Engineering Excellence
2018 Annual Report
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CEAS Acknowledgments
We gratefully acknowledge the generous support of our donors.

Investing in the Future of CEAS
Opportunities to partner with CEAS.

Acknowledgments
Deanna Wicklund
For sharing her artwork which was weaved throughout. Pages 6 and 7 modified from Wicklund’s original design

Cover Design: Daphne Jorgensen
Cover Art: Deanna Wicklund

Margaret B. Hartley
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Hyperlinked Digital Version
https://www.albany.edu/ceasweb/ceas_2018ar.pdf
A College on the Move

While still in a nascent stage after only three years of existence, the College of Engineering and Applied Sciences at the University at Albany has flourished over the 2017-18 academic year. The 67% increase in federal grant submissions in 2018 over last year, and the fact that our first quarter 2018 expenditures were 75% of the entire previous year, are testimony that we are building a vigorous research agenda in the tradition of the best high-caliber public programs in the country. Three new degree programs in electrical and computer engineering (BS, MS, and Ph.D.) were launched, while programs in environmental and sustainable engineering are in development. No grass grows under the feet of our exceptional faculty as they have made their mark in scholarship, publication, and leadership opportunities on an international scale. Here is just a snapshot of this past year.

Publications

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<th>77</th>
<th>Journal Papers</th>
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<td>115</td>
<td>Conference Papers</td>
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<td>22</td>
<td>Journal Editorships</td>
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<td>12</td>
<td>Book Chapters</td>
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<td>1</td>
<td>Book</td>
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Faculty Honors and Recognition

- 3 IEEE Fellows
- 1 ABET PEV
- 1 Jefferson Science Fellow
- 2 IAPR Fellows
- 1 IMA Fellow
- 1 AAAS Fellow

- GE Global Research Whitney Technical Achievement Award
- NASA "Robert H. Goddard Exceptional Achievement for Engineering" Award
- Outstanding Service Award, IEEE SMC 2017 Conference
- 45 Conference Leadership Roles
- 16 Patents Issued
- 4 Best Papers
Research

Research Expenditures in First Quarter of 2018
= 75% of Entire 2017-18

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International Partnership

Dual Degree Program with CQUPT in Chongqing, China

291 students in 3rd year

Greatness Lives Here
James Thurber, best known as the author of “The Secret Life of Walter Mitty,” is a rich source of quotations, most of them both insightful and acerbically amusing. This one, I think, holds a valuable message for engineers.

Note that Thurber doesn’t tell us not to look backward, nor does he admonish us not to look forward; he simply advises us to set anger and fear aside — to clear our minds and lose our prejudices — when we do. Engineers make a career of looking forward, fearlessly and with optimism. While optimism may be best tempered with a dose of realism, there’s no such thing as a successful, pessimistic engineer. And looking back, understanding our history as a profession, helps us avoid entrapment in Brownian motion or, worse, running in circles.

But here I want to consider the simple, but essential, act of looking around. As engineers, we need to be aware of the world in which we ply our craft; that context sets the problems we address and determines society’s willingness to accept the solutions we offer. “Science in Service to Society” means, among other things, that we cannot succeed while operating in a social vacuum.

Since our launch three years ago, we have grown to three departments: Computer Science, Electrical & Computer Engineering, and Environmental & Sustainable Engineering. We’re building Bioengineering as I write this; Mechanical Engineering is in planning. We already serve more than a thousand students as we build a college that is fully featured, research intensive, and broad based. We are developing attractive programs to meet the needs of our region, the
state, and the nation. And students, as well as federal funding agencies, are noticing.

With such a short history, we lack many advantages – especially name recognition – that come with legacy. However, neither are we saddled with the burdens of legacy. Our clean start is fostering an esprit de corps that is suppressing the creation of siloes. Our rapidly growing portfolio of extramurally funded research tilts toward interdisciplinary teams, drawn from across the college and the university. Our faculty members are looking around to identify important problems and build teams with colleagues across engineering, and in the basic and social sciences, as well, to address them.

Attending an engineering school that’s part of a comprehensive, research-intensive, and diverse university such as ours offers some advantages. By sharing the campus with students from a wide range of academic disciplines and backgrounds, our students absorb the societal contexts that will lead them to truly important problems, and help them to bring forth solutions to those problems that are not only technically sound and financially viable, but acceptable to society, as well. In short, they are learning to look around.

And so am I. Because we’re still a novelty here, I find myself explaining to colleagues across the campus what engineering is, and isn’t. I’m happy to have the conversation, of course, but as I try to formulate a thoughtful response I find the answer to be something of a moving target. While the essence of engineering will remain stable indefinitely, much of what we learn (or teach) at some level will soon be obsolete. Our students, and we as engineering educators, need to be intellectually adept. It is incumbent on a professional in any field to continue learning, staying current throughout one’s career. In much the same way, a college (of engineering, or whatever) will either adapt and grow, or risk falling into irrelevance. While our college is just three years old and unbound by legacy, as mentioned earlier, our collective ability to look around and adapt will be critical to maintaining vigor and, yes, relevance, as we mature.

Besides the judicious selection of disciplines and degree programs to build, what form should that adaptation take? To approach this issue, I will now do what many engineers (especially engineering professors) do… I’ll change the question. What distinguishes engineering education from, say, job training? After all, job training involves rapid (fast-follower) adaptation, too.

In addition to the humanities and related components of a well-rounded education, a proper engineering education provides grounding in the fundamentals of the basic and engineering sciences to serve the student well over the arc of a four-decade career. Tools and techniques, the technologies du jour, will come and go, often between the time a student begins her studies and when she graduates. Fundamentals, however, will last. That doesn’t mean we don’t introduce our students to the latest tools. Of course we do. They leave here ready to contribute on Day One. But the tools are not the point of their education. A student well grounded in fundamentals drawn from a broad disciplinary base can adapt and contribute in a variety of ways across multiple intellectual spaces. That’s the student the College of Engineering and Applied Sciences at UAlbany prepares.

Requiring a solid grounding in the fundamentals argues against the development of overly specialized niche programs that could leave our graduates stranded when (not if) the world moves on. While “specializations” leading to certificates and tagged degrees can augment an existing degree program, especially for working professionals, and bring added value as they do, they are no substitute for a proper engineering education.

And that’s what I see when I look around.

To read more about Kim Boyer, visit: http://www.albany.edu/ceas/60631.php
the New Faces of Engineering

WON NAMGOONG
Associate Dean for Research, Professor
Electrical and Computer Engineering
Stanford University
Research Interests: Mixed-signal integrated circuits, signal processing systems, communications

PRABIR BHATTACHARYA
Professor and Chair
Computer Science
University of Oxford
Research Interests: Medical imaging, biometrics, mobile network security, game-theoretic applications, driver safety, digital watermarking

YANNA LIANG
Professor and Chair
Environmental and Sustainable Engineering
Utah State University
Research Interests: Development of innovative, practical and efficient methods for cleaning up sites contaminated by emerging pollutants; waste conversion to commodity fuels and chemicals through biochemical, thermochemical and bioelectrochemical pathways; use of omics-approaches for understanding complex natural and engineered systems; and process optimization for maximizing yield of value-added products for commercial scale-up

MOHAMMED AGAMY
Associate Professor
Electrical and Computer Engineering
Queen’s University
Research Interests: Resonant converters, power factor correction, soft switching techniques, modeling and control of power converters for renewable energy applications and ac and dc microgrids

QI WANG
Lecturer
Computer Science
California State University at Northridge, California
Research Interests: Computer Science, software development

YAOZE LIU
Assistant Professor
Environmental and Sustainable Engineering
Purdue University
Research Interests: Water resources, hydrology, water quality, green infrastructure, best management practices, land use change, climate change, optimization
MUSTAFA AKSOY
Assistant Professor
Electrical and Computer Engineering
The Ohio State University
Postdoc University of Maryland
Research Interests: Microwave remote sensing, electromagnetic theory, geosciences, signal processing and data analytics

RIXIANG HUANG
Assistant Professor
Environmental and Sustainable Engineering
Baylor University, Postdoc Georgia Institute of Technology
Research Interests: Wastes to resources conversion via material, technology, and process innovations; cycling of critical elements and contaminants in natural environment

MD AYNUL BARI
Assistant Professor
Environmental and Sustainable Engineering
University of Stuttgart, Postdoc University of Alberta
Research Interests: Characterization of ambient and indoor air quality, source apportionment for controlling emissions, sustainable air pollution management, atmospheric deposition, environmental impact assessment, influences of oil and gas development on air quality, household air pollution, low-cost air quality sensors, exposure assessment

K Young-Yeol Kim
Professor of Practice
Environmental and Sustainable Engineering
Gwangju Institute of Science and Technology
Postdoc Penn State University
Research Interests: Energy recovery from wastewater, microbial electrochemical technologies for resource recovery, developing energy-efficient wastewater treatment process, membrane technology for wastewater treatment

Michael Phipps
Lecturer
Computer Science
University at Albany
Research Interests: Programming languages, compiler design, computer architecture and organization, user interface design, operating systems

VLADIMIR KUPERMAN
Professor of Practice
Computer Science
Moscow Mendeleyev University of Chemical Technology
Research Interests: Information and computer technologies, computer networking, mathematics for decision making, global economics

JMAYA
Assistant Professor
Environmental and Sustainable Engineering
Baylor University, Postdoc Georgia Institute of Technology
Research Interests: Wastes to resources conversion via material, technology, and process innovations; cycling of critical elements and contaminants in natural environment

To learn more about our newest faculty, please visit: http://www.albany.edu/ceas/76069.php
Feng Chen (right) is the newest CEAS faculty member to receive the highly competitive Faculty Early Career Development (CAREER) Award, the National Science Foundation’s most prestigious award in support of early career-development activities of teacher-scholars who most effectively integrate research and education in their work. The awards support a select group of junior faculty across the nation who exhibit exceptional promise for combining outstanding research with excellent teaching. Chen’s award, which comes with a grant of $537,044, will be used to develop a unified, theoretical framework for discovering complex patterns in big data in a multitude of tasks. His project is entitled “SPARK: A Theoretical Framework for Discovering Complex Patterns in Big Attributed Networks.”

Chen is an assistant professor in Computer Science. Pictured with Chen are Siwei Lyu (center) and Jeong-Hyon Hwang (left), associate professors of Computer Science who were honored with this award in 2010 and 2012 respectively. Lyu’s award to develop new methods to detect altered or faked digital images and videos has led to additional funding through NSF and an international platform to share this research. Hwang’s award was used in the development of G*, a system capable of efficiently storing and querying series of graphs on multiple servers. Read more here.
Bolstered by a $1.5M NSF grant, a research team led by Mariya Zheleva and Petko Bogdanov is exploring ways to substantially improve the effectiveness of emergency preparedness and response (EPR) in rural communities. Through a partnership with the town of Thurman, N.Y., and the Warren County Office of Emergency Services, the researchers are developing a platform for timely information collection, integration, exchange and dissemination to support EPR in rural areas.

Using Next-Gen Wireless Technology to Improve Emergency Response

The framework will utilize TV ‘white spaces’ – the unused channels between active broadcast TV stations – which are capable of delivering WiFi over a much broader area than currently deployed technologies. It will also leverage machine learning to optimize the scarce communication resources and improve the efficiency of emergency information dissemination.

“Rural communities, with their social and economic composition, are uniquely vulnerable to emergencies both small- and large-scale,” said Zheleva. “With this project, our aim is to leverage the wide-area wireless backhaul over TV white spaces, WiFi and phone-to-phone switching to provide continuous communication to first responders and timely EPR information access to residents.”

Zheleva and Bogdanov, assistant professors of Computer Science, plan to design a smartphone app that can support the collection and exchange of information among first responders, government agencies and residents. Researchers at CTG UAlbany, led by Mila Gascó-Hernandez and J. Ramon Gil-Garcia, will assess adoption and use of the technology within the community. Read more here.

CEAS Researchers Awarded an NSF Grant for $750,000 to Build CHRONOS

Dola Saha, Aveek Dutta, and Hany Elgala were awarded the NSF CISE Research Infrastructure grant of $750,000, for their project “CHRONOS: Cloud based Hybrid RF-Optical Network Over Synchronous links.” The project will develop a large wireless testbed that expands the capabilities of current Cloud Radio Access Networks (C-RAN). The primary goal of CHRONOS is to design, build and maintain a multi-node, heterogeneous, wideband, scalable and synchronous C-RAN that will enable emerging applications like Virtual Reality (VR), Industrial Internet of Things (I-IoT), 3D broadcast video, tele-surgery, etc. Using multiple antennas that are dispersed in different locations, CHRONOS collects the signals that are generated from both radio
frequencies and optical links and processes them in the Cloud infrastructure. This integration of synchronous radio frequency and optical links will enhance the capabilities of conventional wireless networks by augmenting Wi-Fi access points with visible light and LEDs.

The CHRONOS infrastructure spans multiple domains of engineering including wireless networking and communication, signal processing, optical communication, reconfigurable computing, and parallel processing. Accordingly, the researchers anticipate collaborative research partnerships with experts in all of those domains to work on this unique testbed they are developing. The long-term goal of this project is to utilize the testbed to enable practical research in wireless and optical communication with emphasis on new hardware and software architectures for signal processing.

In addition to global technological and social impact, students at the University at Albany will be trained using this testbed. Our highly-diversified student body includes traditionally underrepresented communities, who will greatly benefit from hands-on workshops, seminars, summer programs and student interest groups hosted by the researchers throughout the duration of the project. The testbed will not only enable research at UAlbany, but will also foster long-term collaborations beyond the campus and will be state of the art among universities.

Dola Saha, Aveek Dutta, and Hany Elgala are assistant professors in the Department of Electrical and Computer Engineering. Read more about this research here.
Furthering Robotics Research

The National Science Foundation (NSF) awarded Weifu Wang, an assistant professor of Electrical and Computer Engineering, a total of $277,685 for two projects that further research in robotics.

The objective of the Computational Joinery project is to develop the theory, techniques, and mechanical designs needed for robots to rapidly build large, rigid structures from blocks that geometrically interlock, without the need for fasteners, cement, or glue. The work is motivated by the desire to quickly assemble structurally strong buildings, furniture, and devices, in such a way that the structure may later be disassembled and the parts re-used. Fabricating in parts presents many advantages: for instance, individual components may be fabricated efficiently, packed for storage and transport, repaired or replaced as needed, and design changes can be made readily in response to changing customer needs. Design of smooth surface finishes allows applications such as modular furniture and packaging of delicate parts for shipping, and embedding mechanical or electrical components will allow rapid construction of robots and other devices. Read more about the Computational Joinery research here.

Teaching Human Motion at Population Scale will develop technology and study methods for teaching motion tasks, with the teaching of sign language as a first application. Simultaneous placement or quick movement of parts of the body is hard to observe, explain, and execute. While tactile-sensing and augmented-reality systems have been developed to enable machine-human communication of physical processes, the focus has largely been on execution, rather than on teaching and learning. The initial focus of the project will be on teaching sign language, but principles and techniques discovered will be generalized to research the learning of increasingly complex physical motions, ranging from simple posing tasks to high-speed fine manipulation tasks. This research is transformative in that it will directly address the scientific question of how to use technology to understand correct or incorrect human motion and provide constructive guidance, leading to a better understanding of human motion learning. Results of this project will be communicated broadly through collaborations with local high schools and museums, and through participation in events such as the USA Science and Engineering Festival.

Read more about the Teaching Human Motion at Population Scale here. Visit Weifu Wang’s faculty page here.

GPU Parallel Program Development Using CUDA

By Tolga Soyata

GPU Parallel Program Development Using CUDA teaches GPU programming by showing the differences among different families of Graphics Processing Units. This approach prepares the reader for the next generation and future generations of GPUs. The book emphasizes fundamentals rather than concepts that are platform-specific, while also providing platform-dependent explanations. Published February 2018.
Developing Machine Learning Algorithms to Help Us Understand Student's Online Learning Process

Shaghayegh (Sherry) Sahebi was awarded an NSF Grant of $174,669 to support her research aiming to achieve a better understanding of students’ learning process in online educational systems. To achieve this goal, researchers will develop multi-view machine learning algorithms that minimize the error of student performance prediction while maximizing the correlations among multiple views to the learning data.

As the national interest in higher and professional education has been increasing, interest in online learning systems has also grown. Online learning systems, such as Massive Open Online Courses and Intelligent Tutoring Systems, aim to contribute to society by providing high quality, affordable, and accessible education, at scale. They highly impact advancement of the national prosperity by preparing skillful professionals for high-demand jobs. Sahebi says, “Delivering such high-impact goals requires automatic tools that can help us understand students’ learning process and answer questions such as what knowledge is gained by watching a video lecture, what is a student’s state of, and how a specific student would perform on a test. The current tools are limited in scope and ignore the heterogeneity of learning materials from which students may learn.”

To achieve her goal, Sahebi will develop multi-view machine learning algorithms that can better predict student performance while maximizing the correlations among multiple views to the learning data.

The project will present an integrated research and education plan (1) to model student interactions with both gradable and non-gradable learning material types, (2) to integrate the proposed models with learning material content, and (3) to evaluate the proposed models by experimenting with real-world online educational datasets. The project will also provide learning and research opportunities to graduate and undergraduate students.

Sherry Sahebi is an assistant professor of Computer Science. Read more here.

Ensemble Detector Tool Aimed to Help Us Better Understand the Universe

Mustafa Aksoy’s project titled “Ensemble Detector: A Novel Tool for Analysis of Non-Stationary Processes,” is being sponsored by NASA with funding of $55,481.00. This project is about developing a new method to analyze non-stationary processes. Non-stationary processes are any random process whose properties change with time and space. All events in Nature feature unsteady characteristics when considered over sufficiently large temporal or spatial scales.
There are many methods that try to analyze the non-stationary signals. Aksoy will approach the problem in a new way by studying non-stationary random processes in the ensemble domain instead of studying individual realizations of them as non-stationary signals in time domain. This study proposes the mathematical development of the Ensemble Detection Theory, building a MATLAB based software tool called “Ensemble Detector” to implement it, utilization of the tool to analyze atmospheric temperature and space-borne Doppler measurements, and comparison of this novel approach with other non-stationary signal analysis algorithms available in literature.

Aksoy says, “The heart and core of this project is to generate ensemble sets which describe non-stationary random processes so instead of looking at the time domain, we will be looking at the ensemble domain. We will create different realizations of those random processes and analyze them. Therefore, we will be able to fully characterize the non-stationary trends in the processes; and investigate what might have happened instead of just what we observed.”

An example of this is atmospheric temperature whose properties change when observed at different times during an extended time period. Atmospheric scientists and earth scientists who are attempting to understand global warming and trends in the change of atmospheric temperature need to quantify and model the underlying non-stationary random processes. The entire universe and all natural phenomena in it are defined by non-stationary processes, thus an algorithm that can extract their properties over time and space will help scientists understand the universe better.

This is very preliminary research in which Aksoy is trying to establish the theoretical/mathematical basis of the Ensemble Detection, and hopefully in the future, scientists will use this method to solve real-life problems.”

Mustafa Aksoy is an assistant professor in the Department of Electrical and Computer Engineering.
Chang and the research team at UAlbany are charged with collecting authentic video data from strategically placed cameras in a downtown city location. Doctoral student Yi Wei has helped organize and process the collected data set from up to 15 concurrently streaming cameras and review the footage for quality and privacy issues.

Researchers on the project will develop and apply computer vision algorithms to video footage in order to detect abnormal behaviors, such as people entering a restricted area, vandalism, or acting aggressively. The aim is to yield an accurate result as possible. For instance, what percentage of videos displaying pickpockets or someone breaking into a car are correctly flagged with the query? To test for accuracy, Chang and the Kitware team will create a comprehensive evaluation platform and run a baseline algorithm against the algorithms developed from researchers at participating universities, including Tufts, Carnegie Mellon, Stanford, Cornell, and MIT. “In the era of big data, video represents a largest source of raw data, and modern analytic algorithms based on deep neural networks demands a large training data set. They also run well via learning from a large enough data set,” Chang said.

The developed evaluation platform together with the collected large-scale video dataset will be released to the public, and can facilitate the development of advanced video analytic algorithms for behavior recognition in video surveillance. The developed algorithm can also be used to sift through large amounts of footage to find video displaying specific behaviors (e.g., opening the trunk of a car). Once the algorithm is developed, Chang envisions it can be applied in real time in the near future.

Ming-Ching Chang is an assistant professor in the Department of Computer Science. Co-PI on the UAlbany part of the project is Siwei Lyu, associate professor in the Department of Computer Science.

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Yelin Kim was awarded a highly competitive 2018 Google Faculty Research Award for her work in automatic emotion recognition. This seed money of $42,798.00 supported her proposal, “Towards Emotionally Intelligent AI Systems: Robust and Adaptive Multimodal Emotion Recognition,” that aims to advance multimodal (audio-visual) emotion recognition, a technology that can provide emotional intelligence to AI systems.

The heart of her research is developing artificial intelligence systems that can better understand and analyze human behaviors, especially emotion. To do this, she is developing algorithmic and statistical methods for analyzing audio-visual human behavior, particularly focusing on emotional and social signals inferred from speech and facial expressions.

Her work has the potential to dramatically improve human-centered and interactive systems and transform intelligent assistants (such as Google Assistant, Apple Siri, Microsoft Cortana, and Amazon Alexa) into systems that can understand what we are saying as well as our emotional state.

Yelin Kim is an assistant professor in the Department of Electrical and Computer Engineering. Read more here.
Siwei Lyu was honored with a 2018 SUNY Chancellor’s Award for Excellence in Scholarship and Creative Activities. This honor is conferred to recognize consistently superior professional achievement and to encourage the ongoing pursuit of excellence. Lyu was among a dozen University at Albany faculty who received the award for excellence in one of five categories of scholarship or performance. President Havidán Rodríguez presented the awards during a ceremony at the University Art Museum on November 19, 2018.

Lyu is an associate professor of Computer Science and a very productive researcher whose work on methods to detect altered or faked digital images and videos has garnered national attention.

Petko Bogdanov received a US Office of Naval Research grant of $44,184 to support his project titled “LINKS: Multi-Layer Mapping of Cyberspace using Composite Dynamic Graph Extraction, Mining and Visualization.” The purpose of this LINKS system is to allow cyber defenders and analysts to visualize, explore, and understand normal and anomalous patterns that occur across the multi-layer cyberspace domain.

Feng Chen received an NSF award of $249,989 for his project entitled “Collaborative Research: A novel paradigm for detecting complex anomalous patterns in multi-modal, heterogeneous, and high-dimensional multi-source data sets.” Read more about this further research into Big Data analysis here.

Research Briefs

Siwei Lyu Honored with SUNY Chancellor’s Award

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Kim L. Boyer was recognized by his alma mater, Purdue University, with a 2018 Outstanding Electrical and Computer Engineering Award at a banquet on Friday, November 2, 2018. The faculty of the School of Electrical and Computer Engineering at Purdue University voted to bestow on him this honor. Established in 1992, the award recognizes alumni who have demonstrated exemplary accomplishment, leadership, and service to their community. Only 234 distinguished alumni have received the award among a field of more than 20,000.

Boyer, who is Dean of the College of Engineering and Applied Sciences at the University at Albany, State University of New York (UAlbany), received his BSEE (1976), MSEE (1977), and Ph.D. (1986) in electrical engineering from Purdue. After a successful career in industry with Bell Laboratories (Holmdel, NJ) and then Comsat Laboratories (Clarksburg, MD), Boyer joined the faculty of the Department of Electrical and Computer Engineering at The Ohio State University. In 2008, he joined the faculty at Rensselaer Polytechnic Institute (Troy, N.Y.) as Head of the Department of Electrical, Computer, and Systems Engineering. In July 2015, he was appointed as the founding Dean of UAlbany’s new College of Engineering and Applied Sciences.

Dean Boyer is a Fellow of the IEEE, a Fellow of IAPR, and a former IEEE Computer Society Distinguished Visitor (distinguished speaker). He is also a National Academies Jefferson Science Fellow at the US Department of State, spending 2006-07 in Washington as Senior Science Advisor to the Bureau of Western Hemisphere Affairs.

More about Kim Boyer can be found here. Photos of the event can be found here.

This year’s honorees with Pedro Irazoqui, Head of Purdue’s School of Electrical and Computer Engineering. From left front: Dr. Valerie Taylor, Dr. Pedro Irazoqui, Dr. Kim Boyer, Dr. Anthony Yen; Back Left: Dr. Eric Walters, Dr. Robert Morrow, Mr. Bruce Eastmond. Photo Credit: ecedraw
Siwei Lyu and Daphney-Stavroula Zois were among the 44 faculty and student researchers who were recognized at the University at Albany’s inaugural Celebration of Scholarship on May 1, 2018. Part of a system-wide initiative to honor scholarly excellence and achievement across SUNY’s 64 campuses, the event is also strongly aligned to the University’s strategic plan regarding campus-wide scholarship, research, and creative activities. Both Lyu and Zois were nominated by College of Engineering and Applied Sciences Dean Kim Boyer under the category of Extramurally Funded Research/Scholarly Activity. Siwei Lyu is associate professor of Computer Science and Daphney-Stavroula Zois is assistant professor of Electrical and Computer Engineering.

ASEE TV 2018 – CEAS was one of several colleges that were featured on ASEE TV at the 125th American Society for Engineering Education (ASEE) Annual Conference and Exposition. Conference attendees had the opportunity to view the video about 500 times at the conference and on their hotel televisions. Dean Kim Boyer and faculty from every department conveyed the excitement and challenges of building a fully featured college of engineering and applied sciences from scratch, as well as a robust research agenda. Faculty members Dola Saha, Mustafa Aksoy, Yelin Kim, Siwei Lyu, Weifu Wang, Hany Elgala and their doctoral students represented some of the exciting research coming out of the college. View the video [here](#).

ASEE producer Bart Johnson interviewed faculty and filmed college researchers in their labs.
Electrical and Computer Engineering Launches Three New Programs in 2018

CEAS has reached another major milestone, officially launching three new degree programs in electrical and computer engineering in 2018. The new Bachelor of Science, Master of Science, and Ph.D. programs in Electrical and Computer Engineering (B.S. ECE, M.S. ECE and Ph.D. ECE) were all approved by the New York State Education Department (NYSED) in Fall 2018.

The B.S. ECE replaces our earlier degree in Computer Engineering. Electrical engineers need a strong foundation in computer programming and hardware while computer engineers need a solid background in electronics and systems. Our new program provides this foundation in both computer and electrical engineering topics while giving students flexibility to customize their program to best meet their interests and career goals. Using upper division electives, students can design their plan of study to emphasize computer engineering, electrical engineering or both, making B.S. ECE graduates well-prepared for today’s job market or to advance to graduate studies.

The new graduate degree programs will provide learning opportunities in a wide range of topics spanning computer engineering, communications and networks, signal and information processing, electronic circuits and systems, power electronics, and control.

“The launch of these programs is another major step in the evolution of our College of Engineering and Applied Sciences,” said University at Albany Provost James Stellar. “UAlbany is creating pathways for students from all backgrounds to pursue careers in engineering while having access to the interdisciplinary opportunities a comprehensive public university offers and that benefit students in seeking jobs and further education.”

“Building a fully-featured, research-intensive College of Engineering and Applied Sciences at UAlbany continues apace,” said CEAS Dean Kim Boyer. “In keeping with our mission of ‘Science in Service to Society,’ these new graduate programs, our first foray in graduate education beyond computer science, will educate the next generation of professional innovators and undergird our rapidly expanding research enterprise.”

Honoring Outstanding Service

Pradeep Atrey received an Outstanding Service Award at the IEEE SMC 2017 Conference in recognition for his exceptional record of service for a number of conferences. Atrey is an associate professor of Computer Science and directs the Computer Science undergraduate program. For more about Professor Atrey, visit his faculty page here.
7th Annual Bunshaft Lecture

Eliot Weinman ’77, media entrepreneur and executive business leader, gave the 7th Annual Bunshaft Lecture on November 5, 2018. His lecture, “The State of Enterprise AI” was accompanied by a panel discussion from among CEAS faculty whose research is in the area of artificial intelligence (AI). This blending of perspectives from the AI marketplace with current AI research was enriching to all present.

Established through the generosity of Albert Bunshaft ’80 and Caryn Bunshaft ’82, The Bunshaft Endowment in the College of Engineering and Applied Sciences provides support for this lecture, which was designed to provide information to the student community about a broad range of topics related to careers in computing science. With the advent of the new college and its engineering programs, the Bunshafts graciously agreed to expand the series to include engineering sciences as well. Read more about the Bunshaft Lecture here.

Pictured: Eliot Weinman delivering his Bunshaft Lecture

Panel of faculty AI researchers. Each took a turn at the mic to share their research and answer questions. Left to Right: Pradeep Atrey, Yelin (Lynn) Kim, Chinwe Ekenna, and Siwei Lyu

Left to Right: Albert Bunshaft, Caryn Bunshaft, Kim Boyer, Eliot Weinman
At the College of Engineering and Applied Sciences, we are committed to student success. Aligned with UAlbany’s core priorities and values, we celebrate academic excellence, research excellence, diversity and inclusion, and public engagement, using Science in Service to Society. Following is a sampling of some of the accomplishments of our extraordinary students.

Pictured above: Outgoing Student Association Vice President and 2018 President’s Award for Leadership Outstanding Student, Madeeha Khan, was chosen to serve as the student speaker for the May 2018 undergraduate commencement ceremony when she earned her B.S. in Computer Science and Applied Math.
Andrew Boggio-Dandry, Anthony Castro, Egzon Shehu and Steven Yoo earned third place and a check for $5,000 at the CREATE Symposium on April 25, 2018 for their project, “Bee Notified,” a tool that was developed to help persons with disabilities gain employment by providing reminders and streamlining time management.

As part of their degree requirements in the Department of Electrical and Computer Engineering, the four seniors partnered with the New York State Industries for the Disabled (NYSID) and Living Resources, two agencies whose mission is to improve the lives of persons with disabilities (PWDs). Working with these agencies, the engineering students developed an innovative technology that could be applied in a real-world setting. The project was called “Bee Notified” in recognition of the industrious creatures that, despite their size, are remarkable workers.

NYSID launched CREATE to encourage assistive technology innovation for New Yorkers with disabilities in order to remove barriers from the workplace. CREATE (Cultivating Resources for Employment with Assistive TTechnology) brings undergraduate and graduate engineers from colleges and universities within New York State together with community rehabilitation agencies to create new and inspiring technologies and devices which improve lives and livelihoods.

For more about this innovative project, see the video, and coverage by UAlbany NewsCenter, Spectrum News, Times Union, and NPR (WAMC).

Veena Ravishankar received a 2018 Distinguished Dissertation Award for her dissertation titled, “ASYMMETRIC UNIFICATION AND DIS-UNIFICATION.” Ravishankar earned her Ph.D. in Computer Science in May 2018. Her dissertation committee co-chairs were Paliath Narendran and Kimberly Cornell. Narendran is a professor of Computer Science at UAlbany and Cornell, a former student of Narendran’s, is an assistant professor at St. Rose. Graduating with Ravishankar were Zumrut Akcam-Kibis and Daniel Hono, both from Computer Science and all three students of Narendran. Congratulations to all and to Professor Narendran for helping them successfully navigate to the completion of their doctoral program.
Andrew Boggio-Dandry received the President’s Excellence in Undergraduate Research Award for his project titled, “Soft Sensing in Smart Cities: Handling 3Vs Using Recommender Systems, Machine Intelligence, and Data Analytics.” The Presidential Award for Undergraduate Research is a competitive honor established to encourage and recognize undergraduate research and scholarship. Having earned his B.S. in Computer Engineering in May 2018, Boggio-Dandry entered the Electrical and Computer Engineering Ph.D. program. His faculty advisor is Tolga Soyata, an associate professor of Electrical and Computer Engineering.

Madeeha Khan was one of ten UAlbany students recognized with SUNY’s highest honor, the Chancellor’s Award for Student Excellence. Khan served as the Student Association Vice President, was an undergraduate student representative on the university’s presidential search committee, an orientation leader, a Writing and Critical Inquiry peer mentor and a resident assistant. She was also a Purple and Gold ambassador. Khan had previously received the UAlbany President’s Award for Leadership in the category of Diversity and Inclusion for her role in enhancing the quality of life at the University. In 2016, she received the President’s Award for International Student Leadership. The next year, Khan’s merit was recognized when she earned the Spellman Undergraduate Leadership Award. Khan hails from New Delhi, India, and majored in computer science with a minor in business. A job in Risk Advisory at Ernst and Young was waiting for her upon graduation.

SUNY Chancellor Kristina M. Johnson and UAlbany President Havidán Rodríguez presented the awards to each student. Read more here.

Ethan Webster and Hadi Habibzadeh received a Best Paper Award at the 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON) for their paper titled, “An Unsupervised Channel-Selection Method for SSVEP-based BCI Systems.” Webster, a senior computer engineering student, was first author, and Habibzadeh, an Electrical and Computer Engineering (ECE) doctoral student was second author and also presented the paper at the conference. Among the other authors on the paper was their faculty advisor, Tolga Soyata, associate professor in ECE.

Pictured: Ethan Webster. Hadi Habibzadeh is featured on inside back cover.
Christopher Z. Yong, an international student from Malaysia, presented his research at the 2018 IEEE MIT Undergraduate Research Technology Conference (URTC) in October 2018. An official IEEE conference, URTC brings together undergraduates from around the world to present, discuss, and develop solutions to advance technology for humanity. This year’s conference was hosted by MIT in Cambridge, Massachusetts.

Yong, a computer science major, presented his poster, “Is it a Pothole or Graffiti? The Ins and Outs of Participatory Urban Issue Monitoring.” His research was performed under the supervision of Professors Daphney-Stavroula Zois and Charalampos Chelmis of Electrical and Computer Engineering and Computer Science, respectively. Yong worked on textual features to classify non-emergency issue reports on the online website SeeClickFix. Yong said, “It’s basically natural language processing, where we try to classify the type of issue that was reported based solely on the reporters’ textual descriptions. With this automated classification process, we can notify the appropriate governmental agencies to resolve some of the citizens’ reported issues in a more efficient manner; in other words, we can help improve living conditions of residents.”

Yong has always been interested in obtaining research experience during his college years because he is fascinated by how the scientific method is applied in real life and says that the experience working with Zois and Charalampos have been invaluable. He would like to attend graduate school and believes this research experience is good preparation and will help him decide where his research interests and passions will focus. He is currently interested in machine learning and artificial intelligence and is furthering his research with Prof. Chelmis as he studies on whether certain social behaviors or lifestyles within a neighborhood correlate with the types of non-emergency issues the residents reported.

Yong said, “I just love the fact that, through machine learning, we can reveal hidden correlations or patterns from a seemingly chaotic data set. I also love that I get to apply machine learning techniques and data analysis on real life data. I found that by grounding these abstract mathematical concepts, I gained a much better understanding and appreciation for them. Moreover, I am excited with the idea that my research* work can potentially improve people’s lives.”

Yong is the recipient of UAlbany’s 2018 Undergraduate Research Endowed Fellowship, a prestigious honor, and also the 2017 Spellman Achievement Award for Academic Excellence. This was Yong’s second research conference presentation. His first was at the 15th Annual Undergraduate Research Conference at the University at Albany, entitled “Building Smarter Communities with Data Science: Resolving Reported Issues in SeeClickFix,” (pictured below).

*Supported by the Smart and Connected Communities program of the National Science Foundation under Grant No. ECCS-1737443.
The Computer Science Department, with assistance from the CEAS Dean’s Office, hosted a two-week all-day summer camp program for local high school students in August 2018. Fourteen students (ten males, four females) from seven high schools in the capital region attended the Python Programming and Data Analytics Summer Camp to either learn or sharpen their Python programming skill and learn basic concepts in data analytics, particularly big-data analytics to solve problems in science and engineering. Although most of the participants were high school juniors and seniors, one student was in seventh grade.

Feng Chen designed, advertised, and executed the camp with the invaluable assistance of computer science master’s students Preet Parikh and Ashita Kalidindi, who served as session instructors. The camp, which was free to participants, was funded with Chen’s NSF CAREER Award grant and will be offered again over the next several years.

Shenendehowa High School freshman Emily Yin explained why she attended the camp. “I’ve always had a lot of interest in coding. In the past, I have learned C++, but Python is slowly overtaking it in terms of usefulness. I have taken online course to learn Python, but I wanted a place to learn more, receive feedback, and discover further application of Python,” said Yin.

Andrew DeCandia, senior at Bethlehem Central High School, said, “I was not looking forward to coming to this program as I already knew a fair amount about Python programming and felt the camp would be a waste. However, after having participated, I feel as though I managed to learn quite a lot. Even with my prior experience.”

Camp participants were not the only beneficiaries of the program. Both Parikh and Kalidindi expressed how the camp also helped them to develop academically and professionally. Kalidindi said, “This camp has given me the opportunity to revise my basics by preparing materials to make high school students understand Python programming. I personally love to share knowledge and teach others the importance of data analytics in the field of science.”

Parikh said, “I was very excited that I would be able to teach these students, as explaining coding to high school students is a challenge. By teaching the students, I was also able to learn something from them or from their doubts and questions.”

Editor’s note: As an outside observer, I was impressed to see the more experienced programmers in the camp readily assist their less knowledgable counterparts (e.g., front left photo).
Women in Technology

Following are brief snapshots of some of our excellent women in STEM at the College of Engineering and Applied Sciences.

**Monet Khadr** presented a paper at the IEEE International Conference on Communications (ICC) that was held in Kansas City in May 2018. In the paper, “Identity Modulation (ID-M),” Khadr introduced Identity Modulation (ID-M), a novel modulation technique proposed for Visible Light Communications (VLC). Khadr is an Electrical and Computer Engineering (ECE) doctoral student who is supervised by Hany Elgala, an assistant professor in ECE. Elgala was second author on the paper.

Khadr received support with a travel grant from the N2Women foundation, which is sponsored by the NSF, IEEE, Google and Microsoft, among others.

Khadr is part of Elgala’s research team at the SINE Lab. Her specialization is Visible Light Communications (VLC) and her research scope is focused on the Optimization of MIMO and Multi-User techniques in VLC systems. Read more about her here.

**Miley Yao**, a Computer Science doctoral student, presented research on cyberbullying detection in online social networks at the 2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM) in August 2018. Cyberbullying has emerged as a serious societal and public health problem that demands accurate methods for the detection of cyberbullying instances in an effort to mitigate the consequences. This research, led by Charalampos Chelmis (CS) and Daphney-Stavroula Zois (ECE), addresses a gap in how quickly cyberbullying can be detected in online social networks by using a novel algorithm designed to reduce the time to raise a cyberbullying alert by drastically reducing the number of feature evaluations necessary for a decision to be made. Using a real-world data set from Twitter, the researchers demonstrated the effectiveness of their approach and that it was highly scalable without sacrificing accuracy for scalability.

Yao and the research team also had their work accepted at the 2018 IEEE International Conference on Acoustics, Speech, and Signal Processing in April of 2018. Another student represented the team for the presentation at that conference. See poster here.

**Yanna Liang** is professor and chair of the Department of Environmental and Sustainable Engineering. Joining CEAS in summer of 2017, she has accomplished much in a short time. She immediately set out to develop an undergraduate program in environmental and sustainable engineering and saw it move through the various stages of the approval process. At the time of this writing, it is before NYSED. She recently hired four new faculty members, a post-doc, and lab personnel. She is currently developing the graduate program with her faculty. She says, “Throughout my career, I have grown to be passionate about sustainability. This is such an important and serious term and concept, and I believe that every scientific field and every corner of our society should apply the principle of sustainable development. No matter if it is environment, energy, and economy, we must consider our future generations and not just our own needs. This passion has been a driving force for my research over the years. ...I wish to contribute to the training, educating and equipping of the next generation of scientists and engineers to be critical thinkers, problem solvers, lifelong learners and life changers.” Read more here.
“Science in Service to Society” is the mission statement for the College of Engineering and Applied Sciences. Engineering begins with the bare bones of science to create solutions for problems of societal significance. In CEAS, our robust, interdisciplinary research agenda is driven by faculty and students from all of our disciplines – working together and with colleagues from outside the College, as well. This section, despite its size, offers just a sampling of ongoing research in CEAS. We invite you to peruse these brief position papers as our faculty discuss current trends, challenges, and opportunities in their respective areas of endeavor.

This is The View from UAlbany.
Passive Microwave Remote Sensing of Earth and Space: The Present, Future and Challenges
By Mustafa Aksoy

UAlbany’s College of Engineering and Applied Sciences targets to lead the innovations regarding small and smart microwave radiometer systems for Earth and Space monitoring through a strong collaboration among its Electrical and Computer Engineering, Computer Science, and Environmental and Sustainable Engineering Departments.

Passive Microwave Remote Sensing

Remote sensing is defined as a set of multidisciplinary techniques to obtain information about the environment through remote measurements of reflected or emitted energies. It is called “Microwave Remote Sensing” if the measurand is electromagnetic energy at microwave frequencies (1 – 300 GHz).

Microwave remote sensors can be either “active” or “passive.” Active microwave sensors, i.e., radars, emit their own energy and estimate the properties of the environment based on its reflections. Thus, they include both transmitters and receivers. Passive sensors, namely microwave radiometers, on the other hand, are merely receivers and measure natural thermal radiation from the environment (or in rare cases, the reflection of solar energy impinged upon the environment). Microwave thermal radiation from objects is defined by their “brightness temperature,” i.e., their physical temperature multiplied by their “emissivity” (see Figure 1). Emissivity is the effectiveness of an object in emitting thermal radiation and highly dependent on its physical and chemical properties as well as the radiation frequency, direction, and polarization.

The main goal of passive remote sensing (also called microwave radiometry) applications is, therefore, to retrieve physical and chemical properties of the objects through brightness temperatures measured by microwave radiometers at specific frequencies and angles, and in various polarizations.

Current Technologies

Ground-based (Figure 2), air-borne (Figure 3) and space-borne (Figures 4 and 5) microwave radiometers have been used to measure environmental parameters on Earth such as soil moisture, ocean salinity, atmospheric temperature, wind speed, snow and ice temperature and precipitation rates, as well as space exploration for decades. Space-borne systems provide greater coverage in shorter measurement time periods for global scale investigations, whereas ground-based and air-borne radiometers are mostly used for local measurements which require higher accuracy and spatial resolution.

Today, a common radiometer system consists of an antenna to capture the electromagnetic radiation, followed by a series of filters, amplifiers as well as detectors, digital boards and computers to acquire, process and analyze the measured data. The antenna size is usually determined by the operating frequency of the radiometer and the spatial resolution requirements (electrically larger antennas are more directive and have smaller footprints). On the other hand, developments in design and manufacture of microelectronics and field-programmable gate arrays, along with the advancements in data processing, machine learning and artificial intelligence have been transforming the radiometer designs, and prepare the future of passive microwave remote sensing of Earth and Space.

Figure 1 - Passive microwave remote sensing observations using a microwave radiometer where β is the antenna beamwidth, D is the target range, e_s T_s and e_bkg T_bkg are target and background brightness temperatures (e is emissivity and T is physical temperature), and T_env is the contributions from the space not observed directly by the antenna [1].
Figure 2 - 3-channel (23.8, 30, and 89 GHz) ground-based microwave radiometers deployed in the Southern Great Plains by the Atmospheric Radiation Measurement (ARM) Climate Research Facility to measure precipitable water vapor and liquid water path in the atmosphere [2].

Figure 3 - NASA’s Airborne Earth Science Microwave Imaging Radiometer (AESMIR) on the NASA P-3B research aircraft. AESMIR covers the 6–100 GHz bands that are essential for observing key Earth System elements such as precipitation, snow, soil moisture, ocean winds, sea ice, sea surface temperature, vegetation, etc.

Figure 4 - Special Sensor Microwave Imager/Sounder (SSMIS) on a Defense Meteorological Satellite Program Satellite. SSMIS, covering a wide range of frequencies from 19 - 183 GHz, is a radiometer used to measure rainfall rates [4].

Figure 5 - Chinese Chang’E-1 satellite carried a 4-channel (3, 7.8, 19.35 and 37 GHz) microwave radiometer to measure the Lunar Regolith thickness between 2007 and 2009 [5].

Future of Earth and Space Exploration via Microwave Radiometry

The architecture of microwave radiometers has been changing rapidly in the past few years. Instead of large, complex, expensive and high power consuming instruments, government agencies, universities, and private companies created programs based on small, cheap and low-power radiometers. Rapid developments in high-efficiency solar cells, high-energy-density batteries, microelectromechanical systems (MEMS), advanced materials, and micro-sensors have also allowed the usage of these new generation instruments in “small satellites” or “cubesats” for space-borne scientific missions to explore Earth and the rest of the universe. Due to their low cost, small size, low weight and reduced power requirements, constellations of small radiometers are considered for future Earth and Space science missions which require high spatiotemporal resolution and wide, global-scale coverage. Indeed, such constellations have significant advantages which include resiliency of a distributed observation system and graceful degradation with low-cost replenishment of the constellation. Recent breakthroughs in machine learning, artificial intelligence, data fusion and processing techniques also support such efforts by enabling the required technologies for inter-element interactions and constellation-level data handling. For example, in the 2016 Microwave Technologies Review and Strategy Report prepared by the NASA Earth Science Technology Office, “The use of multiple Small-Sats to replace or enhance functionality currently resident only in large,
expensive, monolithic systems” is stated as a topic of keen interest as these constellations “may enable simultaneous spatially-extended measurements, cost-effective persistence, and large aperture synthesis” [6]. Thus, the future of passive microwave remote sensing lies on small and cost effective distributed radiometers (See Figure 6).

**Main Challenges**

Miniaturizing microwave radiometers brings unique challenges in terms of their calibration. Small lightweight instruments usually lack radiation shielding and thermal mass (which control and stabilize the internal temperature of the instrument) and they are more easily impacted by ambient conditions. For space-borne systems, size and mass limitations also restrict the use of stable blackbody targets as calibration references. As a result, even though building and deploying small radiometers have recently become easier, obtaining accurate and robust estimations of geophysical parameters through their measurements is now a harder task.

The other major problem that microwave radiometry has been facing is the fact that the radio spectrum, a limited resource, is being occupied more and more densely everyday as new technologies emerge in communications and defense industries. Radiometers are passive devices which measure the electromagnetic power captured by their antenna, but they are not sensitive to the source of the emission. Thus, human-made emissions interfering with radiometer measurements (radio frequency interference or RFI) cause biases in retrieved information regarding the environment. Figure 7 demonstrates the RFI problem on a global 1.4 GHz brightness temperature map generated by NASA’s Soil Moisture Active Passive (SMAP) Radiometer. Although the SMAP radiometer operates in a protected frequency band in which all human-made emissions are prohibited by the International Telecommunication Union, its measurements are still contaminated by RFI. For microwave radiometers functioning in unprotected frequency bands, the problem is even more severe. Effective detection and mitigation algorithms for limited number of narrowband and short-duration interference signals are present in the scientific literature, and have been implemented in remote sensing missions; however, their efficacy is still questionable in case of wideband, long duration, or large number of RFI signals, which will represent the future RFI environment. (See Figure 7 on next page.)

**Passive Microwave Remote Sensing Research at UAlbany**

UAlbany’s College of Engineering and Applied Sciences targets to lead the innovations regarding small and smart microwave radiometer systems for Earth and Space monitoring through a strong collaboration among its Electrical and Computer Engineering, Computer Science, and Environmental and Sustainable Engineering Departments. The passive remote sensing research in the Electrical and Computer Engineering Department also focuses on overcoming the main challenges about radiometer calibration and RFI detection and mitigation, besides engaging in more traditional studies on electromagnetic emission and propagation modeling, and retrieval studies for geophysical properties based on measured brightness temperatures.
Figure 7: Horizontally polarized brightness temperatures (in Kelvins) measured by SMAP between June 3 and June 9, 2015 (top) before and (bottom) after the RFI mitigation. Extreme brightness temperatures indicated by red color imply significant RFI contamination [10].

References

Receiver Design for Cognitive Radios
By Won Namgoong

Designing an efficient wideband radio that can sense over a broad spectrum (e.g., in excess of a gigahertz) is challenging. This is especially true as high-levels of integration and low power consumption are essential for cognitive radio systems operating in battery-powered mobile systems.

Modern wireless communications occur primarily in the radio spectrum, which is the radio-frequency (RF) portion of the electromagnetic spectrum. The available radio spectrum, however, is insufficient to support the ever-increasing demands for higher data rates and the emergence of new devices such as for the Internet of Things (IoT) and machine-to-machine communications. This spectrum scarcity problem is in large part due to the manner in which the radio spectrum is allocated. Currently, government regulators employ a fixed spectrum access policy, where each piece of spectrum is assigned to one or more dedicated licensees. Only the licensed users have access to the assigned spectrum, while others are not allowed to use it. Various studies have shown that this fixed spectral allocation policy results in highly underutilized radio spectrum. Depending on time and geographic location, a large portion of the licensed spectrum is left unused. For example, even in major metropolitan areas such as in New York City, studies have shown that most frequency bands rarely exceed 50% utilization, and half of them are below 10%.

To improve the usage efficiency of this valuable spectral resource, the cognitive radio (CR) paradigm has been proposed. As in the current spectrum access policy, a radio spectral band is licensed to dedicated users, who are referred to as the primary users (PUs) in CR parlance. The difference, however, is that this usage is not exclusive. Other users or secondary users (SUs) are allowed access to these licensed spectral bands as long as the PUs are not active. To achieve such opportunistic communication, the SUs must regularly scan for unused bands then adapt their transmission and reception parameters accordingly to enable SU communication while ensuring negligible interference to the PUs. By granting SUs access to licensed bands, the overall spectrum utilization efficiency can be significantly improved, and the expected data throughput bottleneck could be largely mitigated.

As the spectrum scarcity is a critical issue, the CR technology has been extensively studied in the literature in the last decade. Although a great deal of work has been reported including numerous promising techniques, the underlying assumption in much of these works is the availability of a high-performance CR receiver, which has received significantly less attention by comparison. Designing an efficient wideband radio that can sense over a broad spectrum (e.g., in excess of a gigahertz) is challenging. This is especially true as high-levels of integration and low power consumption are essential for CR systems operating in battery-powered mobile systems. There are two primary challenges in realizing a high-performance wideband CR receiver: wideband analog front-end and analog-to-digital converters (ADCs) for spectral sensing.

Wideband Receiver Front-End

Fig. 1 shows a simplified block diagram of the signal path of a conventional narrowband receiver. The received RF signal first passes through an off-chip surface acoustic wave (SAW) filter to attenuate out-of-band interferers, which can be orders of magnitude stronger than the desired signal. The resulting signal is subsequently amplified using a low-noise amplifier (LNA), whose output is downconverted to baseband via mixers, then filtered and further amplified for digitization.

![Figure 1. Block diagram of a conventional narrowband receiver chain](image-url)
The RF prefiltering performed by the SAW filter is essential as the large out-of-band interferers would otherwise saturate the receiver signal chain, causing significant nonlinear distortion. In CR receivers, however, the SAW RF prefilters cannot be employed as they are not tunable and would limit the receiver’s operating frequency range. As a result, the receiver needs to process the entire frequency band including the large out-of-band interferers, which become in-band interferers in the absence of SAW filters. To support such a wideband signal, the receiver linearity needs to improve by orders of magnitude compared to that in existing receivers. Fortunately, significant progress in receiver linearity has been made in recent years in the context of software-defined radios. Among the recent developments are the noise-canceling topologies, current-mode reception, and harmonic-rejection receivers. Despite these innovations, additional improvements in linearity are needed to enable many of the envisioned CR system applications.

Spectral Sensing

As the wireless spectrum is dynamic, the CR receiver needs to regularly scan the entire frequency range of interest to detect the available spectral bands. To reduce the sensing time, a large segment of the spectrum can be downconverted then digitized for spectral sensing in the digital domain. Processing a wider spectral segment at a time enables faster scanning time, but this improvement is at the expense of significantly increased ADC power consumption. In addition to the higher sampling frequency required to process the wider spectral segment, the ADC dynamic range needs to be high to support the PU signals whose power levels can vary by several orders of magnitude. As high-sampling and high-resolution ADC requires the use of architectural topologies with poor energy efficiency, wideband data conversion for rapid spectral sensing suffers from high ADC power dissipation, which is often a major source of the overall receiver power consumption, especially in wideband digital receivers.

More recently, sensing strategies based on compressed sensing have been proposed to achieve near ideal sensing time at minimal power dissipation levels. Since the radio spectrum is underutilized as shown in Fig. 2, the compressed sensing CR receiver exploits the sparsity of the PU signals in the frequency domain to perform a fully-parallel search at a much reduced sampling frequency that is defined by the information bandwidth instead of the instantaneous bandwidth. The primary advantages are that the ADC requirements are greatly relaxed, resulting in significant receiver power and complexity reduction, and that spectrum sensing time is minimized to achieve high CR reception performance.

Numerous techniques for achieving compressed sensing for CRs have been proposed, but each suffers from practical implementation challenges.

Concluding Remarks

Cognitive radio is widely regarded as one of the most promising enabling wireless communication technology for supporting the ever-increasing demands for wireless access. To realize a truly cognitive radio is a challenging task that requires efforts from various disciplines including communication theory, networking, signal processing, and digital/analog hardware design. Our earlier work has focused on realizing such a cognitive radio by rethinking many of the existing circuit design techniques from a more multi-disciplinary perspective. We have developed general techniques for realizing highly efficient wideband spectral sensing and have recently implemented in silicon a compressed sensing cognitive radio receiver that overcomes many of the current implementation challenges. Our current research is on addressing the practical hardware implementation aspects, which remain a key challenge for cognitive radios from becoming a viable solution to the spectrum shortage problem.

Won Namgoong is Associate Dean for Research and Professor of Electrical and Computer Engineering. Visit his faculty page here.
The Need for “Ever-Smarter Goggles” to Explore Big Data

By Petko Bogdanov

Our increasing ability to measure phenomena in the sciences, engineering, business, government and every aspect of everyday life has led to an analog of Moore’s law for data. This steep upward trend is changing “business as usual” in all the above domains, making collection, storage and analysis of data a central priority. However, to capitalize on these ever-growing data repositories, we will need novel algorithms that go beyond standard data types and handle uncertainty, temporal information and multi-resolution data. In addition to sophisticated algorithms, we will also need to bridge the gap between data analytics and domain expertise by training and collaborating with domain experts to ensure our algorithms are relevant and routinely and widely employed. Hence to “detect” actionable patterns in Big Data, we will need “smarter and smarter goggles” which are a combination of advanced algorithms and incentivized users who are ready to invest their time to co-design, learn and employ them. While the above two families of challenges have been around for a long time, the increasing diversity, scale and veracity of data and endless emerging applications have amplified the need to address them now more than ever before.

Let us think in terms of an example problem to appreciate the challenges and opportunities brought about by Big Data. How to simulate the online behavior (e.g. social media content creation, opinion dynamics, collaboration on open source software, etc.) of the whole population of the US? What if there are automated bot users, and multiple social media platforms, information overload and unobserved back channels? These are the questions set out by one of DARPA’s recent programs, in which our team is participating. To create a truthful simulator for online behavior at such a scale, we need data from multiple sources: Twitter, Facebook, Wikipedia, Github and we need to be able to adequately model the individual and group behavior across these systems. There is no doubt that large amounts of observational data is necessary to even start modeling behavior at this scale, but it is also equally important to align data with existing behavioral and cognitive models from sociology and the behavioral sciences in a manner that ensures truthful simulation and enables “what if” scenarios exploration. The challenge is further exacerbated by the fact the people behave differently online than when in small groups for which classical behavioral models have been developed. This is only one application scenario in which big data and domain scientists’ expertise will eventually enable understanding of a large-scale socio-behavioral system and give us the ability to study the effects of misinformation, virality, decision making at a large population scale.

Not everything is a nail, hammer wielder! Bountiful data has incited a commensurate growth in machine learning and particularly deep architectures. It is, however, important to recognize that the most widely researched and used algorithms from this area are suitable for typical scenarios and often fall short in terms of interpretability, ability to incorporate domain knowledge and handle complex data types. Deep learning has driven a tremendous improvement in speech, text and natural image processing. However, models are often complex and do not have easy-to-understand mapping to processes and physical features of the underlying data. This is particularly true when they are applied to new data domains such as, for example, signals over graphs, spatio-temporal data and 3D structures and properties of nanomaterials. In addition, often the value of statistical models is not only being able to classify or predict, but rather explain dependencies that would allow improvements in the domain of inter-
est. Beyond lack of interpretability, the advantages of deep architectures are mostly demonstrated empirically, leaving much to be yet understood about their theoretical performance and guarantees. As a result, caution needs to be employed when popular models are adopted in new domains and care must be taken to extract appropriate data features in collaboration with domain experts that would then be able to make better sense from model outputs. Furthermore, this intimate understanding of the important features of the data will allow Occam’s razor minimal models and, thus, further reduce model complexity and overfitting, while improving interpretability. Our lab is successfully pursuing such collaborations with biologists, nano-material, socio-behavioral scientist and wireless networks researchers, where novel, domain-specific and expert-informed algorithmic frameworks are enabling significant improvements over off-the-shelf popular techniques.

Handling big data also requires system support and, in this domain, established frameworks such as Hadoop, SPARC (and others) have enabled seamless distributed processing at large scales. However, these wildly popular systems limit the application programming interface and, thus, the complexity and richness of data types that could be handled. One weakly-supported domain is network or graph data, which encodes both data items and various types of inter-relationships among them. Such data arises in social media, communications and infrastructure domains such as transportation and smart grids. There are no large-scale distributed systems that can mine such data for user-defined subnetwork patterns of interest. Our lab has teamed up with distributed systems researchers to develop the first system for distributed, ranked subgraph discovery according to a general user-defined criterion of interest. Similar efforts will be necessary for newly arising data types as, just like with deep learning, one kind of hammer would not fit all nails.

**The importance of complex networks and graph data.** Many popular data systems and models from the last several decades conveniently assume that data entities are independent. A great example is the widely adopted relational database in which relations (or tables) are lists of data items with various properties. Such nicely structured data model lends itself to powerful optimizations for its analytics and transaction management, however, the majority of modern Big Data is less structured and the relationships between data entities are equally and sometimes even more important for applications than the items themselves. This has led to the adoption of graphs as a popular data structure to manage and analyze complex data. The richer expressivity of graphs comes with the corresponding challenges: many graph analytics problems are computationally very hard to solve, meaning that the time required to compute them grows super-linearly with the size of the data, often times exponentially. Taming this complexity via advanced algorithms is an active research direction and one of the central focuses our research group. Apart from making graph analytics computationally feasible, it is also challenging to model the most important relationships among entities, and once again domain knowledge in combination with algorithms (our smart goggles) becomes essential to accurately represent, model and analyze semi-structured graph data.

The advantage of graph data and in general modeling relationships, is that we can truthfully represent the footprint of complex dynamic processes in various domains from social, mobile and communication networks to infrastructure and biological networks. Beyond the classical static graph paradigm from computer science, the temporal information of when graph events occur (e.g. vertex or edge creation and use) is an important new dimension for improving the quality, interpretation and utility of mined patterns. However, mining dynamic graphs poses, among others, an important and often overlooked challenge: observed data must be analyzed at an appropriate temporal resolution (timescale), commensurate with the underlying rate of application-specific processes. If the temporal resolution is too high, evidence for ongoing processes may be fragmented in time; if it is too low, data relevant to many processes may be mixed, thus obstructing discovery. Existing approaches typically adopt a fixed timescale (e.g., minutes, days, years), and they mine for patterns in the corresponding aggregated graph snapshots. However, timescale-aware methods must consider non-uniform resolution across both time and the graph, and thus, account for heterogeneous network processes evolving at varying rates in different graph regions. Our group is at the forefront of developing timescale-aware approaches to mine dynamic interaction data. We have applied our approaches to many application scenarios including security, social
network analysis, transportation and health.

**Bridging the gap by putting data to work.** The smart goggles for Big Data become worthy and relevant only when there is someone to wear them. It is not uncommon that data mining researchers make assumptions about the problems they are solving without consulting experts in application domains. Sometimes we do this to stay general in our solutions and sometimes because access to domain experts to co-design algorithmic solutions depends on long-term collaborative relationships with a steep up-front cost of aligning “language”, goals and reconciling differences in community expectations. Starting and maintaining such collaborations, while widely lauded by funding agencies and universities alike, is a high-investment high-return endeavor particularly so for young researchers trying to establish themselves in their respective domains. At the same time the benefits are numerous: purpose-driven design of relevant data mining solutions, opportunities to disrupt whole fields that have not fully embraced data, opportunity to train the next-generation interdisciplinary researchers who will understand both the application domain and the computer science of such collaborations, and last but not least, the opportunity to see data and our algorithms at work.

Our goal as algorithmic data analysis researchers should be to not only design novel algorithms, but also understand their need, uses and adoption through “intimate” collaborations with experts. In pursuit of this goal, our lab has initiated and maintained several collaborations with industrial and academic partners. We are spearheading novel methodology for nanomaterial design in collaboration with materials scientists from national labs and academia. Our methodology has been employed in designing new materials of desired properties. The established state-of-the-art in nanomaterial design from the past is to model materials from first physical principles. However, such an approach has limitations in that it makes necessary assumptions to keep computations practical and feasible. Experimentalists, however, are quickly amassing observational data which paves the way for data-driven approaches and even composite first-principle and data driven predictions. The field of nanomaterials is on the verge of being disrupted by Big Data and we as data researchers should be equally excited about the opportunities.

Our lab is also actively collaborating with experts in communications technology to develop data-driven spectrum analysis solutions for next-generation adaptive wireless communication and applications to emergency preparedness in rural areas. While within the bounds of computer sciences and engineering, the communications domain can also significantly benefit from influx of novel data-driven approaches with an accent on computational efficiency and approximate methods. We are also collaborating with industrial partner Charles River Analytics to incorporate dynamic graph mining approaches into cybersecurity analysis tools funded by a recent STTR grant from the Office of Naval research. All above are examples of putting data to work in order to understand the relevance of our algorithmic solutions and further improve them, while disrupting an application domain that can benefit from Big Data solutions.

In summary, the Big Data wave is here to stay and stronger than ever. How-ever, how we ride it is of great importance in making the most out of it by both advancing our field of computer science and the numerous application domains. In order to maintain and improve our “Big Data smart goggles”, we need to be open to new data modalities, adopt and develop appropriate data-informed methodology and put those goggles more and more in the hands of our collaborators.

**References**

1) DARPA Computational Simulation of Online Social Behavior (SocialSim) https://www.darpa.mil/program/computational-simulation-of-online-social-behavior

2) Graphs are another name for networks used commonly by computer scientists. In their simplest form they are discrete mathematical objects consisting of vertices (data items) and edge (relationships among vertices).

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Sustainable water resources management, which aims to solve or avoid water quantity and quality issues, is essential for the sustainability of the global economy, society, and environment. The sustainability of water resources is significantly impacted by population growth, climate change, and land use/land cover change. Issues and challenges of sustainable water resources management in both urban and agricultural contexts need to be addressed.

1. Hydrology and water quality issues

Urbanization and greater demands for agricultural productivity, which change land use/land cover, have become global trends due to significantly increased population. Urban development changes land uses from pervious surfaces (such as grass and forest cover) to impervious surfaces (for instance, rooftops, parking lots, and roads). The higher imperviousness of the area generally leads to increased surface runoff volume and runoff velocities; decreased hydrologic recession time, groundwater recharge, baseflow recharge, and lag time between precipitation and runoff. Flooding occurs when precipitation overpowers the capability of urban drainage systems, or flows overwhelm the capacity of rivers, lakes, or oceans. Urban sprawl enhances the possibility of accumulating and delivering nonpoint source pollution due to urban activities (such as lawn care, transportation, and construction) with runoff. Although polluted urban stormwater can be collected and delivered by combined sewer systems and then treated by treatment plants, combined sewer overflows (CSOs) may occur when capacities of sewer systems are overloaded due to intense rainfall events. CSOs may cause severe water pollution problems in rivers, lakes, and even oceans. Agricultural activities, such as fertilizer/pesticide application, can be significant reasons for nonpoint source pollution from agricultural areas, which results in an adverse influence on water quality if the runoff is discharged untreated. Continued gas emissions to the atmosphere, which result in rising greenhouse gas concentrations, will have impacts on climate, such as changing the patterns and quantities of rainfall, and increasing the global temperature. Climate change may also have adverse impacts on hydrology and water quality, such as increased runoff volume and peak runoff, and degraded water quality.

2. Addressing hydrology and water quality issues by applying best management practices (Figure 1)
Increasing numbers of BMPs have been studied in research projects and implemented in watershed management projects, but a gap remains in quantifying their effectiveness through time. The current knowledge about BMP efficiencies indicates that most empirical studies have focused on short-term efficiencies, while few have explored long-term efficiencies. For planning purposes, computer models are commonly used to predict the impacts of BMPs at the watershed level due to the expense of collecting empirical data (measured data), hydrometeorological variability and countless possible implementation scenarios. Most simulation efforts that consider BMPs assume constant performance irrespective of ages of the practices, generally based on anticipated maintenance activities or the expected performance over the life of the BMP(s). However, efficiencies of BMPs likely change over time irrespective of maintenance due to factors such as degradation of structures and accumulation of pollutants. Generally, the impacts of BMPs implemented in water quality protection programs at watershed levels have not been as rapid or large as expected, possibly due to overly high expectations for practice long-term efficiency, with BMPs even being sources of pollutants under some conditions and during some time periods. The review of available datasets reveals that current data are limited regarding both short-term and long-term BMP efficiency.

3. Current knowledge and future research for BMP efficiencies (Figure 2)

Figure 2. Current knowledge and future research needs of BMP efficiencies

3.1 Current knowledge

Increasing numbers of BMPs have been studied in research projects and implemented in watershed management projects, but a gap remains in quantifying their effectiveness through time. The current knowledge about BMP efficiencies indicates that most empirical studies have focused on short-term efficiencies, while few have explored long-term efficiencies. For planning purposes, computer models are commonly used to predict the impacts of BMPs at the watershed level due to the expense of collecting empirical data (measured data), hydrometeorological variability and countless possible implementation scenarios. Most simulation efforts that consider BMPs assume constant performance irrespective of ages of the practices, generally based on anticipated maintenance activities or the expected performance over the life of the BMP(s). However, efficiencies of BMPs likely change over time irrespective of maintenance due to factors such as degradation of structures and accumulation of pollutants. Generally, the impacts of BMPs implemented in water quality protection programs at watershed levels have not been as rapid or large as expected, possibly due to overly high expectations for practice long-term efficiency, with BMPs even being sources of pollutants under some conditions and during some time periods. The review of available datasets reveals that current data are limited regarding both short-term and long-term BMP efficiency.

3.2 Future research

To better understand BMP performance that can assist decision making, the effectiveness of practices needs to be explored further in future research.

(1) A clear starting point is the collection of practice efficiencies from current databases, reports, and scientific literature. However, existing data have limited applicability for assessing BMP performance over time. This is not only
because of the limited data availability, but also because many data details are not available, such as accumulated runoff volume/pollutant loads treated, installation details, characteristics of storm events, and maintenance activities.

(2) New data on BMP efficiencies (paired inflow and outflow volume/pollutant concentrations) also need to be collected that consider the impacts of factors, such as total runoff volume/pollutant loads treated over time, design, installation, maintenance activities, age, life cycle, characteristics of storm events (size, duration, and intensity), date, practice condition at time of data collection, and local conditions (soil, land use, slope, vegetation, climate, and practices implemented in series with runoff treated by one practice flowing into another practice).

(3) A standard describing the data that should be collected is needed. The BMP data collected could be reported in a dynamic online database, and new information added to the database as future data become available. As existing and new data are assembled, analyses of efficiencies of BMPs over time will be possible. Based on the paired inflow and outflow volume/pollutant concentrations data collected, reductions of pollutant loads/concentrations (percent reductions or absolute reductions for meeting water quality standards and Total Maximum Daily Load goals, as well as other ways to express efficiencies) can be calculated. Then, these data collected can be further analyzed, such as exploring frequency distributions of reductions or meeting water quality standards at the BMP outlet. Fundamental differences in BMP efficiencies reported from plot studies vs. field or small watersheds, annual cycle vs. single or few storm events, simulated vs. natural rainfall, and other similar issues need to be addressed. It is inappropriate to compare a BMP efficiency derived from a plot study using a single simulated rainfall event with a value determined by annual monitoring of field-level BMPs under natural precipitation/runoff.

(4) New modeling techniques need to be developed to represent effectiveness of BMPs over time that could be used in multiple hydrologic/water quality models. The new modeling techniques should include BMP efficiencies over different periods of their life spans, such as establishment periods and periods between maintenance. By incorporating these techniques, we can explore the impacts of considering BMP efficiencies changing over time. A framework to simulate BMP efficiencies changing with time is also needed. The changes would consider the practice establishment period, initial practice conditions, storm events, practice maintenance, and practice life cycle.

(5) The research community needs to work together on collecting existing and new BMP performance data, exploring the data collected, and developing modeling techniques to represent practice effectiveness over time that can be used in hydrologic/water quality models. Global climate change will likely impact practice performance over time due to intensity and frequency changes of extreme climate events compared to current and past climate conditions, which could also be studied using modeling methods. The completion of this work will assist decision makers in making better decisions on BMP implementation in watershed management projects.

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Electrical Impedance Tomography

By Gary Saulnier

At UAlbany, we will be designing, building, and testing the next generation ACT instrumentation which will make images at a higher frame rate with higher accuracy and precision than earlier systems, enabling us to resolve smaller changes that occur in the lungs with the progression of cystic fibrosis.

Electrical Impedance Tomography (EIT) is an imaging modality that produces images of the electrical properties of the interior of a region using electrical measurements made on its surface. Much of the work in EIT has focused on medical imaging applications in which the differences between the electrical properties of various tissues, fluids, and gases along with the movement of these components with time make it possible to produce structural and functional images of the interior of the body. Although EIT produces low resolution images, it uses compact, inexpensive instrumentation, produces images in real time, and has no known harmful effect on the body. Unlike x-ray techniques, which subject a patient to ionizing radiation or MRI systems which are large and expensive, EIT is suitable for monitoring applications in which data can be collected over a long period of time. Since it images electrical properties, EIT also has different sensitivities than other imaging modalities including ultrasound which also has portable instrumentation. EIT has been studied for many medical applications including cancer detection (breast, cervix), brain imaging (epileptic foci, activity), gastric emptying monitoring, and pulmonary (heart and lung) imaging. It is this latter application – pulmonary imaging – where EIT has shown the most promise and seen the most research activity in recent years.

In most EIT systems, very small alternating currents with a frequency in the range of 10 kHz to 1 MHz are injected into the body using a set of electrodes on its surface and the resulting voltages are measured. The data set to produce an image is created by measuring the voltages produced when an appropriate set of current patterns is applied, where each pattern defines the current value for each of the electrodes. Images of the distributed electrical impedance (impedivity) in the interior region are produced by solving the inverse problem, i.e. finding the impedivity that produces the measured voltages from the applied currents. EIT systems fall into two main classes, ones that apply current to only a single pair of electrodes at a time (Applied Potential Tomography - APT) and those that apply currents to all the electrodes simultaneously (Adaptive Current Tomography - ACT). The many current sources in ACT systems makes the instrumentation more complex but produces better data sets by producing more optimal current flow in the body. EIT has its roots in Electrical Resistivity Tomography (ERT), a geophysical subsurface imaging technique dating from the 1930’s in which measurements made using electrodes applied to the surface of the earth and down boreholes are used to locate and characterize sub-surface structures. The first practical EIT systems were produced during the 1980’s.

Figure 1. Four rings of 8 electrodes each on a subject for lung imaging.

Imaging of the heart and lungs is usually performed using one or more rings of electrodes placed around the thorax. A single ring of 32 electrodes, two rings of 16 electrodes each, or four rings of 8 each are commonly used. A single ring of electrodes allows an image of a cross-sectional slice of the thorax containing the lungs and heart to be recon-
structed. However, unlike x-rays which essentially follow a straight path, electric current follows along a path of least resistance and may travel outside of the plane defined by the ring of electrodes. The reconstruction algorithm that produces the image has no information in the direction perpendicular to the plane of the electrodes and, therefore, must assume that all current flows in the plane of the electrodes. Consequently, features in the regions immediately above and below the plane will be projected into the reconstructed image. Using multiple rings of electrodes enables three dimensional images to be reconstructed with less sensitivity to features above and below the roughly cylindrical region surrounded by the electrodes.

EIT is very well suited for pulmonary imaging because of the ability to locate electrodes near the region of interest, the high impedivity contrast between air-filled lungs and surrounding tissue, and the ability to image a large portion of the chest with high temporal resolution over an extended period. EIT can provide regional ventilation information that can be particularly useful for adjusting ventilator settings for intubated patients to achieve the appropriate level of lung inflation. EIT systems generally can take 20 – 50 images per second and this high temporal resolution enables the system to also image the pulsatility due to blood flow in the lungs. Blood is highly conductive so perfused lung tissue will show small variations in impedivity at the cardiac rate as blood volume in the lungs increases and decreases. Out-of-phase variations will also be seen in the heart region as blood leaves the heart and goes to the lungs and vice-versa. Using EIT measurements, it is then possible to estimate the regional ventilation to perfusion ratio in the lungs.

The image reconstruction problem in EIT is non-linear and ill-posed. One way to appreciate the difficulty of the problem is to recognize that a large change in impedivity far away from the electrodes, say at the center of a circular or cylindrical region, produces very small changes in the measured voltages. As a result, EIT instrumentation must be of high accuracy and precision, both in the application of the currents and the measurement of the voltages. Also, the resolution of the images, i.e., the number of meaningful pixels (2-D case) or voxels (3-D case), is a function of both the number of electrodes and the precision of the measurements. Having more electrodes creates more degrees of freedom but the ability to use them to increase the image resolution depends on the accuracy and signal-to-noise ratio of the system. Absolute EIT, where images of the actual impedivity of the interior are produced, is more difficult than difference EIT which generally produces images of changes in impedivity in time. Errors caused by inexact knowledge of the electrode locations (people are irregularly shaped) and variations in electrode contact tend to be reduced by the differencing operation in difference EIT.

Since the 1980s, my colleagues at Rensselaer Polytechnic Institute – Dr. David Isaacson, Department of Mathematical Sciences, and Dr. Jonathan Newell, Department of Biomedical Engineering – and I have been at the forefront in developing EIT theory, algorithms, applications, and instrumentation. We have pioneered the ACT-type EIT systems which apply currents to all electrodes simultaneously and, using our second and third generation systems (ACT 2 and ACT 3), were the first to demonstrate the feasibility of imaging the lung and heart, showing both ventilation and blood flow related changes.
Interest in distance education and learning has grown rapidly in recent years. Accessibility to high-quality learning resources, affordability of online education, and flexibility in learning pace is appealing to many students. For educational institutions, lower costs of online education and reusability of its resources are some of the advantage points. At the same time, based on recent research studies, employers’ trust has been increased in online certificates and degrees. All of these have resulted in higher enrollments in online educational courses. According to the Digital Learning Compass report, almost 30% of higher education students in the United States in 2015 were enrolled in at least one distance learning course compared to 9.6% in 2002; 33% of all graduate-level enrollments in 2014 was in online or hybrid online and traditional courses; and online graduate programs, especially in computer and information technology, have had one of the highest growth rates since 2004. Having such a high demand for online education, learning management systems and Massive Open Online Courses (MOOCs) have been attracting more and more learners. These modern learning systems are capable of supporting large number of students, multiple types of learning resources (such as video lectures, textbook readings, annotated examples, etc.), and social and collaborative learning tools.

Despite these advantages, as online education systems get more automated, their drawbacks become more evident. Some critics argue against online learning systems by pointing out that these systems cannot provide learning depth, require self-regulation in students, rely on noisy user-generated content, and have high drop-out rates, especially in MOOCs.

Educational Data Mining (EDM) has emerged as a research field to develop machine learning and data mining techniques specifically for educational systems, in order to alleviate the abovementioned issues. In online educational systems, every click, interaction, or assessment can be collected and analyzed. This enables these systems to provide instant feedback to students and teachers in various formats, such as summary statistics and monitoring dashboards. In addition, this abundance of data creates an opportunity to use machine learning and data mining techniques to address distance education challenges. For example, predicting student performance and modeling student knowledge growth using student activity logs and scores can help in evaluating knowledge depth in students; recommending hints and next learning activities to students may lead to better self-regulation; modeling learning materials’ content can improve filtering out noisy user-generated content; and mining student behavior sequences may result

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Educational Data Mining: Learning about Human Learners
By Shaghayegh (Sherry) Sahebi
in early detection of drop-out risk and hint towards appropriate interventions to prevent quitting.

However, this potentially useful data comes with its own challenges. Some of the challenges of dealing with such data are shared across the general field of machine learning and data mining, namely volume, variety, velocity, and veracity of the data. For example, educational data can be big, high dimensional, and sparse as there are many students and learning activities in some online educational systems; at the same time, most of the information on how each student performs on various learning activities is missing. Being highly associated with human behavior, such data suffers from uncertainties arising from students gaming the system, guessing problem solutions, or uploading non-related content. Also, having many learning material types (e.g., problems, readings, videos, forums, etc.) in both structured and unstructured formats leads to the high data variety problem. While the machine learning and data mining community are actively researching for solutions to these universal problems, the field of educational data mining has its own complexities that limit the effectiveness of applying generic data mining approaches to the problems in this field. In the following, I discuss some of such complexities in domain and student knowledge modeling and briefly present the solutions we are developing in our research lab.

One of the important problems in EDM is domain knowledge modeling. This problem focuses on finding and quantifying the underlying concepts that each of the learning materials presents to students. It is necessary for tasks such as understanding the skills each learning material provides to students, assisting teachers in arranging course materials, and recommending useful materials to students. Traditionally, labeling learning materials with their concepts were done manually by the domain experts or instructors. However, as their quantity increases, manually categorizing and labeling all learning materials can be daunting or even infeasible. To automate this task, if the learning materials are textual, generic topic models and latent factor models can be used. However, some learning materials can be non-textual such as animations and videos. Some others, such as program snippets and math equations, cannot be treated in a bag-of-words model. To resolve this issue, EDM researchers have relied on student performance on the learning materials to discover their underlying concepts as latent variables. The assumption is that if two learning materials have the same concepts, students’ performance on them should be similar: if students do not know the concepts that appear in both problems, they will fail in solving both of them; and if they know the concepts, they will succeed in both. The problem with this approach is ignoring the learning process by just taking into account a snapshot of student activity.

To address this issue, in one of our projects we look at the whole trajectory of each of the students, during the semester to discover a semester-wide consistent domain model that can represent fine-grained similarities between learning materials. We model student activity sequence on learning material in a tensor and decompose the tensor to obtain latent factors as domain knowledge concepts. Here, common tensor factorization approaches, such as Tucker or CANDECOMP, will not be useful as they ignore the constraints of educational domain. We developed a new algorithm to decompose student activity tensor to a lower-dimensional matrix, representing the domain model, and another lower-dimensional tensor, representing student progress.

Student knowledge modeling is another essential task in EDM that can be used to evaluate knowledge depth, examine student progress, provide hints to nudge students towards correct learning paths, etc. The focus of this problem is quantifying student knowledge in course concepts at any given learning period. Having sequences of student activities on problems, generic solutions such as Markov Models can be used to model student knowledge as system states and student success or failure in problems.
as observed variables. However, the parameters leaned in such generic settings may not be plausible or interpretable. For example, EDM researchers consider emission probabilities in Hidden Markov Models as the probability of students being able to solve a problem, depending on their knowledge state in problem concepts. If students know the concept, they should succeed in solving the problem, and if they don’t, they should fail in it. However, there is always the possibility of guessing the right answer without knowing the concepts, or slipping despite knowing the concepts. In these cases, for the learned emission probabilities to be plausible, EDM researchers use constraints that limit guess and slip probabilities. For instance, it is common to limit these probabilities to less than 0.5, implying that if a student succeeds in solving a problem, the probability that the student knows the concept should be more than the probability that she has guessed the correct answer; and if a student fails in solving the problem, it is more likely for the student not to know the required concepts rather than slipping.

One of the problems in many current student models is that they are not personalized: e.g., the guessing probability is the same for all students. In reality, we know that each individual student has their personal learning pace. To resolve this issue, inspired by the field of personalization and recommendation systems, we develop tensor factorization models that represent student knowledge during a learning period in lower-dimensional tensors. The new discovered dimensions can be used as individualized student profiles, showing their personal progress in learning the concepts. Additionally, considering that learning process happens gradually during time and inspired by item response theory in psychometrics, we use a constraint on students’ knowledge increase that limits sudden changes of knowledge. Our experiments have shown that using this model we can achieve significant improvements in the task of predicting student performance.

Another main challenge in modeling student knowledge is quantifying the knowledge transfer that happens among different learning material types. For example, how does the concepts learned using a reading, help students in solving a problem? This veracity problem gets more complicated as learning materials include both graded and non-graded ones. Unlike student interactions with graded material types, like problems and quizzes that include student scores as reliable observations, quantifying the knowledge gain and its transfer is more difficult for non-graded learning resource types, such as reading materials or lecture videos. This is because non-graded learning resource types do not provide an explicit evidence of student knowledge. Having these problems and the educational field specifications, our recently NSF funded project focuses on multi-task learning approaches for both domain knowledge modeling and student knowledge modeling tasks, while considering knowledge gain and transfer in multiple types of learning material during students’ learning process.

These were some examples of creating field-specific models and algorithms for educational data mining in our lab. The field of educational data mining is growing rapidly because of high demand. However, despite this fast growth, there are many unresolved problems in the field and thus, there is space for more and more improvements. Recommending the next best learning material, personalized curriculum development, automatic assessment of creativity-driven assignments, and explainable education are examples of EDM problems that are both underexplored and practically necessary.

Figure 2. Multi-type learning process

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In modern society, the lives of billions of people have increasingly come to depend on the Internet and wireless connectivity. In less than two decades, more and more of everyday life and work has gone online—from emailing and shopping to Cloud-based computing and business analysis. It is estimated that by 2019, 54% of the world’s total data traffic will run over wireless networks. Emerging high throughput network applications such as 3D and 4K video streaming services (4K video resolution is high-definition (HD) video that has four times the resolution of 1080p HD video) and delay sensitive network applications such as telepresence and telesurgery require the advancement of existing communication technologies and traditional networking infrastructures to meet the needs of future deployments and services. Driven by the dramatically increasing capacity demand and low latency with extremely high availability, reliability, and security requirements, optical fiber communication (OFC) systems are becoming increasingly important and are needed not only in backbone networks (transporting and multiplexing large traffic volume between cities, countries, and continents) but also in access networks (linking subscribers to a public telecommunication network or service provider). Optical wireless communications (OWC) has also witnessed a revival recently among researchers in both academia and industry.

Consequently, fiber-optics assets are now the indispensable backbone of today’s hybrid communication network of fixed-line and mobile infrastructure and data centers. Telecommunications providers have been gradually expanding fiber-optics beyond the core of their networks. In the leading Asian economies, more than 44% of all homes and buildings are already directly connected to the fiber-optic cable network (Fiber-to-the-Home (FTTH) or Fiber-to-the-Building (FTTB)); in North America penetration is 8.4%, in Europe 5.6%. Free space optical (FSO) systems, which transmit data-modulated optical signals through the atmosphere instead of fiber have multiple advantages over fiber-based systems, including ease and cost of deployment, mobility, and networking flexibility. They aim to combine the high bandwidth quality of optical transmission with the primary benefits of wireless systems.

Outdoor optical wireless deployments have been proposed for two main applications: short-range ‘last-mile’ network connectivity and indoor communications. The primary last-mile applications are urban or suburban connectivity, wireless network backhaul to an Internet gateway, and dedicated point-to-point applications, usually assuming stationary roof-top or tower-top mounting. The range is limited to a few kilometers (1–4 km), and systems handle data rates up to a few Gb/s using Infrared (IR) lasers. Practical outdoor applications include long-range FSO communication for ground-to-satellite, satellite-to-ground and inter-satellite communication. Indoor OWC began in the early 1980s, using the IR technology in remote control devices. Recently, a resurgence of interest in indoor OWC is primarily due to the advent of light-emitting diode (LED) based illumination, and the potential of the visible light communications (VLC) technology using light bulbs simultaneously for lighting and communications. White LEDs are modulated at high speeds, too fast for the
This resurgence is also related to the exhausted radio-frequency (RF) spectrum, which is getting too crowded to handle the increasingly high demand for data rates. The resulting network is referred to as LiFi and is primarily focused on communications using mobile devices such as smartphones and laptops. The indoor optical channel is quite different from the outdoor link and presents many difficulties, as it is highly dependent on the room configuration, reflective surfaces and transceiver orientation. In addition to increasing numbers of research groups exploring VLC and LiFi, there are standardization efforts in the IEEE 802.15.7 wireless personal area networks (WPAN) and 802.11 wireless local area networks (WLAN).

Significant tradeoffs between optical and other wireless technologies including RF exist, inspiring research in the field. The College of Engineering and Applied Sciences at University at Albany is well-positioned to actively contribute to the next networks’ revolution based on optical wireless technologies. Specifically, the main research directions of Dr. Hany Elgala and his research group at the Signals and Networks laboratory – SINE Lab is to understand the principles of optical communication waveforms and propagation channels to engineer a practical infrastructure for the future networks. They are particularly experts in VLC transmission and LiFi networks and are interested in Heterogeneous Networks, Wireless Backscattering, Physical Layer Security and Indoor Localization. The work has been funded through state and federal money - Metropolitan Transportation Authority (MTA) in New York and the National Science Foundation (NSF). The group has several patents and more than 60 publications in notable conferences and journals.
Small is Big: A Bottom-Up Approach Toward Environmental Sustainability
By Rixiang Huang

Many critical environmental issues we are facing nowadays can be ascribed to alterations to the environment by human activities that introduce excessive elements and alien compounds to the accommodating environments. For example, fossil fuel consumption and agriculture accelerate carbon (C) migration from the lithosphere to the atmosphere, contributing to the climate change problem. Environmental researchers usually adopt a Bottom-Up approach to address these issues, by trying to understand the presence, transport, transform, and fate of critical elements or contaminants, and the associated processes (which can be physical, chemical, and/or biological) in the natural environment, and to develop technologies or strategies to minimize their generation and release. Fundamental to this approach is molecular-level understanding of the physics, chemistry, and biology underlying element/contaminant cycling and the technologies developed. Below I will elaborate this approach with examples from my past work.

Phosphorus (P) in the Food-Energy-Water (FEW) nexus.

P is a nutrient essential for the survival and growth of all organisms. P plays a pivotal role in the FEW nexus, because (1) food production relies heavily on its adequate supply, (2) its release into water bodies from agriculture and wastes (for example, animal manures, sewage, and municipal solid wastes) is one of the main contributors to the water eutrophication problem, and (3) P is closely associated with the energy sector, because of its role in biofuel production and waste treatment. Despite the fact that most of our consumed P is from phosphate rock that is an unsustainable resource, P is not efficiently used and excessive P is lost into the environment (Figure 1A). It is increasingly recognized that efficient and effective use and recycling of P are critical for achieving sustainability in the FEW nexus. Molecular-level understanding of the states and relevant reaction processes of P, and the capability to control them are important for this goal.

Low P utilization efficiency in agriculture is caused by the unsynchronized P application and plant uptake. Most P fertilizers used in agriculture are inorganic phosphates (ammonium or calcium salts), which are very soluble and easily lost from soil during rainfalls. For P entering the food chain, most end up in all kinds of wastes, which currently is not effectively recycled because technical, economic and policy barriers exist. Although P returning from wastes to agriculture has been and will still be a desirable P recycling strategy, there are many barriers hindering its practice. In addition to contamination of pathogens, organic and inorganic pollutants, biowastes without proper treatments have low P efficiency like inorganic P fertilizer and contribute to serious water pollution. Because of biowastes’ properties such as large volume, high water content, and high contamination, P recovery via pure P compound production is challenging.

My work in the past few years aimed at effective P recycling from biowastes and its returning back to agriculture, by removing the technical barriers using a molecular approach. Thermochemical techniques were used to treat P rich biowastes, because they can significantly decompose pathogens and organic contaminants, reduce waste volume, and upgrade biowastes into products with enhanced value and broader applications. We traced the molecular P states, defined the reaction processes, and revealed the effects of treatment conditions and feedstock properties. According to findings from waste treatment and plant growth experiments, the treatment products can be slow-release P fertilizers with improved P efficiency.

Carbon sequestration via biomass-to-biochar conversion.

One contribution of agriculture to the climate change problem is accelerated oxidation of soil organic carbon (SOC) and biomass. On the one hand, SOC buried in soil is exposed to abiotic and microbial oxidation during agriculture practices (for example, extensive tillage and fertilization). On the other hand, tremendous amounts of biomass are produced, which are a labile C pool that rapidly transforms into CO₂. In the context of societal battle for climate change mitigation, tremendous efforts are devoted to sequestrate C and slow down its migration
Similar to C sequestration practice in the energy sector where the produced CO$_2$ is captured and stored, various practices can be adopted in agriculture to slow down SOC and biomass oxidation. Converting agriculture biomass into biochar (a carbonaceous material enriched in C and produced via heating biomass in oxygen-limited environments) and returning it back to soil has been considered as a C sequestration strategy, because biochar is relatively more stable than biomass and may have a longer residence time in soil. To evaluate the potential and effectiveness of this strategy, it is necessary to quantitatively understand (or predict) the behavior of biochar in soil, which is the result of complex interplay between biochar, soil properties, and other factors (such as climate and agriculture practices). My past work in this direction focused on the effects of treatment methods and feedstock composition on biochar properties (such as composition, stability, and adsorptive reactivity). We revealed the molecular structure of C in biochar produced from various types of biomass under different thermal conditions (primary temperature and duration), and aromatic C structures were found to be responsible for the enhanced stability of biochar (Figure 2). Future research will be expanded to the interaction between biochar and soil components (such as contaminants, nutrients, organic matters, and microbes). This aligns with current efforts in this field towards sustainable biochar applications, such as climate change mitigation, sustainable agriculture, and environmental remediation.

Figure 1. (A) Human-impacted P cycling, numbers are annual P flux in 10$^{12}$g/yr, this figure is adapted from Yuan et al., ES&T, 2018 (Copyright @American Chemical Society). Complex physicochemical and biological processes control the P fluxes between different human activities (such as mining, agriculture, and food production and consumption) and the environment. (B) Molecular states of P affect its transport in the environment, as exemplified in its loss from animal wastes into rivers.

Figure 2. (A) Biomass to biochar conversion using thermochemical treatments, during which more condense aromatic C were formed at elevated treatment temperatures, (B) biochar has a relatively longer residence time in soil than raw biomass because of its stable C structures (the data is arbitrary).
Figure 3. (A) An aerial view of Advanced Photon Source (APS at Argonne National Laboratory (Credit: Argonne National Laboratory). The circular infrastructure is characteristic to a synchrotron facility, where electrons are circulating at a speed close to the light speed and generates X-ray. (B) The interaction of X-ray with a sample (nucleus) and the physics behind an element-specific absorption spectrum. The spectrum can reveal the oxidation state and local environment of an element.

**Methodology.**

Molecular-level understanding of the physics, chemistry, and biology in natural and engineering systems is not an easy task. Particularly, environmental researchers often study trace-level compounds present in complex matrices such as soil, sediment, and waste. Therefore, a suite of advanced analytical techniques is needed. Synchrotron-based X-ray techniques are one group of such tools that capable of revealing detailed chemistry of a broad range of elements in the periodic table. Those synchrotron facilities (only a few are built in the world, for example, the Advanced Photon Source in Chicago, Figure 3A) host a variety of techniques, including X-ray absorption spectroscopy (Figure 3B), scattering, diffraction, and spectromicroscopy. In addition to the unique information provided individually, these techniques possess the strengths of being highly sensitive and non-destructive, making them ideal for studying complex samples. Other molecular techniques with broad applications include nuclear magnetic resonance spectroscopy (NMR), electron microscopy (SEM and TEM), and calorimetry.

**Molecule to sustainability, where multi-disciplinary and trans-sector collaborations are needed.**

Many environmental problems are rooted in complex interactions between various human activities and the natural environment, spanning in space and time. In order to solve these problems and achieve sustainability, it is increasingly recognized that life cycle thinking and system approaches are needed. This is exemplified in the P problem, where the food, energy, and water systems interact and the whole life cycle of P needs to be considered. To close the human P cycle (where P is efficiently used and effectively recycled, with limited exploitation of phosphate resources), it is necessary to have collaborations between multiple sectors, such as government, waste management industry, academia, and farmers.

This new perspective opens up plenty of collaboration opportunities. At the University at Albany, we will strive to contribute to current societal pressing for sustainability, by collaborating with experts from relevant fields with our expertise in tracing elemental cycling in natural and engineering systems.

Rixiang Huang is an Assistant Professor in Environmental and Sustainable Engineering. Visit his faculty page [here](#).
Introduction

Modern power distribution grids have been exhibiting significant changes on both generation and load ends. Loads are becoming increasingly non-linear and electronic in nature, requiring a direct current (DC) source rather than the standard alternating current (AC) provided by the grid. Therefore, extensive work has been performed in the 1980s and 90s to design power converters that interface such loads to the distribution grid and compensate for their non-linear and switching behaviors. In recent years, there has been a dramatic change on the supply side of the distribution grid. Distribution networks are now seeing ever increasing penetration of distributed energy resources (DER). DER cover both generation such as solar photovoltaic or wind generation and distributed storage or flexible demand represented by battery systems and electric vehicles. Therefore, there is a lot of focus nowadays on upgrading the distribution grid, both in terms of components and control in order to adapt to the higher penetration of DER. Upgrades to the distribution network include: (i) allowing bidirectional power flow, (ii) integrating energy storage systems for load leveling and to balance consumption and production, (iii) upgrading the communication infrastructure to enable smart load/DER management and power dispatch between different sections of the distribution grid.

The integration of DER to the power grid requires power converters as an interface stage. Typical features expected of such converters include (i) high efficiency, such that the utilization of DER is maximized, (ii) high reliability both at a converter and system levels and (iii) maintained stability of the distribution power grid. However, the high penetration of such converters and the associated distributed generation, additional features are also required of such power system components, including (i) grid support capability, by injecting inductive or capacitive reactive power into the distribution grid to compensate for non-linear loads, improve feeder voltage regulation and maximize feeder efficiency with the added generation. These features have been standardized for large scale converters/inverters connected to the transmission system, but with the increased use of distributed generation on the distribution network, these requirements are starting to be expected of low power converters as well. (ii) fault limiting and fault isolation functions. The added controllability provided by having distributed converters enables a higher system up time by limiting fault current and isolating fault zones without interrupting the operation of wider zones of the distribution network. (iii) flexibility to provide DC distribution networks to improve overall efficiency. Distributed resources such as solar PV or energy storage provide DC power and many of the loads now added on to the distribution network also require DC power, such as LED lighting, telecom and computer loads, the ability to use distributed power electronics provides the capability of creating a DC interconnection point with all the needed regulation and protection and without the need to add two addition AC grid interface stages on the source and load sides and thus improving the overall system efficiency and simplifying the control requirements.

High Frequency Converters

High frequency converters provide several benefits in modern grid applications, such as high power density, high control bandwidth and design modularity with easy
integration and swapping of converter units. However, for this high frequency operation to be achieved, the efficiency of the converter becomes a key factor. Recent advances in semiconductor devices with the introduction of wide bandgap (WBG) devices such as silicon carbide (SiC) and gallium nitride (GaN) are leveraged to achieve high switching frequency, high power density and high efficiency. Transition from traditional silicon devices to WBG devices can provide over 50% reduction in losses as a drop in replacement or over 50% size reduction if the loss budget of the converter is kept constant. In many cases intermediate design points are chosen where efficiency is improved and size is reduced. This way, converters can be more readily be integrated into renewable energy systems such as solar panels or in electric vehicles for battery charging.

Alternatively, another design approach to increase power density at high efficiency is soft switching converters. In this case, conventional silicon semiconductor devices are operated such that their switching transitions occur at zero voltage or zero current and thus losses due to switching can be eliminated or greatly reduced and therefore switching frequency can be dramatically increased from a few kilohertz in legacy converters to 100s of kilohertz. Consequently, the size of all passive components in the power converters can be significantly reduced and very high efficiency power conversion can be achieved in a very small footprint. A very attractive application for high frequency soft switching converters is solid state transformers. Solid state transformers are aimed to replace standard utility transformers in many applications that require high power density, more simplified control and high efficiency. Solid state transformers rely on the use of high frequency switching converters on both primary and secondary, with a high frequency transformer providing the isolation as shown in Fig. 2. In case of faults, isolating the fault by stopping the switching of semiconductor devices on either side of the transformer provides protection systems and fault localization schemes that are orders of magnitude faster than classical methods.

Going from a standard 50Hz or 60Hz line frequency transformer to 200kHz transformer can provide a size reduction of approximately 90% as shown in Fig. 3 while
maintaining the same power and insulation levels. Combining the use of WBG devices and soft switching circuits provides very high efficiency solutions that occupy a very small footprint and have reduced cooling requirements. Therefore, these power conversion systems can be installed inside buildings, upgrading their power grid, on isolated distribution grids on locomotives or onboard ships or in wind farms replacing power conversion systems that can occupy a huge space at the bottom of each tower with a converter system of combined series/parallel connected high frequency power blocks, as shown in Fig. 4, which can then be placed in the nacelle right next to the generator providing significant savings in cable and cooling system cost & complexity as shown in Fig. 5.

**System Level Advantages of Distributed Power Converters**

Having a large number of converters distributed all over a distribution network provides great flexibility for system level control an optimization. Some of advantages of distributed power conversions include: 1. The ability to maintain a high-power system availability, as only a small fraction of the system is isolated during faults and the remaining units can keep running.

2. Power flow optimization on the distribution grid. With a highly distributed network of DER and their associated power converters, grid operators now have much better and more granular visibility into both load and generation patterns. Therefore, it is possible to centrally coordinate commands of active and reactive power generation to optimize feeder efficiency, to get a more stable feeder voltage profile, or to coordinate power dispatch between different section on the distribution network. Further, proper energy storage within the converters allow them to locally ride through grid transients rather than disconnect, thus reduce the possibility of generation/load imbalance during and after these transient.

3. Upgrade and retrofit of existing systems becomes significantly easier with distributed power converters, as different generations of energy generation or storage elements can be integrated to the same network with converters balancing their terminal parameters at the point of coupling. Higher density converters can be fully integrated with the battery or solar panel, which also simplifies the installation process and improves safety as the DER elements can be operated as regular appliances.

Obviously, these benefits are traded off against the cost of the added components in the system. However, this is a trend that is moving increasingly in favor of distributed power conversion systems as power converter costs represent a progressively small percentage of the DER system as the production volume increases and with improving efficiencies and control algorithms, can extract more energy from the system, which further offsets their initial costs.

**Research Trends**

Power converter research for renewable energy is continuously moving towards more efficient and more compact topologies. The progress in wide band gap semiconductors is providing means to achieve these goals with much simpler topologies. Furthermore, with the ever increasing granularity of control of power generation and demands at every converter terminals, the integration of DER on the Internet of Things is also gaining very wide attention as the data generated by these converters can provide an invaluable tool to predict load patterns, coordinate power generation with weather patterns, predict degradations and failures of power system components by correlating voltage and current signatures to fault scenarios of different.
ent elements, thus improving grid robustness and availability. System level model-based control can also be used to optimize how each generation unit or load terminal is operated or stressed, not only to optimize the grid operation but also to maximize the life of the system components based on their planned mission profile and state of health. Fig. 6 shows a block diagram of model-based control/system health monitoring concept of distributed power conversion system.

The Application of Topological Data Analysis to Robot Motion Planning Algorithms
By Chinwe Ekenna

Even with existing motion planning algorithms that approximate the planning space for robots, there is still a lot of unknown in terms of how to measure this approximation and the role topological data analysis plays. This is a very viable field in mathematics that sees a lot of meaningful application in robot motion planning.

An important research area in robotics is motion planning, navigation and localization which aids in the quest for precision and accuracy in robots. Planning motions is needed in many disciplines such as planning for deformable robots, manipulation planning, character animation for games and movies, and virtual prototyping. A robot is a movable object where the position and orientation is defined by a set of parameters such as the degrees of freedom, angles and displacement of its links. The robot’s configuration can be described based on the configuration space (the set of all possible placement of the robot) which contains both feasible and infeasible regions of the space.

The configuration space has become an integral concept in algorithmic motion planning. With important applications dependent on the successful characterization of this space.

Motion planning is a well coined concept in robotics with a simple definition - “find a path for a robot from its start to a goal position as shown in Figure 1” where the start and goal is determined by the task the robot is expected to perform e.g., navigate a factory floor, manipulate an arm to pick up an object etc. This however is a NP-hard problem.

To efficiently plan motions one would need to utilize com-
Computational resources in regions in the configuration space that would ensure a trajectory the robot will follow, is generated. This can be possible and seamless if the complete knowledge of the configuration space is known beforehand, but unfortunately this is not the case.

To mitigate this shortcoming, sampling based methods were developed that approximate the space by placing configurations randomly within the configuration space. Various research have shown the algorithms developed to be probabilistic complete. This means if a solution exists in the space, with sufficient samples they can be found or else it will return that no such solution exists.

Although great progress has been made with these different algorithms developed to approximate the space, much less progress has been made that measures the accuracy of this approximation. Our work aims to develop algorithms that better approximates the planning space and produce a measure for this approximation using topology and geometric based formulations. Knowing how well we approximate will potentially give more control to sampling methods to determine what regions in the planning space to make more or less samples, which in turn improves on the time needed to perform motion planning. Applicable sampling based methods run with an upper bound of $O(nm)$ - where $n$ is the number of samples generated and $m$ the number of edges, and this time complexity impedes the ability to perform real time planning. Real time planning is crucial in enabling robots and humans to collaborate successfully, i.e., have a robot follow a human around and be reactive to changing scenarios in the environment.

Various methods exist to represent and approximate the planning configurations spaces with research focusing on optimal path planning, reachable spaces, obstacle avoidance, and topology applications to path planning, etc. However, these popular methods do not capture all the rich topological properties such as the existence of holes and voids. They also do not capture the homology and homotopy essence (rich topology informations) and persistent homology of the planning space apart from path connectivity.

Our work will investigate and create formal definitions, theorems and algorithms to better capture the topological property in the planning space from geometry such as the Vietoris rips as seen in Figure 2 and simplicial collapses which gives a fast approximation and measure in metric space and topology spaces. While embedding this method into the configuration space, we will show mathematically and via theorems that there is an equivalence between the Vietoris complex and the Cech complexes and will provide a measure of the approximation made when generating samples in planning space.

Figure 3 shows the planning environment, start, goal and top position of a robot we will be testing our algorithms on. This robot is an 8 DOF robot in an environment with four different rooms. Its base has 5 DOFs that allow it to move forward, backward and rotate, and its arm has 3 DOFs. The robot moves through different rooms within narrow passages and arrives at its destination where it performs an action (grasps or puts an object down).

Our method will potentially be applicable to any robot dimension and can have application in life-saving and real world scenarios, such as search and rescue and agricultural robot monitoring applications.
Hany Elgala

A cross-cultural approach to living and learning

Hany Elgala is an assistant professor in the Department of Electrical and Computer Engineering (ECE), part of the College of Engineering and Applied Sciences (CEAS).

Elgala received his undergraduate degree in Communications and Electronics in 2000 from Ain-Shams University in Egypt, and a master’s in Electrical Engineering in Smart Systems in 2003 from Furtwangen University in Baden-Württemberg, Germany. He did his doctoral work at Jacobs University in Bremen, Germany, researching optical wireless communication systems. He was the first faculty hire at of the ECE department at CEAS.

“I started in August 2015, so I’m in my third year at UAlbany. Currently, I have three Ph.D. students, one MSc and two BSc students conducting research in my research lab, Signals and Networks laboratory (SINE Lab),” Elgala said. “It is a unique opportunity and adventure to start a new department. The growth rate of the full-time faculty members and students as well as quality standards have exceeded my expectations.”

What are your working on now?

Currently, for different indoor wireless applications and services, we are switching between different wireless radio frequency (RF) technologies such as 4G LTE, WiFi and Bluetooth. These wireless technologies are based on different hardware transceiver modules that are transmitting different modulated RF signals. In addition, existing solutions can hardly meet the demands of simultaneous wireless services: Internet access, IoT connectivity, and sensing. Are you aware of any commercial product that offers a wireless sensing application based on existing WiFi Internet access?

Together with my research team at SINE Lab, we are working on designing a universal modulating signal to vary the intensity of light sources and enable light fixtures to be the future wireless access points based on the visible light communications (VLC)/LiFi technology. The VLC/LiFi technology will transform spaces, where lighting products are used for completely new purposes. Our designed signal will enable high-end and low-end VLC/LiFi enabled devices to capture and process the same signal, to reliably estimate the transmitted data and identify beacons used in sensing. Our solution could enable a light fixture to be the WiFi successor in offering high speed Internet access for high-end mobile devices, being a connection hub for low-end IoT devices, sensing people and tracking assets.
What made you decide to pursue your field?

Engineers are constantly changing the world with inventions and solutions that affect everyone’s lives. I decided to be an engineer because I thought it would be a lot of fun. Unfortunately, I figured out late that there isn’t a Nobel Prize in engineering!

During my sophomore year in college, the first global system for mobiles (GSM) network was launched in Egypt, November 1996. At that time, the field of wireless communication was booming and I decided not to stick with the original plan. I specialized in communications and electronics instead of civil engineering. I never regretted the decision.

If you weren’t teaching at a university, what would you be doing?

I’m really fascinated by the human brain, so a career in neuroscience, neurology, psychiatry, or psychology could satisfy my curiosity.

What’s one thing students might be surprised to know about you?

Before moving to the U.S. from Germany, I was living on campus at Jacobs University — not as a student. Together with my wife, Riham Galal, we were the resident directors or “College Masters” of one of the residential halls. For almost nine years, we lived and worked on a cross-cultural campus, accommodating students from more than 100 countries, supervising college employees, coordinating events and resolving student conflict. We enjoyed such a unique experience and are still willing to take similar positions in the future.

What’s your favorite food, to eat or cook, and why?

Like a typical German, I like rye bread, sauerkraut, Brezel and beer. Since 2016, the whole family cannot resist eating sushi at any time. Of course, with chopsticks! At the SINE lab, we go off-campus every second week and explore a new restaurant.
masters and doctorate degrees.

At the University of Southern California (USC), Chelmis set his sights on a career in academic research.

“After completing my PhD on online social network modeling and analysis in 2013, I considered it a natural fit to grow as a postdoctoral researcher at USC,” he said. “I joined UAlbany, which I think of as the next logical step for my academic career in Fall 2016; UAlbany is a great place to achieve my research independence and become a world-renown expert in Big Data and Network Science.”

At UAlbany, Chelmis is director of the Intelligent Big Data Analytics, Applications, and Systems (IDIAS) Lab. IDIAS conducts cutting-edge research in the intersection of network science, data mining, machine learning and data integration, working toward solving problems involving networked data application domains such as online social networks and the so-called “internet of things.”

What are you working on now?

Engineering a better world! What this really boils down to is 1. designing novel Network Science capabilities to support meaningful understanding of social behavior by leveraging Big Data; 2. summarizing Big Data for near-real-time decision making, and 3. translating theory to practice to advance the public good, with applications ranging from social work and urban analytics to cybercrime and public health.

What made you decide to pursue your field?

I was always fascinated by astrophysics and the way it employs the principles of physics to ascertain the nature, behavior, and interactions of the heavenly bodies. In many ways social networks behave as planets and stars, and this is where graphs (those “strange” mathematical structures used to model pairwise relations between objects) come into picture. Everything can be represented as a graph in my mind, and hence, my fascination with Big Networked Data.

What’s your favorite class to teach?

ICSI 432/532. It’s about Network Science, which I love! But also, it’s also my favorite because of the quite interesting mix of graduate and undergraduate students that make up this class, their experiences and opinions, their enthusiasm and energy, as well as their refreshing out-of-the-box thinking about how data all around us can be abstracted and studied as networks.

Who is someone who influenced you?

My wife, Daphney-Stavroula Zois, also a faculty of the College of Engineering and Applied Sciences. She is my “hidden figure” so to speak. She is the one who persuaded me to apply for a PhD in the first place. She is also the one who I look up to in terms of her determination to tackle problems that really matter. Academic curiosity is great but we always need to remember to step back and ask ourselves about the real-world applicability and impact of the theory and technology we develop.

What’s one thing students might be surprised to know about you?

I was member of a Greek folk dance performance group in my youth. Greek dance (called “horos” in Greek) is a very old tradition, being referred to by authors including Plato and Aristotle. Because of the many islands surrounding the Greek mainland, a plethora of choreographies and styles have been developed. I have learned quite a few of these and to this day I can adequately perform dances including the very famous sirtaki dance or “the dance of Zorba” (known from the 1964 film Zorba the Greek).
Daphney-Stavroula Zois

An engineering pedigree and a yen for problem solving.

Daphney-Stavroula Zois is an assistant professor of Electrical and Computer Engineering (ECE) in the College of Engineering and Applied Sciences. She joined UAlbany in Fall 2016 after a two-year postdoctoral research appointment with the Coordinated Science Laboratory at the University of Illinois, Urbana-Champaign, and said she was attracted to the University by “the unique opportunity to work together with other colleagues to build the ECE department from scratch and shape its future.”

Zois researches the design and development of computational methods for making effective decisions. “My research has various applications, including but not limited to physical activity monitoring for health, improved delivery of human and physical services, precision farming for increased production, and detection of accidents in roads.”

What are you working on now?

I am very passionate about my research and thus, I am always working on various diverse research projects at the same time. For instance, I am currently working on a research project to simplify and improve the discovery of human and physical services while enabling efficient usage of the service providers’ resources. At the same time, I also work on designing algorithms to quickly detect cybercrime incidents, and accidents in roads.

What made you decide to pursue your field?

Both of my parents are academics in engineering departments, and we have always had more computers in home than other things! So it felt very natural but also exciting to study Computer Engineering.

If you weren’t teaching at a university, what would you be doing?

I will probably had started my own start-up companies. And I am saying companies because I am always into generating new ideas for solving various types of problems.

What’s your favorite movie?

Mulholland Drive by David Lynch, since the lives of the characters are intensively intertwined and you cannot see what is a dream and what is the reality. It also takes place in one of my favorite cities, Los Angeles.

What’s your favorite food, to eat or cook, and why?

Since I am from Greece, I really love to cook and eat Greek food. My favorite one is Greek pita sandwich.
Faculty Research

Department of Electrical and Computer Engineering

Mohammed Agamy
Associate Professor
Queen’s University
Research Interests: Resonant power conversion, renewable resources, power factor correction, grid interface of distributed energy resources, modeling and control of power converter systems

Hany Elgala
Assistant Professor
Jacobs University, Germany
Research Interests: Visible light communications (VLC) technology and LiFi networks, coexistence in wireless heterogeneous networks, localization, Internet-of-Things (IoT) security, backscatter communication, artificial intelligence in wireless communications

Dola Saha
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University of Colorado Boulder
Research Interests: Cloud RAN, drone communication, IoT, 5G and beyond wireless communication, coexistence of networks, localization

Mustafa Aksoy
Assistant Professor
The Ohio State University
Research Interests: Microwave remote sensing, electromagnetic theory, geosciences, signal processing and data analytics

Gary Saulnier
Professor
Rensselaer Polytechnic Institute
Research Interests: Communications, signal processing, electronic instrumentation, impedance tomography systems for medical applications, acoustic data and power transmission systems

Kim Boyer
Professor
Purdue University
Research Interests: Computer vision and medical image analysis, including perceptual organization, structural analysis, graph theoretical methods, stereopsis in weakly constrained environments, optimal feature extraction, large model bases, and robust methods

Tolga Soyata
Associate Professor
University of Rochester and Johns Hopkins University
Research Interests: Cyber physical systems, digital health (D-Health), high-performance parallel computing architectures --GPU, FPGA, ASIC

Guy Cortesi
Professor of Practice
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Research Interests: Effective use of information technology in distance reporting and virtual organizational settings; the relation of communication channel and task on group composition, participation, and performance in virtual organizations

Weifu Wang
Assistant Professor
Dartmouth College
Research Interests: Robotics, geometry, motion planning, manipulation

Aveek Dutta
Assistant Professor
University of Colorado Boulder
Research Interests: Vehicular networking, enforcement methods for spectrum policies, blockchain for networking applications, hardware architecture for cloud radio access networks

Jonathan Muckell
Professor of Practice
University at Albany
Research Interests: Geospatial compression algorithms, supply chain tracking, performance benchmarks, assistive living technology

Daphney-Stavroula Zois
Assistant Professor
University of Southern California, Postdoc University of Illinois
Research Interests: Decision making under uncertainty, machine learning, detection and estimation theory, intelligent systems design, signal processing
Department of Computer Science

Pradeep Atrey
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Research Interests: Multimedia data analytics with a focus on security and privacy issues in application areas such as surveillance, social media, and cloud computing

Prabir Bhattacharya
Professor and Chair
University of Oxford
Research Interests: Medical imaging, biometrics, mobile network security, game-theoretic applications, driver safety, digital watermarking

Peter Bloniarz
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Research Interests: Computer vision, video analytics, artificial intelligence

Charalampos Chelmis
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Research Interests: Large-scale data mining, graph mining, and machine learning, with a specific focus on event and anomalous pattern detection and forecasting in complex and heterogeneous network data

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Chinwe Ekenna
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Research Interests: Databases, distributed systems, real-time data processing, graph analytics

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Tomek Strzalkowski
Professor
Simon Fraser University
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Qi Wang
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California State University at Northridge
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Mariya Zheleva
Assistant Professor
University at Albany
Research Interests: Next generation mobile wireless networks, focusing on autonomous spectrum measurement and dynamic access, architectures and resource allocation in IoT-and-Traditional (IoT&T) networks, measurement infrastructures and networked system design, integration and in-situ deployment
Department of Environmental and Sustainable Engineering

Yanna Liang
Chair and Professor
Utah State University
Research Interests: Development of innovative, practical and efficient methods for cleaning up sites contaminated by emerging pollutants; waste conversion to commodity fuels and chemicals through biochemical, thermochemical and bioelectrochemical pathways; use of omics-approaches for understanding complex natural and engineered systems; and process optimization for maximizing yield of value-added products for commercial scale-up

Md Aynul Bari
Assistant Professor
University of Stuttgart
Research Interests: Characterization of ambient and indoor air quality, source apportionment for controlling emissions, sustainable air pollution management, atmospheric deposition, environmental impact assessment, influences of oil and gas development on air quality, household air pollution, low-cost air quality sensors, exposure assessment

Rixiang Huang
Assistant Professor
Baylor University
Research Interests: Wastes to resources conversion via material, technology, and process innovations; cycling of critical elements and contaminants in natural environment

Kyoung-Yeol Kim
Assistant Professor
Gwangju Institute of Science and Technology
Research Interests: Energy recovery from wastewater, microbial electrochemical technologies for resource recovery, developing energy-efficient wastewater treatment process, membrane technology for wastewater treatment

Yaoze Liu
Assistant Professor
Purdue University
Research Interests: Water resources, hydrology, water quality, green infrastructure, best management practices, land use change, climate change, optimization
College Research Labs

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Pradeep Atrey
Amirreza Masoumzadeh

Breakthrough Interactive Thinking Systems (BITS) Laboratories
Tolga Soyata

Computer Vision and Machine Learning (CVML) Lab
Siwei Lyu
Ming-Ching Chang

Data Management Systems (DMS) Lab
Jeong-Hyon Hwang

Data Mining and Management (DMM) Lab
Petko Bogdanov

Environmental Molecular Sciences and Processes Lab
Rixiang Huang

Event and Detection Lab
Feng Chen

Hydrology and Water Quality Lab
Yaoze Liu

IMAgINE Lab
Daphney-Stavroula Zois

Intelligent Big Data Analytics, Applications, and Systems (IDIAS) Lab
Charalampos Chelmis

Interaction Sensing and Perception in Real Environment (INSPIRE) Lab
Yelin Kim

Kim’s Research Group
Kyoung-Yeol Kim

Microwave Remote Sensing Lab
Mustafa Aksoy

Mobile Emerging Systems and Applications (MESA) Lab
Aveek Dutta
Dola Saha

Robotic Manipulation Lab
Weifu Wang

Robots, Algorithms and Computable Systems Research Group (RACS)
Chinwe Ekenna

Signals and Networks (SINE) Lab
Hany Elgala

Software Engineering Research Lab
Mei-Hwa Chen

Sustainable Design Lab
Yanna Liang

UbiNET Lab
Mariya Zheleva
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