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IC Academic Research Symposium

Contents

Stacey A. Dixon

Dr. Stacey A. Dixon is the eighth Deputy Director of the National Geospatial-Intelligence Agency (NGA). In this role, she assists the director in leading the agency and in managing the National System for Geospatial Intelligence. She became NGA's deputy director on June 23, 2019.

Prior to this, she served as IARPA's fourth director from September 2018 to June 2019, after serving as IARPA's deputy director from January 2016 to August 2018. Before joining IARPA, Dr. Dixon served as the deputy director of NGA's research directorate, where she oversaw geospatial intelligence research and development. Previous to that, she served as the chief of Congressional and Intergovernmental Affairs and then deputy director in NGA's Office of Corporate Communications.

From 2007 to 2010, she was a staff member for the House Permanent Select Committee on Intelligence, and from 2003 to 2007, she worked for the Central Intelligence Agency, where she was assigned to the National Reconnaissance Office's Advanced Systems and Technology directorate.

Dr. Dixon holds both a doctorate and master's degree in mechanical engineering from the Georgia Institute of Technology, and a bachelor's degree in mechanical engineering from Stanford University. She was also a chemical engineer postdoctoral fellow at the University of Minnesota. Dr. Dixon is a native of the District of Columbia, where she currently resides.

Newton Howard

Professor Howard's passion for science and technology began during his childhood. He pursued his interests in his studies and in 2000 while a graduate member of the Department of Mathematical Sciences at the University of Oxford, he proposed the Theory of Intention Awareness (IA). In 2002, he received a second doctoral degree in cognitive informatics and mathematics from the prestigious La Sorbonne in France. In 2007 he was awarded the Habilitation a Diriger des Recherches (HDR) for his leading work on the Physics of Cognition and its applications to complex medical, economical, and security equilibriums.

In 2014 he received his doctorate of philosophy from the University of Oxford for his work on neurodegenerative diseases, specifically his "Brain Code" Theorem. His work has made a significant impact on the design of command and control systems as well as information exchange systems used at tactical, operational and strategic levels. As the creator of IA, Dr. Howard was able to develop operational systems for military and law enforcement projects. These utilize an intent-centric approach to inform decision-making and ensure secure information sharing.

His work has brought him into various academic and government projects of significant magnitude, which focus on science and the technological transfer to industry. While Prof. Howard's career formed in military scientific research, in 2002 he founded the Center for Advanced Defense Studies a leading Washington, D.C, national security group. Currently, Dr. Howard serves as the Director of the Board. He also is a national security advisor to several U.S. Government organizations.

Prof. Howard's several years of working on systems design and dynamic systems analysis in military applications, as well as his personal research experiences, led him to studying the human brain.

In 2008, Dr. Howard founded the Mind Machine Project at MIT; an interdisciplinary initiative to reconcile natural intelligence with machine intelligence, which led to the establishment of the Brain Sciences Foundation in 2011. That same year, he published the Mood State Indicators (MSI) algorithm which models and explains the mental processes involved in human speech and writing to predict emotional states.

His cognitive natural-language approach to systems understanding and design has led to building more accurate engines for modeling behavioral and cognitive feedback. Due to this work, in 2012, Dr. Howard became the Director of the Synthetic Intelligence Lab at MIT, where he focuses on the molecular basis for human intelligence. This could yield significant benefits and enable the progress in artificial intelligence and neuroscience as a whole.

As Prof. Howard has begun focusing on the development of functional brain and neuron interfacing abilities, he particularly concentrated on theoretical mathematical models to represent the exchange of information inside the human brain. This work, published in 2012, called the Fundamental Code Unit, has proven applicable in the diagnosis and study of brain disorders and has aided in developing and implementing necessary pharmacological and therapeutic tools for physicians. He has also developed individualized strategies to incorporate solutions for psychiatric and brain prosthetic.

Dr. Howard serves as Professor of Computational Neurology and Functional Neurosurgery at the University of Oxford and Nuffield Department of Surgical Sciences at John Radcliffe Hospital. He is also the Founder and Director of the Oxford Computational Neuroscience Lab.

Bernard S. Meyerson

Dr. Meyerson, an IBM Fellow, serves as IBM's Chief Innovation Officer Emeritus.

Joining IBM in 1980, Dr. Meyerson invented Silicon-Germanium technology, ultimately founding and leading IBM's highly successful Analog and Mixed Signal business. He went on to many executive roles, leading global semiconductor development, strategic alliances for the Systems and Technology Group, and culminating in his role from 2010 as IBM's Chief Innovation Officer. His team led the definition and integration of corporate-wide technical and business strategic initiatives. He has also served as Chairman of the World Economic Forum's Meta-Council on Emerging Technology, an ongoing project with Scientific American.

Dr. Meyerson is a Fellow of the American Physical Society and the Institute of Electrical and Electronics Engineers (IEEE) and a member of the United States National Academy of Engineering. He has received numerous technical and business awards, as for example the Lifetime Achievement Award from SEMI, the 2011 Pake Prize of the American Physical Society, 2014 Turing Lecturer at the Royal Institute. Most recently Dr. Meyerson was honored with the 2015 National Medal for Public Service by the government of Singapore for his many years of service and impact as advisor to the nation.

Guillermo Sapiro

Guillermo Sapiro received his degrees from the Technion, Israel. After his post-doc at MIT, he became a Member of Technical Staff at HP Labs. He was the Distinguished McKnight University Professor and Vincentine Hermes-Luh Chair at the University of Minnesota. He is currently a James B. Duke Distinguished Professor, Duke University.

He works on differential geometry and geometric PDEs, learning theory, network analysis, theory and applications in computer vision, computer graphics, medical imaging, and image analysis. He has co-authored over 450 papers and a book, and transferred numerous technologies to private companies and to government agencies.

He was awarded the Rothschild Fellowship for Post-Doctoral Studies in 1993, the ONR Young Investigator Award in 1998, the Presidential Early Career Awards for Scientist and Engineers in 1998, and the NSF Career Award in 1999. He delivered the first Science Lecture at the Abel Prize, 2009, and is a Plenary Speaker for SIAM Image Sciences 2010 and SIAM Annual Meeting 2018. He was also awarded the National Security Science and Engineering Faculty Fellowship and twice the Test-of-Time Award, for one of the most cited papers in computer vision and again for one of the most cited papers in machine learning. He is a SIAM and an IEEE Fellow, member of the American Academy of Arts and Sciences, and founding Editor-in-Chief of the SIAM Journal on Imaging Sciences.

Panel: Laboratory for Analytic Sciences at North Carolina State University—Advancing the Science of Analysis

Ryan Bock

Dr. Ryan E. Bock is an analyst with the Laboratory for Analytic Sciences (LAS) at North Carolina State University in Raleigh, North Carolina. He serves as LAS government lead of the Advancing Analytic Rigor Team and holds degrees from Kansas State University (BA, Political Science and French), American University (MA, International Affairs), and the University of Maryland-College Park (MA and PhD, Government and Politics).

Christine Brugh

Dr. Christine Brugh is a postdoctoral research scholar with the Laboratory for Analytic Sciences at North Carolina State University. She completed her doctoral studies in psychology at North Carolina State University under the direction of Dr. Sarah Desmarais and Dr. Joseph Simons-Rudolph. Her dissertation research used rigorous methods to examine subpopulations of terrorism involved individuals, which identified likely correlates of terrorism involvement. She has published work on the characteristics of women involved in jihadism-inspired terrorism and contributed to a systematic review of the extant terrorism literature. Dr. Brugh is currently involved in projects on lone actor terrorists, state-level correlates of terrorism, and differences in roles within terrorist organizations. Her research interests include drivers of women's involvement in terrorism and prison radicalization.

Jing Feng

Dr. Jing Feng is an Associate Professor in the Human Factors and Applied Cognition Program at the Department of Psychology, North Carolina State University. She conducts research integrating theories of attention and relevant applications in human factors. In particular, her research explores attention and cognition, age-related changes, cognitive training, human factors in driving and display design. She has been a participating researcher at the Laboratory for Analytic Sciences (LAS) at NC State University, and as a member of a multi-disciplinary team studying how to assess and develop anticipatory thinking skills of analysts.

Jason Moonberry

Mr. Jason Mooberry is a government researcher with the Laboratory for Analytic Sciences (LAS) at North Carolina State University in Raleigh, North Carolina. He is a member of the LAS Artificial Intelligence and Machine Learning Team and holds degrees from Kettering University (BS, Computer Engineering) and Rochester Institute of Technology (MS, Computer Science).

Sarah Margaret Tulloss

Ms. Sarah Margaret Tulloss is an analyst with the Laboratory for Analytic Sciences (LAS) at North Carolina State University in Raleigh, North Carolina. She serves as LAS government lead of the Human-Machine Collaboration Team and holds degrees from Meredith College (BA, History) and New York University (MA, Near Eastern Studies).

Panel: FBI- Academic Efforts to Protect Against Threats of Foreign Influence and Technology Transfer

In recent years, there has been a surge of foreign threats, including theft of trade secrets, economic espionage, and malign foreign influence targeting US universities. The FBI is actively working to protect universities and researchers from these threats by raising awareness through active engagement. This panel will discuss how the FBI views the threats of foreign influence and technology transfer.

Susan Brockhaus

Susan Brockhaus has been an Intelligence Analyst with the FBI for 16 years and currently works in the Directorate of Intelligence. Susan has a B.A. degree from Miami University in Oxford, Ohio, an M.A. in Political Science from the University of North Carolina-Chapel Hill, and a M.S. in Strategic Intelligence from the National Intelligence University. She currently focuses on topics and outreach related to US academia, among other research areas.

John Hartnett

John Hartnett entered the Federal Bureau of Investigation in 2004. For the first part of his career, Special Agent Hartnett focused on counterintelligence matters in the New York City area. Since 2012, SA Hartnett was promoted to Supervisory Special Agent at FBI Headquarters where he managed economic espionage investigations from a national perspective. Prior to his career with the FBI, John Hartnett spent ten years in the finance industry; working at Thomson Financial and The Pioneer Group. SA Hartnett holds a graduate degree (Masters of Science Finance) from Northeastern University's School of Business and an undergraduate degree (Bachelors of Business Administration) from the University of Massachusetts.

John Napier

John Napier has been an Intelligence Analyst with the FBI Counterintelligence Division for four years during which he has engaged with numerous federal agencies, the private sector, academia, and congressional elements. IA Napier is a graduate of James Madison University.

Patrick Shiflett

Supervisory Intelligence Analyst (SIA) Patrick Shiflett supervises analysis in FBI's Counterintelligence Division which provides written and oral finished strategic and tactical analysis for a wide range of consumers. Production from SIA Shiflett's team in Counterintelligence Division serves the analytic needs of the US intelligence community, FBI field offices, foreign partners, academia, and industry.

SIA Shiflett jointed the FBI as an intelligence analyst for the WMD Directorate in 2010 at FBI Headquarters on strategic issues embedded in Counterintelligence Division. SIA Shiflett became a manager for Counterintelligence Division in 2017. Prior to joining the FBI, SIA Shiflett was a post-doctoral researcher with the US Airforce Research Laboratory focused on host-pathogen studies using Bacillus anthracis as a model system. SIA Shiflett acquired his PhD in Biomedical Sciences in 2008 from the University of New Mexico while he did research at Los Alamos National Laboratory studying the biology of Bacillus anthracis.

Phillip Agbesi

Phillip Agbesi is currently a senior majoring in Environmental Earth and Geospatial at North Carolina Central University in Durham, NC. His previous research includes geospatially analyzing the effects of fatherless-ness on children in the black community. He also served as an NSF fellow at the Coastal Carolina University C-SURF REU Program where he conducted research on the social vulnerability of areas in Horry County due to hurricane flooding.

GIS-Based Characterization of Flood-Vulnerable, Residential Communities in Horry County, South Carolina

In recent years Horry County has experienced multiple hurricane and flooding events that resulted in loss of life, damage to property and key infrastructure, disruptions in tourism, and closure of major roads and highways. Prime examples are Hurricane Matthew in 2016 and Hurricane Florence in 2018 with each hurricane having its own unique characteristics in terms of how the county was impacted. The approach of Hurricane Matthew triggered the evacuation of the entire South Carolina coast with seventy-seven emergency shelters opened across the State to support the coastal evacuation. Hurricane Matthew displaced 355,000 citizens, damaged or destroyed 1,929 homes, and breached 25 dams. In South Carolina and there was prevalent flooding in Great Pee Dee, Little Pee Dee, Waccamaw, Black and Lynches Rivers. Hurricane Florence was a very slow moving system pouring more than 30 inches of rain across portions of eastern North Carolina and over 20 inches of rain in Chesterfield County and Horry County. As the storm subsided counties in South Carolina continued to experience flooding due to floodwaters in North Carolina flowing downstream and cresting the rivers in South Carolina. The most extensive flooding was seen throughout the Yadkin-Pee Dee River Basin, as floodwaters from North Carolina flowed through major rivers in South Carolina to reach the Atlantic Ocean through Winyah Bay. As a low-lying area in a coastal zone, it is very susceptible to flooding with some regions of the county more susceptible than others. In the past previous storms such as Hurricane Hugo, flooding completely devastated the Grand Strand causing over 6 billion dollars' worth of damage with 49 lives lost as a result of the storm.

Poster

Loren Alegria

Loren Alegria is interested in the materials science foundations of quantum technologies. Loren pursued his undergraduate studies under the advisorship of John Lipa and Aharon Kapitulnik at Stanford, developing precision measurements of low-temperature phase transitions in solids. In his graduate career he worked with Jason Petta at Princeton, studying applications of the newly-described topological insulator materials within the context of quantum electronics. He subsequently performed postdoctoral research at MIT with Jagadeesh Moodera, studying the quantum anomalous hall effect. As an IC Postdoctoral Fellow, he works with Amir Yacoby at Harvard.

Towards Strong On-Chip Transmon to Spin-Qubit Coupling

Nanostructured superconductor materials permit the superconducting phase to persist in large magnetic fields, enabling circuits which preserve quantum information in the fields typical of spin-based quantum information experiments. We fabricate Al and TiN superconducting resonator structures with both lithographically-defined and self-assembled nanostructure. Narrow resonators possess impedances which exceed the impedance quantum, suiting them to the critical problem of long-range coupling of small electric dipoles such as spin qubits. By the same token, the magnetic-field-resilient resonators can form sensitive probes of new electronic phases, for example, within proximal van der Waals heterostructures. Finally, we are studying routes to electrostatically tune resonators, providing a solution to frequency crowding in present quantum information processor implementations. We will describe progress and plans on these three aligned directions.

Lindsay Anderson

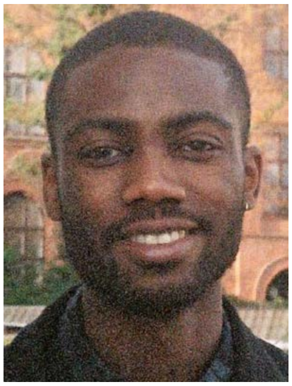
As a Lead Research Analyst in the Strategy, Policy, and Planning Division at the Virginia Tech Applied Research Corporation (VT-ARC), Lindsay conducts a range of technical investigations for VT-ARC's national security clients. Lindsay leads small teams on projects requiring deep knowledge and expertise on a specific technology, as well as teams providing our clients with information on broad, emerging technology topics. Using a mixture of quantitative and qualitative methodologies, Lindsay's goal is to assist the USG in making wiser strategic S&T decisions.

Prior to joining VT-ARC, Lindsay supported the USG as researcher for the Intelligence Community and has worked collaboratively with all 17 elements of the IC. She has also supported the Department of Defense as a CBRN Scientist and her background includes conducting scientific research in molecular virology. She holds a M.S. in Biotechnology and Bioinformatics from University of Maryland University College and a B.S. in Biology from Bowie State University.

Genomics for Human Characterization: A Data-Driven Study of an Advanced Technology

The global research community has witnessed an explosion in S&T development and innovation in recent decades. As new discoveries beget novel applications and new technology enables more rapid discovery, the base of S&T knowledge is expanding rapidly and making its comprehension ever more challenging. Sponsored by the National Intelligence University and the Pacific Northwest National Laboratory, VT-ARC has developed a product to combat the challenge of quickly comprehending a large, growing body of S&T by students. By combining VT-ARC's proprietary machine learning and natural language processing algorithms and in-house subject matter expertise, we've created materials wherein individuals can rapidly search, read, and analyze topics, derived from a taxonomic analysis, on the state of the science of "Genomics for Human Characterization". Using these reference tools, students will be able to focus their time on specific topics of interest and acquire a "cliff's notes" version of the latest research findings, methods, applications, trends and trajectories within the larger domain.

Jerone Andrews



Jerone T. A. Andrews is a Research Fellow in the Department of Computer Science, University College London (UCL), and holder of a Royal Academy of Engineering UK Intelligence Community Research Fellowship (2018-2020). He received an MSci (Hons) in Mathematics from King's College London in 2013, an MRes in Security Science from UCL in 2014, and a PhD in Computer Science from UCL in 2018 for a thesis 'Representation Learning for Anomaly Detection in Computer Vision'. His current research is centred on the detection and generation of manipulated digital face images—i.e., perceptible and semantically meaningful facial alterations. Broadly, his research combines unsupervised representation learning, transfer learning, and anomaly detection.

Multiple-Identity Image Attacks Against Face-Based Identity Verification

Facial verification systems are vulnerable to poisoning attacks that make use of multiple-identity images (MIIs)—face images stored in a database that resemble multiple persons, such that novel images of any of the constituent persons are verified as matching the identity of the MII. Research on this mode of attack has focused on defence by detection, with no explanation as to why the vulnerability exists. New quantitative results are presented that support an explanation in terms of the geometry of the representations spaces used by the verification systems. In the spherical geometry of those spaces, the angular distance distributions of matching and non-matching pairs of face representations are only modestly separated, approximately centered at 90 and 40-60 degrees, respectively. This is sufficient for open-set verification on normal data but provides an opportunity for MII attacks. Our analysis considers ideal MII algorithms, demonstrating that, if realisable, they would deliver faces roughly 45 degrees from their constituent faces, thus classed as matching them. We study the performance of three methods for MII generation—gallery search, image space morphing, and representation space inversion—and show that the latter two realise the ideal well enough to produce effective attacks, while the former could succeed but only with an implausibly large gallery to search. Gallery search and inversion MIIs depend on having access to a facial comparator, for optimisation, but our results show that these attacks can still be effective when attacking disparate comparators, thus securing a deployed comparator is an insufficient defence.

Charles Bachman

Dr. Charles Bachmann is Frederick and Anna B. Wiedman Chair, Associate Professor, and Graduate Program Coordinator in the Digital Imaging and Remote Sensing Laboratory at the Chester F. Carlson Center for Imaging Science at the Rochester Institute of Technology. He received the A.B. degree in Physics from Princeton University in 1984 and the Sc.M. and Ph.D. degrees in physics from Brown University in 1986 and 1990. From 1990-2013, he was a research physicist with the US Naval Research Laboratory (NRL), serving in various capacities as Head of the Target Classification Section in the Airborne Radar Branch, Radar Division (1994–1997) and Head of the Coastal Science and Interpretation Section in the Coastal and Ocean Remote Sensing Branch of the Remote Sensing Division (2003-2013). At NRL, he was Principal Investigator of numerous programs sponsored by various DoD agencies, culminating in a two-year project (2012-2013) as US Technical Lead of a joint NRL/Australia DSTO project and exchange scientist to the Australia DSTO through the US Navy Engineer and Scientist Exchange Program. His R&D efforts focus on remote sensing using hyperspectral and multi-sensor imagery, radiative transfer modeling for geophysical parameter retrieval from BRDF, manifold algorithms for nonparametric analysis, field and laboratory validation and calibration using novel instrumentation such as goniometers developed in his laboratory. He holds two U.S. Patents for hyperspectral remote sensing imagery analysis.

Hyperspectral Video Imaging and Mapping of Littoral Conditions—Charles M. Bachmann, Gregory Badura, Christopher Lapszynski, Rehman Eon, and Charles Tabor

The overall goal of our research program is to improve the ability to map key geotechnical parameters influencing trafficability in the littoral zone from remote sensing imagery. We have demonstrated a low-rate hyperspectral video imaging capability that can be readily deployed to monitor the rapidly changing littoral environment. This year using multi-view, multi-temporal hyperspectral imagery and contemporaneous ground truth collected on a tidal flat during one of our field campaigns, we were able to demonstrate direct retrieval of sediment fill factor, and thus the sediment density, which is directly proportional to the fill factor (R2=0.82) in a realistic setting. We used hyperspectral imagery of a beach from our in-house UAS to validate another radiative transfer model for soil moisture content (R2=0.92). We have also been investigating the retrieval of grain size distribution based on both the UAS and mast-mounted hyperspectral imagery which were collected simultaneously during the field campaign. Laboratory studies with our hyperspectral goniometer system have demonstrated excellent results for a spectral method of retrieving surface roughness estimates from the continuum removed variance of relatively broad-band spectral regions. Our related studies with a well-known radiative transfer model have highlighted needed improvements to better model the impact of roughness correction factors in the radiative transfer model. We are also investigating the impact of mixing in the near-surface particle layers of sediments on hyperspectral reflectance.

Nathan Banek

Nathan obtained his MS in Chemistry from The University of Toledo studying nanosized cubic zirconium tungstate, a negative thermal expansion material, in addition to in-situ, non-ambient X-ray diffraction studies of indium tungstate. After publishing the discovery of an zirconium tungstate auto-hydration mechanism, he continued to research the material's hydration kinetics to determine the validity of its use in low-CTE polymer composites. Thereafter, he obtained his PhD in Chemistry from The George Washington University developing novel carbon nanomaterials from biomass for high-rate and low-temperature Li-ion cells, developed new synthetic methods to Si and Ge nanomaterials for Li-ion batteries, and designed a Li-ion cell for in-situ NMR analysis. His time at GWU resulted in four patent applications and ten publications. He received awards at the GWU Technology Commercialization Competition for best new technology two consecutive years, the 2018 American Institute of Chemists Student award, and the Bell Atlantic Graduate Fellowship.

Graphite from Biomass and Nanostructured Silicon for Advanced Li-Ion Energy Storage

The present work as an IC Postdoctoral Fellow involves researching materials for high-energy density cells for satellites. The commercial Li-ion anode is predominantly graphite as it has high efficiency, long cycle life, and high operating potential. A largely overlooked problem with graphite is the production supply constraints that are anticipated to occur as the Li-ion battery market increases. The U.S. does not produce any Li-ion battery grade graphite, and hasn't since 1991, relying on imports. With 70 % of graphite controlled by China, the US and EU have declared graphite a strategic and critical mineral. It makes up a $15b industry with uses from Li-ion batteries, carbon raisers, conductive additives, carbon brushes, steel and aluminum refining. Battery grade graphite can be mined but is deleterious to the environment involving hazardous chemicals such as hydrofluoric acid and wasting up to 70% of the graphite when purifying and shaping. It can also be created synthetically, but this requires high-quality petroleum coke with low sulfur and metal content that is heated to 3000˚C for weeks, a highly energy intensive process that creates harmful emissions. Obtained by either route, Li-ion battery grade graphite is expensive, $14,700 – 18,000 / ton. A new graphite production method is highly desirable, one that can be performed with domestic materials and at lower cost. Biomass can be inexpensive and is rich in carbon, oxygen, and hydrogen. When heated under inert atmosphere it breaks down evolving into liquid and gaseous fuels leaving behind a carbon rich product. Unfortunately, this carbon is non-graphitizable even at temperatures in excess of 3000˚C. We have developed a new synthetic method that converts prevalent biomass and biomass components (sawdust, wood flour, lignin, cellulose, and corn stover) into high- purity, highly-crystalline graphite that is analogous to commercial Li-ion graphite. The graphite demonstrates excellent performance with high efficiency and minimal capacity loss over hundreds of cycles.

The performance of graphite can be greatly enhanced by the addition of silicon (Si). Silicon offers a large increase in volumetric and gravimetric capacity, however also suffers from a large increase in volumetric expansion that rapidly degrades cell performance making Li-ion cells with high Si content impractical. However, next generation anodes can be formed with composites of Si and graphite. We are currently integrating Si nanostructures, produced by a low-temperature solvent-free scalable method we developed. We are investigating the dependence of the performance (efficiency, capacity, and cycle life) on the size and morphology of the Si used in the composites.

Future work will be dedicated to practical pre-lithiation methods to increase the energy density of Li-ion batteries when a Si composite anode is used.

Jennifer Banwart

Ms. Jennifer A. Banwart is the Mission Director for the Laboratory for Analytic Sciences (LAS). In this role, she works with government, academic, and industry partners to investigate and implement innovative classified and unclassified solutions for tactical and strategic analytic challenges in support of Intelligence Community missions. She holds a Master of Letters in International Security Studies and Counterterrorism from University of St Andrews (2007). She graduated from Whitman College with a Bachelor of Arts degree in International Politics and Security in 1998, and also holds a graduate certificate in International Security Studies from Boston University (2000).

Ms. Banwart joined the National Security Agency (NSA) in 2001 as an intelligence analyst. In the eighteen years she has served with the Agency, she has held positions in the areas of Counterterrorism, Data Acquisition/Exploitation Management, Analysis and Production, and International Security Issues. Prior to joining NSA, Ms. Banwart served as a legislative staffer on Capitol Hill (1994-1996), and worked briefly for a ".com" (1998-1999).

Ms. Banwart began her career in the area of tactical operations support as an Intelligence Analyst. The intense experience of her early years fomented a staunch commitment to the improvement and innovation of intelligence analysis. She has worked in a number of innovation centers, joint government agency centers, and with the military, in efforts to continuously improve support to the warfighter and national policymakers. She is a recipient of the Secretary of Defense Medal for the Global War on Terror, two National Intelligence Meritorious Unit Citations, a joint Meritorious Unit Award, and a Director's Award from the National Counterterrorism Center (NCTC).

Ms. Banwart resides in Raleigh, NC with her husband, twin daughters, and son. She enjoys spending time with her family, and playing the occasional round of miniature golf.

Laboratory for Analytic Sciences Overview

Founded in 2013 by the National Security Agency and located at North Carolina State University in Raleigh, NC, the Laboratory for Analytic Sciences (LAS) is a mission-oriented research laboratory that supports the Department of Defense and the Intelligence Community. LAS gathers experts and practitioners from academia, government, and industry to create tools and techniques that help intelligence analysts provide better information to the decision makers who need it. LAS works at the intersection of mission and technology to develop new analytic tradecraft, techniques, and technology to aid intelligence analysts to better perform complex, integrated analysis. The work at LAS covers the spectrum from basic science to applied solutions in human machine collaboration, machine learning integrity, advancing analytic rigor, data exploration and triage, and tradecraft and technology development.

Poster

Daniel Becker

Daniel Becker is a disease ecologist based at Indiana University. He completed his PhD in ecology at the University of Georgia, followed by a postdoctoral position at Montana State University focused on spatiotemporal infection dynamics and zoonotic pathogen spillover. Daniel is interested in how resource availability affects wildlife–pathogen interactions, especially in the context of anthropogenic change, the intra- and inter-specific drivers of host susceptibility, and how these perspectives can scale up to predict the risks of zoonotic pathogen spillover from bats and birds in particular. His Intelligence Community Postdoctoral Fellowship focuses on how the loss of migratory behavior in reservoir hosts from urban habituation and climate shifts affects infectious disease dynamics, focused on dark-eyed juncos and Lyme disease as a model system.

Modeling Changes in Migratory Behavior as a Driver of Zoonotic Disease in an Avian Host

Most zoonoses originate from wildlife reservoirs, many of which are experiencing changes in movement behavior in response to human-driven environmental change. Many naturally migratory species are halting migration and now form resident populations that live year-round in the same location, often driven by more abundant anthropogenic resources in urban habitats. This change from migratory to sedentary behavior is especially common in birds, many of which are reservoirs for zoonotic pathogens. This Intelligence Community Postdoctoral Research Fellowship is using various modeling approaches to understand how changes in migration affect dynamics of zoonotic pathogens, especially Borrelia burgdorferi (Lyme disease), in a well-studied avian host, the dark-eyed junco (Junco hyemalis). We first apply boosted regression trees to comparative data on the ability of 162 bird species to transmit B. burgdorferi to naïve ticks to assess the role of migration patterns in host competence. This model characterized competent reservoirs with 85% accuracy and suggested that migratory birds, especially those that migrate intermediate distances, are most likely to transmit infection to ticks. Alongside identifying bird species that may play important roles in the global epidemiology of Lyme disease, this model confirms that juncos have a high likelihood of being competent for this zoonoses. We then present results from generalized additive models that compare the temporal dynamics of two infections, Lyme disease and avian pox, between a naturally migratory junco population in the southern California mountains and a recently established resident population in urbanized San Diego. These models are complemented with analyses of physiological differences between populations to suggest that urban habituation may confer benefits to host resistance or tolerance via abundant anthropogenic resources. To understand how stronger immunity of urban residents affects disease dynamics, we next outline a susceptible–infected–latent–infected system of ordinary differential equations. This model considers how improved defenses of urban residents during breeding and non-breeding seasons affects pathogen transmission while coupling dynamics to those of migrants that are allopatric during breeding but overwinter in the urban habitat. To facilitate confronting this model with relatively sparse field data, we present a novel algorithm for parameter estimation based on Latin hypercube sampling and trajectory matching. Simulations suggest this method can provide less biased estimation compared to maximum likelihood when the number of timepoints is low. Future work will use multiplex PCR to screen longitudinal samples from these junco populations for a suite of other zoonoses including Babesia microti, Powassan virus, and West Nile virus. Coupling temporal data with statistical and mechanistic models will provide fundamental insights into how changes in migration affect zoonotic risks.

Andrea Bertozzi

Andrea Bertozzi is an applied mathematician with expertise in nonlinear partial differential equations, geometric methods for image processing, crime modeling and analysis, and swarming/cooperative dynamics. Bertozzi completed all her degrees in Mathematics at Princeton. She was an L. E. Dickson Instructor and NSF Postdoctoral Fellow at the University of Chicago from 1991-1995. She was the Maria Geoppert-Mayer Distinguished Scholar at Argonne National Laboratory from 1995-6. She was on the faculty at Duke University from 1995-2004. Bertozzi moved to UCLA in 2003 as a Professor of Mathematics. Since 2005 she has served as Director of Applied Mathematics. In 2012 she was appointed the Betsy Wood Knapp Chair for Innovation and Creativity. Bertozzi's honors include the Sloan Research Fellowship in 1995, the Presidential Early Career Award for Scientists and Engineers in 1996, and SIAM's Kovalevsky Prize in 2009. She was elected to the American Academy of Arts and Sciences in 2010 and to the Fellows of the Society of Industrial and Applied Mathematics (SIAM) in 2010. She became a Fellow of the American Mathematical Society in 2013 and a Fellow of the American Physical Society in 2016. She won a SIAM outstanding paper prize in 2014 with Arjuna Flenner, for her work on geometric graph-based algorithms for machine learning. Bertozzi is a Thomson-Reuters/Clarivate Analytics `highly cited' Researcher in mathematics for both 2015 and 2016, one of about 100 worldwide in her field. She was awarded a Simons Math + X Investigator Award in 2017. In May In 2018 Bertozzi was elected to the US National Academy of Sciences; In 2019 she was awarded SIAM's Kleinman Prize.

Optimal Path Planning and Environmental Crime

Environmental crime, such as poaching and deforestation, is a growing concern in many developing countries. Recently, there has been increased effort in modeling behavior of environmental criminals with the goal of assisting law enforcement agencies in deterring these activities. Previous models for environmental crime are either discrete in nature or use overly restrictive assumptions about the geometry of the protected region. We present a continuous model for deforestation which makes no such assumptions. The key aspect of our method is the level set method, which we use to track criminal movement throughout protected areas. We are currently exploring the validity of our model against deforestation data from the Brazilian rain forest.

In related work, we have employed a control theoretic algorithm for determining optimal walking paths in mountainous terrain. Previous models for human navigation were entirely deterministic, assuming perfect knowledge of the ambient elevation data and human walking velocity as a function of local slope of the terrain. Our model includes a stochastic component which can account for uncertainty in the problem, and thus includes a Hamilton-Jacobi-Bellman equation with viscosity. We discuss the model in the presence and absence of stochastic effects. We discuss two different notions of an optimal path when there is uncertainty in the problem. Finally, we compare the optimal paths suggested by the model at different levels of uncertainty, and observe that as the size of the uncertainty tends to zero (and thus the viscosity in the equation tends to zero), the optimal path tends toward the deterministic optimal path.

Jeffrey Rocco Blais

Dr. J. Rocco Blais is a Cyber Intelligence and Data Analytics Professor within the School of Science and Technology Intelligence at the National Intelligence University. Over the past 15 years, Dr. Blais has served as a Satellite Communications Systems Engineer for the United States Marine Corps, Senior Systems Engineer for the Defense Intelligence Agency, Cyber Systems Engineer for United States Cyber Command, Cryptologic Technician for the United States Navy, and an Infantryman for the United States Army. Rocco earned a doctorate in psychology during 2015, master's in education during 2009, and bachelors in psychology during 2006.

Radiofrequency Machine Learning Applications in Signal Modulation Classification—Maj Lawrence B. Compton and Dr. J. Rocco Blais

Machine learning (ML) techniques using deep neural networks (DNNs) have wide application across industry, defense, and intelligence communities. ML is a foundational component of artificial intelligence (AI) systems and enhances existing systems through technology insertion. Recent research applies DNN image recognition techniques to the radiofrequency (RF) spectrum with promising results. The same DNN machine vision techniques that allow facial recognition and image classification can be extended to the RF domain to identify communications and radar signals. This new application of ML techniques could enhance existing Department of Defense (DoD) systems and provide the foundation for new AI systems operating in the electromagnetic spectrum. This experimental research evaluated five separate neural network architectures for communications signal classification performance using publicly available datasets of labeled modulation types. By transforming Cartesian input data to polar form, this research achieved a gain in classification accuracy of up to 15%. The best performing DNN architecture reached 80% peak accuracy with polar form data compared to 65% peak accuracy with baseline Cartesian input data. These ML experiments show continuing promise for radiofrequency machine learning in various applications across the DoD.

Kevin Brenner

Kevin Brenner received his B.S., M.S., and Ph.D. in Electrical and Computer Engineering from the Georgia Institute of Technology. He conducted his postdoctoral research as an Intelligence Community Postdoctoral Fellow at Stanford University. His research explores the transport physics of synthetic and biological systems, and their translation to devices. He is presently exploring low-dimensional systems like two-dimensional materials, van der Waals heterostructures, and lipid bilayers. He was previously the founder of a nanoelectronic device startup and his awards include small business (SBIR) grants from the National Science Foundation, U.S. Air Force, and U.S. Missile Defense Agency. He is currently an Assistant Professor in the Electrical and Computer Engineering Department at Southern Methodist University in Dallas, TX.

Thermal and Strain Sensing in Two-Dimensional Materials

This research is experimental and has focused on two-dimensional (2D) for nanoelectronic devices. The 2D materialswe have explored are graphene, transition metal dichalcogenides (TMDs), and van der Walls (vdW) heterostructures (i.e., stacks of dissimilar 2D materials). The applications we have explored are mainly focused on sensors, such as thermal and strain sensors. In these areas, we have demonstrated record-breaking values, and both are currently under review for publication.

The temperature coefficient of resistance (TCR) of thin metal lines is often used for applications in thermometry, bolometers, or even thermal accelerometers. However, the TCR of metals is much degraded in films thinner than ~10 nm due to strong surface scattering, preventing their use as fast thermal sensors, which simultaneously require low thermal mass and large TCR. In contrast, we demonstrated for the first time that the TCR of doped, atomically-thin two-dimensional (2D) materials such as MoS2 and MoTe2 is large (~0.6% K-1) even at sub-nanometer thickness, and higher than the TCR of ~500 nm thick Cu lines (~0.45% K-1). Comparison with detailed 2D transport models suggests the TCR could be further enhanced (to >1% K-1) by reducing the density of Coulomb impurities and scattering centers. Such high TCR in atomically thin 2D material devices can lead to the design of ultra-fast thermal sensors.

Two-dimensional materials have a unique response to strain, capable of sensing deformation from the subtlest of processing details while likewise folding as origami without fracturing. Among these materials, monolayer MX2 (M=M, W; X=S, Se) transition metal dichalcogenides are expected to exhibit a giant intrinsic piezoresistance originating from their uniquely strain-tunable band structure. As such, they are poised to enable emerging applications in tactile sensing that require extreme flexibility and sensitivity, like soft robotics. We showed a giant piezoresistance (percent change in resistance per strain) of ~724 in monolayer MoS2, which is the highest value yet reported for a material. In contrast, we also show a remarkably low piezoresistance of ~1 in graphene, even when stacked into a vdW structure that is subject to strain-shear coupling.

Gwendolynn Bury

Dr. Gwendolynn W. Bury studies water quality and freshwater ecosystems. She is an IC Postdoctoral Fellow, and is currently stationed in the Fisheries and Wildlife Department at Oregon State University. Her current project focuses on satellite remote sensing of lentic water bodies, specifically using statistical analyses to identify covariates and commonalities in models of dissimilar water bodies. Previous work used spatial modeling and physiological ecology of indicator species to predict future water conditions in headwater streams. She has also worked on animal behavior, vertebrate natural history, and science education. Her bachelor's degree was earned from Southern Oregon University, master's from Western Washington University, and PhD from Oregon State University in the Integrative Biology department.

A Model Selection Approach to Assess Water Quality Using Satellite Imagery and Field Measurements

High quality water is essential to human health, agriculture, maintenance of local and downstream ecosystems, and though these services: security and avoiding resource conflicts. The goal of this study is to develop best predictive models of water quality using satellite imagery. We used LANDSAT 7 and 8 satellite image layers and in situ data to construct multiple competing models of water quality. To analyze the data, we used model selection techniques to determine which models or combinations of models are most informative. We tested a variety of statistical methods to determine which selected the most predictive models (PCA, multiple types of linear model selection, and correlation matrices). The inclusion of interactions between the variables was important to finding a predictive model. Accurate models for water quality are important to estimate areas where resource based conflicts may arise, and to forecast changes from increased human use, economic development, and environmental fluctuations.

Nathan Carter

Dr. Nathan A. Carter is an Intelligence Community Postdoctoral Fellow in Prof. Michael C. McAlpine's group at the University of Minnesota. He received his Ph.D. from Virginia Tech in 2017 under the supervision of Prof. Tijana Z. Grove. His research interests lie in integrating electronics at the bio-synthetic interface, specifically interfacing fabricated electronics with biomaterials. His current research focuses on 3D printing as a manufacturing strategy affords precise patterning of materials on a number of chemically diverse and conformal surfaces. This work combines self-healing, dynamic chemistries to create usable materials for printed electronic elements that interface well with natural and non-natural materials. Specifically, matching the ink-substrate chemistries can help ensure proper and durable adhesion between printed layers without sacrificing stretchability, self-healing properties or electrical properties.

Conformal, Direct-Write Printing of Flexible and Self-healing, Electronic Inks

3D-printing provides a compelling alternative manufacturing strategy to traditional microfabrication in that it is capable of single-process direct-writing of electronic elements into fully integrated devices with applications such as tissue engineering, soft actuators, deployable smart medical devices, and flexible electronics. Further, direct-write printing is easily adaptable to arbitrary, curved substrates, which are not generally accessible to microfabrication strategies. To exploit these benefits and print integrated electronic devices, printable inks must be formulated to: 1) exhibit good adhesion to a variety of chemically different surfaces, 2) have tunable mechanical properties to ensure printability as well as match the mechanical properties of the substrate and 3) enable low temperature processability to maximize substrate compatibility. Here, we present direct-write printable inks for integrated electronics, by leveraging the bio-inspired, dynamic catechol and boronate chemistries to formulate printable polymer inks. Printed structures exhibit good elasticity, being able to be stretched up to ~1500% strain. Further, the dynamic chemistries maximize substrate compatibility/adhesion as well as impart self-healing properties to ensure device longevity. Further, we show these materials can incorporate low temperature sintering metallic nanoparticle inks, affording single process, direct-write printing of flexible and stretchable integrated electronics.

Janna Caspersen

Janna Caspersen Ph.D. is an Oak Ridge Institute Science and Education Visiting Scientist at the National Geospatial-Intelligence Agency. Her research currently focuses on qualitative narrative analysis of social media using machine learning. Her doctoral work at the University of Tennessee focused on the geographies of social media, mixed methods, qualitative geographic information sciences, and critical race theory. While completing her Ph.D., she worked at Oak Ridge National Laboratory for the Geographic Information Science & Technology Group assisting with population density research. Her broader research interests range from critical toponym studies, civil rights heritage, and hip-hop music landscapes to population dynamics, experiential learning, and flipped classroom teaching methods. Previously, Dr. Caspersen conducted her Master's research by locating Sudanese ethnic groups using subject matter experts and participatory research methods at East Carolina University. She has also assisted on a wide variety of research and development initiatives. These included: locating and mapping MLK Streets for the National Civil Rights Museum, sustainable tourism data gathering in Cuba, suitable habitat modeling in Honduras, and multicultural competence development through experiential and place-based learning.

Exploring Data Reviewers' Impact on Machine Learning

This research represents an initial exploration into the future of automated and near/real-time narrative analyses. Specifically, this research aims to understand how data reviewers influence machine learning outcomes. The ultimate overarching research goal is turning what currently take months of qualitative data analysis by highly trained and specialized analyst into a process that takes seconds and gives that same analyst the time and power to recommend more timely action items. Qualitative analysis is historically and currently a time-consuming process; this research is meant to speed up this type of analysis. This research is driven by the need to accelerate the identification and analysis of narratives spread via electronic communication platforms, such as social media, online news outlets, television, and radio. The volume and speed of data produced across these communication platforms are too high for traditional qualitative analysis methods. Standard qualitative methods used by the intelligence community to understand narratives take too long to make timely, accurate, and appropriate use of these vast electronic communications. This work contributes to the research taking place across the field of machine learning, focused on analyzing and understanding the ever-amassing electronic communications (i.e., social media posts, news, blogs, etc.). Narrative analysis refers to the assessment of the narrative landscape, in which, historical and cultural narratives work to mutually inform one another while securing societal identity and predicting likely behavior. Generally, narratives serve as "mental prisms" by which individuals understand their environment and make decisions; this is why it is necessary to understand narratives and their evolution over time and space in near/real-time. To accomplish that the power of machine learning must be paired in a meaningful way, with narrative analysis. Machine Learning (ML) algorithms have been relatively successful at detecting well-defined structures and features (animals, vehicles, buildings, shapes, etc.). Far more challenging for ML is the detection of nuanced language patterns in social media (slang, narratives, statements lacking punctuation, etc.). The resulting outputs from ML algorithms reflect the quality of the training data used to train the classifiers. The degree to which data reviewers (those individuals who code/annotate training data for use by ML classifies) affect ML outcomes for nuanced language patterns is unclear. The purpose of this research is to model the extent to which professional background and mental biases affect ML outputs.

Poster

Cody Champion

Cody Champion earned his 5-year B.S./M.S. at NMT in 2014 in Biology. He then attended NMSU from 2014 to 2018 for his Ph.D. program. During this time he received the National Science Foundation Graduate Research Fellowship for his work in mosquito physiology and associated microbial communities. Currently, he is working through the IC Postdoctoral Fellowship Program on the development of autonomous drone sensing of plant stress.

Identifying and Estimating Severity of Environmental Stress and Low-level Contaminants in *Sorghum Bicolor* Using Multispectral Imaging and Machine Learning

Plant damage due to climate change and low-level contamination is difficult to detect. The severity of damage is even harder to determine until it is too late to correct the problem. We aim to develop a machine learning model that can use low quality sensor data from different sensors (RGB, thermal, multispectral, and soil gas emissions including VOCs) taken over several months and determine the cause of plant damage in the model plant, *Sorghum bicolor*. If any damage is initially detected, the model will then predict the time until plant death. This model provides two key benefits. The first is that damage can be identified and responded to quickly. The second is that in the case of significant spread-out damage, information about the time to crop death can be used to inform triage mitigation efforts. We have currently identified the AdaBoost algorithm as a candidate for the primary method of classification and are currently field-testing this method in a field trial of dry vs. control farm plots. This field trial will inform future sensor designs and field trials. This work will help better equip both government agencies and agricultural producers to detect and respond to damage due to changes in climate or accidental contamination events.

Bohan Chen

Bohan Chen is a second-year PhD student at UCLA. His major is applied mathematics. He received his bachelor’s degree from the School of Mathematical Science, Peking University.

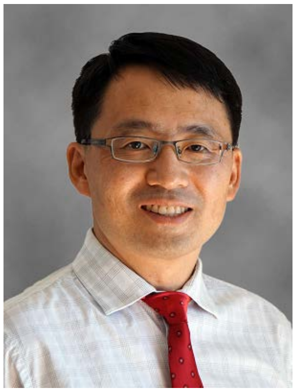
He has researched image and point cloud processing and classification, and is now working on the project of deforestation in Brazil.

He is interested in image & point cloud processing, PDE and level set method.

Patrol Strategies for Illegal Logging in the Brazilian Rainforest

Environmental crime, such as poaching and deforestation, is a growing concern in many developing countries. Recently, there has been increased effort in modeling behavior of environmental criminals with the goal of assisting law enforcement agencies in deterring these activities. Previous models for environmental crime are either discrete in nature or use overly restrictive assumptions about the geometry of the protected region. We present a continuous model for deforestation which makes no such assumptions. The key aspect of our method is the level set method, which we use to track criminal movement throughout protected areas. We compare our model against deforestation data from the Brazilian rain forest.

Jorge Chen



Jorge Chen is currently a research scientist at the Oak Ridge Institute for Science and Education (ORISE). His primary research interest focuses on exploring ways to derive indoor mapping information from remotely sensed data, with a particular emphasis on fusing machine-derived 3D geometry from 360-degree panoramic images with more accurate but data-heavy measurements from laser scanners. Dr. Chen also has a broader interest in geospatial information and developing open source geographic information system applications. Prior to joining ORISE, Dr. Chen was a graduate student and postdoctoral researcher at the University of California, Santa Barbara, performing research on the same subject matter. Before working in research, Dr. Chen spent over a decade working as a civil engineer in the design, construction, and maintenance of buildings and transportation infrastructure. He is a retired Lieutenant Colonel in the Air Force Reserve and has served as a civil engineer on two combat tours as well as several other overseas deployments.

Automated Extraction of Room Geometry

Indoor space remains a relatively unexplored area in mapping science, especially when it comes to three-dimensional cartographic representation. Two factors that have historically contributed to this limitation include a scarcity of remotely sensed indoor data and adequate computational resources and techniques for processing that data. Miniaturization and commoditization of various remote sensing systems has solved the first problem while powerful computers paired with machine learning has helped address the second. The overall research project seeks to pair these two advancements to enable the automation of indoor scene understanding, turning raw indoor data into cartographic maps that have both geometric and semantic content.

The poster presented at this conference examines one approach for understanding the geometric aspect of indoor space that involves fusing information from 360-degree spherical images with laser scanning data---also referred to as LiDAR (light detection and ranging). Until recently, most research on indoor scene understanding has focused on using point clouds---i.e., massive collections of xyz coordinates---generated using LiDAR, structured light, or other types of scanners and processed using conventional statistics or, more recently, deep learning. However, the large volume and unstructured nature of point cloud data makes working with them difficult. An alternative approach uses imagery. If a human can deduce the general layout of a room using a simple 2D photo, can we train a computer to do the same? The answer, of course, is yes. Very recent advancements in spherical image understanding using deep learning have made it possible to derive general 3D geometries of rooms using single 2D spherical images. Spherical image cameras now cost about as much as a regular consumer-grade camera, they are easy to operate (i.e., just point and shoot), and they produce simple raster images with reasonably small file sizes. However, geometries derived from spherical images are rough approximations based on unitless pixel-level measurements. This research, a work-in-progress, seeks to take the best of each approach and fuse them into one system. Namely, the speed and ease of the spherical image-based approach and the metric accuracy of LiDAR.

John Chivers

John Chivers has a B.S. in Physics from the University of Massachusetts at Amherst and a Ph.D. in Electrical Engineering from Tufts University. He is an IC Postdoctroal Fellow and his research focuses on materials and devices for use in infrared energy harvesting. Current projects include selective emitters for infrared wavelengths, high speed diodes, nano-scale antennas, and Si/Ge/Sn molecular beam epitaxy. All research projects are focused on application to infrared energy harvesting.

An Integrated System for Thermophotovoltaic Power Generation

We are developing a solid-state power generation system to harvest infrared light. Thermophotovoltaic (TPV) cells can directly convert radiated thermal energy into electric power, through a process similar to how traditional photovoltaics work. Alternately, wavelength-scale rectennas can perform the same function by coupling to and rectifying the incident EM field. Practical power generators must also include additional system components. These components, selective-emitters and filters, shape the way the radiated heat is transferred into the TPV cell for conversion and are critical for efficiency. We are designing a complete system to include all needed components in a single, robust package. This device will allow electricity to be produced from nearly any thermal source for both primary power generation and waste heat harvesting.

Bradley Christensen

Brad received a B.S. in physics from the University of Rochester, where he was awarded the John F. Flagg prize, and received his Ph.D. in physics from the University of Illinois at Urbana-Champaign for his research in quantum optics, with a focus on experimental quantum cryptography and photonic tests of nonlocality. His work on a loophole-free Bell test at NIST during this time received a Department of Commerce gold medal. Brad is now a IC Post-doctoral Fellow at the University of Wisconsin-Madison, where he does research on superconducting qubits. His work focuses on measuring noise in qubit devices, with a focus on flux noise, charge noise, correlations between charge and flux noise, and two-level system induced energy relaxation. His other work includes surface treatment methods to reduce noise, using Josephson photo-multipliers as single-photon detectors, rapid reset of superconducting cavities to their ground state, and using single flux quanta pulses to coherently control superconducting qubits.

Anomalous Charge Noise in Superconducting Quantum Circuits

Superconducting qubits are a leading platform for scalable quantum computation, with devices nearing the threshold for quantum supremacy: the ability to compute specific problems faster than classical computers. Recent progress is largely due to the advent of the transmon design, which allows the qubit frequency to be independent of the charge on the superconducting island that defines the qubit, ensuring insensitivity to low-frequency charge noise. However, this insensitivity comes at the cost of a significant reduction in the anharmonicity of the qubit. The reduced anharmonicity limits gate speed and leads to leakage errors that are particularly detrimental to scaling, as they cannot be mitigated by standard error-correction codes. At the same time, there are proposals for alternative, topologically protected qubits that would achieve protection against local sources of noise at the hardware level, and many of these proposals rely on accurate tuning of the offset charge. These considerations motivate a renewed look at the charge noise environment of superconducting qubits.

There has been extensive prior work on charge noise in single-electron devices such as single electron transistors (SETs), single Cooper pair transistors, and Cooper pair box qubits. These studies reveal a charge noise power spectral density that scales with frequency as 1/f over many decades, with a noise magnitude at 1 Hz of order 10-5-10-7 e2/Hz, where *e* is the fundamental charge. Here, we describe studies of charge noise in a weakly charge-sensitive qubit of the transmon variety. We find a noise magnitude that is significantly higher than that seen in SETs – around 3x10-4 e2/Hz at 1 Hz – and a noise exponent of 1.9. Moreover, we observe a large number of discrete charge jumps with magnitude greater than 0.1e. These results are incompatible with measurements on SETs.

These surprising results point toward a new physical mechanism for the charge noise. In particular, the standard picture of dipole-like two-level fluctuators (TLF) involving electrons or trapped charges that tunnel over microscopic length scales cannot produce the observed distribution of large-magnitude charge jumps. In addition, the large noise exponent suggests charge drift as opposed to a microscopic TLF. In fact, a simplistic model of the random impingement of charged particles in the region that defines the qubit shows a remarkable agreement with the measured data. The agreement indicates the key difference that separates studies of charge noise in modern transmon-type qubits from prior work on SETs is the vastly different device scale: while single-electron devices involve a submicron superconducting island, the transmon island has lateral dimensions of order 10s or even 100s of microns. Our next qubit designs, which dramatically vary the geometry while keeping the device parameters identical, have been fabricated, and future work will begin to explore the noise dependence on system scale.

Lawrence C. Compton

Maj Lawrence Compton is a Cyberspace Operations Officer in the U.S. Air Force Reserve and a Senior Research Engineer at the Georgia Tech Research Institute. In his most recent reserve assignment, he served as a Threat Systems Analyst at the Defense Intelligence Agency, Missile and Space Intelligence Center. Maj Compton has 20 years of experience in airborne electronic warfare applications. His specialty areas include mission data design, electronic attack technique development, and flight test evaluation. Maj Compton is a 2019 graduate of the National Intelligence University Masters of Science and Technology Intelligence program with a cyber and data analytics concentration.

Radiofrequency Machine Learning Applications in Signal Modulation Classification—Maj Compton and Dr. Blais

Machine learning (ML) techniques using deep neural networks (DNNs) have wide application across industry, defense, and intelligence communities. ML is a foundational component of artificial intelligence (AI) systems and enhances existing systems through technology insertion. Recent research applies DNN image recognition techniques to the radiofrequency (RF) spectrum with promising results. The same DNN machine vision techniques that allow facial recognition and image classification can be extended to the RF domain to identify communications and radar signals. This new application of ML techniques could enhance existing Department of Defense (DoD) systems and provide the foundation for new AI systems operating in the electromagnetic spectrum. This experimental research evaluated five separate neural network architectures for communications signal classification performance using publicly available datasets of labeled modulation types. By transforming Cartesian input data to polar form, this research achieved a gain in classification accuracy of up to 15%. The best performing DNN architecture reached 80% peak accuracy with polar form data compared to 65% peak accuracy with baseline Cartesian input data. These ML experiments show continuing promise for radiofrequency machine learning in various applications across the DoD.

Sidney Creutz

Dr. Sidney Creutz was an IC Postdoctoral researcher in Professor Daniel Gamelin's lab at the University of Washington from 2016-2019, where his research focused on the synthesis and characterization of new nanocrystalline materials. Dr. Creutz obtained his PhD in 2016 from the California Institute of Technology, working with Professor Jonas Peters, where he worked on organometallic chemistry and catalysis, focusing primarily on ligand design for iron complexes relevant to nitrogen fixation, and on applications of copper complexes in photoinduced cross-coupling reactions; he was supported during his doctoral work by a National Science Foundation Graduate Fellowship. He graduated with an S.B. in Chemistry in 2010 from the Massachusetts Institute of Technology, where his thesis focused on the reactivity of niobium-phosphorus multiple bonds; he also pursued research in single-particle spectroscopy of quantum dots and organic synthesis, and was awarded a Goldwater scholarship. Since July 2019, Dr. Creutz has been an Assistant Professor in the Department of Chemistry at Mississippi State University. His research group focuses on synthetic inorganic chemistry, developing new small-molecule metal complexes and inorganic materials with applications in catalysis, energy, and other technologies.

Synthetic Approaches to Two-Dimensional Inorganic Nanocrystals and Nanocrystal-Derived Films for Thin-Film Devices

Colloidally-prepared inorganic nanocrystals have numerous potential applications in various device technologies, but further development into synthetic methods for their preparation and deposition as thin films is needed to attain high-quality materials. Because they are well-suited to inexpensive, low-temperature solution-processed deposition approaches, colloidal inorganic nanomaterials have been particularly widely recognized as promising components of flexible and/or transparent devices. However, fundamental science challenges still remain, and we have sought to address some of these challenges by (1) developing new classes of nanomaterials with promising charge-transport and other properties, and (2) developing new (low-temperature) methods to process such nanomaterials into films. Within these areas, we have made progress with three classes of materials (perovskite halides, ferromagnetic chromium halides, and wide-bandgap oxides), as described briefly below.

Perovskite halides. Since they were first reported in 2015, inorganic lead halide perovskite nanocrystals (CsPbX3) have shown excellent performance in a range of device applications, but the lack of lead-free analogues with similar properties has hindered their applications. We have synthesized, for the first time, nanocrystals of Pb-free perovskite analogues (e.g. Cs3Bi2I9) with a two-dimensional structure which should facilitate charge carrier transport. This work capitalizes on our advances in nanocrystal anion-exchange techniques. Low-temperature processing approaches to create high-quality films of these nanocrystals have shown promising initial results.

Ferromagnetic chromium halides. Materials with magnetic properties can give rise to new classes of electronic devices with improved efficiencies, such as spin transistors, or specialized applications, such as data storage; 2-D magnetic materials such as chromium (III) iodide (CrI3) are a relatively new subclass of such materials, but scalable approaches to their preparation have not yet been developed. We have recently developed the first synthesis of CrI3 nanoplatelets which show layer-dependent magnet properties and can be dispersed in solution, making them potentially well-suited to solution-processing techniques.

Chemical soldering of metal oxide nanocrystals. While metal oxide materials (such as indium oxide, zinc oxide, indium gallium oxide, and other alloys) have well-established promise as the active materials in thin-film transistors, methods for converting (under mild conditions) colloidal metal oxide nanocrystals into films with good electronic properties have previously been lacking. We have developed low-temperature chemical soldering techniques using organometallic precursors for post-deposition treatment of nanocrystals that increase conductivity of transparent conducting oxide nanocrystal films by 1-2 orders of magnitude compared to untreated films.

Gabrielle Dinsmore

Gabrielle Dinsmore is a cadet at the United States Coast Guard Academy in New London, Connecticut. She is majoring in marine and environmental sciences, with specialties in physical oceanography and marine biology. This summer, Gabrielle participated in a five-week internship program at the National Geospatial-Intelligence Agency, where she studied the use of remote sensing technologies to detect the motion of sea ice in the Arctic Ocean. Gabrielle completed her summer tour stationed aboard the Coast Guard's tall ship, USCGC Eagle, while underway off Bermuda.

Synthetic Aperture Radar in Arctic Sea Ice Imagery and Analysis–G. Dinsmore and D. Guerreiro

The purpose of the study was to determine how sea ice in different stages of development moves and changes in size over time in the Arctic Ocean in order to identify environmental factors serving as the best predictors of future ice movements. Specifically, we investigated the relative influence of wind velocity (speed and direction) and ocean currents on the trajectories of first-year and multi-year sea ice. We differentiated between first year and multi-year sea ice using Synthetic Aperture Radar (SAR) analyzed in imagery exploitation software. We compared the SAR images with drifting beacon data collected for the same ice floes during the period of interest. Overall, we found that wind speed and direction can have a greater effect on local ice movements than do large-scale ocean currents. However, our data suggest that ocean currents have a greater impact on the movement of sea ice at larger spatial scales. In conclusion, local weather conditions appear to be a better determinate of ice floe behavior at local spatial scales important to transiting ships.

Kevin Dobbs

Dr. Kevin Dobbs is a Visiting Scientist in the NGA/Research Directorate via a program with the Oak Ridge Institute of Science & Education (ORISE) and the Department of Energy. His work has spanned a range of remote sensing and geospatial analysis applications areas, including land use / land cover mapping, unmanned aerial systems (UAS), hydrologic and hydrodynamic modeling, data visualization, remote sensing and geospatial data support for disasters, and teaching graduate level courses in remote sensing and related topics. He has held an appointment at the US Department of State in the Bureau of Intelligence and Research working with an interdisciplinary team within the Office of the Geographer and Global Issues. As part of the Humanitarian Information Unit (HIU) he engaged in interagency collaborations with the US Agency for International Development (USAID), the National Geospatial Intelligence Agency (NGA), the American Red Cross, the European Commission Joint Research Centre (JRC), the World Bank, and others focused on complex humanitarian crises.

Building Multidisciplinary, Multiagency Teams for Integrated Technology Development and Transition Pathways for Innovative Solutions: Opportunities, Challenges, and Insights from FIST Model Development

This research focuses on the nexus between scalable high performance computing (HPC), machine learning, flood modeling, elevation datasets, and remotely sensed imagery. Flooding has the greatest human and economic impact of all natural disasters, yet near real-time flood extent estimates remain a practical challenge to produce. As the quality of elevation data at all scales is rapidly improving, and the quantity satellite imagery that is acquired is rapidly expanding, the time is right for reimaging the way real-time information surrounding flood disasters can and will be derived. In this presentation we offer a technical and organizational overview of the pathways to current collaborations and enabled applications for the FIST model and will delve into the challenges of moving innovative ideas forward though a complex landscape of organizational inertia, evolving data and technologies, and distributed teaming.

Daniel Drew

Daniel Drew received his Ph.D. in Electrical Engineering from UC Berkeley under the supervision of Professor Kris Pister. His dissertation research focused on the design and fabrication of a microrobot that uses atmospheric ion thrusters to fly with no moving parts—the ionocraft. Along the way, he performed parallel work in human-computer interaction in the context of novel debugging and development tools with Professor Bjoern Hartmann. He recently began as a postdoctoral scholar at Stanford University in Mechanical Engineering, working with Professor Sean Follmer on pushing the performance of millirobot systems and investigating new bio-inspired ways for them to communicate and interact. Daniel received his B.S. in Materials Science and Engineering from Virginia Tech, an NSF Graduate Research Fellowship in 2013, and the Intelligence Community Postdoctoral Research Fellowship in 2019.

New Directions for Designing Effective and Efficient Microrobots

In the near future, swarms of millimeter scale robots will be vital and common tools in industrial, commercial, and personal settings. By enabling applications spanning from distributed gas and chemical sensing, to tangible 3D interfaces, to ad-hoc surveillance networks, providing mobility platforms to low-power sensing and actuation nodes will push us that much closer to the dream of ubiquitous computing. Major barriers to making this a reality include the fundamentally different governing physics at the insect scale, the severe energy and payload constraints of even optimistic projected systems, and the proven ineffectiveness of current “swarming” algorithms.

As the size of a flying robot decreases, traditional methods of robotic flight like the propellers of a quadcopter begin to suffer in performance. Bio-inspired alternatives show promise, but we currently lack robust fabrication processes, materials, and actuators at this scale. Electrohydrodynamic thrust, where air is ionized and accelerated such that momentum transferring ion-neutral collisions provide directed propulsion, is an alternative method of flight with proven viability at the centimeter scale. It can be implemented using mature wafer-scale batch-fabrication processes, is mechanically trivial due to a lack of moving parts, and is completely silent. Currently, I am investigating ways to improve the efficiency, thrust density, and ease of fabrication of these systems.

Besides the fundamental challenge of enabling mobility at this scale, another major obstacle is that a disproportionate amount of robot energy and payload mass must be dedicated to locomotion and the minimum sensing capabilities required for control, leaving very little for actually performing useful functions. Nature has found a number of ways to get more done with less; for example, an adaptation ubiquitous in the world of insects is “stridulation,” where passive mechanical structures on the body are excited by the existing locomotion actuators in order to produce substrate- or air-borne acoustic signals for communication. We are currently investigating biomimetic stridulation as a method of communication among insect-scale robots.

Microrobots, much like their natural inspirations, must work together in “swarms” to perform tasks an individual agent is incapable of. Although most researchers implement swarm algorithms strictly on homogeneous platforms, in fact, phenotypic diversity among social insects like ants allows them to specialize for specific colony tasks; heterogeneous swarms of worker ants (i.e. different “castes") work together to perform complex tasks more effectively. In the future, this research will bring together the best that modern microelectronics has to offer in sensing and computation with novel task-specific actuation and structural components in order to create centimeter-scale robots that exploit specialization to maintain functionality without compromising size or cost.

Jared Dunnmon

Dr. Jared Dunnmon is a current Intelligence Community Postdoctoral Research Fellow in Computer Science Department at Stanford University, where his research focuses on combining heterogeneous data modalities, machine learning, and human domain expertise to inform and improve decisionmaking around such topics as human health, energy & environment, and geopolitical stability. Jared has also worked to bridge the gap between technological development and effective deployment in a variety of contexts including foreign policy at the U.S. Senate Foreign Relations Committee, solar electrification at Offgrid Electric, cybersecurity at the Center for Strategic and International Studies, emerging technology investment at Draper Fisher Jurvetson, nuclear fusion modeling at the Oxford Mathematical Institute, and nonlinear energy harvesting at Duke University. Jared holds a PhD from Stanford University, a B.S. from Duke University, and both an MSc. in Mathematical Modeling and Scientific Computing and an M.B.A. from Oxford, where he studied as a Rhodes Scholar.

Cross-Modal Data Programming: Leveraging Multimodality in Weakly Supervised Machine Learning

One of the greatest roadblocks to using modern machine learning models is collecting hand-labeled training data at the massive scale they require. In real-world settings where domain expertise is needed and modeling goals change rapidly, hand-labeling training sets is prohibitively slow, expensive, and static. For these reasons, practitioners are increasingly turning to weak supervision techniques wherein noisier, often programmatically-generated labels are used instead. However, these weak supervision sources have diverse and unknown accuracies, may output correlated labels, and may conflict with one another. In this work, we propose a framework for integrating and modeling such weak supervision sources by solving a matrix completion-style problem that allows us to recover the source accuracies without any labeled data. Such modeling approaches allow us to create higher-quality supervision for training a model. Theoretically, we show that the generalization error of models trained with this approach improves with the number of unlabeled data points, and characterize the scaling with respect to the correlation structure. We also highlight one of the major advantages of this type of supervision – specifically, that information from modalities available at train time (e.g. radiology reports accompanying a set of images) can be used to effectively supervise model training over a different modality (e.g. the raw image) that can then be deployed over the second modality alone at test time. This concept of "cross-modal" weak supervision has shown promise in enabling advances in areas spanning clinical medicine to industry. We will conclude by presenting extensions of these weak supervision ideas to observational settings, where passively collected signals such as eye tracking data can be used to improve model performance.

John Erskine

John Erskine is a rising senior at the United States Military Academy at West Point and is majoring in geospatial information science (GIS). Upon graduation, he hopes to commission into the army as an aviation officer and continue his education in a graduate program. Within GIS, his main interests are in remote sensing and its applications to military and intelligence projects. This includes the use of both airborne and satellite-based systems. At West Point, he has undertaken many research projects, both independently and in conjunction with the National Geospatial-Intelligence Agency (NGA). The topics covered various areas of remote sensing and GIS.

In terms of professional experience, John has interned twice for NGA and has volunteered his skills in GIS to local non-profits near West Point. During his internships at NGA, he worked on projects involving both UAVs and satellite imagery. His work with UAVs consisted of designing, building, and operating a UAV for use at West Point. Working alongside analysts, his work with satellite imagery contributed to ongoing work in research and national defense. Using his skills outside of research, he volunteered to work with a local land trust near West Point by using his GIS skills to produce mapping products for public land they manage.

Integrating Unmanned Aerial Systems into Education and Research

Small Unmanned Aircraft Systems (SUASs) play a critical role in various types of academic, professional, and intelligence gathering projects due to their versatility as a data collection platform. SUASs can carry a variety of optical sensors ranging from conventional digital cameras to multi and hyperspectral sensors capable of imaging beyond the boundaries of visible light. These SUAS sensors are tremendously valuable for surveying, reconnaissance, and remote sensing applications that require timely and detailed imagery products of an area of interest. Additionally, their relatively low cost when compared to traditional aerial or satellite imagery acquisition, makes SUASs a practical solution for many organizations.

This project discusses the partnership between the United States Military Academy (USMA) and the National Geospatial-Intelligence Agency (NGA) on the design, build, and collection of data using a NGA SUAS quadcopter. The project was accomplished in two primary phases: (1) a summer internship where CDT John Erskine worked to help design, build, and operate a SUAS with the help of NGA's program lead and (2) when CDT Erskine returned to USMA and constructed an additional SUAS, teaching other cadets based on his knowledge gained over the summer. These SUAS builds were governed by many factors, such as cost, flight time, and payload capacity, but perhaps the most important being recently updated Department of Defense (DoD) guidelines for the operation of commercial off-the-shelf (COTS) drones. Based on the DoD requirements, the NGA SUAS had to comply with many build component limitations and operating standards.

The GIS Program at USMA currently utilizes various SUAS platforms for ongoing research projects and enhanced classroom instruction. This past summer, two GIS Cadets assisted USMA faculty with numerous SUAS photogrammetric surveys of thermokarst (i.e., localized melting of permafrost) terrain on the Alaskan North Slope. In the photogrammetry course (EV379), instructors employ SUAS platforms to enhance student understanding of key concepts and provide practical hands-on experience. Cadets enrolled in EV379 are exposed to the flight planning, ground control surveying, and flight execution aspects of a SUAS photogrammetric survey. Back in the office, they gain exposure to image processing techniques and the development of relevant geospatial products.

Both NGA and USMA will continue to expand their use of SUASs in the future. NGA has recently stood up its own UAS program under the research division, headed by Mr. Matt Trani, and has plans to expand the capabilities of the UASs they currently operate. Specifically, they have recently integrated a light detection and ranging (LiDAR) sensor onto one of their larger platforms to expand their active remote sensing capabilities. USMA is also pursuing research regarding SUAS-based LiDAR to enhance capabilities associated with survey-grade 3D surveying of terrain, unstable rock slopes, and the built environment. While these examples highlight a specific area where USMA and NGA are working on related goals, both are exploring how to build and implement these technologies across numerous academic and professional projects.

Mattias Fitzpatrick

Mattias Fitzpatrick grew up in Southern Oregon before attending Middlebury College where he majored in physics and mathematics. After undergraduate, he worked with Professor Andrew Houck at Princeton on superconducting circuits for quantum simulation and quantum computation. In his PhD. research, he explored one-dimensional lattices of superconducting coplanar waveguide circuits and qubits where they observed a dissipative phase transition. In addition, Mattias and colleagues developed a mathematical approach for constructing circuits which create photonic materials which are effectively curved and exhibit spectrally isolated flatbands. After developing the mathematical framework, they fabricated and measured the devices in the lab. This work opens up new directions for many-body quantum simulation with superconducting circuits. In his IC Postdoctoral Fellowship work, Mattias will be working with Professor Nathalie de Leon on fast, multiplexed readout of nitrogen vacancy center ensembles for quantum sensing applications.

Nonequilibrium Quantum Simulation with Superconducting Circuits

In recent years, superconducting circuits have emerged as a promising platform for quantum computation and quantum simulation. One of the main driving forces behind this progress has been the ability to fabricate relatively low-disorder, low-loss circuits with a high-degree of control over many of the circuit parameters, both in fabrication and in-situ. This coupled with advances in cryogenics and microwave control electronics have significantly improved the rate of progress. The field, which is broadly called circuit quantum electrodynamics (cQED) has become one of the cleanest and most flexible platforms for studying strong interactions between light and matter.

This talk will describe the study of non-Euclidean lattices which can be made from coplanar waveguide (CPW) lattices. This work relies on the fact that the frequency of the resonators in the lattice is dependent only on the total length of the cavities, not the length between the ends of the cavity. This means that we can form lattices from CPW cavities where the edge distance is not the same. The first result in this direction is the fabrication and measurement of a finite piece of a hyperbolic graph, formed from a ‘regular’ tiling of heptagons. This lattice had an effective curvature which is quite large and in principle exhibited a gapped flat band.

Following up on the hyperbolic lattice work, we will describe the study of exotic new lattices which have band structures that exhibit exotic features such as gapped flat bands and Dirac cones. This work involves looking at the spectra of graphs and their corresponding line-graphs, which are the graphs which are pertinent to the tight-binding Hamiltonian in CPW lattice devices. In this work, we derive the mathematical relationship between the spectrum of a graph and its line graph as well as what is known as the split graph. These operations allow us to exactly maximize the gap between the flat band and the rest of the spectrum for certain line graph lattices.

Jason Gross

Dr. Jason Gross is an associate professor in Department of Mechanical and Aerospace Engineering at West Virginia University (WVU). He received his Ph.D. in Aerospace Engineering from WVU in 2011, received his undergraduate degrees in Mechanical Engineering and Aerospace Engineering from WVU in 2007, and was WVU's Student Body President from 2006-2007. From 2011 to December 2013, he worked as Research Technologist in the Near Earth Tracking Applications Group at Caltech's NASA Jet Propulsion Laboratory. His research focuses on the area of Guidance, Navigation and Control (GNC) technologies as they apply to Unmanned Aerial Systems (UAS), Global Navigation Satellite Systems (GNSS), Robotic Systems, and Space Systems. In these areas, he has authored or co-authored more than 45 technical papers and has been PI or Co-PI on more than 10 externally funded research projects. He is the recipient of a NGA New Investigator Program grant, AFOSR Faculty Fellowship, WVU Big XII Faculty Fellowship, and WVU Statler College teaching and research awards.applications.

Autonomous Navigation of a UAV-UGV Team for the Exploration of Underground Tunnels

Our NURI project explores the use of autonomous robots to assist a search and rescue mission in a subterranean environment. In particular, a heterogeneous team of an Unmanned Ground Vehicle (UGV) and Unmanned Aerial Vehicle (UAV) are being developed to explore an underground tunnel, provide a 3D map, and identify targets of interest. In this configuration, the UAV provides an ability to search areas that cannot be traversed by the UGV, where the UGV can carry more capable sensing and computation.

During this presentation, we will focus on the development and field-testing of the autonomous relative navigation system of the UAV relative to UGV, which is an important enabling technology for using robotic systems in underground ad GPS-denied environments. In particular, we have developed algorithms to track the position of the UAV within the 3D LIDAR scans of the UGV and within an omnidirectional fisheye camera mounted on the UGV. Further, these vision-based estimates are fused with UAV inertial measurements, ultra-wideband ranging radio measurements, and laser/ultrasonic altimeters mounted on the UAV that is shared in near real-time with the UGV. Our presentation will discuss the details of algorithms developed and assesses their performance both in simulation environment and with experimental testing of the integrated UAV and UGV systems that have been conducted in relevant GPS-denied environments.

Moving forward, the emphasis of our NURI will be to develop and test an autonomous planning strategy for the motion of the UAV and UGV that balances the conflicting requirements of maintaining accurate UAV localization and maximizing the exploration coverage of the subterranean environment.

Raoul Guiazon

Dr. Raoul Guiazon is a UK IC Postdoctoral Research Fellow working on “Artificial Behaviour Based Authentication for the Internet of Things” at the University of Leeds, UK. He trained as an engineer in electronics at ENSEA Paris - France, then completed an MSc in Communications and Signal Processing at Imperial College London in 2013. Subsequently, he was awarded a PhD from University College London for his work on “Interference as an Issue and a Resource in Wireless Networks” where he investigated the use of interference for security in IoT (Internet of Things) networks and its mitigation for increased data throughput. His work was funded by British Telecom (BT) and the Engineering and Physical Sciences Research Council (EPSRC).

In 2017, Dr. Guiazon joined the Experimental Quantum Information group at the University of Leeds UK, to investigate novel approaches to cyber-security, first by exploring Free space Quantum Communications and now by developing original authentication methods for connected devices. His current work is funded by the UK Government Office for Science via the Royal Academy of Engineering.

Device Authentication Based on Artificial Behaviour

Cybersecurity is one of the main challenges faced by modern society. An ever-increasing part of our daily activities is conducted online or greatly relies on our ability to safely and reliably exchange data across remote locations. This reliance on communicating devices will only grow as the trend is moving towards autonomous devices and networks, with sensors and actuators that communicate without much human oversight over the Internet of Things (IoT).

The challenge of this work is to develop novel techniques for device authentication that are based on behavioral signatures. Those signatures are by design intended to be unique to each device. However, the innovative step here is to allow the devices’ behavior to evolve in a chaotic manner over time and have a dedicated network controller that is permanently tracking that evolution to maintain and ensure the authenticity of the devices connected to the network. Networks using this authentication strategy are protected against attacks thanks to the complexity of the problem that an attacker needs to solve in order to reproduce accurately a given behavior over any length of time.

Khuzaima Hameed

Khuzaima Hameed is a fourth year Statistics Ph.D. student at North Carolina State University. Advised by Dr. Eric Laber, he currently works on social media influence, dynamic treatment regimes on spatio-temporal data, and autonomous driving. Recent projects include Social Sifter (in collaboration with Laboratory for Analytic Sciences at NC State), a web application that categorizes influential users based on network and temporal features; and Donkey Car, a scaled down autonomous car that uses reinforcement learning to navigate various environments. His research interests include automation, reinforcement learning, and mobile health. He is currently a member of Laber Labs at NC State.

Social Sifter

As highlighted in major, public incidents such as Russia's efforts to influence the outcome of the recent presidential elections in the U.S., Germany, and France, it has become clear that social media has become an optimal target for malicious individuals and institutions to perform influence campaigns. Given the scope and scale of social media data, it is necessary to triage the data into a small network of key users, who drive the influence campaign. Current methods for this task, however, are slow, manual, and forensic. The Social Sifter project aims to provide a single interface which centralizes automated capabilities for collecting large scale social media data and rapidly triaging this data into small networks of interesting, influential, or organized users using a variety of models trained on a large collection of recently released public data from known foreign influence campaigns. These networks of key users can then be visually displayed alongside a variety of metrics and other data, to allow the analyst to monitor and assess these networks as they evolve over time.

The tool is designed with three main modular components: a cross-platform data ingress service, a network analysis service (the core of the project) which executes a variety of models to identify key interesting, influential, or organized users, and finally an interactive, web-based visual display of these networks. The network analysis service utilizes several models, such as Functional Data Analysis (FDA), Text Classification, and other supervised learning models, organized in a modular architecture to identify key users.

One of the features of the Social Sifter system is a new classification method to label social media users appropriately based on the user's online behavior. A user's behavior is treated as a binary time series, indicating times of activity. We consider a generalized multilevel functional model for the response profile. This model separates the user-specific variation from the day within user variation and from the mean trend, while accounting for additional covariate effects. The user-specific and within day user trends are estimated through functional principal components analyses. Classification of the users is accomplished through analyzing the user-specific trends. This multilevel structure has been explored in previous research, however applying this model with the purpose of classification has not been studied. Currently this approach is used for bot detection and identifying users who are working in cohort, but can be expanded to include many other classification labels. For the text classification model, another model built in to Social Sifter, we are utilizing a deep neural net based on the AWD_LSTM architecture, trained following the ULMFiT procedure. Finally, a random forest model uses user attributes alongside network features constructed from retweet networks, including in-degree centrality, out-degree centrality, and PageRank to classify users.

Ryan Hamerly

Ryan had many interests when he was young, but when he saw a Tesla coil in action at high school, he knew he wanted to become a physicist. He taught himself electromagnetism to build his own Tesla coil, but during his studies at Caltech, he veered off into particle physics and general relativity. In graduate school at Stanford (Mabuchi group), he returned to electromagnetism, pursuing research on quantum feedback control, quantum optics, and nonlinear optics. After graduating, he spent a gap year working at NII in Tokyo (Yamamoto group) on quantum annealing and optical parametric oscillator networks for combinatorial optimization. He is presently an IC Postdoctoral Fellow at MIT (Englund group) working on integrated photonics and deep learning.

Challenges and Opportunities for Optically Accelerated Deep Learning

More is different. In AI, more compute has led to the automation of an ever-growing number of increasingly complex tasks. With the end of Moore's Law looming, photonic AI accelerators are a promising approach to continue this trend. This talk will summarize the field of optical neural networks (ONNs) and introduce our group's recent work in large-scale ONNs based on photoelectric multiplication. ONNs perform the bottleneck step of deep learning (matrix multiplication) passively using linear optics, allowing for orders-of-magnitude improvements in compute density and energy consumption compared to digital electronics. However, past ONN demonstrations have been limited by chip area to small proof-of-concept problems where the advantage of photonics is negligible. Our recent work discusses—employing time multiplexing, photoelectric multiplication, and a synergistic fusion of integrated and free-space optics—to improve the scalability of ONNs to large systems where significant performance advantages can be expected.

One important question concerns the near-term and fundamental limits of ONNs. Using a number of problems including MNIST and ImageNet classification, simulations show that ONNs can in principle perform at energy levels below 0.1 aJ/op, a limit set by quantum noise. This bound is low enough to suggest that performance beyond the Landauer limit is theoretically possible in ONNs. On the other hand, with near-term technology the ONN will be limited by I/O costs (ADC, DAC, modulators, detectors), leading to predicted performance at the fJ/op level, which is still 3 orders of magnitude lower than the CMOS state-of-art. We will also discuss the use of ONNs for combinatorial optimization, our early proof-of-concept experiments and roadmap to a chip-based ONN, and benchmarking results based on rigorous computer architecture models and AI workloads.

KaLynn Harris

KaLynn Harris is a new City of Durham's Transportation Apprentice. In May 2019, she gradùted from the illustrious North Carolina Central University, where she majored in Environmental, Earth, and Geospatial Sciences. Her research experience during her four years at North Carolina Central University consisted of applied Toxicology and Geographic Information Systems. She has decided to continue her educational career and is currently attending North Carolina Central University as an Earth Science Graduate student. She enjoys the experience that is gained by attending conferences, as either a presenter or a volunteer, due to her ability to network and embrace new ideas.

Sea Level Rise and Coastal Flooding of Dare County, North Carolina

The greenhouse effect is a natural process that is responsible for warming the Earth's surface. The greenhouse effect takes place when heat-absorbing gases, known as greenhouse gases, trap heat in the atmosphere. Overall, this is a process that is needed to balance Earth's temperature. Unfortunately, human activities, such as burning fossil fuels and deforestation, have enhanced the greenhouse effect by increasing the level of greenhouse gases in the atmosphere — increasing the Earth's temperature. Furthermore, anthropogenic emissions are the main drivers of climate change. Because greenhouse gases are being emitted and trapped in the environment at unsustainable rates, warmer air and water temperatures are causing global glaciers and ice sheets to melt or to break off into the ocean. Adding water or ice from land to the ocean raises sea level, and is by far the biggest future threat. Furthermore, sea levels rising are a long term effect of climate change. The rising of the sea levels can threaten locations that are already below sea level and have the potential of creating underwater cities. By examining the likelihood of floods and sea levels rising for a county in the coastal plain region, we can determine the populations affected, property value at risk ($), houses impacted, and government buildings, roads, and schools that are threatened. Our research can provide insight on the potential threats to coastal areas within the next 40 years.

David Haynes

David Haynes has a BSc in Chemistry and an MSc and PhD in Information Science. He has spent a significant part of his career to date working on library and information management projects in the commercial, government and third sectors. During his time in industry he became interested in information governance and specifically privacy and data protection issues, which he pursued in his doctoral research. He completed his PhD on 'Risk and Regulation of Access to Personal Data on Online Social Networking Services in the UK' in 2015. In 2017, he completed work on the second edition of his book on 'Metadata for Information Management and Retrieval' before starting his IC Postdoctoral Research Fellowship in the Department of Library and Information Science at City, University of London in the United Kingdom. In January 2020 he takes up a tenure post as Lecturer in the Computer Science Department at Edinburgh Napier University in Scotland. His research interests lie in knowledge representation, information governance, privacy, regulatory issues and the interface between these areas.

The Nature of Risk in the Privacy Calculus: A Risk Ontology

This project sets out to address the following research questions:

- Is there a reliable typology for personal risk that can be used to analyse the privacy calculus that users engage in?
- What is the nature of the interactions and risks that users engage in when they use the Internet?
- Can the new risk typology be applied to existing empirical data to refine the privacy calculus?
- What effect will the new categorisation of risk have?
- Can these figures be used to improve the predictions of user behaviour?

Research on privacy calculus has largely been based on user perceptions of the risks and benefits associated with disclosure of personal information (Dinev and Hart, 2006; Krasnova, Veltri and Günther, 2012). Rosenblum (2007) developed a typology of risks associated with online social networking services (SNSs). Haynes and Robinson (2015) looked at personal risk derived from generic risk categories (Swedlow et al., 2009, p. 237). However there is no consensus on a risk typology and further work is needed to provide a consistent approach to privacy calculus.

The online activity of six participants was monitored to identify when they disclosed personal data online and to explore the motivations for these disclosures. They were also questioned about their perceptions of risk. The resulting analysis suggested that an ontology would be better than a typology to represent the complex relationships between risk concepts (Haynes, 2019) dynamics: the capacity to elucidate past responses and inform future ones, enabling us to finally provide decision advantage in a dynamical and noisy world.

Yixuan He

Yixuan He is a Mathematics and Statistics major at the University of Edinburgh, and Mathematics and Applied Mathematics at South China University of Technology (2+2 Dual Bachelor's Degree). This summer, she is visiting UCLA from the CSST program, working on a project to model deforestation events in Brazilian rainforest using level-set method. Her research interests include computer vision, machine learning, mathematical modelling, data analysis and statistical inference. She is interested in conducting research and would love to apply for a PhD this year. she has good grades and enjoy acquiring new knowledge. she also has some research experiences, and is the first author of a paper at a workshop in CVPR2019.

A Modeling of Deforestation for Agricultural Land Clearance in the Brazilian Rainforest

Environmental crime, such as poaching and deforestation, is a growing concern in many developing countries. Recently, there has been increased effort in modeling behavior of environmental criminals with the goal of assisting law enforcement agencies in deterring these activities. Previous models for environmental crime are either discrete in nature or use overly restrictive assumptions about the geometry of the protected region. We present a continuous model for deforestation which makes no such assumptions. The key aspect of our method is the level set method, which we use to track criminal movement throughout protected areas. We compare our model against deforestation data from the Brazilian rain forest.

Tim Helps

Tim Helps received his MEng in Mechanical Engineering from the University of Bristol in 2010. He continued his studies in bio-inspired robotic locomotion, focusing on improving the energetic economy of running and hopping robots, and was awarded his PhD in 2015. He then worked on the Wearable Soft Robotics for Independent Living project, developing soft robotic assistive technologies and devices to improve the mobility and independence of elderly and disabled people. The project received wide press coverage including BBC News, The Times, The Guardian and The Daily Telegraph. He is now an IC Postdoctoral Research Fellow with the Royal Academy of Engineering, developing insect-inspired semi-autonomous robots for remote missions such as intelligence gathering, humanitarian disaster relief and industrial repair. His research interests include robotic locomotion, artificial muscles, soft sensors, and assistive orthotics.

Insect-inspired Strong and Soft Semi-Autonomous Agents for Remote Missions

Insects exhibit many incredible capabilities in terms of locomotion, adaptability and task-specific performance. However, until now, these abilities have largely been overlooked in artificial devices. Small, soft, semi-autonomous robots with biologically comparable performance could revolutionize intelligence gathering, remote intervention, humanitarian disaster relief, and many other fields.

However, the performance of small robotic systems is currently limited by three fundamental challenges:

1. Traditional robots with wheeled or tracked morphologies are not suited to unstable terrain and tightly confined spaces. Alternative locomotion methods more suited to these environments such as worm-like and legged locomotion have been investigated in the laboratory but rarely executed in the field.
2. Current artificial muscles are limited in their performance; while devices exist that are superior to biological muscle according to some performance characteristics, none exist which exceed or even match biological muscle in every way.
3. Current artificial muscles are limited in their energy requirements. In particular, high-actuation- stress, high-specific-energy, high-efficiency artificial muscles simply do not exist. As such, currently developed soft robotic systems require either large on-board energy stores, or bulky umbilical cables to provide power.

In this project, these challenges will be tackled using three ambitious and complementary research themes.

1. Insect characteristics, encompassing biology, biomechanics and behaviour will be investigated, and insect-inspired locomotion strategies will be examined for suitability to micro-robotic systems. A wide range of biological locomotion strategies will be assessed, and the most successful will be selected for later execution by state- of-the-art micro-robots.
2. Cutting-edge artificial muscle technology will be developed, starting from fundamental physical phenomena, taking inspiration from biology and integrating feedback from micro-robotic challenges. Proof-of-concept demonstrators will be refined towards optimised artificial muscle structures which are well-suited to inclusion within soft and strong micro-robots.
3. The most successful research from themes 1) and 2) will be embodied in high-performance micro- robotic demonstrators, which will combine adaptive biologically-inspired locomotion techniques with newly developed task-optimised artificial muscles. These micro-robot demonstrators will navigate over rugged terrain and through tightly-confined environments and perform use-case- inspired remote agent missions.

Through these ambitious research themes, this project will deliver a step-change in semi-autonomous micro-robot performance and provide a jumping-off-point towards fully autonomous, independent robotic agents which can perform mission-critical intelligence gathering and intervention tasks.

Anne Hillegas

Dr. Anne Hillegas' career spans technical and leadership assignments in the defense and homeland security markets and the Executive and Legislative branches of government. Her roles in industry include Vice President, Strategic Programs for ENSCO; Vice President for Business Development in Raytheon Network Centric Systems; Vice President for Homeland Security in Raytheon Technical Services Company and Vice President at Hicks and Associates, Inc., a wholly-owned subsidiary of SAIC. She was also a Principal Scientist at Applied Research Associates (ARA), a mid-sized technology firm. Earlier, she spent thirteen years at TRW, now Northrop Grumman, in a variety of systems engineering and program management positions. Dr. Hillegas' tenure in government included leadership positions at the Missile Defense Agency (MDA) and the Defense Threat Reduction Agency (DTRA), and serving as a Congressional Fellow in the House and Senate. Dr. Hillegas earned her Doctor of Science and Master of Science degrees from George Washington University's School of Engineering and Applied Science via TRW Fellowships. She received a Bachelor of Science degree in Industrial Management from Carnegie Mellon University.

The Challenge: Increasing the Quantity and Quality of Breakthroughs

Scientific imagination is critical to our economy as well as our national security and defense. Research and development, as an expression of scientific imagination, is now a global and intensely competitive enterprise. This competition is heightened by digital and network disruptors that increase the speed and extend the borders of idea exchange affecting the nature and spread of threats and opportunities. Organizations fundamentally based on shaping the future need to leverage every possible advantage to succeed in this environment.

<u>The Approach: Reshaping the Future of Science</u>

Polyplexus is an online platform under development in the GS3 program. The goal of Polyplexus is to reshape today's approaches to science by effectively and efficiently engaging cross-disciplinary researchers and research sponsors to dramatically accelerate the process of non-obvious hypothesis generation.

Polyplexus is a rigorous, collaborative platform driven by expert participants and evidence. Proven game and social practices spur participants–technical experts, researchers, research sponsors–to connect evidence across disciplines and generate new hypotheses. Individuals and teams use the linked information in Polyplexus to develop and explore good questions, formulate concepts, and create DARPA-worthy prospective research plans through a disciplined process of generative dialogue. Private interactions enable individuals and teams to establish direct relationships with sponsors intended to increase the quantity of high-quality funded research projects.

<u>The Value Proposition: Generating Better Questions, Faster</u>

Polyplexus is not about brainstorming, awards, providing immediate solutions, or turning science projects into businesses. Instead, Polyplexus accelerates connections across domain knowledge, allowing experts to assemble evidence and hypotheses from which research plans can quickly evolve and seek funding.

Polyplexus is different from other crowdsourcing, technical challenge, and literature-based compendiums in that it:

- Features a perpetual online imaginative conversation that is rigorous, evidence-based, collaborative, and easily accessed while actively encouraging and seeking significant novel thinking;
- Creates and develops a merit-based network of motivated contributors (from multiple points of view) across disciplines;
- Employs proven gaming and social network practices to drive engagement;
- Delivers an efficient way to match promising research directions to the people with the knowledge to do the research as well as the people and organizations who need it done

Michael Jasser-Stone

Dr. Michael Jasser-Stone is a second year IC Postdoctoral Research Fellow at the the University of Florida in Gainesville, Florida. His research area is on direct shear failure modes of Ultra-High Performance Concrete under dynamic loads. He attended Florida International University for his BSCE where he focused on structures and worked on curtain wall anchorage systems. He began his Masters in Civil Engineering at the University of Florida and continued with his Ph.D., studying failure behavior and energy flow of Ultra-High Performance Concrete (UHPC) beams and cylinders under impact loading with high energy drop hammers. He also assisted with developing equipment for dynamic penetration testing of soils inside centrifuges. His current research focuses on numerical assessment and modeling of direct shear failure mechanisms of UHPC using frequency analysis and energy transfer mechanisms. His other research interests include analyzing structural response to impulsive loads and numerical simulations using finite and discrete element methods.

High Frequency Loading and Direct Shear Behavior in Ultra High Performance Concrete

Direct shear is a sudden and catastrophic failure mechanism in concrete structures under severe impulsive loads (e.g., airblast-induced or direct induced ground shock). The failure mode is characterized by complete failure of the structural system along a plane that is typically located at either a geometric or load discontinuity. This failure occurs rapidly and before other structural resistance mechanisms can be activated. New materials for protective structures include UHPC and ultra-high performance fiber reinforced concrete (UHPFRC). These materials are carefully designed to have extremely high compressive strength capacity, higher tensile capacity, and ductility due to use of refined aggregates, admixtures, and optional inclusion of large amounts of steel fibers for UHPFRC.

Current models for structural direct shear behavior are based on empirical testing of "push-off" specimens and was developed based on experiments using normal-strength (NSC) and high-strength concretes (HSC) with and without fibers. These models relate the shear-stress to the total slip using empirical formulas derived from test specimens. Recent static and dynamic testing of NSC, UHPC, and UHPFRC push-off specimens have shown correlations between structural and loading frequency and the resulting direct-shear response. The current research focuses on investigation of direct shear response of NSC, UHPC, and UHPFRC specimens from a frequency domain assessment. Results from previous experiments are used to develop a new frequency domain model for predicting response of NSC, UHPC, and UHPFRC structures to impulsive loadings. Additionally, specimens are analyzed using a mix of finite element and discrete element models. These results can provide a basis for analysis of direct shear using energy methods instead of empirical models. These energy methods can be used to develop fast-running tools to predict risk and vulnerability of structures to direct-shear failure using methods similar to current pressure-impulse diagrams.

Deepti Joshi

Dr. Deepti Joshi is an Associate Professor of Computer Science at The Citadel, the Military College of South Carolina. Her research interests include spatio-temporal data analytics, integrating wide variety of data for story building purposes, using data-driven approaches to model complex phenomena, and natural language processing. She is currently working in the domains related to anticipating social unrest, understanding natural disaster response, and identifying propaganda. She received the Faculty Excellence Award for Research in 2018 from The Citadel. She also works extensively in the K-12 space to help the teachers learn how to integrate computing the core-disciplines. This is work is funded through the NSF STEM+C and other state grants. She earned her PhD in 2011 from University of Nebraska-Lincoln (UNL) in Computer Science with focus on polygonal spatial clustering. She still continues to maintain close ties with UNL and works on collaborative research projects.

Leveraging Environment and Culture to Anticipate Social Unrest with Integrated Model and Data-Driven Approaches

Social unrest against government or state (in)actions fueled by socio-demographic or environmental factors is a great concern to researchers, strategic planners and policymakers because of its potential impact on security and stability of any society at the national, regional, and global levels. As data of diverse types (e.g., text, imagery, and videos) are generated by different sources (e.g., state, news, and individuals) with disparate themes (e.g., environmental, demographic, and economic) at varying speeds (census data vs. social media) become more prevalent, data-driven approaches have seen increased significance. Finding useful and latent information using data-driven approaches, however, have major challenges. First, timely discovery of interesting information demands substantial narrowing of the search space which can be prohibitively time consuming. Second, data-driven approaches do not always yield explanatory models that are critical to understanding the underlying processes.

Our long-term goal is to address these challenges by developing an integrated model- and data-driven framework to predict social unrest events in a broad range of countries. Thus far, we have (1) created a multi-lingual social-unrest vocabulary focused on India, Pakistan, and Bangladesh; (2) developed a model identifying long-term factors for social unrest; (3) developed data collection, curation, and analysis tools; (4) incorporated infra-structure data; (5) developed an augmented gazetteer for India with village names from census data with open source geospatial information; and (6) developed a map-based visualizer called SURGE. Next steps include: (1) expand the geographic scope to include 19 strategically selected countries in South Asia/Asia Minor, Southeast Asia, and Sub-Saharan Africa; (2) integrate environmental and cultural information from diverse sources to increase the efficacy of our social unrest predictive models; (3) validate integrated models and algorithms by conducting case studies on 5 selected countries; and (4) enhance SURGE to more effectively assist expert visual analysis and explore “what-if” scenarios.

Over the next year, we will focus on the 5W (Where, When, Who, What, Why) analysis of unrest news articles, and integrate it in our research in spatio-temporal data mining and multi-agent simulation of the spread of unrest in space. We will also identify the theories relevant to social unrest from the social sciences. The goal is to integrate the applicable social science theories into our computational models to identify spatial and temporal inflection points in the spread of unrest and determine end of an unrest event/episode. As a part of the integration effort, we will attempt to identify dynamic proxies for critical socio-demographic and economic variables at variable resolutions that will provide more accurate information than statistics collected at coarse spatial (national or regional) or temporal resolutions (decade).

Maria Lawas

As a research scientist in the Counterterrorism and Forensic Science Research Unit at the Federal Bureau of Investigation, Maria Lawas supports caseworkers in their pursuit of justice. After receiving her bachelor's in Biology from the University of Kansas, she spent a year doing charity work before returning to research. The University of Michigan (Go Blue!) granted Maria a graduate fellowship award to conduct research on the discovery and activation of ionic channels that stimulate nutrient-deprivation states and neuronal plaque breakdown in diseases like Alzheimer's and Huntington's. Her thesis on ion channel regulation of lysosomal biogenesis and homeostasis resulted in a master's in Molecular and Cellular Biology from the University of Michigan. Upon graduation, she went on to investigate mechanisms of collective cell migration in Drosophila border cells as a model for tumor formation and metastasis at the Johnson Cancer Research Center. Maria has been awarded an ORISE fellowship at the FBI Laboratory, where she has looked at postmortem root band formation, the use of peptide profiling for distinguishing individuals, the evaluation and characterization of mounting media to discriminate fiber features, and the development of quantitative methods to select hairs for nuclear DNA analysis.

Assessing Peptide Profiling Reproducibility of Single Source Human Head Hair

Recent studies using human hair shaft proteins demonstrate the possibility to detect genetically variant peptides (GVPs) containing single amino acid polymorphisms (SAPs) via nanoflow liquid chromatography tandem-mass spectrometry (nLC-MS/MS). Since non-synonymous single nucleotide polymorphisms can be inferred from SAPs, this method exploits genetic information preserved in hair proteins, which are highly resistant to degradation and damage. SAP profiling can serve as a complementary technique for comparing questioned and known hair shaft evidence when mitochondrial DNA analysis does not provide useful results. However, due to the fact that hair growth is asynchronized in a regionally orchestrated fashion, a concern to be addressed during the evaluation of the SAP profiling technique is the possible presence of single source variability in profiles based on hair samples collected from different areas of the scalp. This study addresses the issue by focusing on the comparison of replicate hair samples taken from the same individual. To assess the single source reproducibility of peptide profiling, scalp hair shaft samples were used for protein extraction. Protein extraction was followed by in-solution trypsin digestion and nLC-MS/MS. Using an in-house custom database composed of 15 hair shaft keratin proteins, 21 SAPs residing in 11 unique proteins were revealed. SAPs were distinct enough to provide an adequate number of markers for SAP profiling and were confirmed by comparing GVP data with DNA sequencing data. The overall average reproducibility of SAP profiles within each source was 92%. In addition, preliminarily findings based on our limited sample size and the number of SAPs reveal the use of hair chemical treatments appears not to affect the reproducibility of single source SAP profiling. Overall, these results demonstrate the potential utility of peptide sequencing as another objective tool to complement microscopic hair comparison.

Maria Lawas

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Characterization of Mounting Media for Hair and Fiber Microscopy

Nine commercially available mounting media were identified through microscopist surveys, vendor inquiries, and a scientific literature review. These were evaluated on their color, setting time, media autofluorescence, fiber autofluorescence suppression, and media absorption in the ultraviolet (UV) range. Additionally, color discrimination of fibers embedded in these mounting media were characterized via microspectrophotometry (MSP) to determine which media confer advantages in the UV spectrum. In all evaluative tests, multiple candidates performed well in one or more evaluations.

Yuzhang Li

Yuzhang Li is an Intelligence Community Postdoctoral Fellow at Stanford University with Professor Yi Cui. He received his bachelor's in Chemical Engineering from UC Berkeley and his Ph.D. in Materials Science and Engineering from Stanford University. As a graduate student, Yuzhang developed both engineering solutions and advanced characterization tools to make breakthroughs in next-generation batteries. Now, Yuzhang's research pursues innovations in energy and environmental technologies, which require advancements in both (1) fundamental characterization and (2) materials design. Yuzhang's research has been highlighted by news media (Forbes, Popular Mechanics, ABC7 Bay Area) and recognized with several awards (Dan Cubicciotti Award of the Electrochemical Society, Graduate Student Gold Award of the Materials Research Society).

Graphene Cage Design and Cryo-Electron Microscopy Characterization for High Energy Batteries

Lithium-ion (Li-ion) batteries with high energy density and long cycle life is critical for the widespread adoption of electrical vehicles and grid-scale energy storage. To meet the goal of three to four times state-of-the-art Li-ion capacity (1,350 – 1,800 mAh g-1) combined with long cycle life (100,000 cycles) and safe operation, new chemistries are needed. Although both silicon (Si) and Li metal meet the required high energy capacity (~2,000 mAh g-1 and 3,860 mAh g-1, respectively), intrinsic failure modes prevent their rechargeability and safe operation. In this talk, we highlight our initial accomplishments in two major thrusts that addresses both the fundamental and practical challenges of Si and Li metal. In the first thrust (engineering and design),Yuzhang uses his background in advanced nanomaterials design to engineer a graphene cage architecture (Y. Li, Nature Energy 1, 15029, 2016) that can stabilize large-volume-change battery materials during operation. In the second thrust (fundamental understanding), we use the recently developed cryo-electron microscopy (cryo-EM) approach (Y. Li, Science 358, 506, 2017) to study these reactive battery materials in their native environment with atomic resolution, which uncover new findings that guide future nanomaterials design. The synergy between these two thrusts will not only bring practical applications in the short-term, but also result in fundamental insights that will facilitate long-term solutions to stabilizing high-energy battery materials.

David Limbaugh

David Limbaugh is an Intelligence Community Postdoct Fellow working on applying to intelligence analysis lessons learned from the ways medicine handles data. His research is directed by Barry Smith at University at Buffalo and centers around ontology, referent tracking, and object-based production. David holds a Ph.D. from the University at Buffalo for a dissertation on the representation of possibility and necessity. It develops an account of how instances of dispositions explain the truth of statements like “Our satellite is capable of capturing that area” or “A collision is unavoidable”.

Enhanced Object-Based Production

The goal of this research is to draw lessons from medical treatment of data [1] and apply them to intelligence analysis. The current state of this work is the development of an Enhanced Object-Based Production (E-OBP) strategy. Future work will see this strategy applied to machine-assisted intelligence analysis. E-OBP can track more types of entities, can track errors within an E-OBP system itself, is scalable across organizations, is flexible to accommodate many new sorts of cases, and takes into account different features of information like providence, evidence, and warrant [2]. The central tenet of E-OBP is: name everything and delete nothing.

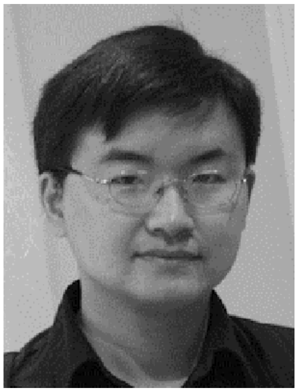
Name everything: anything that is relevant to a context—any process, person, location, and so on—receives a name that picks out that entity and no other. The name is an individual unique identifier (IUI) and is used to exclusively represent an entity; and once an entity is named with an IUI it can then be described in a database using tags.

Delete nothing: data is never deleted in an E-OBP database. Though data may be marked as ‘deprecated’ or as ‘inaccurate’ but it is never removed.

The data in an E-OBP database is a collection of IUIs and tags. IUIs represent individual entities, and tags represent the features of individual entities, and the relationships be-tween individual entities. For instance, were you to be represented in an E-OBP data-base, then you would receive an IUI. Though your IUI would refer to you, and only you, it would say nothing about what you are like or how you are related to the referents of other IUIs. To capture information about what you are like your IUI would have to be combined with various tags that indicate that you are, for example, of this-or-that gender or affiliated with these-or-those groups. Very little can be known about an entity and it can still be assigned an IUI and tagged. Tags are ideally terms from an ontology—a controlled vocabulary of hierarchical terms—that refer to what any two things might have in common; tags represent the general properties or features of entities.

The result of applying E-OBP is a self-explanatory database, which is to say that little to no work is required to understand how the structure of a particular E-OBP database relates to the structure of reality. An E-OBP database mirrors reality’s structure which is a collection of individual entities that have features and relationships. In contrast, other traditional databases mirror the structure of, not reality, but systems of concepts or terms. This makes E-OBP databases easier to manage and retrieve information from, by both humans and machines, especially over long periods of time.

Xiaoming Liu



Xiaoming Liu (Ph.D, Carnegie Mellon University) is an Associate Professor at the Department of Computer Science and Engineering of Michigan State University. His research interests include computer vision, patter recognition, and machine learning. Before joining MSU in Fall 2012, he was a research scientist at General Electric (GE) Global Research. As a co-author, he is a recipient of the Best Paper Honorable Mention Award at IEEE workshop on Biometrics 2009, the Best Student Paper Award at WACV 2012 and 2014, Best Poster Award at BMVC 2016. He is an Area Chair of a number of international conferences, including ICPR’12, ICB’13, WACV’14, FG’15, CVPR’17, CVPR’19 and ICCV’19. He is the program co-chair of BTAS 2018 and WACV 2018. He has authored more than 100 scientific publications with over 7000 citations and H-index of 43, and has filed 22 U.S. patents..

Learning to Fuse Information with Missing Modalities

One of the key GEOINT capabilities is to be able to automatically recognize a large array of objects, such as specific locations, scenes, road, building, forest, and vehicle, from visual data. To enable this capability, researchers have developed various fusion methods that combine information collected from multiple sensing modalities, including RGB imagery, LiDAR point cloud, multispectral and hyperspectral imaging. Fusing multi-modal data has shown to improve the reliability and accuracy of object recognition thanks to complementarity among modalities. However, in practice it is very common that the sensing equipment experiences unforeseeable sensor malfunction or configuration issues, leading to corrupted data points with one or more missing modalities for learning. Most existing multi-modal learning algorithms require that the sensor data of all modalities are available for every training data instance and would discard either all modalities with missing values or all corrupted data. To leverage the valuable information in these corrupted data, we propose to impute the missing data given the observed information, by leveraging the relatedness among different modalities.

While imputation has been well studied for missing at random (MAR), imputing the block-wise missing data of modalities is rarely studied. The problem is challenging because methods developed for MAR are not capable of recovering enough details for corrupted modalities, leading to a suboptimal recognition performance. In the first year of this project, we propose a novel Cascaded Residual Autoencoder (CRA) to impute missing modalities. In the second year of the project, we address the problem of joint data imputation and classifier learning, by working on the specific problem of large-pose face recognition with DR-GAN. In the third year, we work on the problem of data imputation with weak supervision or no supervision, especially on learning 3DMM for faces.

In the fourth year of the project, we continue to work on the problem of data imputation with weak supervision or no supervision, especially in 3DMM for generic objects. Inferring 3D structure of a generic object from a 2D image is a long-standing objective of computer vision. Conventional approaches either learn completely from CAD generated synthetic data, which have difficulty in inference from real images, or generate 2.5D depth image via intrinsic decomposition, which is limited compared to the full 3D reconstruction. One fundamental challenge lies in the lack of ground truth 3D shapes associated with real 2D images. To address this issue, we take an alternative approach with semi-supervised learning. That is, for a 2D image of a generic object, we decompose it into latent representations of 3D shape and albedo, lighting and camera projection matrix, decode the representations to 3D shape and albedo respectively, and fuse these components rendering an image well approximating the input image. With the novel design of color occupancy field, we show that the complete shape and albedo modeling enables us to leverage real 2D images in both modeling and model fitting (i.e., decomposition). The effectiveness of our approach is demonstrated through the modeling results, as well as superior 3D reconstruction from a single image, being either synthetic or real.

Jeffrey Lopez

Jeffrey Lopez earned his Ph.D. in 2018 from Stanford University under the supervision of Prof. Zhenan Bao. He was awarded a NSF Graduate Research Fellowship and a NDSEG Fellowship to fund his graduate work, which focused on developing new self-healing polymers and elastomers with novel mechanical properties for improving the stability of lithium ion batteries. Jeffrey is currently an Intelligence Community Postdoctoral Fellow at the Massachusetts Institute of Technology working with Prof. Yang Shao-Horn where he is studying mechanisms of electrochemical instability and ion transport in polymer electrolyte materials. Jeffrey has received multiple awards for his research including the ACS Eastman Chemical Student Award in Applied Polymer Science in 2018, the AIChE Excellence in Graduate Polymer Research Award 1st Prize in 2016. Jeffrey was involved with the Stanford Polymer Collective as President from 2013-2016 supporting the polymer research community on Stanford's campus, and has worked with various programs at Stanford and MIT to promote improved access to higher education among students from underrepresented minority groups.

In Situ Characterization of Fluorinated Electrolyte at the Lithium Metal Interface

Lithium ion batteries have become the dominant form of energy storage used in consumer electronics and, recently, electric vehicles. However, high costs have prevented widespread deployment of lithium ion batteries for applications other than portable electronics, and the safety issues associated with liquid organic electrolytes remain to be addressed. In order to enable the greater utilization of electric vehicles, allow for grid scale energy storage, and meet the demands of new electronic applications, new materials for high energy density batteries must be developed. High capacity electrode materials like lithium metal have the potential to facilitate these technologies, but lithium metal electrodes are presently limited by significant side reactions, poor quality deposition, and the potential to form hazardous dendrites. Therefore, it is important to develop a clear understanding of the surface reactivity and growth behavior of the lithium metal at the interface with the electrolyte in order to enable stable long-term cycling.

The products that form as a result of electrolyte decomposition reactions at the electrode interface are known to be extremely important in determining the final cell performance. Specifically, fluorinated salts and solvent additives have been shown to enable stable cycling of Li metal anodes. This improvement is ascribed to the formation of LiF in the solid electrolyte interphase (SEI), yet the understanding of how LiF and other SEI compounds are formed and how they affect battery cycling is not complete. In this presentation, in situ spectroelectrochemical techniques including infrared spectroscopy (FTIR), differential electrochemical mass spectrometry (DEMS), and electrochemical quartz crystal microbalance (EQCM), are used to clearly identify components of the Li metal SEI. An understanding of SEI formation with respect to electrochemical potential and time will be discussed. With this understanding we provide new insights into the formation and chemical nature of SEI components that promote stable cycling of lithium metal electrodes.

David Luzader

David Luzader is a Veteran of the United States Army. During his time spent conducting Army training exercises, He developed a keen interest in conducting research, collecting geographic intel and geologic data collection. He is a FL native who eventually made his way to NC after completing his Military career. He is a father of 2 children, which are a huge motivator in furthering his education. Upon moving to NC, He decided to further his education at DTCC. Where he gained interest in the Geosciences. After completing his AA degree, he decided to transfer to NCCU and continue his education majoring in Geospatial Science and minoring in GIS. Throughout his undergraduate career, he has developed strong interest in the GEOINT community. The interest has landed him with a GEOINT company Geo Owl, where he is an intern as a Geospatial Production Analyst. He plans to spend Summer20 in D.C. on a 10-week federal government internship with NGA. He has submitted numerous research posters, participate in multiple Conferences and begin hands on practical experience by working with numerous grant funded projects. The skills he has developed, in combination with his real-life military experience has not only made him a very talented, goal driven student, but also made him extremely marketable. He has presented at multiple other local symposiums, and in front of many IC professionals. He has plans to pursue his master's degree in Geospatial Intelligence.

An Analysis of Straight-Line Boundaries and Conflict in the Mideast Region

Given the current state of conflict in the Mideast, this study looks at how colonial and imperial boundaries have impacted geopolitical stability and public policy of the region. This research analyses straight line boundaries found in the Mideast today, and compare those to the cultural boundaries of the different ethnical groups that live in this part of the world today. The geospatial intelligence community needs to focus on understanding how these boundaries have and will continue to cause conflict between the ethnical groups throughout the world. This research considered the physical straight lines boundaries found in several countries in the Mideast and shows how the creation of these boundaries has forced different cultural groups to coexist with one another and have caused and continues to cause conflict, which impacts the stability of the region.

Claire Marvinney

Claire Marvinney is an Intelligence Community Postdoctoral Fellow working at Oak Ridge National Laboratory under the direction of Ben Lawrie in the Quantum Information Science Group. Here she is studying the phononic and electronic structures of quantum emitters at millikelvin temperatures. Claire received her Ph.D. from Vanderbilt University under the direction of Richard Haglund, with a dissertation entitled “Ultraviolet Band-Edge Emission from Zinc Oxide Nanostructures.” She then worked as a postdoc with Josh Caldwell at Vanderbilt, studying the mid-to-far infrared optical properties of semiconductor materials. During her Ph.D. Claire was chosen for the NSF East Asia and Pacific Summer Institute and researched plasmon-exciton coupling in metal nanoparticle coated ZnO at Northeast Normal University. Through her research, she has expertise in nanomaterial growth, characterization, and analytical techniques including dilution refrigerator operation, 2D material transfer, electron beam deposition, ultrafast photoluminescence spectroscopy, Fourier-transform infrared spectroscopy, Raman spectroscopy, scanning electron microscopy, and Lumerical FDTD simulations. Outside of research, Claire has been involved in science outreach, volunteering with the ORNL Introduce Your Daughter to AI Day, Vanderbilt Student Volunteers for Science, and the Vanderbilt Chapter of the Materials Research Society, of which she was president for two years during her graduate studies.

Towards Strong Phonon-Quantum Emitter Coupling in 2D and Bulk Systems

Growing interest in the phononic analogue to cavity quantum electrodynamics, that of cavity-quantum phonodynamics, has centered on the idea of strong phononic coupling to two level systems, with recent examples including nanomechanical interactions with diamond nitrogen vacancy (NV) center spins embedded in a cantilever, resonant driving of a quantum dot inside a nanomechanical oscillator, and strong coupling of a superconducting transmon qubit to a phononic cavity. The quality factor of phononic cavities increases with decreasing temperature, removing phononic decoherence pathways from the system. In this work, optical experiments studying both the photonic and phononic structure of quantum emitters and their coupling will employ quantum state characterization at mK temperatures in order to characterize strong phonon coupling in 2D and bulk systems.

For these experiments, we have installed a dilution refrigerator equipped with a cold insertable probe with free-space optical access to a confocal microscope. The probe reduces the sample transfer time from 4-5 days to 1 day and has a base temperature of 18.5 mK with a cooling power of 100 μW at 128 mK. For optical excitation, an OPO laser (tunable from 450 – 650 nm and 900 – 1300 nm) is used, while the emission can be collected onto a spectrometer or through a Hanbury Brown – Twiss interferometer onto broadband, large-area superconducting nanowire single photon detectors (SNSPDs).

With installation and alignment nearing completion, we are preparing to extend our recent characterization of single-photon emitters (SPEs) in two-dimensional (2D) materials like hexagonal boron nitride and tungsten diselenide and bulk materials like diamond NV centers to mK temperatures. Then, we will proceed to explorations of strong phononic coupling between 2D SPEs and phononic cavities like those fabricated by our collaborators in the Rakich group. The use of a 2D architecture for the material containing the SPE improves placement control and enables easy manipulation of strain for control of emitter-photon coupling. In addition, we will study similar phononic cavities coupled to bulk diamond NV centers through a collaboration with Hailin Wang. Overall, this research will enable control over single phonons, over phonon-phonon interactions, and over phonon-photon interactions in low-dimensional or diamond defect systems. These capabilities are critical to the development of nanoscale quantum coherent interfaces between microwave and visible wavelengths and can be used as a pathway towards quantum sensors and quantum computers.

Charles McElroy

Charles McElroy earned his PhD from Case Western Reserve University, (Cleveland, OH) in Information Systems. There he studied how diverse scientific teams used sophisticated forms of cyberinfrastructure to formulate complex arguments. In addition, he also earned an MLA from the University of Pennsylvania where he focused on national security issues. His interests include data science, machine learning, collective intelligence and how these tools are applied to a wide spectrum of disciplines including cybersecurity, and computer science. Professor McElroy was excited to be a part of the IC Postdoctroal Fellowship Program (2018 – 2019) where he conducted his research at the Center for Data Driven Discovery (CD3) at the California Institute of Technology (Pasadena, CA). Professor McElroy subsequently won a Fulbright Fellowship at Oxford University, Cyber Security Center. In addition, Professor McElroy recently won one component of IARPA's CASE (Credibility Assessment Standardized Evaluation) competition where he provided the winning entry to describe how to establish ground truth in a real world setting.

Credibility Assessment: Establishing Ground Truth in a Realistic Environment—The IARPA CASE Challenge

We all make assessments every day as to whether the people and information sources around us are credible, e.g., are they reliable, honest, and trustworthy. Often, we rely on our own judgements—based on our own experiences—to make these assessments. However, there are a plethora of tools to augment our judgements with these in-person and virtual interactions. These tools might be listening to the tone and cadence of a story, assessing if an ID is authentic, verifying a biometric result or even analyzing someone's physiological responses to questions, e.g., reading a polygraph. Each of these examples represents very different types of evidence on which to base our judgements. Unfortunately, there is no rigorous, standardized methodology to evaluate and validate these tools. In order to address this issue, IARPA instituted the CASE (Credibility Assessment Standardized Evaluation). This presentation will review IARPA's pursuit of this answer through a collective intelligence approach. It will also review the preparation process of my winning IARPA CASE entry which was selected as the best novel approach to establish the ground truth for this new methodology.

Poster

Joseph McGuire

Joseph was born and raised in Arroyo Grande, CA. After high school, he attended Allan Hancock Community College, transferring to Sonoma State University in 2017 with an Associates Degree in Computer Science and Liberal Arts. He is in his 3rd year at Sonoma State, and is majoring in Physics and Mathematics.He attended the REU in Mathematical Modeling at UCLA during summer 2019. He enjoys hiking, playing with his dogs, and being a coffee connoisseur.

A Modeling of Deforestation for Agricultural Land Clearance in the Brazilian Rainforest

Environmental crime, such as poaching and deforestation, is a growing concern in many developing countries. Recently, there has been increased effort in modeling behavior of environmental criminals with the goal of assisting law enforcement agencies in deterring these activities. Previous models for environmental crime are either discrete in nature or use overly restrictive assumptions about the geometry of the protected region. We present a continuous model for deforestation which makes no such assumptions. The key aspect of our method is the level set method, which we use to track criminal movement throughout protected areas. We compare our model against deforestation data from the Brazilian rain forest.

Terry McNeill

Mr. McNeill completed his undergraduate degree in Geography at Fayetteville State University in 2017. He is currently pursuing his graduate degree (Master of Science) at North Carolina Central University in the Department of Environmental, Earth, Geospatial Sciences. His master's research project is related to working with US Army Corps of Engineers (USACE) historical maps of the Falls Lake and Jordan Lake watershed areas in North Carolina. The project was completed in partnership with Geodynamics. Mr. McNeill's interests are in Geospatial technology and its application to mapping spatial locations using COGO and ArcGIS applications. In his free time, Mr. McNeill likes to ride his motorcycle, play the drums, and play with his pet.

Using Deed/Tract Records to Create Digital Maps Using COGO Analysis

The USACE provided information about tracts in the form of deeds and tract maps. This information was then spatial converted using COGO as an editing tool to construct polygons of different shapes and sizes based on the official deeds. Once the polygons were created, they were edited and checked for accuracy and the attribute information (ownership) provided was joined to create a full spatial database. This study resulted in the creation of over 1200 polygons for Jordan Lake and over 600 polygons for Falls Lake in North Carolina. The spatial data created in this study will help decision makers access information in a timely manner. The information that resided in distance and direction is now available in spatial format to the USACE.

Jessica Morgan

Jessica Morgan is a lecturer of marine science at the U.S. Coast Guard Academy, New London, Connecticut. She teaches courses in atmospheric and marine science, geographic information systems, and geospatial intelligence. Dr. Morgan earned her Ph.D. from the University of Rhode Island and was a postdoctoral research fellow at the EPA Atlantic Ecology Division Laboratory in Narragansett, RI prior to teaching at the Coast Guard Academy. Her background includes research on remote sensing and GIS analysis of ecological response to stormwater best management practices, scaling issues in land use/land cover data analysis, and most recently, geospatial intelligence applications for maritime domain awareness.

Geospatial Comparison of Two Sources of Satellite-based Automatic Identification System (Ship-Tracking) Information in U. S. Arctic Waters-Lucy S. Vlietstra and Jessica N. Morgan

Maritime domain awareness (MDA) is critical for ensuring effective preparedness and response operations related to safety, security, and stewardship of the oceans. In remote areas of the sea, MDA is particularly reliant upon commercial satellite services for information on shipping activity. Satellite-based Automatic Identification Systems (S-AIS) transmit ship position reports between vessels for navigational purposes and to the U.S. Coast Guard and other end users for purposes of asset management and maritime safety and security. In this presentation, we describe how S-AIS information is used to introduce U.S. Coast Guard Academy cadets to real-world challenges related to Arctic MDA, to teach them technical and analytical skills, and to instill in them an appreciation for geospatial intelligence and its application to maritime operations. The goal of this study was to determine whether S-AIS information acquired from different commercial sources led to the same picture of maritime traffic in the U.S. Arctic Ocean. If it did not, we wanted to understand how differences might influence situational awareness for the end user. We compared ship position reports collected by two commercial sources of S-AIS data (Spire Global and ORBCOMM) from July 1-October to 31 December, 2018. Focusing on a region of the U.S. Exclusive Economic Zone north of the Bering Strait and south of 72 °N latitude, we compared the total number of position reports collected by each source, number of vessels, and signal latency time, including variability related to such factors as ship type, transponder type, and assigned flag state. We also compared S-AIS datasets in terms of reconstructed vessel tracks to evaluate whether differences in position reports affected the accuracy of individual ship tracks in post hoc reconstruction. Overall, we found a relatively high degree of variability between the two sources in parameters supporting real-time situational awareness. Despite these differences, both sources of S-AIS information yielded relatively similar reconstructed vessels tracks, with most (>90%) position reports falling within 1.0 nm of the "average" track line. Future work will include additional sources of S-AIS data in the region and expand the temporal and spatial extent of the analysis to other regions of the Arctic Ocean.

Chris Oxendine

Colonel Chris Oxendine, Ph.D. is the Director for the Center of Environmental and Geographic Sciences and an Associate Professor of Geospatial Information Sciences in the Department of Geography and Environmental Engineering at the United States Military Academy. He earned a Ph.D. in Earth Systems and GeoInformation Science from George Mason University (2013), a MS in Cartography/GIS from the University of Wisconsin-Madison (2004), and a BS in Mapping, Charting, & Geodesy from West Point (1996). His research interests include producing 3D models, visualizations & simulations from UAS derived imagery, GIS analysis in social media, humanitarian assistance, and disaster response. For fun, Chris runs ultra-marathons and rows.

The United States Military Academy and the National Geospatial Intelligence Agency Partnership: Today and Tomorrow- COL C. Oxendine and LTC W. Wright

This presentation discusses the current and future partnership between the United States Military Academy and NGA. Last year's research partnership falls within three main categories, (1) efforts with NGA's small Unmanned Aerial Systems (sUAS) research group, (2) Cadet research projects mentored by NGA analysts and West Point Faculty as part of independent studies or/and the Military Geospatial Operations course, and (3) NGA sponsored summer internships. An overview of each of these research efforts is presented. Additionally, as part of the internship program, LTC William Wright presents his lessons learned from a summer deployment to Djibouti, Djibouti where he was embedded with the NGA Horn of Africa team. The partnership with West Point and NGA continues to benefit both organizations. An outline of approved future work is presented including a continuation of cadet research projects and internships along with studies exploring the different GEOINT requirements when conducting operations in megacities.

Pencho Petrushev

Pencho Petrushev (PhD, Sofia University, Bulgaria) teaches mathematics at the University of South Carolina. Dr. Petrushev has authored one monograph (Cambridge University Press) and more than 100 research articles published in highly ranked journals such as Transactions of AMS, Proceedings of the London Mathematical Society, Journal of Functional Analysis. He is on the editorial boards of several prestigious mathematics journals: Foundations of Computational Mathematics, Constructive Approximation, SIAM Journal on Mathematical Analysis, Journal of Fourier Analysis and Applications, Transactions of Mathematics and Its Applications. His research interests are mainly in Approximation Theory, Harmonic Analysis, and their applications, including Geomagnetic and Geopotential field modeling, Voice assessment of high-speed videoendoscopy, Data analysis, Image and signal processing.

Highly Effective Computational Methods in Geomagnetic Field Modeling

Earth's magnetic field data are collected at accelerating rates with higher and higher resolution and accuracy every year. To meet the pressing requirements for higher resolution and accuracy a team from NOAA’s National Centers for Environmental Information has developed the Enhanced Magnetic Model (EMM2015), which utilizes spherical harmonics of degree 740. The model has later been updated to EMM2017 utilizing spherical harmonics of degree 790. We present the development of an algorithm and its software realization for efficient and precise evaluation of magnetic quantities, represented in high degree solid spherical harmonics at arbitrarily scattered points in the space exterior to the surface of the Earth. Our algorithm is based on representation of the quantities of interest in solid ellipsoidal harmonics and application of tensor product trigonometric needlets. The tensor product trigonometric needlets provide an effective tool for solution of the problem for memory efficient, fast and accurate evaluation of geomagnetic and gravimetric quantities due to their superb localization and compatibility with spherical and ellipsoidal harmonics. MATLAB and FORTRAN realizations of our algorithm has been developed and extensively tested. The capabilities of the code are demonstrated on the example of the following components of the geomagnetic field: North component in geocentric coordinates, East component in geocentric coordinates, Down component in geocentric coordinates, North component in geodetic coordinates, East component in geodetic coordinates, Down component in geodetic coordinates, Horizontal intensity, Total intensity, Inclination, and Declination. For the range from - 415 meters under the Earth reference ellipsoid up to 1,000 kilometers above it the current version of the software runs 189 times faster than the software using the standard spherical harmonic series method while the accuracy is less than 1 nano Tesla and the memory (RAM) usage is 9 GB.

Dieter Pfoser

Dr. Dieter Pfoser received a PhD in computer science from Aalborg University, Denmark in 2000. He is currently a professor and chair, Dept. of Geography and GeoInformation Science at George Mason University. At GMU he teaches courses related to geospatial data management, Linked Data, Web application development using open-source software, and data-driven storytelling. His research interests include geospatial data management, data mining for spatial and spatiotemporal data, graph algorithms for dynamic networks, and user-generated geospatial content, e.g., map-matching and map construction algorithms. He has co-authored over 100 fully refereed papers, one book, edited five books and several journal issues, organized conferences, served on more than 40 program committees and on the editorial board of two journals. His research has been supported by NSF, DARPA, DHS and the European Commission.

Generation and Management of Crowdsourced Place Gazetteers

The contribution of this project is towards a better understanding of human activities with respect to space. Traditional gazetteers and maps are artifacts of a geometry-driven view of the world, communicating primarily predefined locations and their coordinates, and lacking the meaning assigned to space by human activities, interactions, and perceptions. Our initial research has focused on developing methods to extract palatial content from Web content (social media, textual narratives). These so-called places-of-interest are a natural evolution of traditional point-of-interest data, and reflect the assignment of meaning to locations by means of human activities, (geo)events, and perception. Furthermore, links-of-interest capture the semantics of relationships among places (e.g., the rally may be part of a wider civil unrest movement). Combined, places and links comprise a time-parameterized Web of Places, which can be used to generate a micro perspective of space. By aggregating references to human activities within urban spaces we can observe the emergence of unique themes that characterize different locations. For example, by contrasting tweets and Wikipedia entries we show how particular thematic characteristics of places are emerging from such crowd-contributed content, allowing us to observe the meaning that the general public is assigning to specific locations. Such discernible sociocultural signatures provide us with a macro perspective of place.

As we saw in our initial work, focusing on only one data source does not capture the diversity and plurality of human activities, interactions, and perceptions of space. Dedicated volunteered geographic information collection efforts such as Openstreetmap have revolutionized spatial data collection. Our recent effort exploits the social aspect in Openstreetmap, namely the changelog information and how it can be used to capture urban change. Interesting research into urbanization has shown that many properties of cities can be modeled as power law functions of population size. Similar to this, we try to understand how (a change in) urban function affects the properties of a city. In an initial effort, our goal was to model a change in the spatiotemporal distribution of coffee shops and how it affects property prices in New York City. Employing several spatiotemporal statistical analysis methods, we found that a positive effect exists and that our models can indeed predict property price changes based on a simple spatiotemporal property such as coffee shop data. Most recently our efforts have been towards analyzing movement patterns in urban areas. Using public transport trip data we were able to ascertain temporal connections between places and also deduce the underlying motivations for such trips.

Qiang Qiu

Qiang Qiu received his Bachelor's degree with first class honors in Computer Science in 2001, and his Master's degree in Computer Science in 2002, from National University of Singapore. He received his Ph.D. degree in Computer Science in 2013 from University of Maryland, College Park. During 2002-2007, he was a Senior Research Engineer at Institute for Infocomm Research, Singapore. He is currently an Assistant Research Professor with the Department of Electrical and Computer Engineering, Duke University. His research interests include machine learning, computer vision, and pattern recognition.

Domain-Adaptive Filter Decomposition—Z. Wang, X. Cheng, G. Sapiro, and, Q. Qiu

Severe changes between training and testing domains are frequently encountered in real-world scenarios. In this work, we consider the problem of transferring a Convolutional Neural Network (CNN) trained in one domain to another, where abundant labeled data are available in the source domain, and limited or no labeled data in the target domain. By exploiting the observation that a convolutional filter can be well approximated as a linear combination of a small set of basis elements, we show for the first time, both empirically and theoretically, that domain adaptation can be effectively handled by decomposing a regular convolutional layer into a domain-specific basis layer and a domain-shared basis coefficient layer, while both remain convolutional. An input channel will now first convolve spatially with each respective domain-specific basis to “absorb” domain variations, and then output channels are linearly combined using domain-shared basis coefficients trained to promote common semantics across domains. We use toy examples, rigorous analysis, and real-world examples to show its effectiveness in domain adaptation. With the proposed architecture, we need only a small set of basis elements to model each additional domain, which brings a negligible amount of additional parameters, typically a few hundred vs. millions in regular settings.

Shawn Ratcliff

Shawn Ratcliff is a PhD Candidate in the Department of Sociology at the University of Nebraska-Lincoln. His research focuses on the correlates of policy adoption in the United States, the (un)intended consequences of social policies, predominantly firearm-related policies, on social problems, and correlates of social unrest within and between countries. He is currently working on his dissertation, "Social Movement Professionalization and the (Un)Intended Consequences of Social Policy", which explores how social movement organizations in the United States employ large-scale economic resources to impact the adoption of firearm policies and the impact these policies have on county-level homicides and suicides. Across his research, Shawn focuses on how social inequities impact sociological and criminological phenomena, including how social inequalities impact social unrest. Shawn has received multiple awards from the UNL Department of Sociology to support his research endeavors.

Grievance-Based Approaches to Social Unrest: A Case Study of Protests in India, 2010-2012

Social unrest against government or state (in)actions fueled by socio-demographic or environmental factors is a great concern to researchers, strategic planners and policymakers because of its potential impact on security and stability of any society at the national, regional, and global levels. As data of diverse types (e.g., text, imagery, and videos) are generated by different sources (e.g., state, news, and individuals) with disparate themes (e.g., environmental, demographic, and economic) at varying speeds (census data vs. social media) become more prevalent, data-driven approaches have seen increased significance. Finding useful and latent information using data-driven approaches, however, have major challenges. First, timely discovery of interesting information demands substantial narrowing of the search space which can be prohibitively time consuming. Second, data-driven approaches do not always yield explanatory models that are critical to understanding the underlying processes.

Our long-term goal is to address these challenges by developing an integrated model- and data-driven framework to predict social unrest events in a broad range of countries. Thus far, we have (1) created a multi-lingual social-unrest vocabulary focused on India, Pakistan, and Bangladesh; (2) developed a model identifying long-term factors for social unrest; (3) developed data collection, curation, and analysis tools; (4) incorporated infrastructure data; (5) developed an augmented gazetteer for India with village names from census data with open source geospatial information; and (6) developed a map-based visualizer called SURGE. Next steps include: (1) expand the geographic scope to include 19 strategically selected countries in South Asia/Asia Minor, Southeast Asia, and Sub-Saharan Africa; (2) integrate environmental and cultural information from diverse sources to increase the efficacy of our social un-rest predictive models; (3) validate integrated models and algorithms by conducting case studies on 5 selected countries; and (4) enhance SURGE to more effectively assist expert visual analysis and explore "what-if" scenarios.

Over the next year, we will focus on the 5W (Where, When, Who, What, Why) analysis of unrest news articles, and integrate it in our research in spatio-temporal data mining and multi-agent simulation of the spread of unrest in space. We will also identify the theories relevant to social unrest from the social sciences. The goal is to integrate the applicable social science theories into our computational models to identify spatial and temporal inflection points in the spread of unrest and determine end of an unrest event/episode. As a part of the integration effort, we will attempt to identify dynamic proxies for critical socio-demographic and economic variables at variable resolutions that will provide more accurate information than statistics collected at coarse spatial (national or regional) or temporal resolutions (decade).

Rachel Reynolds

Rachel Reynolds is a Major in the US Air Force. She is currently a student at the School of Advanced Air and Space Studies at Maxwell Air Force Base in Alabama where she is studying for a Master of Philosophy degree in military strategy. Her work on the seasonality of terrorism began at the National Intelligence University where she conducted a big-data analysis of trends in the Global Terrorism Database. She is working to publish her thesis research on terrorism in the Studies in Conflict and Terrorism journal. Major Reynolds grew up in Houston, Texas and entered the US Air Force Academy in June 2003. She has supported the F-16 fighter jet mission and the NATO nuclear surety mission at Aviano Air Base in Italy. She has deployed in support of Operations Iraqi Freedom and Enduring Freedom as well as the Air Defense of the Arabian Gulf and Combined Joint Task Force – Horn of Africa. Previously, Major Reynolds directed operations at the Air Force's enlisted cyber support and command and control schoolhouses where she oversaw the delivery of 45 cyber, command and control, nuclear command and control, postal, public affairs, administration, and battlefield airmen courses to 15,000 joint and international students annually. Major Reynolds holds a bachelor's degree in materials science and biochemistry from the Air Force Academy, a master's degree in ecology and evolutionary biology from the University of Colorado at Boulder, and a master's degree in science and technology intelligence from the National Intelligence University.

Seasonal and Latitudinal Drivers of Global Terrorism: A Circular Statistics Methodology—Maj R. Reynolds and H. Anthony Smith

This study employs a new methodology—circular statistics—to answer questions about the drivers of global terrorism events. Circular statistics is a data analysis technique typically used to assess biogeographical phenomena (such as epidemiological investigations, studies on wind and water currents, and animal behavior research). Absent any such application of circular statistics to the topic of global terrorism within the academic literature, this study examines two questions about terrorism dynamics as a proof-of-concept of its novel methodology. First, are global terrorism events seasonal, and if so, what seasonality trends are present in the data? Second, does tropicality (latitudinal distance from the equator) impact any identified seasonal trends in terrorism events?

Circular statistics (sometimes "directional statistics") is a branch of statistics used to examine cyclical phenomena that have no maximum or minimum values falling on a linear number line. The tools and tests of circular statistics enable the comparison of data that might be recorded on a 24-hour clock, by a magnetic compass, or over multiple 12-month annual cycles. Using programming tools in the open-source R Studio statistics software environment, this study analyzes data queried from the University of Maryland's National Consortium for the Study of Terrorism and Responses to Terrorism (START) Global Terrorism Database (GTD) to identify and compare seasonal and latitudinal patterns of terrorist event frequency.

This study finds statistically significant seasonal trends in terrorism events—the mean seasonal value for global events from 1970-2017 falls in late spring to mid-summer regardless of latitude. Additionally, multiple statistical tests indicate that latitude affects the degree to which seasonal trends are present and may also shift the seasonal "kick-off" of higher-intensity terrorism frequency later in the year as latitude increases. The tropicality results were mixed—some tests supported the hypothesis, while others did not produce enough evidence to show the statistical significance of the impact of tropicality on terrorism frequency. Furthermore, the results suggest that patterns of seasonality in terrorist events have changed over time; more study is recommended to further clarify this potential relationship.

This study is written both as a research paper that presents specific findings as well as in the style of a guide for future practitioners or analysts interested in more robust yet readily accessible tools to analyze terrorism data. Importantly, this study not only fills specific, immediate gaps in the terrorism literature about seasonal and tropical dynamics of terrorism; it also demonstrates the utility of a new analytical approach to terrorism data: circular statistics. This methodology offers analysts and researchers in academic, intelligence, and other governmental communities a new, interdisciplinary tool to tackle policy- and decision-makers' biggest questions.

James Robinson

James Robinson is a UK IC Postgraduate Research Fellow at the Electrochemical Innovation Laboratory, UCL. Having completed his PhD investigating the thermal properties of electrochemical power systems in 2014, he undertook an EPSRC funded research fellowship examining the failure of Li and Na-ion battery systems. His primary research focus is now to develop flexible Zn-air cells for wearable electronics. He has published in excess of 25 peer reviewed papers which have been cited over 700 times. James has also been heavily involved in the development in advanced diagnostic techniques in Li-ion batteries including acoustic imaging and rapid computer tomography as a mechanism to identify and mitigate against structural deformations in cells.

Flexible, Rechargeable Zn-Air Batteries for Wearable Technology

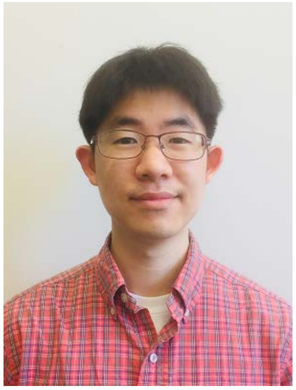
Flexible rechargeable batteries have the potential to be a transformative technology in the field of wearable electronics. To date, traditional batteries have been favoured in wearable electronics. However, the metallic current collectors, hazardous components and printed electrodes employed in these devices make them unsuitable for flexible applications. The housing of traditional cells in sealed housing also inhibits their versatility in incorporating them into devices. In order to fulfil the potential of this area, there is a need for novel strategies to design, construct and inter-link batteries, in addition to addressing some of the major concerns associated with batteries; namely, durability, longevity and safety. To solve these issues, it is proposed to harness the potential of Zn-air based cells to produce flexible, safe and robust cells suitable for incorporation into wearable applications.

By using a Zn based chemistry it is possible to build upon a well-established cell type which has characteristics well suited to wearable devices, namely non-toxic, low-cost electrodes, with air-breathing cathodes. This novel application of a Zn-air battery will provide new opportunities for wearable electronics by enabling the incorporation of the power supply not only in standard battery housing, but also within the fabrics used to produce devices.

At a small scale, the Zn-air chemistry provides a number of advantages: primarily, by removing the need for a thick, printed cathode, the size of the battery can be significantly reduced. In addition, by selective deposition of the air catalyst to a flexible conductive layer, an opportunity exists for the electrode to be used as a structural component in fabrics. In conventional Zn-air systems, the major impediment in the incorporation of this chemistry into fabrics is the use of an aqueous electrolyte. Here we propose the use of a polymeric anion conducting membrane (AAEM) as the electrolyte, which removes the need for both a separator and liquid electrolyte. These individual cells can be manufactured to any shape or size, enabling the coupling of multiple cells to provide sufficient voltage and power requirements for the intended device.

Here, we will discuss the development of this novel technology, discussing the methods used to construct and optimise the cells, highlighting the key mechanisms used to obtain reliable recharging of the batteries. Finally, the operational advantages of the cells in flexible electronics will be compared to alternative battery chemistries.

Albert Ryou



Dr. Albert Ryou is currently a postdoctoral researcher in Electrical and Computer Engineering Department at the University of Washington, Seattle, conducting research in nanophotonics and novel light-matter interactions with Professor Arka Majumdar. Dr. Ryou received his PhD in atomic, molecular, and optical physics at the University of Chicago and a BA in physics at the University of Pennsylvania. His main research interest is in exploring quantum many-body physics by engineering exotic environments with coupled nanophotonic cavities and quantum matter, as well as investigating strong nonlinear optical candidates for building neuromorphic photonics. He is a recipient of NDSEG Graduate Fellowship, IC Postdoctoral Research Fellowship, and the Mistletoe Research Fellowship. He has co-authored ~30 publications, which have been cited more than 250 times (Google Scholar). Outside the laboratory, Albert enjoys watching movies, traveling, and hiking throughout the Pacific Northwest.

Towards Cryogenic Electro-optic Modulators using Nano-Cavity-Integrated Heterostructures of 2D Materials

Controlling light-matter interactions is at the heart of numerous technologies from lasers and sensors to energy harvesting. It is also key to unlocking, for instance, quantum simulations of high-temperature superconductivity, and generation and storage of flying qubits for quantum computing. An attractive platform for engineering light-matter interactions is integrated nanophotonics. Rapid progress in large-scale electromagnetic design and nanofabrication now enables fabrication of microscopic optical resonators that can trap light both spatially and temporally. Embedding layered materials on the resonators can yield novel applications, including sensors, modulators, nonlinear switches, and exotic light sources.

One of the most interesting applications of the hybrid devices is an ultra-low-power microwave-to-optical signal transducer. Superconducting circuits, a potential candidate for next-generation high-performance computers, place stringent criteria on the speed and energy of operation of cryogenic electro-optic modulators. Neither commercial bulk modulators based on the Pockels effect nor on-chip silicon photonic modulators can satisfy the required transduction via 1-mV-tall and 2-picoseconds-wide single flux quanta electronic signals. Our solution is to combine atomically thin 2D materials, which exhibit significantly greater response to applied electric fields, with optical nano-cavities, with a goal to demonstrate electro-optic modulation at liquid helium temperature (4K) with 10 GHz speed and 10 attojoules of operating energy.

To that end, our group is taking a dual approach. On the nanophotonic devices side, we developed a one-dimensional photonic crystal cavity called a nanobeam, which exhibits a high-quality factor and a small mode volume. It is made of silicon nitride for low loss in the visible wavelength range. In addition, the nanobeam sits on a substrate, making it robust against multiple transfer cycles of 2D materials. We have published works on TMDC-embedded nanobeams, deterministically-positioned quantum dots, and large themo-optic tuning. On the 2D materials side, we have recently developed a high-precision local transfer method for TMDC monolayers.

Another research direction based on strong light-matter interactions is an all-optical implementation of an artificial neural network. The past few years have seen an outpouring of interest in artificial intelligence and machine learning. The availability of vast amounts of data and the phenomenal success of Deep Learning led to a re-examination of neuromorphic optical computing as an efficient means to implement artificial neural networks. We are currently studying optical neural networks both in free space with macroscopic DBR cavities and in integrated optics with 3D-printed metasurface stacks. We have also published our work on simulating an image-amplifying degenerate cavity, with an eye toward integrating it with strong optical nonlinearity for image classification tasks.

Aswin Sankaranarayanan

Aswin Sankaranarayanan is an associate professor in the ECE department at Carnegie Mellon University, where he is the PI of the Image Science Lab. His research interests are broadly in computational photography with focus on 3D shape estimation as well as building imaging systems with enriched capabilities. His doctoral research was in the University of Maryland where his dissertation won the distinguished dissertation award from the ECE department in 2009. Aswin is the recipient of the 2019 CVPR best paper award, the CIT Dean's Early Career Fellowship in 2018, and the NSF CAREER award on 2017.

Programmable Spectrometry—Per-Pixel Classification of Materials using Learned Spectral Filters

Many materials have distinct spectral profiles, which facilitates estimation the material composition of a scene by measuring a hyperspectral image. However, capturing a hyperspectral image is often an overkill and inherently wasteful since only a small set of linear projections of the acquired measurements contribute to the classification task. We propose a novel programmable camera that is capable of producing images of a scene with an arbitrary spectral filter. We use this camera to optically implement the spectral filtering of the scene's hyperspectral image with the bank of spectral profiles needed to perform per-pixel material classification. This provides gains both in terms of acquisition speed—since only the relevant measurements are acquired—and in signal-to-noise ratio—since we invariably avoid narrowband filters that are light inefficient. Given training data, we use a range of classical and modern techniques including SVMs and neural networks to identify the bank of spectral profiles that facilitate material classification. We verify the method in simulations on standard datasets as well as real data using a lab prototype of the camera.

Guillermo Sapiro

Guillermo Sapiro received his degrees from the Technion, Israel. After post-doc work at MIT, he became a Member of Technical Staff at HP Labs. He was the Distinguished McKnight University Professor and Vincentine Hermes-Luh Chair at the University of Minnesota. He is currently a James B. Duke Distinguished Professor, Duke University.

He works on differential geometry and geometric PDEs, learning theory, network analysis, theory and applications in computer vision, computer graphics, medical imaging, and image analysis. He has co-authored over 450 papers and a book, and transferred numerous technologies to private companies and to government agencies.

He was awarded the Rothschild Fellowship for Post-Doctoral Studies in 1993, the ONR Young Investigator Award in 1998, the Presidential Early Career Awards for Scientist and Engineers in 1998, and the NSF Career Award in 1999. He delivered the first Science Lecture at the Abel Prize, 2009, and is a Plenary Speaker for SIAM Image Sciences 2010 and SIAM Annual Meeting 2018. He was also awarded the National Security Science and Engineering Faculty Fellowship and twice the Test-of-Time Award, for one of the most cited papers in computer vision and again for one of the most cited papers in machine learning. He is a SIAM and an IEEE Fellow, member of the American Academy of Arts and Sciences, and founding Editor-in-Chief of the SIAM Journal on Imaging Sciences.

Domain-Adaptive Filter Decomposition—Z. Wang, X. Cheng, G. Sapiro, and Q. Qiu

Severe changes between training and testing domains are frequently encountered in real-world scenarios. In this work, we consider the problem of transferring a Convolutional Neural Network (CNN) trained in one domain to another, where abundant labeled data are available in the source domain, and limited or no labeled data in the target domain. By exploiting the observation that a convolutional filter can be well approximated as a linear combination of a small set of basis elements, we show for the first time, both empirically and theoretically, that domain adaptation can be effectively handled by decomposing a regular convolutional layer into a domain-specific basis layer and a domain-shared basis coefficient layer, while both remain convolutional. An input channel will now first convolve spatially with each respective domain-specific basis to “absorb” domain variations, and then output channels are linearly combined using domain-shared basis coefficients trained to promote common semantics across domains. We use toy examples, rigorous analysis, and real-world examples to show its effectiveness in domain adaptation. With the proposed architecture, we need only a small set of basis elements to model each additional domain, which brings a negligible amount of additional parameters, typically a few hundred vs. millions in regular settings.

Joseph Shaheen

Joseph Shaheen is an IC Postdoctral Fellow. He earned his Doctorate in Computational Social Science from George Mason University. In his free time he enjoys long walks and photography.

An Empirical Method for Evaluating Robustness of Network Centrality Measures

The Intelligence Community faces continuous challenges in the collection and aggregation of human-centric network data, partially due to a lack of availability of said data and tampering by the adversary. Moreover, chronic methodological issues manifest themselves in the applied analytical process post data retrieval; these can be summarized as a deficiency of empirical foundations. This is especially true in the evaluation of node positions commonly captured by centrality measures. This presentation is a simple bootstrapping method utilizing a scalar measure that provides a strong empirical foundation for determining centrality information loss in collected network data with minimal underlying assumptions. The method's use is illustrated using a theoretical network framework. Strengths, weaknesses, and opportunities are discussed.

Arlena Shala

Born and raised in Kosovo, Arelena Shala is a senior majoring in Geospatial Information Sciences with a minor in Middle Eastern Regional Studies at the United States Military Academy at West Point. During her undergraduate study, Arelena has focused her academics toward her overall passion for the development of military intelligence capabilities and contributing to international security. Her research focused on developing efficient video-based methods of three-dimensional reconstruction of indoor environments to facilitate military intelligence acquisition and virtually simulated training. She has interned at the Institute for Creative Technologies in the University of Southern California, where she contributed to research for the Army Research Laboratory. In the upcoming year, she will continue to investigate the possibility of developing a customized multi-camera system that could further support covert intelligence acquisition.

Upon graduation, she hopes to commission into the army as a military intelligence officer and obtain a graduate degree in international affairs. In her career, she intends to combine international studies with her technical knowledge of geospatial operations to promote cross-border cooperation in the intelligence community, specifically in the Balkans military landscape.

Indoor 3D Modeling with a Body Mounted Video Camera—Arelena Shala; Matt S. O'Banion, PhD; Christopher E. Oxendine, PhD; William C. Wright, PhD

Three-dimensional (3D) capture and modeling of indoor environments has great potential for assisting in intelligence gathering, military operation planning, and virtual training; however, issues related to site access, required equipment/sensors, and acquisition inefficiencies limit the practicality of current solutions, especially in covert reconnaissance scenarios. This study focused on the feasibility of creating indoor 3D photogrammetric models using ultra high definition (UHD) video from a body mounted smartphone. Existing technology, such as terrestrial laser scanning and the Matterport 3D camera, has been proven to generate high quality indoor models; however, video-based photogrammetric reconstruction has the potential to improve the efficiency, accessibility, and costs of indoor modeling. For this study, interior 3D models of the historical West Point Train Station in New York were generated using UHD video recorded at 60 frames/sec on an Apple iPhone XS Max. The smartphone was mounted to the shoulder of the user during video acquisition. Various collection configurations (i.e., walking paths) throughout the open interior space were assessed to determine which configuration resulted in the best model. Additionally, the video keyframe sampling interval was evaluated in an effort to optimize processing efficiency while maintaining model quality. The proposed body mounted camera solution is useful for generating floor plans, observing indoor points of interest, and depicting structural details of the interior. While the resulting 3D reconstructions would not meet survey-grade specifications, this video-based technique has potential to be a low-cost and inconspicuous solution for indoor modeling. Future research will investigate the possibility of auto-scaling the 3D reconstruction using the integrated accelerometers present in modern smartphones and developing a small form factor, multi-camera system that could further support covert acquisition and improve processing efficiency.

Shashi Shekhar

Shashi Shekhar is a McKnight Distinguished University Professor at the University of Minnesota (Computer Science faculty). For contributions to geographic information systems (GIS), spatial databases, and spatial data mining, he was elected an IEEE Fellow as well as an AAAS Fellow and received the IEEE-CS Technical Achievement Award, and the UCGIS Education Award. He has a distinguished academic record that includes 300+ refereed papers, a popular textbook on Spatial Databases (Prentice Hall, 2003) and an authoritative Encyclopedia of GIS (Springer, 2nd Ed. 2017). Shashi is serving as the president of the University Consortium for GIS, a member of Computing Research Association (CRA) Board and as a co-Editor-in-Chief of Geo-Informatica: An International Journal on Advances in Computer Sciences for GIS (Springer). Earlier, he served on the CRA Computing Community Consortium Council (2012-15), and multiple National Academies' committees including Models of the World for USDOD-NGA (2015), Future Workforce for Geospatial Intelligence (2011) and Priorities for GEOINT Research (2004-2005).

Identifying and Analyzing Patterns of Evasion

We propose to develop space-time aware methods for modeling patterns of evasive behavior by insurgents and other security targets. These targets increasingly employ techniques to mask their movements and locations. Denial, deception and evasion techniques skew data collection and hinder traditional data mining techniques. We propose an overarching framework to identify and analyze these denial and deception instances. First, we propose a method to distinguish between evasive and non-evasive behaving groups by quantifying the space-time entropy or predictability of individuals' behavior. Second, we will identify "blackholes," areas where no target movement is observed, despite predictions that such movement would occur. Third, since conventional data mining techniques cannot be applied in areas lacking reported observations (blackholes), we look to theoretical understanding of human behavior to help generate hypotheses about target location and travel routes. Specifically, we apply routine activity theory, a well-known theory used by environmental criminologists, which holds that individuals typically follow set patterns in their daily lives. To help quantify this behavior, we look to the physical science concept of return periods, the notion of certain events happening with a given occurrence rate (e.g., 100 year earthquake of certain magnitude). We utilize return periods to estimate a target's schedule to aid in interception and surveillance.

Jonathan Silver

Jonathan Silver is a Royal Academy of Engineering UK Intelligence Community Postdoctoral Research Fellow studying optical microresonators, specialising in sensing applications that exploit the intrinsic Kerr nonlinearity of the resonator. He works in the group of Dr. Pascal Del'Haye at the UK's National Physical Laboratory, in collaboration with Prof. Kenneth Grattan and Prof. Tong Sun at City, University of London. He was awarded a PhD in 2016 for his dissertation entitled "Interaction of a Single Ion with Ultracold Atoms and an Optical Fibre Cavity" completed in the group of Prof. Michael Köhl at the Universities of Cambridge, UK and Bonn, Germany. He grew up in London and holds Bachelor's and Master's degrees in Natural Sciences from the University of Cambridge.

Nonlinear, Enhanced Sensing With Optical Microresonators

Optical microresonators are tiny glass rings in which light may be stored by circulating up to a million times. These long storage times, combined with the small volumes in which the light is confined, allow optical intensities of billions of watts per square centimetre to build up inside the material with less than one watt of input power. This enables the realisation of several interesting nonlinear optical phenomena, including the generation of frequency combs from monochromatic light and optical nonreciprocity, in which light can travel in one direction but not the other. Our research has is enabling us to exploit some of these phenomena to work towards a new generation of hyper-accurate chip-scale sensors for rotation, acceleration, refractive index and nanoparticles, as well as ultrafast spectroscopy systems for trace gas sensing.

In 2016, we discovered a spontaneous symmetry breaking effect that occurs when a ring resonator is simultaneously pumped with light in both circulating directions. Predicted in the 1980s, it has applications in optical switching, isolators and circulators. Under a certain condition, namely the critical point of the symmetry breaking regime, the resonator becomes orders of magnitude more responsive than usual to tiny perturbations in its environment. This allows the realisation of simple yet highly sensitive detectors for rotation and refractive index, and could also be applied to ultraprecise position measurement of a near-field probe, for example in a chip-based accelerometer in which the probe is positioned at the end of a nanomechanical cantilever.

During the first year of research, we have been studying in detail, both experimentally and theoretically, the dynamical response of a critical-point-based enhanced gyroscope, demonstrating universal critical behaviours and achieving a proof-of-principle rotation sensitivity of around 2 deg/s. We have also optically detected nanometre-scale movements of a tungsten tip placed within a few microns of the resonator, and have generated single-soliton frequency combs in silica microresonators for the first time. During our remaining year, we will focus on generating two counterpropagating soliton frequency combs in a single microresonator, and on using these to demonstrate ultrafast gas spectroscopy.

Howard Smith

Mr. Howard Anthony Smith is a full-time professor at the National Intelligence University (NIU) focusing on data analytics and cyber disciplines. He has designed hands-on exercises and curriculum incorporating forensic, attack and defense tools that reinforce learning outcomes. He is actively engaged in cyber and data analytics research and chairs student thesis committees. Recent publications include "North Atlantic Treaty Organization: Challenges to Collective Defense in Cyberspace", "Signal Pollution: The Unseen Threat", "Cyber Terrorism or Annoyism" and "Cyber Security: A Leverage Point for the Competitive Intelligence Manager."

Mr. Smith holds an MS in Network Security, a BS in Economics and is currently enrolled in a Research & Technology PhD program.

Prior to NIU, Mr. Smith was a Signals Intelligence Analyst and French Linguist in the United States Military. He also served as a Senior Research Scientist at a Department of Energy National Laboratory and as a Senior Threat Analyst with BAE. During this time, he developed novel methodologies for malware analysis and designed a course on high frequency radio wave propagation and signal de-multiplexing.

Seasonal and Latitudinal Drivers of Global Terrorism: A Circular Statistics Methodology—R. Reynolds and H. Anthony Smith

This study employs a new methodology—circular statistics—to answer questions about the drivers of global terrorism events. Circular statistics is a data analysis technique typically used to assess biogeographical phenomena (such as epidemiological investigations, studies on wind and water currents, and animal behavior research). Absent any application of circular statistics to the topic of global terrorism within the academic literature, we examine two questions about terrorism dynamics as a proof-of-concept of its novel methodology. First, are global terrorism events seasonal, and if so, what seasonality trends are present in the data? Second, does tropicality (latitudinal distance from the equator) impact any identified seasonal trends in terrorism events?

Circular statistics is a branch of statistics used to examine cyclical data that might be recorded on a 24-hour clock, by a magnetic compass, or over multiple 12-month annual cycles. Using open-source code libraries in the R Studio environment, this study analyzes data from the National Consortium for the Study of Terrorism and Responses to Terrorism (START) Global Terrorism Database (GTD) to identify and compare seasonal and latitudinal patterns of terrorist event frequency.

We find significant seasonal trends in terrorism events—the mean season value for global events from 1970-2017 falls in late spring to mid-summer regardless of latitude. Additionally, multiple tests indicate that latitude affects the degree to which seasonal trends are present and may also shift seasonal increases in terrorism event frequency later in the year as latitude increases. Tropicality results are mixed—some tests support the hypothesis, while others do not show a statistically significant impact of tropicality on terrorism frequency. Furthermore, our results suggest that patterns of seasonality in terrorist events have changed over time; we recommend further study to characterize seasonal trends across the time series.

Importantly, this study not only fills specific, immediate gaps in the terrorism literature about seasonal and tropical dynamics of terrorism; it also demonstrates the utility of a new analytical approach to terrorism data: circular statistics. Our methodology offers analysts and researchers in academic, intelligence, and other governmental communities a new, interdisciplinary tool to tackle policy- and decision-makers' biggest questions.

Martin Smyth

Martin ("Marty") Smyth is a PhD candidate in Technology, Policy and Innovation at Stony Brook University (a research center of the State University of New York). As a Visiting Scientist in the NGA/Research Directorate via a program with the Oak Ridge Institute of Science & Education (ORISE) and the Department of Energy, Marty works closely with research-mentor Dr. Michael ("Mike") Egan. Together, Mike and Marty seek to move the frontier of human knowledge about complex adaptive socio-technological systems. Their research applies insights from network science, mechanical engineering, political economy and epidemiology to understand emergent en masse behavioral phenomena, as revealed in the aggregate activity of millions of social-media platform-users. They are excited to share the results of their work for the first time at ICARS 2019.

During 2017 and 2018, Marty taught a foundational course in analytic methods and research skills at New York University's Center for Global Affairs. He previously taught courses at Stony Brook University and at Farmingdale State College. In his teaching, Marty seeks to instill in students an appreciation of the 'golden rules' of research practice, most importantly: doing good work and loving the good work you do.

In addition to a BA in Earth + Space Sciences and MA in Public Policy from Stony Brook University, Marty currently holds an MA in Political Science from Northeastern University and an MPA from the Columbia University School of International + Public Affairs.

Global Critical Event Prediction: Toward an Applied Science of Emergent Critical Phenomena—M. Smyth and M. Egan

Our research is directed toward understanding the dynamics of emergent en masse behavioral phenomena on the network graphs of social media service platforms. Where earlier work on the emergence of mass-behavioral phenomena applied analytic approaches (Granovetter 1978, Lohmann 1994, Watts 2002, Lang and de Sterck 2016), or agent-based modeling (e.g., Epstein 2002), the work described here draws on findings by Sornette and Bouchard (1996), who endeavored to identify a predictive signal in the behavior of financial market indices in the advent of a market crash. Sornette's market index model is characterized by the log-periodic power-law singularity (LPPLS) waveform, which has been shown to effectively capture pre-crash financial market index dynamics (Sornette and Bouchard 1996). Sornette identified this log-periodic power-law behavior following similar work on acoustic emissions preceding failure in aerospace industry gas pressure-tanks (Anfrani et al 1995). He speculates that LPPLS models may also be applied to describe emergent socio-political phenomena. Our research aims to test this applicability. 'Emergence' is here understood as the rapid propagation of phenomenological engagement across a network graph, representing e.g. the revelation of formerly 'falsified' (i.e., hidden) political preferences (per Kuran 1995). The questions that this research seeks to answer are:

1. Can LPPLS models (heretofore used to model financial market bubbles and mechanical system failures) similarly be used to identify the emergence of an en masse behavioral phenomenon on the network graph of a social media service platform? In particular: can aggregate activity preceding a 'phase transition' in the behavior of the described social system (i.e., an emergent en masse behavioral event) be characterized using an LPPLS model-fit?
2. What are the specific information-spreading dynamics that yield the LPPLS waveform characteristic of en masse behavioral emergence? Under what specific parameterizations of the information-spreading process does this characteristic signal emerge?

We present some preliminary findings, describe next-steps and discuss avenues now under exploration vis-à-vis future work.

Steven Spiegel

Steven Spiegel is a Visiting Scientist in the NGA/Research Directorate via a program with the Oak Ridge Institute of Science & Education (ORISE) & the Department of Energy. His research focuses on point cloud collection, processing, and classification. These point cloud collections include Electro-Optical (EO) and LiDAR data. Previously, Steven received a master's degree in Geographic Information Sciences from Saint Louis University and an undergraduate degree in mathematics from Truman State University.

LiDAR Segmentation Using Image Morphology and Connected Pixels

Point clouds have proven to be an irreplaceable tool in surveying, automotive, remote sensing, and defense industries. However, these point clouds often have hundreds of millions of points, making manual feature extraction, segmentation, and classification infeasible. Hence, research into point cloud classification aims to automate this time-intensive process. Specifically, this research aims at creating a segmentation and classification pipeline of low altitude, airborne LiDAR collections. This is conducted by first removing outlier points, segmenting ground returns, and then using image processing techniques to segment the remaining points.

Point cloud segmentation is an important preprocessing step in point cloud classification. There are numerous strategies to conduct this segmentation in 3-D space including voxelization, Euclidean clustering, and region growing and seeding. However, for aerial and airborne LiDAR collections, point clouds can be projected to 2-D space utilizing well-established image segmentation techniques. This simplifies the segmentation problem and reduces processing time.

The first step is to remove outlier points using a statistical filter. The second step involves segmenting the ground via morphology using a progressively growing window. This varying window size allows buildings, trees, light poles, and other object features to be separated from ground returns. Then, the remaining point cloud is projected to a high resolution multi-band 2-D image, with pixel values representing point curvature, intensity, and height. The remaining segmentation is conducted as follows: intensity transformation, foreground segmentation, morphological filtering, and connecting labeled pixels. The segmented image is then projected onto the point cloud. As a result, the segmented point cloud can be passed into a classification pipeline.

Charles Tabor

Charles A. Tabor Jr. received a B.S. in Applied Mathematics from the University at Buffalo, an M.S. in Applied Mathematics from Purdue University and has more than 18 years of industry and government experience in the field of remote sensing. He is currently employed with the National Geospatial-Intelligence Agency and is pursuing a Ph.D in Imaging Science from the Rochester Institute of Technology. His research interests are in hyperspectral remote sensing and radiative transfer.

Improved Modeling of Reflected and Emitted Radiation in Intimately Mixed and Layered Media to Enhance Species Identification and Retrieval of Geophysical Parameters—Charles A Tabor Jr. and Charles M. Bachmann

Natural surfaces are often best characterized as intimately mixed and layered media. Indeed, residue resulting from the accidental spillage of hazardous material or agricultural water runoff is likely mixed with or partially obscured by other natural materials such as wind-blown dirt or sand. The land surface conditions commonly found near estuaries are subject to marine and riverine influences forming a complex, evolving and continuously mixed sedimentary environment. As such, the remote study of these problem sets can benefit from robust radiometric models that account for both the chemical/spectral and geophysical parameters that influence measured reflected and emitted surface radiance.

The goal of my dissertation research is to characterize the effects of thin particle layers and other surface coverings on reflected and emitted surface radiance and to improve the detection and characterization of underlying substrate media. Creating prescribed surfaces for controlled study can be challenging and our initial research efforts have focused on identifying spectrally contrasting component materials, developing sample composition techniques for layered media, demonstrating experimental repeatability and confirming the manifestation of hypothesized spectral signatures. We have obtained silica quartz sand and olivine sand for sample composition and have demonstrated the repeatability of created layered and mixture media measurements in a laboratory environment using VNIR/SWIR hyperspectral goniometer data and LWIR hyperspectral data. Additionally we have addressed challenges associated with laboratory hyperspectral LWIR measurements of exposed samples through the development of tailored laboratory procedures. Subsequent research will focus on understanding the sensitivity of substrate material detection to overlaying particle layer thickness, retrieval of geophysical parameters from layered and mixed media and distinctions between emissive and reflective phenomenologies. We will evaluate radiative transfer models such as Ambartsumian's Method of Invariance and simpler two stream models such as Kubelka-Monk, and the efficacy of those models in enabling the retrieval of particle layer thickness. We will also assess the mixing formulas of Hapke and the efficacy of those models in predicting the reflected and emitted radiance of various mixtures. Ultimately, we seek to understand the potential benefits of non-linear mixing models to characterize intimate mixtures and to identify opportunities to improve broad area search and target detection performance.

Charles Tahan

Dr. Charles Tahan drives technical progress in the future of information technology as Technical Director of the Laboratory for Physical Sciences, whose research spans novel device physics for computing, communications, and sensing to hardware architectures for high-performance computing. As a technical lead, Dr. Tahan has stood up new research initiatives in silicon and superconducting quantum computing; quantum characterization, verification, and validation; and new and emerging qubit science and technology. As a practicing physicist, he works with students and postdocs from the University of Maryland-College Park to conduct original research in quantum information science. His contributions have been recognized by the Researcher of the Year Award, the Presidential Early Career Award for Scientists and Engineers, election as a Fellow of the American Physical Society, and elevation to the Senior Executive Service. He received the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2012 and was elected a Fellow of the American Physical Society in 2015.

Dr. Tahan earned a PhD in Physics at the University of Wisconsin-Madison in 2005 and a B.Sc. in Physics and Computer Science from the College of William & Mary in 2000. From 2005-2007 he was a National Science Foundation Distinguished International Postdoctoral Research Fellow at the University of Cambridge, UK; the Center for Quantum Computing Technology, Australia; and the University of Tokyo, Japan. He served as technical consultant for quantum information science and technology programs in DARPA's Microsystems Technology Office (MTO) while at Booz Allen Hamilton from 2007-2009. He has a long-term commitment to science and society including creating Meqanic, one of the first games meant to build intuition about quantum computing. He currently serves as Executive Secretary for OSTP's Subcommittee on Quantum Information Science.

Laboratory for Physical Sciences Overview

Since 1956, the Laboratory for Physical Sciences, in partnership with the University of Maryland, has advanced the physics and engineering behind information science and technology. A unique organization where university, industry, and federal government scientists collaborate on research in advanced communication, sensing, and computer technologies, the LPS currently houses four main divisions: Solid-State and Quantum Physics, Optical and RF Innovations, Microelectronics Integration, and Advanced Computing Systems.

Yun Tao

Yun Tao is an Intelligence Community Postdoctoral Research Fellow working at the interface of behavioral, disease, and population biology using mixed quantitative approaches to investigate the transient, hidden dynamics in complex biological systems. He has developed mathematical and computational frameworks for modeling large-scale ecological and movement patterns, predicting risks of zoonotic outbreaks, and informing vaccination strategies in advance of epidemics. Yun Tao completed his PhD in Ecology at the University of California, Davis, subsequently worked closely with the University of Helsinki and EcoHealth Alliance, followed by postdoctoral appointments at the Center for Infectious Disease Dynamics at Penn State University and the University of California, Riverside. He is the recipient of NSF Graduate Research Fellowship, NSF Research Opportunities Worldwide Fellowship, EcoHealthNet Research Exchange Fellowship, and the Lotka-Volterra Award from the Ecological Society of America.

Point-counterpoint of Behavioral Disease Dynamics: Modeling Movement Responses During Outbreaks and Their Management

Both disease and behavioral research have experienced groundbreaking progress in recent years owing to technological and theoretical advancements. In the emerging field of movement ecology, studies increasingly demonstrate that the movement of infective hosts, at-risk individuals, and even healthcare personnel (e.g. vaccination teams) could vary significantly over the course of an epidemic as a consequence of pathological progression, social attitudes, or actions related to management priorities and operational constraints. In other words, animal (including human) movements are the outcomes of dynamic interactions between epidemiological, environmental, and individual-level conditions. However, many disease models to date (e.g. agent-based simulations, compartmental models) mostly describe movement as time-invariant properties insensitive to the state of infectious diseases. Introducing dynamic behavioral responses such habitat avoidance, infection-induced aggression, or mass panic is thus critical to the improvement of model predictions, realistic risk assessment, and the development of rapid management decisions during outbreaks when information is uncertain and individual and public behaviors are susceptible to sudden and spontaneous changes.

Using examples from wildlife, livestock, and human epidemics, we applied advanced statistical analyses to identify variable movement responses to ecological and disease dynamics. In conjunction, we developed mechanistic models that predict the outbreak and management consequences of behavior-disease feedback. In part one, we examine the migratory patterns of bats in Bangladesh around the time of Nipah virus outbreaks and aim to determine the impacts of habitat fragmentation on the intensity and range of pathogen shedding. In part two, we are modeling the phenomenon of recurrent, inter-epidemics of Rift Valley Fever in Sub-Saharan Africa as driven by seasonal ungulate home ranging behavior. Parts three and four highlight the roles of human movement in disease control. In a retrospective analysis of the 2001 foot-and-mouth outbreak in Great Britain, we statistically identify the key factors that led to operational delays and simulated their consequences for management decisions. Lastly, we are modeling the potential advantage of a vaccination strategy capable of adaptively deploying healthcare personnel in an emerging outbreak under uncertain information. These results thus demonstrate a radical transformation in disease research shaped by a growing appreciation of movement dynamics: the capacity to elucidate past responses and inform future ones, enabling us to finally provide decision advantage in a dynamical and noisy world.

Michael Thomas

As the Deputy Transparency Officer for the Office of the Director of National Intelligence, Michael coordinates transparency programs across the U.S. intelligence community. Both behind the scenes and on the public stage, his work has transformed the way the IC approaches and engages with the public, most recently with the launch of the new Intelligence.gov transparency website. Michael joined the Intelligence Community in 2012 to lead ODNI's digital strategy. This includes the creation of IC on the Record, a signature transparency initiative and the online release of "Bin Laden's Bookshelf," material recovered during the 2011 raid on Osama Bin Laden's Pakistan compound. Michael's tenure at ODNI represents a return to government service after a decade in the private sector, where he spent time with a series of start-ups, including two ranked among Inc. Magazine's annual list of the 500 fastest growing companies in America. Michael is also an arts festival organizer, former consumer safety advocate and recovering corporate investigator. He is Louisiana born and Washington, DC proud.

We Are on a Not-So-Secret Mission: Getting to Know the Humans of the Intelligence Community

You've seen the Bond movies, binge-watched Homeland, and maybe even have a few visits to the International Spy Museum under your belt. But how well do you know the real stories, missions, challenges, and humans behind the Intelligence Community? Learn about the types of problems the analysts, collectors, and scientists of the Intelligence Community tackle every day, and how your research and innovation help us to protect U.S. national security. This is also your chance to ask any burning questions you might have about life in the IC, career opportunities, or what really happened in Area 51. (Note: no org charts will be harmed in the making of this presentation.)

Katherine Tobin

Katherine Tobin is the Director of Lateral Innovation at the Office of the Director of National Intelligence. In this role she helps amplify and connect innovative efforts across the Intelligence Community, as well as leads design sprints to support IC-wide challenges. Prior to this role, she spent over four years at CIA as a manager of emerging technology and design projects to support the Directorate of Analysis.

We Are on a Not-So-Secret Mission: Getting to Know the Humans of the Intelligence Community

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Helen Tran

Dr. Tran is an Intelligence Community Postdoctoral Fellow at Stanford University under the mentorship of Professor Zhenan Bao in the Chemical Engineering Department. She received her BS in Chemistry with a minor in Chemical Engineering from the University of California—Berkeley in 2009, conducting undergraduate research with Prof. Tsu-Jae King Liu (Electrical Engineering, Berkeley) and Prof. Christopher Schuh (Material Science, Massachusetts Institute of Technology). In the two subsequent years, Dr. Tran was a post-baccalaureate fellow and Scientific Engineering Assistant in Dr. Ronald Zuckermann's research group at the Molecular Foundry at Berkeley National Labs. She completed her PhD at Columbia University in 2016 under the supervision of Prof. Luis Campos. At Columbia University, she was awarded the National Science Foundation Graduate Research fellowship, the National Defense Science and Engineering Graduate fellowship, International Center for Materials Research fellowship, and George Pegram Award. Dr. Tran has been committed to scientific outreach (e.g. co-founded program between Columbia and Harlem charter school), endorses communication among interdisciplinary disciplines (e.g. co-founded seminar series at Columbia), and has mentored over twelve students (high school to graduate level).

Stretchable and Fully Degradable Semiconductors for Transient Electronics

This research focuses on understanding the structure-property relationships of polymers to develop emergent properties. As an undergraduate, she fabricated platform devices to explore the dynamics of sacrificial etching for scaled nanoelectromechanical systems device release processes. At the Molecular Foundry, she designed information-rich functionalized crystalline peptoid (peptidomimetic polymers) nanosheets and synthesized combinatorial libraries for protein binding experiments. As a graduate student, Dr. Tran investigated block copolymers as templates for organizing semiconducting and biologically-active moieties as well as highly-dense lithographic masks for 2D materials such as graphene and MoS2. Currently at Stanford, Dr. Tran is developing high-performance, stretchable electronics that are low power and biodegradable. This project critically hinges on tuning the surface energies of the disparate elastomeric matrix and degradable semiconductor to induce confinement into crystalline fibrous nanostructures. The elastomer and semiconductor's molecular structure were carefully designed and synthesized, accounting for solubility, electrical performance, and dissolution. It's unique morphology and dynamic chemical bonding concurrently enables strain independent field-effect transistor mobilities and predictable transience. Optically, films show no evidence of damage whereas neat semiconductor films show distinct tears. To push its performance for low power applications, the chemical structure of the degradable semiconductor must be revisited. Alternatives of p-phenyldiamine, the condensation counterpart to the dialdehyde diketopyrrolopyrrole (DPP), will be explored for higher field-effect transistor mobilities. Collectively, these projects center on molecularly designing polymers and controlling its assembly to yield materials with emergent properties.

Matthew Trusheim

Matt Trusheim, a native Minnesotan, received his B.S. in Applied Physics from Yale University in 2010, and his M.S. from Columbia University in 2011. Subsequently, he joined the Quantum Photonics Group at MIT under Prof. Dirk Englund, where his research culminated in a 2018 PhD thesis entitled 'Nanoscale Engineering of Spin-Based Quantum Devices in Diamond'. Along the way, Matt expanded his horizons through the NSF Interdisciplinary Quantum Information Science and Engineering traineeship and an MIT-Lincoln Laboratory internship, and mentored several undergraduate researchers under MITs SuperUROP program. He continues his work at MIT under the Intelligence Community Postdoctoral Fellowship, with a focus on quantum sensing. Matt is broadly interested using photonics and solid-state quantum emitters to build cutting-edge systems, with research directions including exploring new color centers for quantum networking, scaling diamond sensors via CMOS integration, and the development of locally entangled spin clusters towards Heisenberg-limited sensing and modular quantum computing.

Next-Generation Quantum Sensors in Diamond

Quantum sensors based on color centers in diamond, in particular the nitrogen-vacancy (NV) center, show promise for a variety of applications as they are highly sensitive at room-temperature and enable nanometer-scale spatial resolution. This presentation will highlight recent experimental advances in the application, engineering and control of diamond quantum sensors. These results include simultaneous magneto-thermal imaging of integrated circuits using conformally-coated nanodiamond sensors; the integration of diamond with customized CMOS electronics towards a miniaturized, packaged quantum sensing platform; and the development of sub-diffraction non-destructive spin readout techniques for NV spin clusters. Secondly, we will discuss newly-discovered color centers in diamond with the potential to enable quantum advantage through distributed sensing. These novel quantum emitters, including the Pb-vacancy and Sn-vacancy, have intrinsic protection from electric-field noise due to their crystallographic symmetry, resulting in stable and coherent optical transitions even in nanostructured environments. Combined with long spin coherence, this system can form the cornerstone of a modular quantum network that realizes quantum sensing algorithms at the Heisenberg limit.

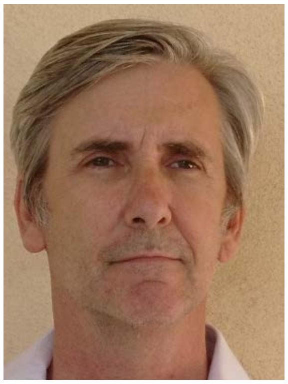
Lucy Vliestra

Lucy Vlietstra is a professor at the U.S. Coast Guard Academy, New London, Connecticut, where she teaches courses in marine ecology, biological oceanography, and emergency management. Her current research focuses on the influence of climate change on maritime safety and environmental protection in U.S. Arctic waters. Past research interests include the ecology of marine predators and their prey in the North Pacific Ocean and interactions between seabirds and wind energy facilities in coastal New England. Dr. Vlietstra coordinates the Academy's partnership with the National Geospatial-Intelligence Agency, which offers research and internship opportunities for Coast Guard Academy cadets interested in exploring problems at the interface of marine science and geospatial intelligence.

Geospatial Comparison of Two Sources of Satellite-based Automatic Identification System (Ship-Tracking) Information in U. S. Arctic Waters—Lucy S. Vlietstra and Jessica N. Morgan

Maritime domain awareness (MDA) is critical for ensuring effective preparedness and response operations related to safety, security, and stewardship of the oceans. In remote areas of the sea, MDA is particularly reliant upon commercial satellite services for information on shipping activity. Satellite-based Automatic Identification Systems (S-AIS) transmit ship position reports between vessels for navigational purposes and to the U.S. Coast Guard and other end users for purposes of asset management and maritime safety and security. In this presentation, we describe how S-AIS information is used to introduce U.S. Coast Guard Academy cadets to real-world challenges related to Arctic MDA, to teach them technical and analytical skills, and to instill in them an appreciation for geospatial intelligence and its application to maritime operations. The goal of this study was to determine whether S-AIS information acquired from different commercial sources led to the same picture of maritime traffic in the U.S. Arctic Ocean. If it did not, we wanted to understand how differences might influence situational awareness for the end user. We compared ship position reports collected by two commercial sources of S-AIS data (Spire Global and ORBCOMM) from July 1-October to 31 December, 2018. Focusing on a region of the U.S. Exclusive Economic Zone north of the Bering Strait and south of 72 °N latitude, we compared the total number of position reports collected by each source, number of vessels, and signal latency time, including variability related to such factors as ship type, transponder type, and assigned flag state. We also compared S-AIS datasets in terms of reconstructed vessel tracks to evaluate whether differences in position reports affected the accuracy of individual ship tracks in post hoc reconstruction. Overall, we found a relatively high degree of variability between the two sources in parameters supporting real-time situational awareness. Despite these differences, both sources of S-AIS information yielded relatively similar reconstructed vessels tracks, with most (>90%) position reports falling within 1.0 nm of the "average" track line. Future work will include additional sources of S-AIS data in the region and expand the temporal and spatial extent of the analysis to other regions of the Arctic Ocean.

John Waynelovich



John Waynelovich is an IC Postdoctoral Fellow who works with the Intelligence Community to pioneer the development of artificially intelligent and biologically inspired unmanned aerial vehicles.

John entered college 25 years after high school and spent the interim studying a wide variety of topics which led to diverse, interesting careers ranging from diamond setting to training seaplane pilots. A seasoned entrepreneur, he has developed several startups whose customers included MIT, Harvard and Stanford Universities. These adventures provide a rich skill set which John draws on daily.

In today's technology, the ability to move freely and fluently between multiple disciplines is crucial to achieving results in many advanced projects and it was this principle that guided John's academic career. Using the Mathematics Department as a base, he applied his skills to lead advanced projects in multiple departments including Physics, Biology and Engineering. As a result of these interactions, he has deep, hands on training in electrical and mechanical engineering, computer modeling, genetic manipulation and thermodynamics. He was awarded Outstanding Baccalaureate in Mathematics.

John used his graduate studies to develop projects in Artificial Intelligence in both hard and soft robotics. His dissertation, *Synthesis of Nervous Systems in Hybrid Robots Utilizing Hierarchical Q – Learning and Temporal Shifting*, resulted in a Ph.D. in Computational Science from Claremont Graduate University.

Development of Biophysically Inspired, Artificially Intelligent Unmanned Aerial Vehicles

In recent years, the potential uses for small unmanned aerial vehicles (UAVs), has begun to be realized. While there are many commercial uses for lightweight, maneuverable aircraft, there are also a host of uses on the battlefield and in intelligence gathering. Already, the easy availability of hobbyist quadcopters through online retailers, has allowed battlefield adversaries to create precision guided munitions by attaching explosives to a cheap camera linked drone. This essentially gives the enemy the ability to maneuver this flying IED into vulnerable troop positions. One defense against this rapidly growing threat is to exploit a weakness that all small UAVs share, which is their inability to fly without either user control, GPS, or both. Because of this, radio jamming and GPS spoofing have become a way to render a UAV useless. In addition to exterior limitations, most structures block GPS data. The result is that searching a building with a UAV requires a remote pilot to fly with a high degree of precision that is often not possible with current UAVs and can be denied via radio jamming.

The goal of this project is to design and build a small UAV which overcomes the weaknesses listed above, and thus allow the prototype to complete complex missions while denying this capability to our opponents. This will be of great benefit for reconnaissance both inside structures and cross country. Historically, attempts at autonomous navigation without GPS have relied on computer vision libraries which tried to extract information from a 2D matrix of pixels in a logical, methodical way. Recent advents in artificial intelligence, however, particularly in the area of convolutional neural networks, have provided a more biomimetic approach to this problem. By modeling the layered neurons of the human neocortex, deep learning has allowed computers to be trained to recognize and classify objects. This has made it possible for a computer to distinguish abstract aspects of an image; for instance, accurately telling a dog from a cat. While this is simple for a human to do, explaining the criteria one uses to accomplish it is elusive. Another recent biomimetic design aspect has been added that is inspired by flying insects. The ability to land and crawl while exploring its environment adds a layer of stability and stamina to its flight. The newest prototype combines a very light weight six-legged undercarriage for landing gear. Upon landing it has the ability to walk, turn, tilt, sit and analyze, using only a small fraction of the energy required to fly.

The prototype being built for this project is intended to navigate both across unknown territory and within structures by exploiting the capabilities of a very powerful, lightweight single board computer combined with Intel's newest class of 3D cameras and a FLIR thermal imager to classify images.

Anthony Weishampel

Anthony Weishampel is a fourth year graduate student in the Department of Statistics. He is a student of Dr. Ana-Maria Stiacu of the Department of Statistics and Dr. Bill Rand of Poole College of Management. Anthony's research work focuses on classification methods for generalized time series data. Anthony has developed methods through Markovian-like Models and Functional Data Analyses. These methods have applied to Twitter data to detect automated users, users who work in cohort, and latent characteristics of social media users. Before studying at NC State, Anthony worked as a Data Analyst for BAE Systems Applied Intelligence. Anthony has been collaborating with Laboratory for Analytic Sciences since January 2017.

Social Sifter

As highlighted in major, public incidents such as Russia's efforts to influence the outcome of the recent presidential elections in the U.S., Germany, and France, it has become clear that social media has become an optimal target for malicious individuals and institutions to perform influence campaigns. Given the scope and scale of social media data, it is necessary to triage the data into a small network of key users, who drive the influence campaign. Current methods for this task, however, are slow, manual, and forensic. The Social Sifter project aims to provide a single interface which centralizes automated capabilities for collecting large scale social media data and rapidly triaging this data into small networks of interesting, influential, or organized users using a variety of models trained on a large collection of recently released public data from known foreign influence campaigns. These networks of key users can then be visually displayed alongside a variety of metrics and other data, to allow the analyst to monitor and assess these networks as they evolve over time.

The tool is designed with three main modular components: a cross-platform data ingress service, a network analysis service (the core of the project) which executes a variety of models to identify key interesting, influential, or organized users, and finally an interactive, web-based visual display of these networks. The network analysis service utilizes several models, such as Functional Data Analysis (FDA), Text Classification, and other supervised learning models, organized in a modular architecture to identify key users.

One of the features of the Social Sifter system is a new classification method to label social media users appropriately based on the user's online behavior. A user's behavior is treated as a binary time series, indicating times of activity. We consider a generalized multilevel functional model for the response profile. This model separates the user-specific variation from the day within user variation and from the mean trend, while accounting for additional covariate effects. The user-specific and within day user trends are estimated through functional principal components analyses. Classification of the users is accomplished through analyzing the user-specific trends. This multilevel structure has been explored in previous research, however applying this model with the purpose of classification has not been studied. Currently this approach is used for bot detection and identifying users who are working in cohort, but can be expanded to include many other classification labels. For the text classification model, another model built in to Social Sifter, we are utilizing a deep neural net based on the AWD_LSTM architecture, trained following the ULMFiT procedure. Finally, a random forest model uses user attributes alongside network features constructed from retweet networks, including in-degree centrality, out-degree centrality, and PageRank to classify users.

Rebecca Willett

Rebecca Willett is a Professor of Statistics and Computer Science at the University of Chicago. Her research is focused on machine learning, signal processing, and large-scale data science. She completed her PhD in Electrical and Computer Engineering at Rice University in 2005 and was an Assistant then tenured Associate Professor of Electrical and Computer Engineering at Duke University from 2005 to 2013. She was an Associate Professor of Electrical and Computer Engineering, Harvey D. Spangler Faculty Scholar, and Fellow of the Wisconsin Institutes for Discovery at the University of Wisconsin-Madison from 2013 to 2018. Willett received the National Science Foundation CAREER Award in 2007, was a member of the DARPA Computer Science Study Group, and received an Air Force Office of Scientific Research Young Investigator Program award in 2010.

Testing and Estimation for Autoregressive Point Processes

Consider observing a series of events associated with a group of interacting nodes in a network, where the interactions among those nodes govern the likelihood of future events. Such data are common in spike trains recorded from biological neural networks, interactions within a social network, pricing changes within financial networks, and crime and military engagements. The above data can all be modeled as autoregressive point processes, in which the likelihood of future events depends on past events. Our work addresses the estimation of the network structure and autoregressive parameters from such data.

Recent and ongoing activities are focused on three main directions.

The first activity is the development of methods that incorporate side information about each event (for example, the text of a tweet) to gain more nuanced estimates of influences within a network structure and those influences depend on the context represented by the side information. We both developed new models of context-dependent events on networks and computationally efficient algorithms with statistical guarantees. At the heart of our approach is a logistic normal distribution model that can approximate Dirichlet distributions used in topic modeling frameworks but also admit convex optimization methods for estimation tasks, resulting in strong guarantees on the optimality of our estimates. The second activity is a set of methods for determining the time(s) at which the network structure changes, reflecting an increase or decrease in the influence of a subset of network nodes. Detecting when the underlying data generating distribution changes using only the observed time series is a fundamental problem arising in a broad spectrum of applications.

Distinguishing statistically significant changes in the network from random fluctuations in event rates is a challenging problem requiring both new computational tools and theoretical bounds that capture how many events are required for reliable change detection. Third, related to the fundamental change-point detection problem, there remains the fundamental related question of developing suitable hypothesis tests for whether a network influence parameter has changed across two different time periods. In our work, we develop a sharp theoretical characterization of how the number of time points and network structure determines whether we can detect a meaningful difference in network structure across linear autoregressive models. In all of these tasks, our theoretical bounds help us understand how the network size, degree distribution, and other characteristics impact our estimators' accuracy.

Alyson Wilson

Dr. Alyson G. Wilson is a professor of statistics in the Department of Statistics and the principal investigator for the Laboratory for Analytic Sciences at North Carolina State University (NCSU). Her research interests include statistical reliability, Bayesian methods, and the application of statistics to problems in defense and security. Previously, Dr. Wilson was a research staff member at the Institute for Defense Analyses, a faculty member at Iowa State University, and a technical staff member at Los Alamos National Laboratory. Dr. Wilson is currently a member of the National Academies Committee on Applied and Theoretical Statistics. She is a fellow of the American Statistical Association and the American Association for the Advancement of Science and a recipient of the Army Wilks Award. Dr. Wilson earned her Ph.D. in statistics from Duke University.

Laboratory for Analytic Sciences Overview

Founded in 2013 by the National Security Agency and located at North Carolina State University in Raleigh, NC, the Laboratory for Analytic Sciences (LAS) is a mission-oriented research laboratory that supports the Department of Defense and the Intelligence Community. LAS gathers experts and practitioners from academia, government, and industry to create tools and techniques that help intelligence analysts provide better information to the decision makers who need it. LAS works at the intersection of mission and technology to develop new analytic tradecraft, techniques, and technology to aid intelligence analysts to better perform complex, integrated analysis. The work at LAS covers the spectrum from basic science to applied solutions in human machine collaboration, machine learning integrity, advancing analytic rigor, data exploration and triage, and tradecraft and technology development.

Mark Wilson

Mark A. Wilson is an Associate Professor of Psychology at NC State University in the Industrial/Organizational Psychology Doctoral Program. He spent the early years of his career teaching in business schools. He received his Ph.D. in I/O from Ohio State University. His research interests include psychometric quality of work analysis, multidimensional models of job performance, and employee selection often in the context of law enforcement, US Army Special Forces, and intelligence analysis. He designed the current Trooper selection system for the North Carolina State Highway Patrol and founded the National Summit Meeting of Highway Patrols and State Police for Selection and Promotion Systems. He also designed a new selection system for Field Agents for the North Carolina State Bureau of Investigation. He has pioneered the use of work analysis and performance measurement techniques for organizational development. He is a past President of North Carolina I/O Psychologists and former Editor of Ergometrika. He has served as a Principal Investigator with the Laboratory for Analytic Sciences since it opened five years ago. He developed the concept of “the people space” which he argues the IC ignores at its peril.

Using Work Analysis and Performance Measurement as Organizational Development Tools in the IC: The WestWolf Process

Traditional work analysis and performance measurement techniques are often time consuming and expensive to develop and maintain. In the fast changing world of knowledge organizations these limitations often doom them to irrelevance at best and a waste of resources and more importantly, valuable time at worst. A rapid collection and feedback system called WestWolf will be discussed which directly confronts these limitations will be discussed. All phases of the process will be discussed and visualizations of the data developed with intelligence analysts will be presented. Appropriate level of analysis and initial validation of the approach will also be presented. Owning the People Space is essential to high performance in the current environment and WestWolf is a potential tool to help in that effort.

Mark Wilson

Mark A. Wilson is an Associate Professor of Psychology at NC State University in the Industrial/Organizational Psychology Doctoral Program. He spent the early years of his career teaching in business schools. He received his Ph.D. in I/O from Ohio State University. His research interests include psychometric quality of work analysis, multidimensional models of job performance, and employee selection often in the context of law enforcement, US Army Special Forces, and intelligence analysis. He designed the current Trooper selection system for the North Carolina State Highway Patrol and founded the National Summit Meeting of Highway Patrols and State Police for Selection and Promotion Systems. He also designed a new selection system for Field Agents for the North Carolina State Bureau of Investigation. He has pioneered the use of work analysis and performance measurement techniques for organizational development. He is a past President of North Carolina I/O Psychologists and former Editor of Ergometrika. He has served as a Principal Investigator with the Laboratory for Analytic Sciences since it opened five years ago. He developed the concept of "the people space" which he argues the IC ignores at its peril.

WestWolf: Insights into the Fundamental Structure of Intelligence Analyst Workflow and Mission Performance

This poster examines the factor structure of workflow and performance data of intelligence analysts (n = 398). It identifies different subgroups of analysts and discusses what about workflow effects performance measures. This initial study will be followed by a second study that includes more analysts and looks at changes over time.

Matt Wolfe

Dr. Matt Wolfe is the director of VT-ARC's commercialization activities. In this position, Matt evaluates technology developed within the Virginia Tech enterprise and identifies those with promising commercial potential. Working with the Virginia Tech Center for Advancing Industry Partnerships (LINK) and Virginia Tech Intellectual Properties (VTIP), Matt develops business cases and strategies for bringing Virginia Tech technology-based products and services to market.

Before joining VT-ARC, Matt spent six years in the intelligence community as a civil servant performing S&T development, procurement, and technical operations activities. Prior to joining the federal government, Matt provided technical expertise in support of medical diagnostics, counter-WMD, and special operations forces technical programs at DARPA.

Matt holds a Bachelor of Science degree in Biochemistry (magna cum laude) from the College of Charleston, earned his doctorate in Biochemistry and Biophysics from the University of Minnesota, and performed research as a post-doctoral and Lenfant Biomedical fellow at the National Institutes of Health. He has published and presented original research and has authored numerous white papers and proposals that have led to the development of several advanced technologies.Learning to Fuse Information with Missing Modalities.

Genomics for Human Characterization: A Data-Driven Study of an Advanced Technology

The global research community has witnessed an explosion in S&T development and innovation in recent decades. As new discoveries beget novel applications and new technology enables more rapid discovery, the base of S&T knowledge is expanding rapidly and making its comprehension ever more challenging. Sponsored by the National Intelligence University and the Pacific Northwest National Laboratory, Virginia Tech Applied Research Corporation (VT-ARC) has developed a product to combat the challenge of quickly comprehending a large, growing body of S&T by students. By combining VT-ARC's proprietary machine learning and natural language processing algorithms and in-house subject matter expertise, we've created materials wherein individuals can rapidly search, read, and analyze topics, derived from a taxonomic analysis, on the state of the science of "Genomics for Human Characterization". Using these reference tools, students will be able to focus their time on specific topics of interest and acquire a "cliff's notes" version of the latest research findings, methods, applications, trends and trajectories within the larger domain.

Poster

Tysean Wooten

Tysean Wooten is from New Haven, Connecticut and is currently a Senior at North Carolina Central University. He is pursuing a degree in Environmental and Geographic Science with a concentration in Geoscience and a minor in Geographic Information Systems (GIS). He is adept at using geospatial techniques in GIS to assess environmental and geographic questions and issues.

Developing Geospatial Data in Support of Health Disparity Mapping in North Carolina

This study will be done on North Carolina Residents of multiple age groups in an 11-county study area to find the leading cause of death for a few health disparities affecting them. Such health disparities are brought about from a lack of food security so this study will also look at the income levels of areas that have a high concentration of one disparity. It is important to recognize the relationship between the deaths and their geospatial area to find out why certain health disparities are prevalent in certain areas. There will be queries done for the different type of deaths that come from these disparities by using the International Death Codes or ICD codes. Mapping these places with GIS will give a coherent visual and understanding of the areas affected while statistical graphs will show the significance of how income plays a role.

William C. Wright

LTC William C. Wright (PhD, University of Florida) is the Director of the Geospatial Information Science program at West Point, NY. LTC Wright began his career as an Armor officer in Cavalry units. In his early career he deployed with 3rd Armored Cavalry to Bosnia and Iraq. After his Troop Command, LTC Wright was selected into the Space Operations functional area where he served as a Missile and Space Domain Chief at NORAD. In that capacity he monitored and reported on events detected by strategic remote sensing systems. He teaches remote sensing, advanced remote sensing, surveying, computer cartography, and geographic information systems at the United States Military Academy. He recently returned from a summer deployment to Djibouti where he was embedded with the National Geospatial-Intelligence Agency. LTC Wright's research interests include modeling signal loss in complex environments, photogrammetry, Global Navigation Satellite Systems (GNSS), LiDAR, remote sensing and Geographic Information Systems (GIS).

The United States Military Academy and the National Geospatial Intelligence Agency Partnership: Today and Tomorrow—COL C. Oxendine and LTC W. Wright

This presentation discusses the current and future partnership between the United States Military Academy and NGA. Last year's research partnership falls within three main categories, (1) efforts with NGA's small Unmanned Aerial Systems (sUAS) research group, (2) Cadet research projects mentored by NGA analysts and West Point Faculty as part of independent studies or/and the Military Geospatial Operations course, and (3) NGA sponsored summer internships. An overview of each of these research efforts is presented. Additionally, as part of the internship program, LTC Wright presents his lessons learned from a summer deployment to Djibouti, Djibouti where he was embedded with the NGA Horn of Africa team. The partnership with West Point and NGA continues to benefit both organizations. An outline of approved future work is presented including a continuation of cadet research projects and internships along with studies exploring the different GEOINT requirements when conducting operations in megacities.

Sunita Yadav

Sunita Yadav is a Visiting Scientist in the NGA/Research Directorate via a program with the Oak Ridge Institute of Science & Education (ORISE) & the Department of Energy; she is current located at the USDA. Her research interests include: remote sensing of agricultural and natural systems with optical and radar imagery, phenology, sampling design and bias, ecological modeling, disease modeling, and reproducible science. With roots in integrated biology, she tries to apply her knowledge of evolutionary biology in her current work in remote sensing.

She received her B.S. in Computer Science from the University of Miami, M.A. in Geography from the University of Kansas, and a Ph.D. in Biological Science from the University of Cincinnati. Her dissertation research combined population genetic analysis with species distribution modeling to investigate environmental influences on breeding system distribution in a Hawaiian endemic plant genus. She has also worked on projects to understand species boundaries, plant-pollinator interactions in the Canadian Rockies, mapping persistence of bark beetle disturbance using an inter-annual time-series, and quantifying the performance of winter cover crops in the Chesapeake Bay.

Evaluating Training Data Needs for Crop Type Classification: How Much is Enough

In her role as an ORISE Visiting Scientist, Sunita Yadav, provides research expertise in key topics at the USDA International Production Assessment Division (IPAD). One of the main projects was to research primary literature, collate the various field data collection strategies employed by regional crop analysts, and communicate with analysts and partners to develop a robust and feasible sampling design based on hypothesis-based experiments. This protocol takes into account regional differences using global agro-ecological zones for stratification and testing different sample sizes in test regions to understand the minimum required sample size for IPAD in-situ reference data. Additionally, various algorithms were tested to classify crop types using global cropland data sets with and without time-series. This improved sampling methodology together with machine learning crop type classification models on the Google Earth Engine platform will allow IPAD to conduct faster analysis of their field collected data, apply statistical models, and customize sampling design to specific regions.

Sunita is interested to continue her work analyzing crop field delineation algorithms on different platforms. In addition, she is interested to apply her previous experience in distribution modeling in conjunction with earth observation data to analyze the effects of environmental factors on crop health and growth, crop phenotype, and pathogen range and distribution.

Brent Younce

Brent Younce is a software developer at the Laboratory for Analytic Sciences (LAS). He is a recent graduate with a Master's degree in computer science from North Carolina State University. Prior to his position as a software developer with LAS, he worked on a variety of web development, machine learning, and other software engineering projects with LAS in an intern role followed by in a graduate research assistant role. Within computer science, he is particularly interested in full-stack web development, distributed systems, and machine learning.

Social Sifter

As highlighted in major, public incidents such as Russia's efforts to influence the outcome of the recent presidential elections in the U.S., Germany, and France, it has become clear that social media has become an optimal target for malicious individuals and institutions to perform influence campaigns. Given the scope and scale of social media data, it is necessary to triage the data into a small network of key users, who drive the influence campaign. Current methods for this task, however, are slow, manual, and forensic. The Social Sifter project aims to provide a single interface which centralizes automated capabilities for collecting large scale social media data and rapidly triaging this data into small networks of interesting, influential, or organized users using a variety of models trained on a large collection of recently released public data from known foreign influence campaigns. These networks of key users can then be visually displayed alongside a variety of metrics and other data, to allow the analyst to monitor and assess these networks as they evolve over time.

The tool is designed with three main modular components: a cross-platform data ingress service, a network analysis service (the core of the project) which executes a variety of models to identify key interesting, influential, or organized users, and finally an interactive, web-based visual display of these networks. The network analysis service utilizes several models, such as Functional Data Analysis (FDA), Text Classification, and other supervised learning models, organized in a modular architecture to identify key users.

One of the features of the Social Sifter system is a new classification method to label social media users appropriately based on the user's online behavior. A user's behavior is treated as a binary time series, indicating times of activity. We consider a generalized multilevel functional model for the response profile. This model separates the user-specific variation from the day within user variation and from the mean trend, while accounting for additional covariate effects. The user-specific and within day user trends are estimated through functional principal components analyses. Classification of the users is accomplished through analyzing the user-specific trends. This multilevel structure has been explored in previous research, however applying this model with the purpose of classification has not been studied. Currently this approach is used for bot detection and identifying users who are working in cohort, but can be expanded to include many other classification labels. For the text classification model, another model built in to Social Sifter, we are utilizing a deep neural net based on the AWD_LSTM architecture, trained following the ULMFiT procedure. Finally, a random forest model uses user attributes alongside network features constructed from retweet networks, including in-degree centrality, out-degree centrality, and PageRank to classify users.