zakir Durumeric, Software Systems Lab, *Mining Your Ps and Qs: Detection of Widespread Weak Keys in Network Devices*

Honorable Mentions: Amjad Abu Jbara, Artificial Intelligence Lab, *Mining Multiple Perspectives From Social Media* and Hsin-Hao Su, Theory Lab, *A Scaling Algorithm for Maximum Weight Matching in Bipartite Graphs*

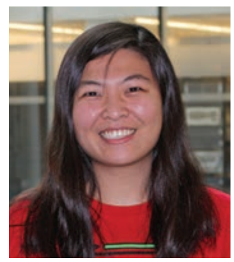
MAAV Team Top in North America, Second in the World

The Michigan Autonomous Aerial Vehicles (MAAV) student team came out on top in the North American venue of this year's International Aerial Robotics Competition, a contest that just closed its 23rd year, and its sixth mission. Missions are repeated each year if not completed by any team. In 2012, U-M's group came the closest of the 21 participating teams worldwide to complete Mission 6. But 2013 was "the year that everything broke," as the team's previously solid platform developed crashes and bugs that required troubleshooting right up until competition. The team's autonomous robotic quadrotor completed all mission objectives except for one: picking up a flash drive and leaving a decoy in its place. Still, they received more points than any other in the U.S. competition. But in the Asia venue for the competition, Tsinghua University was able to complete the mission, and thereby win the entire competition. The MAAV engineers are rightfully proud of what they accomplished. "What did we learn?" said Jonathan Bendes, CS undergraduate and MAAV Navigation Lead. "Perseverance and a good sense of humor can pull you through anything." What's next? Mission 7!

Students Win at ICCAD Place-and-Route Competition

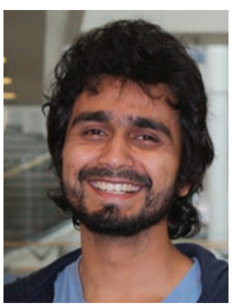
Jin Hu (PhD CSE '12) and Myung-Chul Kim (PhD EE '12) won first place at the ICCAD 2012 Place-and-Route Competition, which challenges student teams to optimize the design of circuit elements and configurations for increased performance. 56 teams from all over the world participated in the contest.

Hu and Kim fully leveraged their doctoral research performed under the guidance of Prof. Igor Markov to win the combination. Hu's dissertation was on high-performance routing algorithms (defended in October 2012) and Kim's was on multiobjective algorithms for VLSI placement (defended in August 2012). Together, they developed a placement algorithm that produced high-quality layouts for integrated circuits with several million independently-placeable objects, and did so significantly faster than other top competitors.

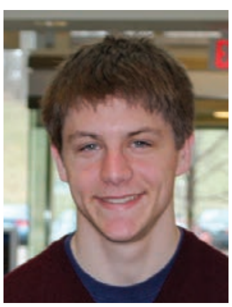


Jin Hu

Myung-Chul Kim



Pankit Thapar



Benjamin Vandersloot

Students Earn Two Awards at ISPD Gate Sizing Contest

Team Trident, a student team including CSE graduate student Pankit Thapar and CS undergraduate Benjamin Vandersloot, won two awards in the 2013 ISPD Discrete Gate Sizing Contest, which took place on March 27, 2013 at the *ACM International Symposium on Physical Design*. The team, coached by Prof. Igor Markov and by Prof. Andrew Kahng at UCSD, placed first in the competition's secondary metric category and second in the primary metric category. The contest focused on gate-sizing and threshold voltage assignment for a given circuit to achieve the lowest possible operating power that still satisfied performance constraints.

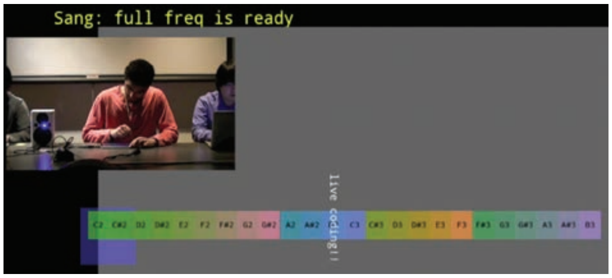
EECS 583 Code Optimization Contest

Students in Prof. Scott Mahlke's *Advanced Compilers* course (EECS 583) competed in the 2012 Annual Code Optimization contest to create a compiler that generates the fastest applications.

The students were judged on four compute-intensive benchmarks. The first criteria was that all the applications had to run correctly. Then, highest performance was used to select the winner.

The overall winner was undergraduate Ari Chivukula, who achieved a geometric mean of 1.5x speedup on the four benchmarks and a class high of 3.5x on one of the benchmarks. CSE graduate students Supriya Rao and Qi Chen placed 2nd and 3rd in the overall competition. Congratulations also went to Justin Paupore and Earlence Fernandes, who scored first place finishes on individual benchmarks.

Student Team Places Third in Inaugural Live-Coding Competition



A team of three students advised by Prof. Georg Essl has won third prize in the first live-coding competition held at the inaugural LIVE workshop on May 19, 2013 in San Francisco. The team, which used Prof. Essl's mobile music performance platform, urMus, pushed boundaries by being both the highest-placing team to live-code music, and the highest-placing team to live-code on mobile devices. For their entry, two of the students dynamically wrote code to construct a live mobile music instrument on the fly that was simultaneously performed by the third student. The performance incorporated both musical and visual elements as well as engaged the audience in the process through text. The team was led by CSE PhD candidate Sang Won Lee, who is developing the area of collaborative mobile music performance through live-coding as part of his doctoral work, and included undergraduate students Cameron Hejazi and Bruno Yoshioka.

Over 100 Students Compete in Barracuda Networks Programming Competition

The second annual Barracuda Networks Programming Competition at U-M took place in October 2012 with more than 100 students competing. The contest provided 24 hours of white knuckle excitement as students developed game-playing "bots" which competed against each other in a multi-stage game competition. During the contest, students were able to continuously test and refine the performance of their bots, adding to the tension and excitement. Winning teams were:

1st Place: Team M&M – Mark Gordon (Mark also won in 2011) and Caoxie Zhang

2nd Place: Team AppleGuys – Junfeng Zhuang, Lin Hao Peng, Erdong Li, and Yijia Tang

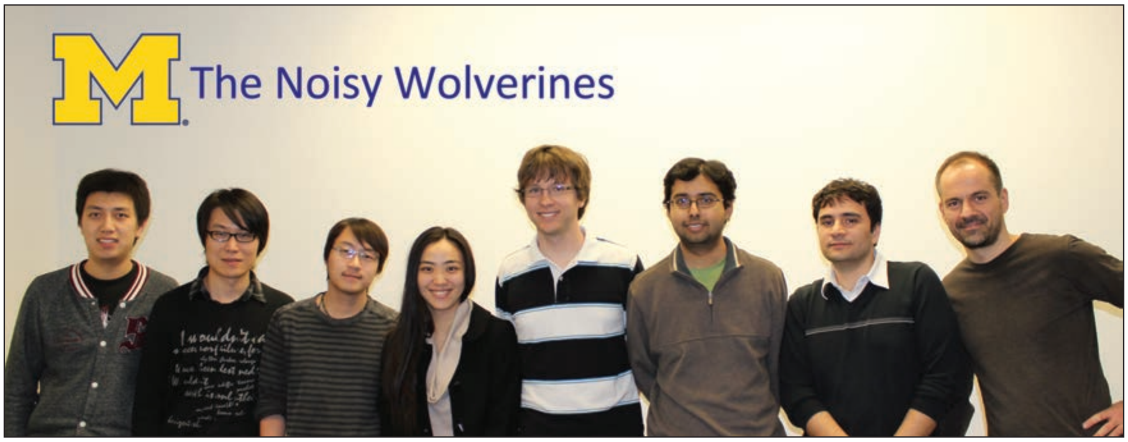
3rd Place: Team STOMP 2.0 – Michael Groshans, Eric Anderle, and Bill Hass

Michigan Hybrid Racing

In their second year of competition, the Michigan Hybrid Racing team and their car, Spark, overcame several obstacles on their way to a 4th place finish in the 2013 Formula Hybrid Racing Competition, held at the New Hampshire Motor Speedway April 29–May 1, 2013. They also took 2nd place in the Chrysler Innovation Award.

Being able to actually race a car is one of the biggest hurdles at the track. Only half the teams were able to compete in this portion of the competition. It was a close call for Michigan as well due to some last minute snafus.

When asked what were the greatest moments of the competition, Sam Haberl, co-leader of the entire team double majoring in EE and CE, said with a tone of reverence, "Oh – watching it drive – watching it drive. And getting the innovation prize." "Everybody at the competition loved this car," he added. "It has a very unique powertrain, and we use regen[erative] braking. And it flies – it's a muscle hybrid, it's very fast. We also have excellent handling because we have all-wheel drive power." The team is very optimistic about their chances next year, and Sam believes a win is definitely possible.



Noisy Wolverines Will Now Compete for Gold

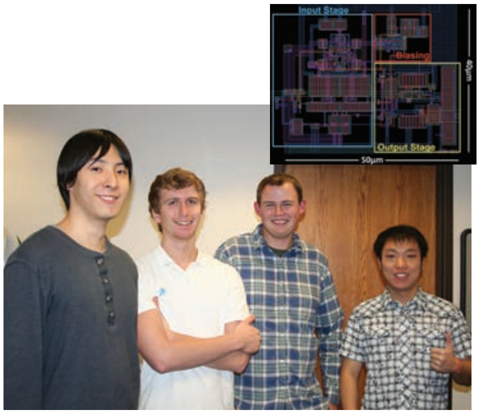
A team of "Noisy Wolverines" made it through the first round of competition to be among the top 15 teams in the nation to compete in the DARPA Spectrum Challenge competition. They hope to take home the prize for best communication system design.

The team of graduate students, led by Prof. Achilleas Anastasopoulos, ranked 4th among 90 competing teams in the qualification round; only 46 teams were able to complete all three qualification hurdles. To win the competition, the students will demonstrate a radio protocol that is able to provide the most reliable communication in an environment fraught with competing radios and other disrupting elements.

To compete in the challenge, Prof. Anastasopoulos put together a team of Electrical Engineering:Systems and Computer Science and Engineering graduate students with expertise in programming, physical layer design, and Universal Software Radio Peripheral (USRP) design. His own expertise includes communication theory with an emphasis on designing effective transmission schemes for noisy channels, and code design for wireless channels.

EECS Courses + Contests

EECS 413: Monolithic Amplifier Circuits
Prof. Michael Flynn
Sponsor: Cirrus Logic, Inc.



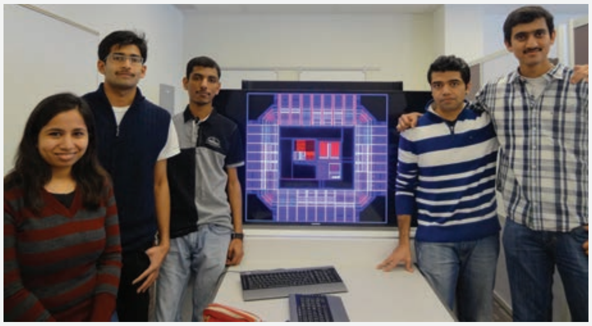
Haito Wang, Brandon Maierle, Adam Mendrela, Wenjia Wang.

1st Place: *A Rail to Rail Class AB Amplifier*, by Haitao Wang, Adam Mendrela, Wenjia Wang, Brandon Maierle

2nd Place: *Ultra Low Power Crystal Oscillator,* by Yi Yuan, Shiming Song, Zachary Lyzen

AMD/Michigan Student Design Contest

EECS 427: VLSI Design I
Prof. Zhengya Zhang
Sponsor: Advanced Micro Devices (AMD)



Akanksha Jain, Nischit Bharadwaj, Naveen Bharathwaj Akesh, Abhijith Kini Gokuldas, Aditya Maskeri.

1st Place: *Ultra-Low Leakage Subthreshold 8T SRAM with Speed Compensation*, by Abhijith Kini Gokuldas, Naveen Bharathwaj Akesh, Aditya Maskeri, Nischit Bharadwaj, Akanksha Jain

2nd Place: *Low Power 3T Embedded DRAM*, by Adrian Montero, Hang Li, Lili Wang, Shihan Huang

3rd Place (tie): *An Ultra Low Leakage 10T SRAM with Speed Compensation Scheme*, by Wanyeong Jung, Michael Laskey, Zhao Xu, Myungjoon Choi, Donguk Yang

3rd Place (tie): *A Low-Power, Low-Voltage ALU and Register File for Energy-constrained Applications*, by Kyusok Lee, Adam Mendrela, Jihong Min, Madin Kim, Yu-Ju Lin

Computer Games Showcase

EECS 494: Computer Game Design
Prof. John Laird
Sponsors: Electronic Arts and Microsoft

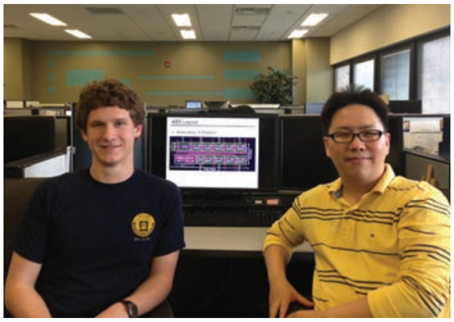
In December 2012 students showcased their final projects to a packed house at this annual event. The evening began with short presentations by the student developers, followed by an opportunity for all attendees to play the games running on computers in the Beyster Building's Tishman Hall. Attendees were then able to vote for their top three favorite games. The winners were:

1st Place: *Chimera*, by Jake Chrumka, Kyle Fassnacht, Michael Schroder, and Joshua Wehrly

2nd Place: *Into the Darkness*, by Bryan Bush, Max Corman, and Rebecca Moore

3rd Place: *Snowball Blast*, by Jared Combs, Daniel Scalise, Jeffrey Chang, and Sen Lu

EECS 511: Integrated Analog/Digital Interface Circuits
Prof. Michael Flynn
Sponsor: Analog Devices, Inc.

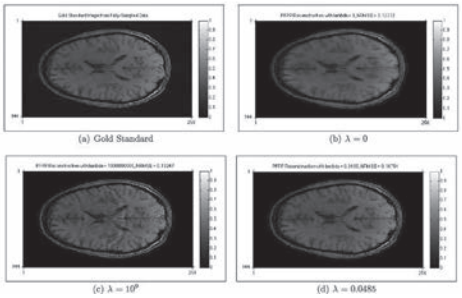


David Moore and Yong Lim (Mehmet Dayanik not available for photo).

1st Place: *A 50MS/s, 10.5-Bits, 21.3fJ/conv.steps Pipeline ADC using Ring Amplifier,* by Yong Lim, Mehmet Batuhan Dayanik, David Moore

2nd Place: *18b Incremental Zoom-ADC in 0.13μm CMOS,* by Seok-hyeon Jeong, Wanyeong Jung, Sechang Oh

EECS 556: Image Processing
Prof. Jeff Fessler
Sponsor: KLA-Tencor



Yash Shah, Gopal Nataraj, Brandon Oselio.

1st Place: *Reconstruction of Accelerated MRI Acquisitions which use Partial Fourier, Partial Parallel (PFPP) Imaging Techniques*, by Gopal Nataraj, Brandon Oselio, Yash Shah

2nd Place: *Optimal Motion-compensated Frame Rate Up Conversion*, by Taining Liu, Xiaolin Song, Jinze Yu

Alumni Career Panel

Students were excited to hear from EECS alumni at a Homecoming Career Panel, Thursday, October 11, 2012. The illustrious panel included Dr. Cahit Akin, co-founder and CEO of Mushroom Networks, Inc., which provides innovative networking solutions based on their patent pending Broadband Bonding technology; Dr. Craig Labovitz, co-founder and CEO of DeepField, an Ann Arbor based company that provides analytics and cloud intelligence for companies doing business on the Internet; Richard Sheridan, co-founder and CEO of Menlo Innovations, an Ann Arbor based agile software development firm; and David Tarver, co-founder of Telecom Analysis Systems and author of *A Proving Ground*.

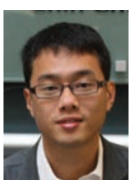
David Tarver, Cahit Akin, Rich Sheridan, Craig Labovitz.

Individual Honors and Awards

Chris Berry (EE graduate student) received an IEEE Antennas and Propagation Society (AP-S) Doctoral Research Award to support his doctoral research in the area of plasmonic photoconductive antennas for high power terahertz generation.

Meghan Clark (CSE graduate student) received a Microsoft Graduate Women's Scholarship to support her work in the areas of embedded systems, ubiquitous computing, and security.

Brad Campbell and **Patrick Pannuto** (CSE graduate students) received an Honorable Mention and $50K prize for the 2013 Qualcomm Innovation Fellowship for their proposal for a new wireless sensor network architecture that decouples synchronization from communication.

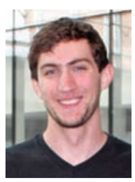


Chih-Chun Chia (EE:Systems graduate student) was selected as a J. Robert Beyster Computational Innovation Graduate Fellow to support his work in developing computational techniques that can leverage large physiological datasets to improve understanding of major diseases.

Hyoun Kyu Cho (CSE graduate student) has received a Rackham Predoctoral Fellowship to support his research into compiler and architecture techniques for improving programmability of parallel systems.

Yunzing Dai (CSE master's student) received the Barracuda Networks Fellowship, which provides support for a promising full-time master's student who is pursuing a course of study leading to a career in the computer science industry.

Bharan Giridhar (EE graduate student) received a Rackham Predoctoral Fellowship to support his research while he completes his dissertation entitled, *Circuit Techniques for Adaptive and Reliable, High-Performance Computing*. He also received an Intel Corporation PhD Fellowship.

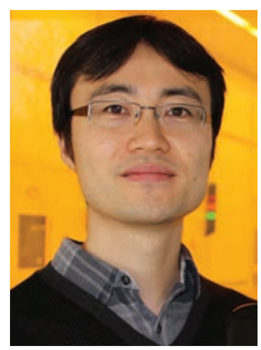


Mark Gordon (CSE graduate student) received a Google Fellowship to pursue his work in applying operating system techniques to the mobile platform.

Michael Hand (BSE EE 2011 and EE:Systems graduate student) is the recipient of the 2013–2014 Bosch Sustainability Fellowship to explore ways to improve diesel efficiency through advanced control and diagnosis strategies.

David Hiskens (EE undergraduate student) received an IEEE Power & Energy Society Scholarship as well as a John W. Estey Outstanding Scholar Award from the *IEEE Power & Energy Society*.

Gyouho Kim (EE graduate student) received a Rackham Predoctoral Fellowship to support his research while he completes his dissertation entitled, *Ultra-Low Power Optical Interfaces for Nearly Invisible Cubic-Millimeter Wireless Sensor Nodes.*



Seunghyun Lee (EE graduate student) received a Gold Graduate Student Award at the Fall 2012 *Material Research Society* meeting based on the paper, *An All-Graphene Flexible and Transparent Circuit for Quaternary Digital Modulation*, co-authored by fellow graduate students Kyunghoon Lee, Chang-Hua Liu, Girish S. Kulkarni, and his advisor, Prof. Zhaohui Zhong.

Biruk Mammo (CSE graduate student) has received a Rackham Predoctoral Fellowship to support his research into solutions to assist processor designers in addressing the challenges in reliability that arise as processors become ever more smaller and more densely packed with transistors.

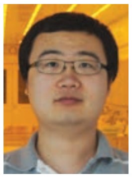
Rachael Miller (CS undergraduate) won the Best Undergrad Poster Award at the Michigan Celebration of Women in Computing Conference for *A Natural User Interface for 3-D Environments.*

Sanae Rosen (CSE graduate student) won the Best Poster Award at the Conference on Data and Application Security and Privacy for *AppProfiler: a Flexible Method of Exposing Privacy-Related Behavior in Android Applications to End Users.*

Patrick Pannuto (CSE graduate student) was selected for both a National Science Foundation Graduate Research Fellowship and a National Defense Science and Engineering Graduate Fellowship from the Department of Defense for his work in developing automated cubic millimeter wireless sensor network technology.

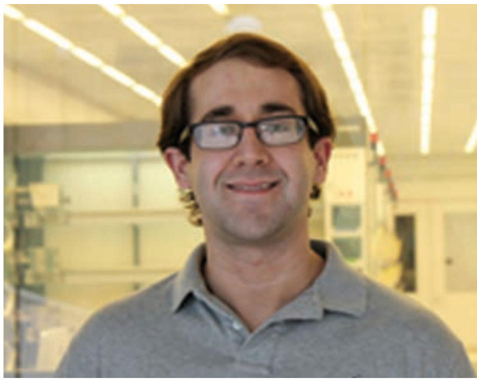
Nicholas Triantafillou (honors math/honors CS undergraduate) has received the Churchill Scholarship, which funds a year of graduate study in mathematics, biological and physical sciences, and engineering at the University of Cambridge.

Nils Stannik (EE graduating senior) received an IEEE Power & Energy Society Scholarship to pursue his undergraduate education in the area of renewable energy.



Cheng Zheng (EE graduate student) received an Optics and Photonics Education Scholarship by the *International Society for Optics and Photonics (SPIE)* to advance his research in the areas of nanophotonics and nanofabrication.

Scott Reed (CSE graduate student) was selected for both a National Science Foundation Graduate Research Fellowship and a National Defense Science and Engineering Graduate Fellowship from the Department of Defense for his work in developing new machine learning methodologies to solve problems in computer vision and other domains.



Ethan Stark (BSE EE '13 and EE graduate student) received an NSF Graduate Research Fellowship to support his research investigating visible light emitters using GaN microstructures for quantum dot and nanowire-based LEDs and lasers.

EECS and CoE Awards for Academic Year 2012–2013

Undergraduate

CoE Distinguished Academic Achievement Award
David Hiskens (EE)
Ryan Roberts (CS)
Yan Zhang (CE)

CoE Harry B. Benford Award for Entrepreneurial Leadership
Keith Porter (CE)

CoE Arlen R. Hellworth Award
Nathan Patel (CS)

CoE Cooley Writing Prize
Nick Ruff (CS), fiction category
Nils Stannik (EE), non-fiction category

CoE Tau Beta Pi First Year Award
Lauren Bilbo (EE)

EECS Outstanding Achievement Award
William Beyer (CE)
Ryan Roberts (CS)
Bochao Wang (EE)

EECS William L. Everitt Student Award of Excellence
Paul Rigge (EE)
Alex Robinson (CS)
Yuan Zong (CS)

EECS Outstanding Research Award
Shaobo Liu (CE)
Calvin McCarter (CS)
Tianhua Zhang (EE)

EECS Outstanding Service Award
Samantha Eaton (CE)
Nathan Patel (CS)
Nils Stannik (EE)

EECS Commercialization/ Entrepreneurship Award
Timothy Jones (CS)
Matthew Schulte (CE)

EECS William Harvey Seeley Prize
Kwesi Rutledge (EE)

EECS Richard K. Brown Memorial Scholarship
Jameson Eisele (EE)

Graduate

EECS Instructor's Aide Award
Vidal Borromeo (CSE)
Lars Hamre (CSE)
Charlie Yan (ECE)

Richard F. and Eleanor A. Towner Prize for Distinguished Academic Achievement
Mads Almassalkhi (EE:Systems)
Andrew Hollowell (EE)
Mehrzad Samadi (CSE)

Richard F. and Eleanor A. Towner Prize for Outstanding GSIs
Apoorva Bansal (CSE)
Jay Patel (EE:Systems)
Holly Tederington (CSE)

EECS Graduate Student Instructor (GSI) Award
Jihyun Cho (ECE)
Pulkit Gupta (CSE)
Alex Kaplan (ECE)
Tai-Chuan Ou (CSE)
Sungjoon Park (ECE)
Prerit Pramod (ECE)
Scott Walls (CSE)

Honorable Mentions for GSI Award
Supreet Jeloka (ECE)
Sudarshan Sivaramakrishnan (ECE)
Aaron Snook (CSE)

Yahoo! GSI Award for CSE Students
Yuzhou Liu
Hongyu Wang

Alumni News

Prof. Khalil Najafi, Odila Braga, Stila Sousa, and José Sousa.

José Sousa (BSE MSE EE ’51 ’52) traveled to Homecoming from Brazil with his wife, Stila Sousa, and daughter, Odila Braga. José brought with him six books written by Brazilian authors, and donated them as a symbolic gesture to celebrate the diffusion of science, knowledge and technology throughout the world. He believes that the University of Michigan with its many foreign students is a beacon for this transfer of knowledge. Mr. Sousa spent his career in the Brazilian Navy, becoming an Admiral. He was in charge of the design and construction of the Navy’s new frigates and submarines.

Don Mayer on a hike near his home in Palos Verdes, CA.

Donald C. Mayer (BS MS Physics ’69 ’70; MS Electrical Science ’77, PhD EE ’77) enjoyed reading about Prof. Ken Wise in the last issue of *EECS News*. He knew Ken and others present at the retirement celebration, and even recognized the sensor chip Prof. Wise had been working on at the time.

Don had a fascinating career himself working first at Hughes Research Labs, and then for The Aerospace Corporation. At Aerospace, he is Director of the Space Electronics Vulnerability Office, where he directs survivability activities related to electronics and optoelectronics vulnerabilities in space, as well as mission assurance activities for DOD, civil, and commercial space programs. Prior to this, he was Director of the Microelectronics Technology Department, where he was responsible for advanced microelectronics technology development, including CMOS, CMOS/SOI, and MEMS, with emphasis on reliability and radiation hardness for space systems applications.

On the side, he teaches undergraduate and graduate-level circuits courses at UCLA.

Jonas Daunoravicius (BSE CE ’03) and his wife Kim welcomed Gabrielle Reese on August 5, 2012. This future wolverine was born at Mott in Ann Arbor.

Ben Stoppe (BSE MSE EE ’78 ’78) received a Meritorious Public Service Award from the U.S. Coast Guard for his outstanding efforts in support of the Coast Guard Aviation Association. Commander Stoppe, USCG (Ret) performed many voluntary services for the Coast Guard, including overseeing two major air station memorial projects and coordinating a book on early Coast Guard Aviation.

Mark Lutvak and Phylis Davis.

Mark Lutvak (BSE EE ’62) attended the Homecoming lunch in 2012 with Phylis Davis, and shared some fun stories about his life. While an undergraduate engineering student, he was a frat roommate with Sam Zell and Bob Lurie, and witnessed one of their earliest business successes. After graduation, Mark worked at Burroughs and got his MBA before moving to Silicon Valley. He worked primarily at Atari and Memorex in the areas of sales and marketing before starting his own company at the age of 50. He is now founder and owner of Synergistic Marketing. He says he’s the side of entrepreneurship that links up smart tech people with the business people who can help make their products a reality. His company primarily deals with medical technology.

ALUMNI SPOTLIGHT

Dick Costolo

In the Moment

Dick Costolo
BS Cpt&Com Sc ’85
CEO
Twitter

If there’s a man of the moment, it’s Twitter CEO Dick Costolo.

The first moment came in 1977, when his father brought home a Radio Shack TRS-80 computer with 16KB of RAM. “I learned to program simple things on it, like getting a little cube to fire a bullet, and making a pixel disappear where the bullet struck,” says Dick. “I thought that was really cool, and it instantly got me hooked, so by the time I went to Michigan I knew I was going to study computer science.”

Dick did study CS at Michigan, graduating with a degree in Computer and Communication Studies. At the time, CCS was offered through the College of LSA, so while in his senior year he took an acting class to fill a requirement. He loved it so much that he took another in the second semester and began performing as a stand-up comedian in the Michigan Union at the University Club. At graduation, he took “a big bet on myself,” turning down three job offers from tech companies to plunge into the world of acting, performing with Chicago’s Annoyance Theater and studying improv at Second City.

It was while studying in Chicago that Dick learned the critical importance of being “in the moment” to success at improv. He leveraged this lesson after returning to the tech world when he saw opportunity once “the Internet happened,” making his move as an entrepreneur and blazing a trail through startups Burning Door Networked Media (web design and development), SpyOnIt (web page monitoring), and FeedBurner (web feed management provider). All of these ventures had successful exits, with Google paying more than $100 million for FeedBurner.

Dick left Google to become COO, and in 2010 CEO, of Twitter, a company that is all about the moment.

“One of the challenges we have at Twitter,” says Dick, “is that because it’s so real-time, it’s life in the moment, and that moment is this moment, not yesterday’s moment. Social media sites are kind of yesterday’s moment, and Twitter is this moment.”

This demands that Twitter deliver tweets as they are generated all over the world, in real-time, which is a challenge that continues to expand in scope. Some of Twitter’s users have tens of millions of followers, and Twitter broadcasts tens of thousands of tweets every second, all in a perfectly chronologically-ordered timeline.

Supporting this torrent of activity, according to Dick, calls for a completely different way of thinking about read-write stores, caching, and data delivery; an approach that is uniquely Twitter. “In one sense, what we have to do architecturally is so wildly different that it requires a rules-breaking way of thinking about it, and in another

Tweet-sized thoughts about Michigan:

“Irrespective of how you enter the University, you graduate from Michigan with a much broader perspective of the world.”

“I always joke that it’s a couple of Michigan engineers who correct my grammar and not the half of the company that are not engineers.”

“I did assignments on the MTS time-share system, & we only had a limited budget of compute time for each project. We were always waiting for terminals.”

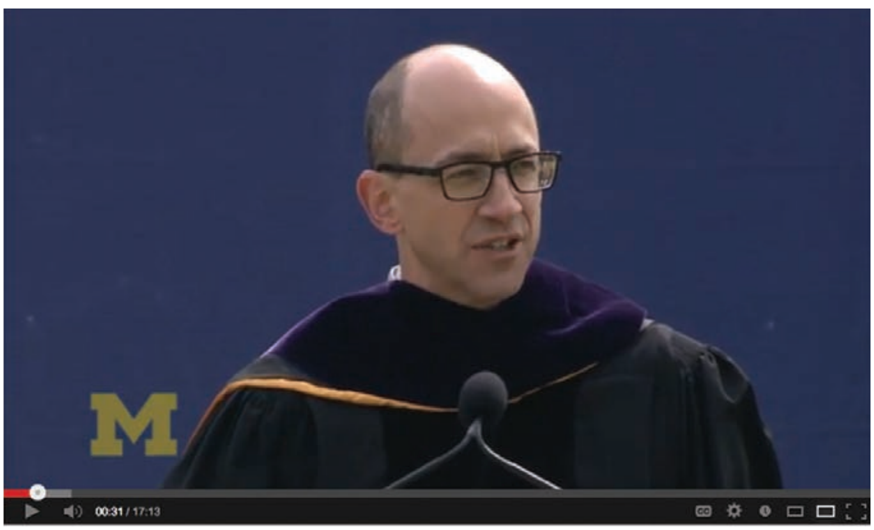
Dick mentors aspiring entrepreneurs through U-M's Business Engagement Center and the Center for Entrepreneurship. He advises the early-stage investment firm LaunchBox Digital and serves as a mentor at TechStarts, which provides startups with seed funding and guidance from top venture capital firms and angel investors. *Fortune* magazine listed him among its top 50 business people of the year in 2010. And in 2011, President Obama appointed him to the National Security Telecommunications Advisory Committee.

sense we're channeling that into building a coherent service-based architecture so that efforts inside the company can use these services instead of building a separate monolithic architecture."

As a startup, Twitter was originally constructed as just such a single monolithic architecture and built in Ruby on Rails. Having to convert Twitter to Scala and make it a truly service-based architecture while the company is running and growing so quickly has been and continues to be a huge challenge. To meet that challenge, over 50% of the Twitter is engineering, and a large number of those engineers develop back-end services. In addition, Twitter's architectural work now extends further – from software to hardware design, including rack design, power consumption, and data center design.

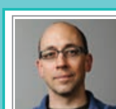
Back in this moment, Dick is always exploring new avenues for Twitter's technology. The company has expanded with Vine, a form of constrained video, just as Twitter is about constrained conversations. There are many tie-ins with other media. "We'll keep thinking about that notion of constrained publishing and as people innovate on things internally we'll produce those when we think they're good enough," says Dick.

Dick Costolo, 2013 Spring Commencement Address.

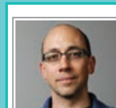


Dick Costolo gave the 2013 Spring Commencement Address at Michigan. Follow the QR code to see the video.

"When I was your age, we didn't have the Internet in our pants. We didn't even have the Internet not in our pants, that's how bad it was."



"Be bold, make courageous choices for yourself, and don't always worry about what your next line is supposed to be."



There's no script. Live your life. Be in this moment. Be in this moment. Be in this moment.

© General Motors

Andrew Farah

The Spark Behind the Volt

Andrew Farah
BSE CE ’82; MSE Electrical Science ’84
Vehicle Chief Engineer, Global Electric Vehicles
Chevrolet Volt, General Motors

VOLT

“I’ve always had the opportunity to work on new things,” says Andrew Farah, Chief Engineer of the Chevrolet Volt, the first extended range electric vehicle from a major automobile manufacturer.

Andrew grew up in Flint, Michigan, an auto hotspot at the time. When it came time to look for an internship as a college student, he selected General Motors (GM) after encouragement from a neighbor who worked there.

Since Andrew knew something about computers he was placed, or stuck as he would put it, in data processing. But in school he was learning more about embedded systems, real time control, and operating systems. He looked across the street from his GM office and saw where the product engineers worked. That’s where he wanted to be, so he told someone in personnel, “I want to get out of data processing and into embedded systems. I want to get into the product.” It was either that, or he was not coming back for another summer.

By the next summer, he was working on a project that ultimately found life in the 1986 Buick Riviera. This car led the way in some of the newest electronic design features, such as touch sensitive displays and networked embedded computers that talked over a serial data network.

Andrew worked for GM throughout his college years, which he extended into a master’s degree. “I knew if I didn’t do it now [get a master’s degree], I’d never find the time to go back,” he recalled. After graduation, Andrew was hired as Product Engineer in GM’s Electrical/Electronics Group. It was just in time to help some of the technology he had worked on as a student go into production and sales.

In 1988, Andrew left GM for an opportunity to apply systems engineering to the automotive battery industry. He was Manager of Electrical/Electronic Vehicle Systems Engineering at Johnson Controls, Inc., which is the largest U.S. automotive supplier as well as a diverse Fortune 500 company. It was just the training he needed to be part of the future of electric automobiles.

Eager for additional challenges, he returned to GM in 1991 to help develop the first modern all-electric car. “I was told I was the perfect fit because of my expertise in both embedded systems and batteries,” said Andrew, “so next thing you know I’m back at GM working on the EV1 [GM’s first generation all electric vehicle] managing the group responsible for propulsion software and controls.”

The EV1 incorporated a completely new battery management system, a new propulsion system and microprocessor-controlled brake-by-wire, all novel and in some cases groundbreaking design features. He built his team from scratch with new processes and procedures, some of which are still in use today.

This all-electric car, considered the first from a modern U.S. automaker, reached an early demise in 1999. “From a market perspective,” mused Andrew, “it was probably an idea before its time.” The car had limited range, only seated two, and had a look that did not have mass appeal. It just did not meet enough peoples’ daily needs.

Then came the Volt. A fix for limited range, it is an extended range electric vehicle that offers inexpensive all-electric mileage for daily commuting trips, but also a regular combustion engine for uninterrupted longer trips.

“I don’t want to work on that,” said Andrew when first asked to run the team as chief engineer. At the time he was working as GM Europe Director, Aftersales Engineering in Rüsselsheim, Germany. He felt burned by the EV1 experience and questioned whether GM had the commitment to stick with this completely new vehicle long term. But he was assured by management, and now affirms that, “through all the different things that happened, including the bankruptcy, the commitment was always there and we got the Volt to market on time.”

When it hit the market, the Volt was widely and highly praised. In its first year, it was named “World Green Car of the Year 2011” and the “North American Car of the Year 2011.” Last year the Volt and its European counterpart, the Opel Ampera, received the “Car of the Year 2012” award by a panel of judges comprised of 59 leading automotive journalists from 23 European nations. This year, the Volt was named Belgium’s Clean Fleet Car of the Year 2013. The Volt has also received awards and high marks for safety.

Andrew Farah takes the first pre-production Chevy Volt for a drive. *© General Motors*

The Volt has more competition in the marketplace now, but continues to excel. "It really shines for people like me," said Andrew, "I drive about 30 miles to work and back. On a typical week, I don't use gasoline at all. Then when I drive to Ann Arbor to go to a football game, it's not like I need to look for a place to plug in once I get there. My only concern is finding a parking spot."

The 2013 and 2014 Volt allows the driver to select when to use the battery so it's potentially not all used on the highway, holding it in reserve for city driving where electric driving has greater benefit. Andrew believes the Volt delivers on everything that a current electric vehicle can offer, including cutting-edge electronic sophistication and excellent overall drivability. Those who have reviewed the car seem to agree. The Volt also comes with the largest government tax credit on the market.

What's next?

"I'm working on the next Volt," said Andrew, "and I'll leave it up to your imagination as to the areas we're working on."

Pit Stop With Andrew Farah: Geared for Students

Opportunities for EECS Students in the Auto Industry: "Limitless," said Andrew. "There are opportunities on both the product and manufacturing side. On the product side, vehicles are becoming so complex, the problem is becoming how to simplify them while offering all the features expected by customers. There are lots of opportunities for people who understand the electronics side of automobiles, and even more for those who understand how the entire system works."

International Experience: "Learning can take place at any time," said Andrew. "If you can get that cultural learning and maybe some language skills before you start your formal career, it could make it easier to make that leap very early in your professional career. And as a student you can take a little more risk, you have a distinct beginning and end, which isn't necessarily the case in a full-time job."

The Michigan Experience: "Michigan did well by me," said Andrew. "But I always like to tell people who go off to college at Michigan or anywhere else, you get out of it what you put into it. And that's critical." Andrew was a member of the student chapter of SAE. He participated in the Career Fair and received several job offers, choosing to return to GM. For fun, he played ice hockey. He enjoyed it so much that after playing with friends, he'd stick around and referee other games.

Favorite Non-work Activities: "There are a lot of them!" said Andrew. There's still his beloved ice hockey, but topping the list is playing with his two children. They were all back in town recently to watch the women's gymnastics team, and they took the opportunity to walk around campus. "They got tired of me reminiscing after a while," he laughed. Also, they have a go kart, like he did when he was a kid, but this one is for his kids... and yes, it's electric!

Nancy Benovich Gilby

Entrepreneur x 10

Nancy Benovich Gilby
Serial Entrepreneur
BSE CE '85, MSE CSE '87

The day her uncle, an engineer at General Motors, brought home an early calculator, she saw it, loved it, and wanted one of her own. She wanted to know what made it tick. She was in first grade, and although she didn't yet realize it, she was on the path to becoming not only an engineer, but a prolific entrepreneur.

Nancy Benovich Gilby grew up in working class Warren, Michigan. Although she excelled in math, would become class valedictorian, and played trumpet in marching band, she didn't consider the possibility of attending the University of Michigan until a math teacher pushed her to apply.

"I'm so glad that I took that step. When I was accepted into Michigan, that was one of the happiest days of my life: I thought it would be so cool to be at Michigan, to be in engineering, and to play in the marching band. And I was very fortunate to be able to do all of those things, and more."

> ***"I've had many successes, but it was my education and experiences at Michigan that brought all of the right elements together to make it possible."***

Nancy made the cut for the Michigan marching band, which just a handful of years previously had begun accepting female musicians. A highlight was the opportunity to play at two Rose Bowl parades and games.

While an engineering student, Nancy landed a job in Dean James Duderstadt's office that would ultimately bring her path into focus. The college leadership was planning a computing transition under which all users would move from large multi-user, mainframe systems to next-generation computing workstations.

Nancy observed the energy and planning that preceded this great leap, and she was invited to sit in on meetings with potential vendors for new computing platforms, which included early workstation company Apollo and Steve Jobs of Apple. Afterwards, she evaluated the demo systems and provided input. The direction of computing suggested by these encounters and the exposure to powerful entrepreneurial thinking had a deep impact on her.

Infected by the examples she found at Michigan, Nancy undertook her own journey to make change through entrepreneurial endeavor. Today, she's at her tenth startup and continues to have a strong interest in innovation and getting the early adopters of new technologies and solutions "across the chasm."

Nancy's first gig at a startup, in 1988, was working for Mitch Kapor, who had previously founded Lotus. The company developed On Location, the first desktop search program, and Meeting Maker, a desktop calendaring system that is still in use today.

Nancy next became a founder at Component Software, again working with Kapor, where they built the precursor to Java and sold it to Sun.

Over the next two decades, Nancy headed efforts to design and develop a stream of innovative products that opened or addressed new markets. Many plowed the ground for the more recognizable names that would follow, sometimes years later.

At Wildfire, she led development of voice recognition and navigation for pre-smartphone, analog mobile phones. At Firefly, she helped to build the first community website with preference-based matching and advertising characteristics. At MarketSoft, she developed enterprise software for marketing and lead management. She built additional products at companies that developed cloud and service solutions for mobile operators. Time and again, these startups were acquired by companies including IBM, Microsoft, Nuance, and Asurion.

Most recently, Nancy has joined the Maker Movement and is using computer-controlled micro manufacturing to build personalized, photorealistic, recycled glass-tiled mosaics. Her company, Starry Night Mosaics, builds custom art from 4mm segments of glass, which can be displayed as traditional art or built into indoor or outdoor installations.

Since 2006, Nancy has shared her experience with students through the Center for Entrepreneurship. She visits campus regularly as a speaker and is currently the mentor for a Michigan I-Corps innovation team. "It sounds a little weird," she says, "but I get as much out of this as the students do. Their passion is inspiring, and Michigan's program on entrepreneurship is absolutely unmatched elsewhere."

In reflecting on her days at Michigan, Nancy said, "I've had many successes, but it was my education and experiences at Michigan that brought all of the right elements together to make it possible. You can have all the passion you want, but without the right catalyst it may never happen."

A large outdoor mosaic made by Starry Night Mosaics.

A Timeline of Ten Ventures

- **1988-1990 — On Technologies:** languages, tools, and search/calendar applications
- **1990-1993 — Component Software:** tools, including precursor to Java
- **1993-1997 — Wildfire:** early speech recognition on mobile phones
- **1996-1998 — Firefly:** early community website
- **1998-2000 — MarketSoft:** enterprise software for marketing and lead management
- **2000-2005 — PocketThis:** mobile data services
- **2006 — SNAPin Software:** customer support solutions on mobile phones
- **2007-2011 — Asurion:** data restoration for mobile devices
- **2011-2012 — A2O Mobile:** enterprise software for mobile devices
- **2013-pres. — Starry Night Mosaics:** custom-designed artful mosaics

Hannah Goldberg

Crazy About Asteroids

Hannah Goldberg
BSE MSE EE ’03 ’04
Senior Systems Engineer
Planetary Resources, Inc.

“I think you need to be a little crazy to work at a place that says its goal is asteroid mining,” says Hannah Goldberg, senior systems engineer at Planetary Resources, Inc.

Hannah Goldberg went from working at one of the premiere labs associated with NASA, to being one of the earliest team members of a young company that wants to further human space exploration – by mining asteroids.

To some it seems crazy – but to quote EECS alumnus and company investor Larry Page, Planetary Resources simply has “a healthy disregard for the impossible.” The company is run by visionaries and entrepreneurs involved in a high risk field that they believe can revolutionize the future of humans in space.

But what could be gained from asteroids? One of the key items is water, which they already know is readily available in these interplanetary rocks. Water, often separated into hydrogen and oxygen, is a typical propellant for spacecraft. For extended Deep Space travel, you can’t possibly carry enough water from Earth – the ship would never get off the ground.

Asteroids are like gas stations for spacecraft, said Hannah, and there are a lot of them (over 1,500 are easier to reach than the Moon, which is their initial target).

Planetary Resources is planning to send up small unmanned robotic spacecraft to mine the water and any precious metals that may also be on the asteroids, such as platinum. The next step, using the water as gasoline for larger spacecraft, is years if not decades down the road.

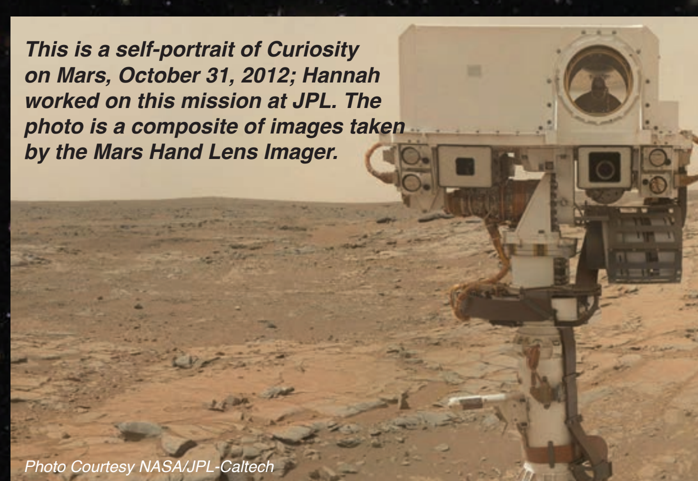
How did Hannah get to work for such a unique company? She had previously worked with the President and Vice President of Planetary Resources at NASA’s Jet Propulsion Laboratory (JPL). They had faith in Hannah to get the job done, whatever that job turned out to be.

At JPL, Hannah worked as part on the navigation and control of spacecrafts for autonomous landing on the moon and Mars. This led to her working on the calibration and testing of Curiosity’s sensor hardware. She still checks the photos coming in from Curiosity. “It’s amazing, the landscape over there,” she says.

She also worked on a project called Micro-inspector spacecraft, which were small autonomous spacecraft that inspected space shuttles. In essence they were small flying robots.

The switch from such a large company as JPL, where there was an expert for everything, to a small company was striking, but that would quickly change. Once part of a 5 member team, she is now one of about 20 and that’s just the full timers. “We also have a lot of interns,” said Hannah. However, she thinks her job title, Senior Systems Engineer, is still just a special phrase for “everything.”

“Everything” includes making sure everything is working the way it should, and that everything on the spacecraft fits together. “The work I’m doing here is more similar to what I was doing at Michigan than at JPL,” said Hannah. At Michigan, she worked on the student satellite Icarus.



This is a self-portrait of Curiosity on Mars, October 31, 2012; Hannah worked on this mission at JPL. The photo is a composite of images taken by the Mars Hand Lens Imager.

Photo Courtesy NASA/JPL-Caltech

Throughout her career in California, Hannah worked with a high school FIRST Robotics team. In fact, when the original team advisor stepped down, she was encouraged to get a teaching certificate so she could be the faculty advisor. "I ended up teaching an engineering class and a robotics class in high school, almost as a side career. The students were great," said Hannah.

In 2010, she received the San Diego Regional Woodie Flowers Award, the highest honor an individual can receive from FIRST. Hannah keeps in touch with many of the students she's taught; some are already out of college.

Her work with high school students continues at Planetary Resources. She manages a team of students from Aviation High School who work on specific projects at the company during the summer. If she can transfer her teaching certificate, we may find her in the classroom once more, inspiring students to take their dreams even higher.

Hannah has about a year before the first Planetary Resources spacecraft is launched, which is a small publically-funded space telescope called ARKYD – and public interest is surging. "One of the most exciting things about this company," said Hannah, "is that we started a conversation about asteroid mining – and everyone thought we were crazy. Now people actually talk about it like it's legitimate."

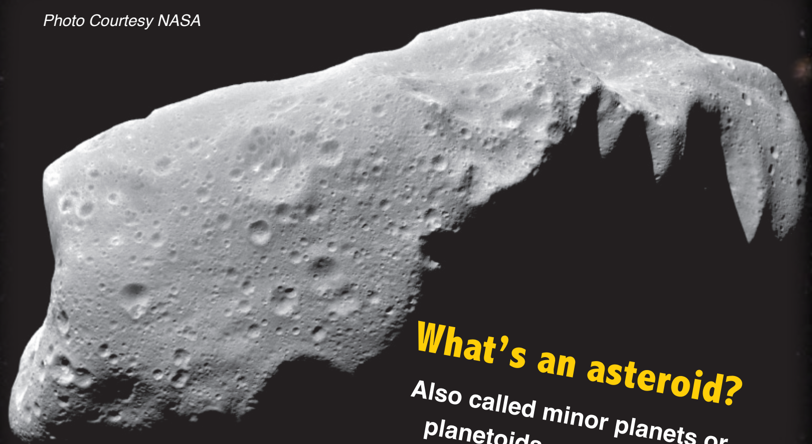


Photo Courtesy NASA

What's an asteroid?

Also called minor planets or planetoids, asteroids are described by NASA as relatively small (compared to a planet), inactive (compared to comets), rocky bodies orbiting the sun. They range from a few feet to several hundred miles wide. Most, more than half a million, are found in the asteroid belt between Mars and Jupiter. Asteroids typically have an irregular shape, and are comprised primarily of clay, silicate rock, and nickel-iron. Many have water.

Especially for Students: What was your best preparation for your current job?

"All my classes were EE-focused," said Hannah, "but I also worked at the Student Space Systems Fabrication Lab and on the Icarus student satellite, which was a UROP project. That's what led me to working on spacecraft. The work I'm doing here [at Planetary Resources] is more similar to what I was doing at Michigan than at JPL." Hannah's work on Icarus throughout her undergraduate years culminated in her being named chief engineer for the project. She was invited to give a talk in Berlin, and then to work for JPL.

"Get involved with the student teams," advises Hannah. "It's what makes the classwork make sense. Working in a team environment is what the real world is like. You have to think on your feet, work with people, and figure out what to do when you don't have immediate access to the right resources. I'm sure that any of the student teams give that type of experience."

For Hannah, working on a NASA spacecraft while an undergraduate student was "everything." "I was treated like a professional from the time when I was a freshman and sophomore, even when I really had no business to be treated like a professional. But it let me understand what it takes to build a spacecraft and put together a system."

Alumni Awards

2013 CoE MERIT AWARD WINNER (CSE)

Alan Steremberg *(BSE CE '94)*

Alan Steremberg is the President of Weather Underground, the first Internet Weather Service and today a leading commercial weather service destination that provides real-time weather and related information.

As a student in 1993, Alan helped to build "Blue Skies," a system to bring Internet weather into K-12 classrooms via a graphical Mac gopher client, which won several awards. He also started Student Mac Programmers, a student organization which gathered talented U-M students in the computing community together.

In the spring of 1995, Weather Underground, Inc. evolved as a commercial entity separate from the University with Alan as a co-founder and Director of Technology. At the same time, he also completed his master's degree in Human Computer Interaction from Stanford University. During 1996 and 1997, Alan helped to transform the site into a dynamic service where information was updated in real-time with several innovative new features. These included one of the first zip code searches, severe weather warnings and advisories, international conditions, marine weather, and detailed local forecasts. Weather Underground also began developing custom weather sites for TV stations and Internet portals. In 1998, Alan was appointed President of Weather Underground.

In early 2013, Weather Underground gave a gift of $500,000 to the Center for Entrepreneurship to endow support for its annual Bay Area student entrepreneurial startup trek. Of the gift, Alan said, "We wouldn't be where we are today if it weren't for the early support of the Michigan community. We're excited to be able to extend the same opportunities we've had to aspiring entrepreneurs."

2012 CoE MERIT AWARD WINNER (CSE)

Krisztián Flautner *(BSE MSE PhD, CSE '96, '98, '01)*

Krisztián Flautner is the Vice President for Research and Development at ARM, Inc., and is the architect of ARM's Intelligent Energy Manager technology. The company is a global leader in technology design for advanced digital products – from wireless, networking and consumer entertainment solutions to imaging, automotive, security and storage devices. The company's focus is on high-performance computing in energy-constrained environments. ARM was recently named one of the "World's Most Innovative Companies" by *Forbes* magazine.

Dr. Flautner leads a global team which is focused on the understanding and development of technologies relevant to the proliferation of the ARM architecture. The group's activities cover a wide breadth of areas including: circuits, processor and system architectures, as well as tools and software. Key activities are related to high-performance computing in energy-constrained environments.

Dr. Flautner works closely with Michigan researchers because of ARM's ongoing research agreement with the University. Under the agreement, ARM will continue to fund and work in collaboration with the researchers on ultra-low energy and sustainable computing. One of the first results of this collaboration, in fact, was an energy management system, enabling mobile phones to automatically optimize their battery usage. Overall, the outcomes of the ARM/U-M research partnership have generated more than 40 patents and numerous publications detailing this research.

Dr. Flautner is a member of the ACM and the IEEE.

2013 CoE Merit Award Winner (ECE)

Stephen Mollenkopf *(MSE EE ’93)*

Steve Mollenkopf serves as President and Chief Operating Officer (COO) of Qualcomm Incorporated, leading the company’s divisions, business operations, market expansion and development areas. Qualcomm is one of the leading semiconductor companies in the world specializing in mobile and computing technologies, especially for cellular and connected consumer electronics.

Mr. Mollenkopf joined Qualcomm in 1994 as an engineer and was a leading contributor to the Globalstar project, which provides satellite phone coverage when terrestrial coverage is unavailable. He joined the Qualcomm Mobile & Computing (QMC, formerly QCT) team in 1999, where he played a central role in developing QMC’s roadmap and led the development and commercialization of the 3GPP family of air interface technologies. Today, QMC is the world’s largest fabless semiconductor producer and the largest provider of wireless chipset and software technology, which powers the majority of all 3G devices commercially available today

Under Steve’s leadership, QMC completed the $3B acquisition of Atheros, the Company’s largest acquisition to date, to accelerate the expansion of Qualcomm’s technologies and platforms to new businesses beyond cellular and to provide access to new growth opportunities.

Since 2008, Mr. Mollenkopf has led QMC while also serving as Executive Vice President and Group President of Qualcomm, Inc. He was named President and COO in 2011, and also serves as a member of the Executive Committee, helping to drive Qualcomm’s overall global strategy.

A published IEEE author, Mr. Mollenkopf holds patents in areas such as power estimation and measurement, multi-standard transmitter system and wireless communication transceiver technology. He serves on the Board of Directors for the Semiconductor Industry Association and also serves as Co-Chairman of the Global Semiconductor Alliance Board of Directors.

Steve Mollenkopf received his bachelor’s degree from Virginia Tech and his master’s degree at Michigan, both in electrical engineering.

2012 COE MERIT AWARD WINNER (ECE)

Daniel Moloney *(BSE EE ’81)*

Dan Moloney spent most of his career at Motorola Mobility, most recently serving as President of the company. During those 30 years, he has been at the forefront of key technological breakthroughs that include building some of the most advanced cable systems in the world, pioneering digital TV and HDTV, introducing third party applications into the TV space, and launching home automation’s first commercial-scale deployment over cable systems.

Mr. Moloney began his career at General Instrument Corporation in 1983, which was acquired by Motorola in early 2000. He led Motorola’s Home business from 2002–2007, which comprised the company’s video network infrastructure and home devices portfolios.

From 2007–2009, he led the Home & Networks Mobility business and grew this division into a worldwide leader in both video and WiMAX wireless solutions. It set the standard for the development of integrated and customized end-to-end media solutions for cable, wireline and wireless service providers.

As President of Motorola Mobility, he provided leadership for Motorola’s Home business, Advanced Technology team, Supply Chain, IT and Government Relations functions, and led Motorola’s strategy for leveraging the convergence of wired/wireless technologies.

In August of 2011, Google announced plans to buy Motorola Mobility for $12.5 billion, with plans to build on the existing Android ecosystem and enhance competition in mobile computing. Mr. Moloney left the company in July 2012 to pursue other opportunities.

Dan received the 2012 Vanguard Award for Associates & Affiliates from the National Cable & Telecommunications Association (NCTA). The Vanguard Awards are the cable industry’s most prestigious awards.

Dan Moloney received his bachelor’s degree from Michigan, and his master of business administration degree from the University of Chicago.

Charlotte Froese Fischer Establishes Professorship in Theoretical Computer Science

Professor Emerita Charlotte Froese Fischer of Vanderbilt University has generously endowed the Patrick C. Fischer Professorship in Theoretical Computer Science within the EECS Department at Michigan. The professorship is named for her late husband, Patrick, who grew up in Ann Arbor, attended Michigan, and who helped to establish theoretical computer science as a distinct and recognized discipline. Prof. Fischer's gift emphasizes the foundational importance of theoretical computer science and will help Michigan to lead in this important area.

On November 5, 2012, the Department hosted a symposium to celebrate the establishment of the Patrick C. Fischer Professorship in Theoretical Computer Science. The symposium featured lectures by three prominent computer scientists who discussed recent advances in the field of theoretical computer science: Russell Impagliazzo of UCSD, Ronitt Rubinfeld of MIT, and Kevin Compton of U-M.

Follow the QR code to see the lectures from the symposium.

Russell Impagliazzo
Professor, Computer Science and Engineering
University of California, San Diego

Meta-Algorithms: Links between Algorithm Design and Lower Bounds

Ronitt Rubinfeld
Professor, Electrical Engineering and Computer Science
Massachusetts Institute of Technology

Something for Almost Nothing: Recent Advances in Sublinear Time Algorithms

Kevin Compton
Professor, Computer Science and Engineering
University of Michigan

Probablistic Transforms in the Analysis of Algorithms

Patrick C. Fischer

Patrick C. Fischer grew up in Ann Arbor, where his father taught math at the University of Michigan. He attended Michigan, where he earned a BS in Mathematics in 1957 and an MBA in Actuarial Science in 1958. He went on to become an expert in computational complexity, interactive database systems, and informational systems for education institutions. After teaching at Harvard, Cornell, Waterloo, and Pennsylvania State University, serving also as Chair at the latter two, Prof. Fischer served as Chair of the Computer Science Department at Vanderbilt University 1980–1995, and remained on the faculty until his retirement in 1998.

Prof. Fischer was an early leader in the field of computational complexity, and helped establish theoretical computer science as a discipline separate from mathematics and electrical engineering. He was the first chair of *SIGACT,* the *Special Interest Group on Algorithms and Computation Theory of the Association for Computing Machinery*, which he founded in 1968. He also founded the annual *Symposium on Theory of Computing*, which is one of the two flagship conferences in theoretical computer science, and he served five times as chair of the conference.

In the 1980's, Prof. Fischer's research focused on database theory, and his work in that realm included the study of the semantics of databases, metadata, and incomplete information. Prof. Fischer helped to define the nested relational model of databases, in which the values in the cells of a relational database may themselves be relations, and his work on the mathematical foundations of database query languages became central to the databases now used by major web servers worldwide.

Thanks to our Donors

The Department thanks the donors named below as well as those who gave anonymously during the past year. Your support is essential in keeping the Department strong and ensuring that the best students attend Michigan to receive the education they deserve.

Individuals

Mark J. Abel
Roshan L. Ahuja
Vinay Ahuja
H. Cahit Akin
Andrew S. Altersohn
Frank R. Arams
Roger D. Arnett
John S. Asvestas
Bryan D. Bagnall
R. James Bennett
Frederick J. Beutler
Sven G. Bilen
Sheila J. Bloch
Timothy Borg
Michael W. Brown
Charles G. Bruch
Thomas P. Budka
John S. Creighton
Anne Cruce
Donald D. Dodge
L. Delf Dodge
Thomas M. Dziuszko
Nancy V. Eisenhart
Zachary L. Evans-Golden
Dr. Charlotte F. Fischer
Kevan and Bridget Flanigan, in memory of Larry K. Flanigan
Karen D. Frampton
Eric Francis
Glenn N. Galler
Susan A. Garrett Doshay
Barbara G. Goldlust
Adrienne Gornstein, in memory of Rodney P. Zimmerman
Subrata Goswami
Donald and Ingrid Graham
Steven E. Grob
Peter Honeyman
William L. Honig
Dr. Rebecca S. Horvath
Christopher Hutchinson
Medhat A. Ibrahim
Michael A. Jaskowiak
Karan J. Jumani
Aaron C. Klink
Ernest Kuh and Bettine Kuh
Kelvin Y. Lam
Nicholas M. Landi
James D. Levine
Yuhua Liu
Brian F. Long
Thomas D. Lovett
Steve Lund
Maya Mandel
Lisa A. Matta
David J. Mehi
Steven M. Mollenkopf
Yuji Morita
David H. Nash
Khoi D. Nguyen
Kevin and Nancy O'Connor
Javin T. Olson
Vinay H. Patel
Susan A. Pierce, in memory of Mr. J. Marcus Ziegler
Frederick J. Porter
Robert J. Prevaux
Sherman C. Puckett
Deborah L. Purcell
Sandra J. Pusdesris
Henry S. Riddle
William F. Ruppel
Catherine M. Sarri
Kristen J. Sarri
Rosemary C. Sarri
Linda J. Schalek
Craig A. Schmatz
Lora Schulwitz
Demetrios Serakos
Prakash P. Shenoy
Enrique R. Sherman
George E. Shortle
David A. Shuster
T. Murray Smith
Wesley M. Sowers
Leland 'Chip' Spangler
Nancy A. Stanke
Suresh Subramanian
Bruce W. Swanson
Kevin K. Tang
Michael J. Tisiker
Salvatore G. Trupiano
Michael C. Vartanian
Kenneth H. Vaughan
Ramji Venkataramanan
Jason W. Weigold
Nathan A. Whetsell
Shannon J. Whorton
Cary A. Wilson
Candace J. Woessner
Jason T. Wolny
Steven E. Wuerthele
Michael Y. Xia
Dawson Yee
David W. Yeung
Robert R. Zahm, in memory of William Wrigley Zahm (Class of 1928) and Robert William Zahm (class of 1967)
Michael C. Zapf

Industry and Foundations

Agilent Technologies, Inc.
Alfred P. Sloan Foundation
AMD
Analog Devices, Inc.
Avon Foundation
Ball Corporation
Barracuda Networks
Bluestone Global Tech, Ltd.
Broadcom Foundation
Capgemini
Cirrus Logic, Inc.
Cisco Systems, Inc.
Consumers Energy Foundation
Crossbar, Inc.
Deloitte Foundation
Eaton Corporation
Electronic Arts
Facebook
Fujitsu Laboratories Limited
Futurewei Technologies, Inc.
General Motors Corporation
Google, Inc.
Grainger Foundation
Harris Corporation
HTC America Innovation, Inc.
IBM Corporation
Integrated Sensing Systems/ ISSYS
Intel Corporation
JPMorgan Chase
Juniper Networks
Juvenile Diabetes Research
Foundation International
Kaneka Corporation
KLA Tencor
Jenny H. Krauss & Otto F. Krauss Charitable Foundation
Lockheed Martin Corporation
MathWorks, Inc.
Mentor Graphics Corporation
Microsoft
MyBuys
Narus Inc.
Northrop Grumman Space Technology
Oracle
Pitney Bowes
Planetary Resources
Qualcomm Incorporated
Raytheon Charitable Foundation
Ricoh Corporation
Robert Bosch, LLC
Samsung Display Co., Ltd.
Seelio, Inc.
Silicon Laboratories, Inc.
STKR.IT, LLC
Stryker Corporation
Texas Instruments Inc. and Texas Instruments Foundation
The Boeing Company
Thomson Reuters
Toyota Motor Corporation
UL, LLC
Union Pacific Corporation
Walmart Foundation
Wedding Wire
Whirlpool Corporation
The Eleanore Wolpaw Brouhard & Robert B. Brouhard Family Foundation
Yahoo! Inc.

Give online

www.eecs.umich.edu/giving

In Memoriam

CLASS OF 1930–39

Robert J. Beuhler ('38; 6/7/2013)
Albin G. Dembowski ('38; 6/29/13)

CLASS OF 1940–49

Lewis O. Heinze ('40; 8/5/2012)
Byron H. Johnson ('41; 9/11/2011)
Louis E. Mueller ('41; 12/15/2009)
Peter G. DeJong ('43; 5/23/2012)
Carl A. Brauer ('45; 7/13/2013)
Harold R. Geimer ('45; 11/29/2012)
Charles K. Birdsall ('46 '48; 3/6/2012)
Forrest R. Dayton ('46; 5/30/2010)
Frederick W. Gehring ('46 '49; 5/29/2012)
James L. Johnson ('46; 4/15/2013)
Ellsworth E. Koonz ('46; 2/8/2013)
Samuel P. Willits ('46 '48; 4/9/2012)
Wayne E. Erickson ('47; 5/2/2012)
Robert O. Buckingham ('48; 7/17/2012)
Robert M. Ginn ('48; 3/5/2013)
Alfred F. Kersey ('48; 1/3/2013)
Andrew J. Vannoord ('48; 6/5/2013)
John D. Wilcox ('48; 12/9/2012)
Charles R. Bilby ('49; 6/25/2012)
Charles F. Brown ('49; 2/14/2013)
Harry E. Colestock ('49; 12/28/2012)
Robert C. MacVeety ('49; 1/19/2013)
John F. Skowron ('49; 12/31/2012)
John Vaneizenga ('49; 3/20/2012)

CLASS OF 1950–59

Robert W. Champion ('50; 1/29/2013)
Edward Chempiel ('50; 4/2/2013)
Martin J. Dobring ('50; 5/29/2013)
Roger J. Gould ('50; 4/26/2012)
Eugene W. Hannahs ('50; 4/17/2013)
Leon M. Jaroff ('50; 10/20/2012)
Anthony M. Kojalowicz ('50; 1/8/2013)
Robert W. Thomas ('50; 4/3/2012)
Donald R. Way ('50; 3/14/2012)
Clifford E. Granger ('51 '57; 5/10/2013)
Russell E. Griffin ('51; 8/30/2013)
Kenneth R. Simmons ('51; 5/7/2013)
Frank H. Tendick ('51; 3/21/2012)
Theodore C. Zwiep ('51; 11/22/2009)
Robert O. Lewis ('52; 7/8/2010)
Clyde Wiltse ('52; 2/14/2012)
Edwin W. Beeby ('53; 7/2/2012)
Vincent T. Gabriel ('53; 8/4/2012)
John B. Lelivelt ('55; 8/3/2012)
Lawrence P. Monahan ('55; 5/22/2012)
Charles R. Wickman ('55 '58; 7/21/2013)
Lawrence L. Sutton ('56; 1/24/2012)
Ralph W. Wiese ('56; 4/3/2013)
Raymond L. Marlatt ('57; 4/22/2013)
Alvin P. Hjorten ('58; 2/18/2013)
Thomas R. Hughes ('58; 7/12/2012)
Harvey L. Garner ('59; 3/24/2013)

CLASS OF 1960–69

David V. Rich ('60; 7/21/2012)
Paul L. Ritzmann ('60; 6/23/2013)
Gerardo S. Viloria ('61; 7/13/2012)
Robert H. Kruggel ('63; 2/28/2013)
Diane A. Vanden Broek ('63; 10/30/2012)
James C. Wilson ('63; 12/16/2012)
Barry D. MacRae ('64; 4/9/2013)
Kenneth S. Conroy ('65; 6/16/2013)
David Jaarsma ('65 '66 '69; 2/28/2013)
Thomas L. Hise ('66; 8/15/2013)
John E. Miley ('66 '68; 6/22/2012)
Bong Ho ('67; 3/10/2012)
Richard G. Sullivan ('67; 9/20/2012)
Robert A. Grimm ('68; 6/4/2012)
James T. VanLoo ('68; 5/1/2013)

CLASS OF 1970–79

Thomas E. Bayer ('71; 5/9/13)
Richard D. Archer ('73; 7/21/2012)
Alan E. Hyrila ('75; 6/8/2013)
William A. Meiman ('75; 7/16/2013)
J. Marcus Ziegler ('75; 5/6/2012)
Jeffrey P. Graebel ('77; 3/05/2012)
Karl B. Jennings ('77; 6/2/2012)

CLASS OF 1980–89

Mark D. Wright ('81; 10/31/2012)
Mark R. Zanella ('84; 3/20/2012)
John E. Bertsch ('83; 12/10/2012)
David H. Smith ('88; 3/8/2013)

CLASS OF 1990–2000

Eric A. Arons ('93; 6/13/2013)

Photo courtesy NASA

Hasso Niemann (1933–2013): From Michigan to Probing Deep Space

Dr. Hasso Niemann (BSE MSE PhD EE '61 '63 '69) was a notable and beloved NASA scientist who impacted our knowledge of Earth and Space through his research. While a graduate student at Michigan, Dr. Niemann worked with Prof. William Gould Dow (former EECS Professor and Chair) and Prof. Nelson Spencer (former EECS Professor before joining NASA) on the development of the Omegatron mass spectrometer.

Dr. Niemann joined NASA Goddard Space Flight Center in 1969. He pioneered exploration of the upper atmosphere of Earth, and later focused on planetary atmospheres. He provided the first *in situ* measurements of the upper atmosphere of Venus on the Pioneer Venus Mission, and developed the prime instrument on the Galileo Probe, which probed the deep atmosphere of Jupiter. He also helped develop the Cassini Huygens Gas Chromatograph Mass Spectrometer and the Cassini Ion and Neutral Mass Spectrometer. Dr. Neimann received NASA's Distinguished Service Medal, the John C. Lindsay Memorial Award for Space Science in 1997, and the Al Seiff Memorial Award in 2007.

Dr. George Carignan, Research Scientist Emeritus of the U-M Department of Atmospheric, Oceanic and Space Sciences, stated, "His loyalty to Michigan provided space exploration opportunity to a large number of students, and his educational and collaborative association with the College of Engineering helped to fuel its strong space science and engineering program."

The primary departmental affiliation (either CSE or ECE) for each faculty member is listed first, followed by any secondary appointments in other departments (a key for the acronyms is found on pg. 83).

Abernethy, Jacob
Assistant Professor
CSE

Ackerman, Mark
George Herbert Mead
Prof. of Human-Computer
Interaction
CSE, SI

Anastasopoulos, Achilleas
Associate Professor
ECE

Atkins, Daniel
W.K. Kellogg Prof. of
Community Informatics
CSE, SI

Austin, Todd
Professor
CSE

Azadegan, Reza
Assistant Research
Scientist
ECE

Babaeva, Natalia
Assistant Research
Scientist
ECE

Bailey, Michael
Research Associate
Professor
CSE

Balzano, Laura
Assistant Professor
ECE

Baveja, Satinder Singh
Professor
CSE

Bertacco, Valeria
Associate Professor
CSE

Bhattacharya, Pallab K.
Charles M. Vest Dist. Univer.
Prof. of EECS; James R.
Mellor Prof. of Engineering
ECE, AP

Blaauw, David T.
Professor
ECE

Brehob, Mark
Lecturer
CSE

Cafarella, Michael
Assistant Professor
CSE

Carmon, Tal
Associate Professor
ECE, AP

Chen, Peter
Arthur F. Thurneau Professor
CSE

Chesney, David
Lecturer
CSE

Chvykov, Vladimir
Associate Research
Scientist
ECE

Compton, Kevin
Associate Professor
CSE

Cook, Jeffrey
Adjunct Faculty
ECE

Das, Reetuparna
Assistant Research Scientist
CSE

DeOrio, Andrew
Lecturer
CSE

Dick, Robert
Associate Professor
ECE

Dorf, Mary Lou
Lecturer
CSE

Dreslinski, Ron
Assistant Research
Scientist
CSE

Durfee, Edmund
Professor
CSE, SI

Dutta, Prabal
Assistant Professor
CSE

England, Anthony W.
Professor
ECE, AOSS, AP

Essl, Georg
Assistant Professor
CSE, SMTD

EECS Faculty 2013

Fessler, Jeffrey A.
Professor
ECE, BME, RAD, AP

Flinn, Jason
Associate Professor
CSE

Flynn, Michael
Professor
ECE

Forrest, Stephen R.
U-M VP for Research;
William Gould Dow Prof. of
Electrical Engineering
ECE, MSE, PHY

Freudenberg, James S.
Professor
ECE

Fu, Kevin
Associate Professor
CSE

Galvanauskas, Almantas
Professor
ECE

Ganago, Alexander
Adjunct Faculty
ECE

Gianchandani, Yogesh
Professor
ECE, ME, AP

Gibson, Jeremy
Lecturer
CSE

Gilchrist, Brian E.
Professor
ECE, AOSS, AP

Grbic, Anthony
Associate Professor
Ernest and Betty Kuh
Dist. Faculty Scholar
ECE, AP

Green, Scott
Assistant Research
Scientist
ECE

Grizzle, Jessy W.
Jerry W. and Carol L. Levin
Prof. of Engineering
ECE, ME

Guo, Lingjie
Professor
ECE, Macro, ME, AP

Halderman, J. Alex
Assistant Professor
CSE

Hayes, John
Claude E. Shannon Prof. of
Engineering Science
CSE

Hero III, Alfred O.
R. Jamison and Betty
Williams Prof. of Engineering
ECE, BME, STATS

Hiskens, Ian A.
Vennema Professor
of Engineering
ECE

Hofmann, Heath F.
Associate Professor
ECE

Honeyman, Peter
Research Professor
CSE

Hou, Bixue
Associate Research
Scientist
ECE

Islam, Mohammed N.
Professor
ECE, BME, IntMed

Jagadish, H.V.
Bernard A. Galler
Prof. of EECS
CSE

Jahanian, Farnam
Edward S. Davidson
Prof. of EECS
CSE

Jamin, Sugih
Associate Professor
CSE

Jarrahi, Mona
Assistant Professor
ECE, AP

Kalinchenko, Galina
Assistant Research
Scientist
ECE

Kanicki, Jerzy
Professor
ECE

Kieras, David
Professor
CSE, PSYCH

Ku, Pei-Cheng
Associate Professor
ECE

Kuipers, Benjamin
Professor
CSE

Kushner, Mark J.
George I. Haddad
Prof. of EECS
ECE, NERS, CE, AP

Lafortune, Stéphane
Professor
Assoc. Chair for Graduate Affairs
ECE

Lahiji, Gholamhassan
Adjunct Faculty
ECE

Laird, John
John L. Tishman Prof.
of Engineering
CSE

EECS Faculty 2013

Lee, Honglak
Assistant Professor
CSE

Lee, Somin
Assistant Professor
ECE, BME

Lee, Yoonmyung
Assistant Research Scientist
ECE

Li, Tao
Assistant Research Scientist
ECE

Liepa, Valdis
Research Scientist
ECE

Liu, Mingyan
Professor
ECE

Lu, Wei
Associate Professor
ECE, AP

Mahlke, Scott
Professor
CSE

Maksimchuk, Anatoly
Research Scientist
ECE

Mao, Z. Morley
Associate Professor
CSE

Markov, Igor
Professor
CSE

Mars, Jason
Assistant Professor
CSE

Mathieu, Johanna
Assistant Professor
ECE

Mazumder, Pinaki
Professor
CSE, AP

Meerkov, Semyon M.
Professor
ECE

Michielssen, Eric
Professor
ECE

Mihalcea, Rada
Associate Professor
CSE

Miller, Carl
Assistant Research Scientist
CSE

Morgan, Andrew
Lecturer
CSE

Mower Provost, Emily
Assistant Professor
CSE

Mortazawi, Amir
Professor
ECE

Mozafari, Barzan
Assistant Professor
CSE

Mudge, Trevor
Bredt Family Prof. of Engineering
CSE

Munson, Jr., David C.
Robert J. Vlasic Dean of Engineering
ECE, AP

Nadakuditi, Rajesh Rao
Assistant Professor
ECE, AP

Najafi, Khalil
Schlumberger Prof. of Engineering and Chair, Electrical and Computer Engineering; Arthur F. Thurnau Professor
ECE, BME

Narayanasamy, Satish
Assistant Professor
CSE

Nashashibi, Adib Y.
Associate Research Scientist
ECE

Nees, John
Associate Research Scientist
ECE

Neuhoff, David L.
Joseph E. and Anne P. Rowe Prof. of Electrical Engineering; Assoc. Chair, Electrical and Computer Engineering;
ECE

Noble, Brian
Prof. and Assoc. Dean for Undergraduate Education
CSE

Norris, Theodore B.
Gérard A. Mourou Prof. of EECS
ECE, AP

Olson, Edwin
Assistant Professor
CSE

Ozay, Necmiye
Assistant Professor
ECE

Paoletti, David
Lecturer
CSE

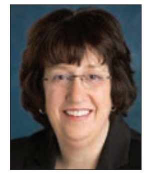
Papaefthymiou, Marios
Prof. and Chair, Computer Science and Engineering
CSE

Peterson, Rebecca
Assistant Professor
ECE

Pettie, Seth
Associate Professor
CSE

Phillips, Jamie
Professor
Assoc. Chair for
Undergraduate Affairs
ECE, AP

Pierce, Leland E.
Associate Research
Scientist
ECE

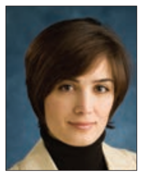


Pollack, Martha
Professor and
University Provost
CSE, SI

Pradhan, Sandeep
Associate Professor
ECE

Prakash, Atul
Professor
CSE

Radev, Dragomir
Professor
CSE, SI



Rais-Zadeh, Mina
Assistant Professor
ECE, ME

Rand, Stephen C.
Professor
ECE, PHY, AP

Revzen, Shai
Assistant Professor
ECE, EEB

Ringenberg, Jeff
Lecturer
CSE

Rivas, Juan
Assistant Professor
ECE

Sakallah, Karem
Prof. and Assoc. Chair,
Computer Science
and Engineering
CSE

Sarabandi, Kamal
Rufus S. Teesdale Prof.
of Engineering
ECE

Savarese, Silvio
Associate Professor
ECE

Schoenebeck, Grant
Assistant Professor
CSE

Schotland, John C.
Professor
MATH, ECE, BME

Scott, Clayton
Associate Professor
ECE

Shi, Yaoyun
Associate Professor
CSE

Shin, Kang
Kevin and Nancy O'Connor
Prof. of Computer Science
CSE

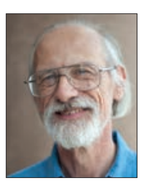
Singh, Jasprit
Professor
ECE, AP

Sodagar, Amir
Assist. Research Scientist
ECE

Soloway, Elliot
Arthur F. Thurneau Professor
CSE, ED, SI

Stark, Wayne E.
Professor
ECE

Steel, Duncan G.
Robert J. Hiller Prof.
of Engineering
ECE, BioPHY, PHY, IoG



Stout, Quentin
Professor
CSE, AERO

Strauss, Martin
Professor
CSE, MATH

Syed, Zeeshan
Assistant Professor
CSE

Sylvester, Dennis M.
Professor
ECE

Tang, Lingjia
Assistant Professor
CSE

Teneketzis, Demosthenis
Professor
ECE

Terry, Fred L.
Professor
ECE, AP

Ulaby, Fawwaz T.
Emmet Leith Dist. Univer.
Prof. of EECS; Chen-To Tai
Prof. of Engin.;
Arthur F. Thurnau Professor
ECE

Wakefield, Gregory H.
Associate Professor
ECE, SMTD, OTO, AP

Wellman, Michael
Professor
CSE

Wenisch, Thomas
Associate Professor
CSE

Wentzloff, David D.
Associate Professor
ECE

Whitaker, John F.
Research Scientist
ECE, AP

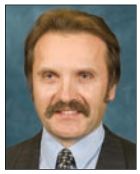
Winful, Herbert G.
Arthur F. Thurnau Professor
ECE

Winick, Kim A.
Professor
ECE

Winsor, Don
Adjunct Faculty
EECS

Xiong, Andy (Zhongmin)
Assistant Research Scientist
ECE

Yagle, Andrew E.
Professor
ECE

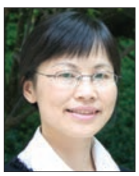


Yanovsky, Victor P.
Research Scientist
ECE

Yoon, Euisik
Professor
ECE, BME

Zhang, Zhengya
Assistant Professor
ECE

Zhong, Zhaohui
Assistant Professor
ECE



Zhou, Xuili (Julie)
Assistant Research Scientist
ECE

Zimmerman, Jeramy
Assistant Research Scientist
ECE

AP – Applied Physics
AERO – Aerospace Engineering
AOSS – Department of Atmospheric, Oceanic & Space Sciences
BioPHY – BioPhysics
BME – Biomedical Engineering
CDB – Cellular and Developmental Biology
CEE – Civil and Environmental Engineering
ChE – Chemical Engineering
CSE – Computer Science & Engineering
DCM&B – Computational Medicine & Bioinformatics
ECE – Electrical & Computer Engineering
EEB – Ecology and Evolutionary Biology
IntMed – Internal Medicine
IoG – Institute of Gerontology
LING – Linquistics
Macro – Macromolecular Science & Engineering
MATH – Mathematics
ME – Mechanical Engneering
MSE – Materials Science and Engineering
NAME – Naval Architecture and Marine Engineering
NERS – Nuclear Engineering and Radiological Sciences
OTO – Otolaryngology
PHY – Physics
PSYCH – Psychology
RAD – Radiology
SI – School of Information
SMTD – School of Music, Theatre & Dance
SOE – School of Education
STATS – Statistics

Affiliated Faculty

Abney, Steve, Associate Professor, *LING, SI, CSE*
Adar, Eytan, Assistant Professor, *SI, CSE*
Atkins, Ella, Associate Professor, *AERO, CSE*
Cain, Charles A., Richard A. Auhll Professor, *BME, ECE*
Chestek, Cynthia, Assistant Professor, *BME, ECE*
Collins-Thompson, Kevyn, Associate Professor, *SI, CSE*
Eustice, Ryan, Associate Professor, *NAME, CSE*
Gilbert, Anna, Associate Professor, *MATH, ECE*
Goldman, Rachel S., Professor, *MSE, ECE*
Guan, YuanFang, Assistant Professor, *DCM&B, CSE*
Holland, John, Professor, *PSYCH, CSE*
Kabamba, Pierre, Professor, *AERO, ECE*
Krushelnick, Karl, Professor, *NERS, ECE*
Kurabayashi, Katsuo, Professor, *ME, ECE*
Lynch, Jerome P., Associate Professor, *CEE, ECE*
Mei, Qiaozhu, Assistant Professor, *SI, CSE*
Merlin, Roberto D., Peter A. Franken Professor of Physics, *PHY, ECE*
Michailidis, George, Professor, *STATS, ECE*
Newman, Mark, Associate Professor, *SI, CSE*
Nguyen, Long, Assistant Professor, *STATS, CSE*
O'Modhrain, Maura Sile, Associate Professor, *SMTD, CSE*
Pipe, Kevin, Associate Professor, *ME, ECE*
Polk, Thad, Associate Professor, Arthur F. Thurnau Professor, *PSYCH, CSE*
Ruf, Christopher S., Professor, *AOSS, ECE*
Stefanopoulou, Anna, Professor, *ME, ECE*
Sun, Jing, Professor, *NAME, ECE*
Tewari, Ambuj, Assistant Professor, *STATS, CSE*
Tilbury, Dawn, Professor, *ME, ECE*
Welsh, Michael J., Professor, *CDB, ECE*

NONPROFIT ORG.
U.S. POSTAGE
PAID
ANN ARBOR, MI
PERMIT NO. 144

ELECTRICAL ENGINEERING
AND COMPUTER SCIENCE
The University of Michigan
1301 Beal Avenue
Ann Arbor, Michigan 48109-2122

EECS News is printed using green processes.

- Printed on 50% post-consumer recycled waste fiber using soy-based inks.
- Printed by University Lithoprinters, a Forest Stewardship Council™ certified printer.

Sign up for our ECE and CSE eNewsletters!

Not receiving our eNews? Submit your name and email to eecscomm@eecs.umich.edu.

MICHIGAN ENGINEERING
UNIVERSITY OF MICHIGAN

eecs.umich.edu