Presentation Abstracts

Dr. Halley Brantley, U.S. Environmental Protection Agency (EPA)

"Mobile Monitoring Data Processing and Analysis Strategies"

Author(s): Halley Brantley, Gayle Hagler, Eben Thoma

Abstract: The development of portable, high-time resolution instruments for measuring the concentrations of a variety of air pollutants has made it possible to collect data while in motion. This strategy, known as mobile monitoring, involves mounting air sensors on variety of different platforms including backpacks, bicycles, cars, and airplanes and is becoming increasingly more prevalent. Among the benefits of mobile monitoring is the ability to collect information over a large geographical area in a relatively short amount of time. Some of the recent applications of mobile monitoring using a vehicle platform include general air quality surveying, quantifying near-source air quality gradients around area sources such as highways, rail yards, and ports, and identifying and quantifying emissions from point sources such methane leaks. As this measurement strategy becomes more common, so does the need for innovative ways of processing and analyzing the complex, multi-pollutant, temporally and spatially variable datasets that are produced. Common data processing strategies employed include time-alignment, short-term emissions event detection, background standardization for discontinuous data sets, averaging techniques, and inverse modeling. These strategies were explored using several mobile monitoring datasets collected during recent field campaigns by EPA 's Office of Research and Development.

Dr. Kurt Bryan, Rose-Hulman Institute of Technology

"Compressed Sensing Techniques for Localization of Radio Frequency Emissions"

Author(s): Kurt Bryan and Deborah Walter

Abstract: In congested, contested spectrum environments mature technologies will employ various techniques for dynamic spectrum access. Currently, geolocation systems may detect the location of emitters, but a spectral-agile emitter may employ frequency-hopping. Radio mapping techniques are being developed to determine real-time spectrum use and the existence of white-space, but the location of the source of emissions is unknown. Consider a single uncooperative emitter that moves while changing frequency. If we try to locate the source of such emissions, it may appear that there are dozens of emitters. The goal of this research is to develop theory and techniques to simultaneously detect, identify, and locate uncooperative, spectral-agile emitters.

In this paper, we consider compressed sensing techniques using a distributed cooperative network of sensors to locate the source of stationary emitters. Questions of particular interest are: what is the optimal arrangement of sensors for locating RF emitters? How many sensors are needed for locating a given number of RF emitters? How does such a system perform in the presence of noise? We will also validate our approach with data collected using a physical testbed designed by a team of Rose-Hulman seniors, in response to an Air Force Research Laboratory Student Challenge.

Author(s) Biography: Kurt Bryan started at Rose in the fall of 1993. He received a B.A in mathematics from Reed College in 1984 and Ph.D. from the University of Washington in 1990, then spent 3 years in a post-doc at the Institute for Computer Applications in Science and Engineering (ICASE, RIP) at NASA Langley Research Center in Hampton, Virginia. He also worked from 1984 to 1990 as a statistician and mathematician at Blount Industries in Portland, Oregon. During the 1999-2000 and 2006-2007 academic years he took sabbaticals in the mathematics department at Rutgers University, and during the 2010-2011 year he was a Distinguished Visiting Professor at the U.S. Air Force Academy.

Ms. Cassandra Carley, IGERT WISeNet Trainee, Duke University

"2D Features for 3D Hand Tracking"

Author(s): Cassandra Carley and Carlo Tomasi

Abstract: We are developing a markerless system to track the joints of a moving human hand with a RGB-D sensor. In our system, an articulated musculoskeletal model of a hand is continuously fit to the sensor data. The current phase of our research focuses on using the shape of the hand's silhouette in the 2D color image from the sensor to initialize the search for the best-fit solution within the high dimensional space of hand-joint parameters. The second phase, which we leave for further research, improves model fit to data with a local optimization algorithm that refines the parameters of the 3D hand model. For initialization, we use graphics software and our model to construct a database of 3D hand configurations and their image silhouettes. A suitable descriptor for a new silhouette from the sensor is used as an index into the database to retrieve nearby hand configurations. The challenge is to design an index where nearby in index space correlates highly with nearby in hand-joint space. To this end, our descriptor captures the main convexities and concavities of the silhouette s boundary, which we believe are more telling of 3D hand configuration than the detailed boundary geometry. We use the notion of topological persistence to filter out irrelevant local extrema.

Dr. Suman Chakravorty, Texas A&M University

"Information Space Receding Horizon Control for Multi-Agent Systems"

Author(s): S. Chakravorty

Abstract: In this talk, we present a receding horizon solution to the problem of optimal scheduling for multiple sensors monitoring a group of dynamical targets. The term 'target' is used here in the classic sense of being the object that is being sensed or observed by the sensors. This problem is motivated by the Space Situational Awareness (SSA) problem. The multi-sensor optimal scheduling problem can be posed as a multi-agent Partially Observed Markov Decision Process (POMDP) whose solution is given by an Information Space (I-space) Dynamic Programming (DP) problem. We present a simulation based stochastic optimization technique that exploits the structure inherent in the problem to obtain variance reduction along with a distributed solution. This stochastic optimization technique is combined with a receding horizon approach which obviates the need to solve the computationally intractable multi-agent I-space DP problem and hence, makes the technique computationally tractable for such problems. The technique is tested on a moderate scale Space Situational Awareness (SSA) example which is nonetheless computationally intractable for existing solution techniques.

Author(s) Biography: Suman Chakravorty obtained his B.Tech in Mechanical Engineering in 1997 from the Indian Institute of Technology, Madras and his Doctoral degree in Aerospace Engineering from the University of Michigan, Ann Arbor in 2004. From August 2004- August 2010, he was an Assistant Professor with the Aerospace Engineering Department at Texas A&M University, College Station and since August 2010, he has been an Associate Professor in the department. Dr. Chakravorty s broad research interests lie in the filtering and control of nonlinear stochastic dynamical systems with application to autonomous distributed robotic mapping and planning, information space planning, and estimation and control of large scale systems. He is a member of AIAA and IEEE.

Dr. Rafael Fierro, University of New Mexico

"Synchronization of Heterogeneous Wireless Robotic Networks"

Author(s): Patricio Cruz, Luis Valbuena, and Rafael Fierro

Abstract: By using multiple robotic platforms with different dynamics and/or capabilities, it is possible to explore an area and detect targets faster than employing a team of homogeneous robots. In this work, we are interested in exploiting the heterogeneity of a robotic network made of ground and aerial agents. For instance, aerial vehicles have the capability to cover an area faster but cannot have a detailed view of caves or buildings. On the other hand, ground robotic platforms can only explore a limited area, but do so with much more accuracy. A reliable wireless connectivity among platforms is an important factor to be considered when dealing with this type of multi-agent systems. Here, we present our efforts for developing coordination and synchronization strategies to enhance connectivity of the wireless robotic network. To be more specific, we describe a target sensing algorithm for a ground mobile sensor network plus a specialized aerial router agent which is better equipped to communicate over longer distances. Since our intention is to combine radio communications and optical data transfer to have robust connectivity in GPS-denied environments, we outline also a formation control approach via stable synchronization of two teams: aerial and ground robots.

Author(s) Biography: Patricio Cruz received the BSc degree in Electronic and Control Engineering from the National Polytechnic School in Ecuador and the MSc degree in Electrical Engineering from the University of New Mexico. He is currently pursuing the PhD degree. His research includes control of heterogeneous systems.

Luis Valbuena earned his bachelor degree in Mechatronics Engineering at National University of Colombia. He is currently a graduate student at the ME Department at the University of New Mexico. His research interests include nonlinear control, hybrid systems, and multi-agent coordination.

Rafael Fierro is a professor of the Department of Electrical & Computer Engineering at UNM. He is the director of the Multi-Agent, Robotics, Hybrid and Embedded Systems (MARHES) Laboratory.

Dr. Ingo Fischer, IFISC (UIB-CSIC)

"Building a Reservoir Computer: Concept, Mechanisms, and Performance"

Author(s): Daniel Brunner, Miguel C.Soriano, Claudio Mirasso, and Ingo Fischer

Abstract: To learn from the brain how to process sensory information has been a fascinating perspective for several decades. Many advances have been made, and powerful computational schemes have been introduced. Nevertheless, even basic mechanisms and requirements of neural sensory information processing remain unclear. Here we choose a minimal design approach, implementing neuro-inspired computational concepts in hardware. This allows gaining insights into their requirements, particularities, robustness and performances. By reducing reservoir computing and related concepts to their bare essentials, we find that nonlinear transient responses of a simple dynamical system enable the processing of information with unprecedented performance and speed. A single nonlinear element with a delayed feedback loop suffices and moreover, allows us to investigate the underlying mechanisms and properties. Besides the relevance for the understanding of basic mechanisms, this approach opens direct technological opportunities.

Author(s) Biography: Ingo Fischer received the Diploma and Ph.D. degrees in physics from Philipps University, Marburg (Germany) in 1992 and 1995, respectively. He was with the TU Darmstadt, (Germany) from 1995 to 2004, and at the VUB (Brussels, Belgium) from 2005 to 2007. In 2007, he became a Full Professor in photonics at Heriot-Watt University, Edinburgh (U.K.) Since 2009, he has been a Professor at the Institute for Cross-Disciplinary Physics and Complex Systems, joint center of the Spanish National Research Council and the University of the Balearic Islands, Palma de Mallorca (Spain). His research interests include nonlinear photonics and bio-inspired information processing, in particular the emission properties and dynamics of modern photonic sources, coupled laser systems, synchronization of lasers and neurons, and utilization of chaos. Dr. Fischer received the Research Prize of the Adolf-Messer Foundation in 2000, and the first Hessian Cooperation Prize of the Technology Transfer Network in 2004.

Ms. Tierney Foster-Wittig, IGERT WISeNet Trainee, Duke University

"Visualizing a Gaussian Inverse Dispersion Technique: TheLlife of a Mobile Sensor"

Author(s): Tierney A. Foster-Wittig and John D. Albertson

Abstract: A Gaussian inverse dispersion technique is presented to determine the source strength of trace gas emissions from a point source. It was tested on controlled release of methane where concentration measurements are made with a wireless sensor at a stationary point between 30 and 150 m downwind of the source. Capturing the plume relies on the wind conditions to carry the plume to the sensor. Continuous wind and concentration measurements were used to model the plume at the sensor location.   The goal of this paper is to describe how this model is applied to the Duke immersive Virtual Environment (DiVE). This interactive environment will allow the user to be the sensor. They will be able to change the distance and angle to the source. For a mobile transect simulation, the user will move through the plume with a steady wind direction. For a stationary transect, the user will be able to change the wind direction experiencing how the concentration of the plume changes with wind direction.   For both simulations, the amount of measured concentration will be visualized based on color.   This visualization will give users an idea of mobile sensor application to air emission measurement.

Author(s) Biography: Ms. Tierney is a fifth year PhD Graduate Student at Duke University, and holds a B.S. in Civil Engineering from the University of Virginia.

Mr. Charles Freundlich, IGERT WISeNet Trainee, Duke University

"Advances in Stereo Vision for Remote Sensing"

Author(s): Charles Freundlich

Abstract: Mobile robotic systems designed for remote sensing need to be inexpensive, lightweight, and able to collect rich and informative data. In many cases, digital camera pairs, or stereo rigs, are an ideal sensor to use, but suffer from serious technical limitations. This presentation will describe some advances in stereo vision and show how we can leverage these advances to inform active sensing strategies that are designed to overcome these limitations. In particular, I will show that pixelation error in visual 3D reconstruction discretizes the world into irregular 3D cells. I derive a novel measurement function based on the argument that the reconstructed points should be located at the centroids of these cells. Moreover, I argue that the second central moments of the cells are actually the covariances of the reconstructions. I then propose a sensing strategy that uses the new measurement function and covariance expressions in a Kalman framework to create an optimal remote sensing policy that minimizes uncertainty. I discuss the theoretical and technical limitations to the various approaches to calculating such a policy, which is the topic of ongoing research.

Author(s) Biography: Charles Freundlich received his B.A. in Physics from Middlebury College in 2010. In 2012, he was awarded the Robert Thurston award for academic excellence upon receiving his M.Eng. in Mechanical Engineering with a focus in Robotics and Control from Stevens Institute of Technology. Charles is currently pursuing his Ph.D. at Duke University.

Mr. Nicholas Haynes, IGERT WISeNet Trainee, Duke University

"Reservoir Computing with Boolean Time-Delay Feedback Networks"

Author(s): Nicholas D. Haynes, David P. Rosin, and Daniel J. Gauthier

Abstract: We present our preliminary work developing a physical realization of a reservoir computing platform using a Boolean network with time-delayed feedback. The nodes of the networks consist of multiple-input XOR gates that accept an input (Boolean) voltage, and the links of the network are time-delayed using cascading inverter gates. We show that even networks with small numbers of nodes and short time-delay links exhibit favorable dynamics for reservoir computing, including a separation of input states, robustness to noise, and a fading memory. We also compare our approach to other physical realizations of reservoir computers, including time-delay optoelectronic networks, and to computer simulations of reservoir computers.

Mr. Dmitry Kalika, Duke University

"Hyperbolic and PLSDA Filter Algorithms to Detect Buried Threats in GPR Data"

Author(s): Dmitry Kalika, Kenneth D. Morton Jr., Leslie M. Collins, Peter A. Torrione

Abstract: Ground Penetrating radar (GPR) is a commonly used modality for the detection of buried threats. This work explores two approaches for buried threat detection in GPR data that we refer to as the hyperbolic filter and PLSDA filter algorithms. The hyperbolic filter algorithm leverages the hyperbolic shape of buried threat GPR responses, while the PLSDA algorithm uses a PLSDA linear classifer to learn a filter based on classifer weights. A hyperbolic filter is trained and optimized by doing a grid search over a set of hyperbola parameters. The PLSDA filter is generated by aligning GPR data and training PLSDA weights on that feature space. The correlation between each filter and the 2D GPR data provides information regarding the presence of buried threats. The PLSDA and hyperbolic filters were generated for a data set containing multiple target types. Both PLSDA and hyperbolic filters outperformed a prescreener for target subsets, and performed similarly over all target types. Relative to one another, both PLSDA and hyperbolic filters performed equally well. PLSDA filters, however, can be trained much faster than the corresponding exhaustive search needed by the hyperbolic filter.

Author(s) Biography: Dmitry is a graduate student working on his Ph.D in the SSPACISS lab at Duke University. His research interests include machine learning and pattern recognition with a focus on buried threat detection.

Mr. John Mallard, Duke University

"Field to Forecast: Leveraging Wireless Environmental Sensor Networks to Facilitate Real-Time Hydrologic Prediction"

Author(s): John Mallard, Brian McGlynn, Zachary Brecheisen, Mukesh Kumar, Norm Pelak, Amilcare Porporato, and Daniel Richter

Abstract: Forecasting hydrologic dynamics in streams and rivers is a well-recognized challenge. A variety of predictive methods exist that utilize watershed models, past hydrographs, or regionalized hydrologic behavior. Hydrologic response, however, is both spatially and temporally dynamic: the response to a given unit of precipitation will often vary strongly as a function of past conditions. Therefore, incorporating non-stationary behavior in modeling efforts could yield enhanced predicative ability critical to providing forecasts that are useful within the relatively short time-scales of, for example, extreme hydrologic events. Models that can ingest real-time information on system state variables (e.g. soil moisture and streamflow) to characterize prior states through time could capitalize on enhanced field to forecast capabilities provided by wireless sensor and communication networks. Here we propose an observational network that leverages wireless sensors within the Calhoun Critical Zone Observatory to evaluate the effectiveness of multi-input, real-time hydrologic forecasting systems as part of this multi-PI and institutional research program. This portion of the larger project focuses on watershed observation networks, runoff generation processes, and parsimonious hydrological models and forecasting tools.

Author(s) Biography: John Mallard is beginning his PhD in Fall 2014 in the Watershed Hydrology and Biogeosciences Laboratory at Duke University, advised by Dr. Brian McGlynn. He has a BS in Environmental Science from the University of North Carolina and an MS in Land Resources and Environmental Sciences from Montana State University, also advised by Dr. Brian McGlynn. His master's thesis, titled "The Role of Stream Network Hydrologic Turnover in Modifying Watershed Runoff Composition," focused on scaling interactions between surface and groundwater from the measurement scale (reach scale) to stream network scales. His PhD research interests focus on spatial and temporal variability in stream network extent; runoff generation in watersheds with deep, heterogeneous soils; distributed, wireless sensing of these processes; and integration with biogeochemical or ecological processes occuring within the critical zone.

Dr. Joshua Martin, Case Western Reserve University

"Controlling Movement in a Changing World: Lessons from an Insect Brain"

Author(s): Joshua P. Martin and Roy E. Ritzmann

Abstract: The flexible, autonomous behavior exhibited by even simple animals, such as insects, would greatly improve the performance of robotic agents. Here I present our work determining how the brains of two related insects, cockroaches and praying mantises, control movements and organize them into strategies suited to their changing environment and physiological drives. Adaptive behavior requires an orchestration of many factors, and the central complex (CC) of the insect brain plays a critical role in conducting that concert. The CC receives inputs from multiple sensors (e.g. vision and antennal mechanosensors) and inputs reflecting physiological state (e.g. hunger). The output of the CC directs movement: activity across the population is specific to locomotion state (forward walking, turning, climbing) and ultimately alters reflexes in the legs to effect the movement. However, we propose that the CC does not simply direct movement toward a goal, but rather can adapt a movement strategy to the current context. Bright light influences a cockroach to tunnel underneath a barrier rather than climb over it, but roaches with damage to the CC no longer switch strategies. Similarly, mantises switch from an ambush strategy to active pursuit when hungry. This switch is mediated by hormones that target the CC.

Author(s) Biography: Joshua Martin is a postdoctoral fellow at Case Western Reserve University. He received a B.S. in Biology from the Ohio State University and a Ph.D. from the University of Arizona, where he studied pheromone perception in moths. His interests involve the neural systems that underlie insect behaviors from sensation to action, focusing on comparisons between species using similar mechanisms to subserve different specialties.

Roy E. Ritzmann is a Professor in the Department of Biology at Case Western Reserve University. He received a B.A. in Zoology from the University of Iowa, and a Ph.D. in Biology from the University of Virginia. At a postdoctoral position at Cornell University he began work on the neural circuitry of escape systems in insects. His laboratory focuses on behavioral and neural properties that are involved in insect movement in complex terrain, most recently focusing upon context dependent control. He has also collaborated on many biologically inspired robotic projects.

Ms. Hanna Oh, IGERT WISeNet Associate, Duke University

"Satisficing Decision-Making Under Time Pressure"

Author(s): Hanna Oh, Pingping Zhu, Kimi Rafie, Marc Sommer, Silvia Ferrari, Jeff Beck, Tobias Egner

Abstract: The study of rational decision-making has traditionally focused on small-world scenarios, where decision-makers are assumed to have perfect knowledge of all possible choices, their respective probabilities and values, and ample time and computational resources to optimally integrate this information. In real life, we are instead faced with large-world scenarios, where some of the relevant information is unknown or highly uncertain, and decision-making is bounded by limited time and mental resources. Humans are thought to overcome such limitations through satisficing , fast but good-enough heuristic decision-making that prioritizes some sources of information while ignoring others. However, the manner in which satisficing is triggered and accomplished remains poorly understood. Here, we developed a novel probabilistic category learning protocol to induce and track such shifts in decision-making strategies. On each trial, participants chose between two stimuli that represented combinations of 4 different binary cues with varying reward probabilities. We manipulated the amount of decision time available, and employed logistic regression and variational Bayesian inference to quantify subjects decision-making strategies (i.e., their weighting of the cue values). We show that under low time pressure, participants performed like naïve Bayesians, correctly weighting and integrating all available cues to arrive at near-optimal decisions. With increasing time pressure, however, subjects gradually shifted their decision strategies by taking only a subset of the most predictive cues into account to arrive at fast yet good-enough decisions. These results, documenting adaptive re-weighting of cue values to compensate for limited decision time, are supportive of bounded rationality models of human decision-making.

Author(s) Biography: Hannah Oh received a B.E. in Interdisciplinary Engineering (with Bioengineering concentration) at the Cooper Union and earned an M.S. in Brain and Cognitive Sciences from Seoul National University. She is now a doctoral student in the Cognitive Neuroscience Admitting Program.

Pingping Zhu (Department of Mechanical Engineering and Materials Science)
Kimi Rafie (Department of Biomedical Engineering)
Marc Sommer (Department of Biomedical Engineering, Center for Cognitive Neuroscience)
Silvia Ferrari (Department of Mechanical Engineering and Materials Science)
Jeffrey Beck (Center for Cognitive Neuroscience)
Tobias Egner (Department of Psychology & Neuroscience, Center for Cognitive Neuroscience)

Mr. Daniel Pages, Duke University

"Sorting of Auditory Scenes in the Monkey Inferior Colliculus"

Author(s): D Pages, V Caruso, S Tokdar, and J Groh

Abstract: Real world auditory environments often contain many different sounds from many different sources. Effective interpretation of auditory scenes requires a process that that can divide the scene into its component sound sources. This is a difficult problem. Yet, humans and monkeys are good at locating and processing a single sound source even in auditory environments that contain many sounds, despite having only two sensors (ears). Our project uses extracellular recordings of action potentials (spikes) in the monkey inferior colliculus to determine where and how the brain achieves this. Our results show that most neurons in the inferior colliculus time their spikes in synchrony with the envelope of one preferred stimulus in the environment. This preference is only present when the animal is exposed to more than one sound at the same time, suggesting that its role is specific to more complex auditory environments. Results suggest that discrete representations may be one factor that contributes to the brain's ability to sort the auditory environment, and this code is present at the level of the inferior colliculus.

Author(s) Biography: Daniel Pages received an undergraduate degree from Oglethorpe University. He is currently pursuing a graduate at Duke University. His advisor is Professor Jennifer Groh.

Mr. Norman Pelak, Duke University

"Integrating Wireless Networks into the Calhoun Critical Zone Observatory"

Author(s): Norman Pelak and Amilcare Porporato

Abstract: We discuss preliminary results on the integration of wireless sensor network data into the Calhoun Critical Zone Observatory (CCZO) with ecohydrological models of soil, carbon and energy dynamics. Within the CCZO long-term experiment, wireless networks are utilized to support ecohydrological and biogeochemical measurements, as well as to examine the impact of human-forced changes in the long-term dynamics of the system.

In each of three CCZO watersheds, the soil moisture, temperature, and CO_2 concentration are measured at different soil depths by a group of co-located sensors. The related data are use to calibrate the parameters and test low-dimensional ecohydrological models to determine the water, carbon, and energy fluxes of the system. These models are composed of a series of coupled equations that describe the water, carbon and energy balance at different depth and times in the soil, revealing the complex interactions among soil evolution processes. A wireless network connects the soil sensor groupings so that data from these sensors can be accessed in real time. The real-time nature of the data allows for its use in a field-to-forecast manner, combining additional information such as weather forecasts and trends with the data to better parameterize the coupled models. This in turn leads to more accurate prediction of the future behavior of the ecohydrological system. The further benefits of the wireless network in relation to the remote monitoring of the site conditions in the event of failure or malfunction of the sensors are also discussed.

Author(s) Biography: Norm is a PhD student in the Porporato research group at Duke University, in the Department of Civil and Environmental Engineering. His current research focuses on modeling the biotic and abiotic processes affecting soil formation, as well as ecohydrological modeling at the Calhoun Critical Zone Observatory.

Mr. Hrishikesh Rao, Duke University

"A Computational Robotic Model for Studying the Neural Basis of Visual Perception"

Author(s): Hrishikesh Rao, Fred Shen, Juan San Juan, Kimi Rafie, Jenifer Villa, and Marc Sommer

Abstract: Frequent and rapid saccadic eye movements disrupt the continuity of visual information. We have developed a biologically-based, robot-embodied model of the visuomotor system to determine the neuronal properties necessary to stabilize visual perception across saccadic eye movements. Many neurons in the primate visual system exhibit predictive visual shifts, called pre-saccadic remapping, prior to the eye movement. Our hypothesis is that these neurons contribute to stabilizing the internal representations of objects across saccades. Visual information from a movable camera of a robot is fed into a neural network which culminates in a biologically relevant layer known to receive both visual information and impending oculomotor information (frontal eye field; FEF). The output of the model will guide arm movements of the robot. The entire system is tasked with one goal: accurately reaching to targets in space despite saccadic camera movements. Through the course of training, our network developed pre-saccadic remapping in the FEF layer similar to that seen physiologically. Scientifically, this model provides a means to test the hypothesis that pre-saccadic remapping is combined with eye position to achieve stable internal representations of objects across eye movements. Technically, this visuomotor model can be used to better the functionality of robotics and create systems that can actively interact with the environment.

Author(s) Biography: Hrishikesh Rao is a graduate student in the Biomedical Engineering program at Duke University. He is currently funded under the NSF Graduate Research Fellowship Program. Prior to coming to Duke, Hrishikesh completed his undergraduate degree, also in Biomedical Engineering, at the University of Minnesota. Currently into his third year, his primary interests are in studying the sensory consequences of saccadic eye movements. To tackle questions in neuroscience, he pursues biologically relevant computational modeling of the visomotor system. The aim is to test these computational findings in experimental setting.

Mr. David Raudales, IGERT WISeNet Trainee, Duke University

"Reduction of Noise and Vibration Transmission onto Wireless Sensors through Multi-Element Multi-Path Structural Design"

Author(s): David Raudales and Donald B. Bliss

Abstract: Wireless sensors are mounted on elastic structures subject to unwarranted vibrations deterring both signal fidelity and structural integrity. Reduction of vibration and noise transmitted to sensors can be achieved through multi-element/multi-path (MEMP) design: dividing a mounting system into several constituent subsystems with separate, elastically coupled, wave transmission paths. MEMP structures utilize the inherent dynamics of the system, rather than damping, to achieve substantial wide-band reduction in the low frequency range, while satisfying constraints on static strength and weight. The increased complexity of MEMP structures provides a wealth of opportunities for reduction, but the approach requires rethinking the structural design process. Previous analytical and experimental work on simple beam systems has been extended to elastically coupled concentric shells, this being the first multi-dimensional study of the concept. Subsystems are modeled using a modal decomposition of the thin shell equations with axially discrete azimuthally-continuous elastic connections occurring at regular intervals along the concentric shells. Large wide-band attenuation is achieved through several processes acting in concert: different subsystem wave speeds, mixed boundary conditions at end points, interaction through elastic couplings, and stop band behavior. Results show the concept can be applied to sensor mounts in environmental, aerospace, energy generating and automotive settings.

Author(s) Biography: David Raudales graduated from Duke University with a B.S. in mechanical engineering in 2013. During his undergraduate career, he researched on the topic of structural vibration attenuation as a Pratt Fellow under the guidance of Dr. Donald Bliss. Focusing on beam-like structures, he analytically and experimentally demonstrated a novel way to reduce the transmission of vibration: Multi-Element Multi-Path design. Now a first year PhD student at Duke and WISeNet trainee, David is continuing his research in the field of acoustics and aeroelasticity with his mentor, Dr. Bliss.

Mr. Matthew Ross, IGERT WISeNet Trainee, Duke University

"Controls on Soil Oxygen by Salt Marsh Plants in the Venice Lagoon"

Author(s): Matthew Ross, Emily Bernhardt, and Marco Marani

Abstract: In the Venice Lagoon, salt marshes provide a suite of ecosystem services such as hatching grounds, CO_2 and nutrient uptake, wave attenuation, and trapping sediment. For salt marshes to remain productive, they must maintain an elevation above average sea-level. These marshes are at high risk of being eroded away into less productive mud flats, because of rising sea levels, physical disturbance, and damage from boat waves. Changes in elevation occur due to changes in (1) inorganic sediment accretion or (2) organic sediment accretion. One way salt marsh plants can directly alter organic sediment accretion rates is by altering the biogeochemistry of the soil by pumping oxygen into anoxic soils. We tested the ability of plants to oxygenate flooded, anoxic soils using continuous monitoring of water pressure (dryness) and oxygen content at shallow (7cm) and deep (~25cm) depths. Our results suggest that plants can pump enough oxygen into the soil to oxygenate the entire soil profile, but only at high plant density and shallow depths. This result has significant implications for the biogeochemistry of organic sediment accretion and salt marsh erosion.

Author(s) Biography: Matthew Ross is a PhD Student in Ecology at Duke University; Emily Bernhardt is an Associate Professor in Biology at Duke; Marco Marani is a Professor in Civil and Environmental Engineering at Duke.

Mr. Weston Ross, IGERT WISeNet Trainee, Duke University

"Rapid Prototyping of Controllers for Autonomous Vehicles"

Author(s): Weston Ross

Abstract: The uses for unmanned vehicles are numerous and widely recognized, especially in the automotive industry and in the military where the removal of a human pilot in the control loop can both improve performance and reduce risk, especially to the pilot herself. Building an controller for unmanned systems using traditional control techniques, though, can be difficult, time consuming, and it is often times not easily adapted to different systems. This paper presents a method for quickly developing a controller using machine learning techniques, provided that the system is controllable by a professional human pilot, as most systems are. Such a controller can serve as the basis for an unmanned vehicle. Artificial neural networks (ANN) are learn the response of the human pilot controlling the system and then used in the controller to reproduce this response. We demonstrate the effectiveness of this technique on a high fidelity simulated race car.

Author(s) Biography: Wes Ross earned the B.S. degree in computer engineering from the University of New Mexico in May 2011. As an IGERT WISeNet trainee, Wes' research focuses on the fusion of behavioral sensing and human driver models for applications in ground vehicles to maximize combined vehicle and driver performance. (See the WISeNet Experiment on Intelligent Sensing and Control for Automotive Human Machine Interface and his IEEE CDC publication for more information about his work.) Outside of the lab, Wes is an active member of the departmental graduate student committee and of the outdoor student-lead leadership group called Building Outdoor Leaders and Doers (BOLD). He expects to graduate in May, 2017.

Mr. Keye Su, IGERT WISeNet Associate, Duke University

"Wind Farm Wake Steering As A Way To Optimize Performance Using Wireless Sensor Networks"

Author(s): Keye Su

Abstract: A wind farm is an array of closely spaced wind turbines located on land or at sea. A significant concern is the reduction of downwind turbine efficiency caused by energy-depleted upwind turbine wakes. This wake shielding effect dramatically reduces the efficiency of the downwind turbines operating in those wakes. This problem could be alleviated through a novel approach that steers the wakes upward, causing them to rise above the downwind turbines. This approach utilizes a tipped axis turbine instead of a more traditional horizontal axis turbine, resulting in the wake rolling up to form a diffuse vortex pair. However, the unsteady airloads resulting from tipping the turbine cause reduced operating efficiency and large unsteady structural vibration. Preliminary studies suggest the introduction of cyclic pitch control could mitigate this problem while preventing the upwind wakes from affecting the downwind turbines, provided the aerodynamic and vibratory state of the blades can be monitored continually in real time along their span. This calls for new applications of wireless sensor networks, making it possible to conduct blade pitch control, rotor tip control and rotor yaw control for each wind turbine to optimize overall wind farm performance.

Author(s) Biography: Keye Su is a first-year Ph.D. student from the Department of Mechanical Engineering and Material Science at Duke University. His research involves aerodynamics, acoustics, and computational modeling. In his spare time he enjoys playing soccer and reading history.

Dr. John Valasek, Texas A&M University

"Machine Learning Control for UAS Fixed Camera Motion Video Tracking of Ground Targets"

Author(s): John Valasek

Abstract: Unmanned Air Systems with video capturing systems for surveillance and visual tracking of ground targets have worked relatively well when employing gimbaled cameras controlled by two or more operators: one to fly the vehicle, and one to orient the camera and visually track ground targets. But autonomous operation of to reduce operator workload and crew levels is more challenging when the camera is strapdown, or fixed to the airframe without a pan and tilt capability, so that the vehicle must be steered to orient the Field of View of the camera. Visual tracking becomes even more difficult when the target follows an unpredictable path. A machine learning approach is developed for visual tracking of stationary and moving ground targets by Unmanned Air Systems with non-gimbaling, fixed pan and tilt cameras. The algorithm is based on Q-learning, and the learning agent determines offline (initially) a control policy for vehicle orientation and flight path such that a target can be tracked in the image frame of the camera without the need for human input. Monte Carlo results for the learned policies are presented for stationary targets, linear moving targets, and small or random changes in target speeds and trajectories.

Author(s) Biography: John Valasek is Director, Center for Autonomous Vehicles and Sensor Systems (CANVASS), Director, Vehicle Systems & Control Laboratory, Professor of Aerospace Engineering, and member of the Honors Faculty at Texas A&M University. He was previously a Flight Control Engineer for the Northrop Corporation, Aircraft Division where he worked in the Flight Controls Research Group, and on the AGM-137 Tri-Services Standoff Attack Missile (TSSAM) program. John is the author / co-author of three recent books: the first ever book on Morphing Aerospace Vehicles and Structures Wiley (2012); Advances in Intelligent and Autonomous Aerospace Systems AIAA (2012), and Nonlinear Multiple Time Scale Systems in Standard and Non-Standard Forms: Analysis and Control SIAM (2014).

John's research group is focused on establishing trust in autonomous systems so that they interact with humans and their environment safely, reliably, and predictably to mutually accomplish desired missions and tasks. This is being done by bridging the gap between traditional computer science topics and aerospace engineering topics in the areas of machine learning and multi-agent systems, intelligent autonomous control, vision based navigation systems, fault tolerant adaptive control, and cockpit systems and displays. This work has been funded by AFOSR, AFRL, ONR, NSF, NASA, FAA, and industry.

John has served as Chair of Committee to 41 completed graduate degrees, and his students have won national and regional student competitions in topics ranging from aircraft design to smart materials to computational intelligence. He has also supervised the research of 54 undergraduate students. John s Ph.D. student was the 2013 recipient of the Texas A&M University Award for Outstanding Accomplishment in Research, Doctoral Level, for a dissertation titled Analysis and Control of Non-Affine, Non-Standard Singularly Perturbed Systems.

John earned the B.S. degree in Aerospace Engineering from California State Polytechnic University, Pomona in 1986 and the M.S. degree with honors and the Ph.D. in Aerospace Engineering from the University of Kansas, in 1990 and 1995 respectively.

Mr. Patrick Wang, IGERT WISeNet Trainee, Duke University

"Perspective-Informed Object Detection"

Author(s): Patrick Wang, Peter Torrione, Leslie Collins, and Kenneth Morton

Abstract: The typical approach to object recognition under varying perspectives is to train a classifier with examples from a wide variety of perspectives. In this case, only a subset of the training examples are informative with respect to any given test image, and it is the classifier's responsibility to sort out which training examples are relevant. We propose an alternative for applications that use features based on gradient information, such as the histogram of oriented gradients. Given the relative poses and intrinsic properties of the cameras, the features extracted from all perspectives are transformed to a common projective space. Training examples from a small subset of perspectives can thereby be used to detect objects under any, potentially disjoint, subset of perspectives. This method allows use of a limited variety of training examples with a simple classifier, while achieving results competitive with current approaches.

Author(s) Biography: Patrick K. Wang received the B.S. degree in biomedical engineering in 2011 and the M.S. degree in electical and computer engineering in 2013, both from Duke University. He is currently pursuing the Ph.D. degree in Electrical and Computer Engineering, also at Duke University. His major research interests include computer vision and machine learning.

Kenneth D. Morton Jr. was born in York, PA, in 1982. He received the B.S. degree in electrical and computer engineering from The University of Pittsburgh, Pittsburgh, PA, in 2004 and the M.S. and Ph.D. degrees in electrical and computer engineering from Duke University, Durham, NC, in 2006 and 2010 respectively. He is currently an Assistant Research Professor at Duke University with research focused on the use of nonparametric Bayesian methods for a variety of applications including acoustic signal processing and landmine detection.Dr. Morton is a member of Tau Beta Pi and Eta Kappa Nu.

Peter Torrione received the B.S.E.E. degree from Tufts University in 1999, and the M.S.E.E. and Ph.D. degrees in electrical engineering from Duke University in 2002 and 2008. He is currently an Assistant Research Professor at Duke University where his interests include physics-based statistical signal processing, pattern recognition, and machine learning.

Leslie M. Collins was born in Raleigh, NC. She received the B.S.E.E. degree from the University of Kentucky, Lexington, in 1985, and the M.S.E.E. and Ph.D. degrees in electrical engineering, both from the University of Michigan, Ann Arbor, in 1986 and 1995, respectively. She was a Senior Engineer with the Westinghouse Research and Development Center, Pittsburgh, PA, from 1986 to 1990. She joined Duke in 1995 as an Assistant Professor and was promoted to Associate Professor in 2002. Her current research interests include incorporating physics-based models into statistical signal processing algorithms, and she is pursuing applications in subsurface sensing as well was enhancing speech understanding by hearing impaired individuals. Dr. Collins is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

Mr. Hongchuan Wei, IGERT WISeNet Associate, Duke University

"Information Value for Nonparametric Dirichlet Process-Gaussian Process Dynamic System Motion Model"

Author(s): Hongchuan Wei, Wenjie Lu, Silvia Ferrari, Miao Liu, Lawrence Carin, Robert H. Klein, Shayegan Omidshafiei, and Jonathan P. How

Abstract: This poster presents a hybrid information value function that can be utilized in online planning for a sensor with limited field-of-view (FoV) to learn complex target behaviors. The target behaviors are said to be complex since the targets can follow a potentially infinite number of unknown motion patterns. Under the assumption that each motion pattern can be depicted as a velocity field, the target behaviors can be described by the Dirichlet process-Gaussian process (DP-GP) mixture model, which has been successfully applied in clustering time invariant spatial phenomena due to its flexibility to adopt the complexity from data without overfitting. The hybrid information value function is designed to cope with the DP-GP mixture model, and is consisted of two parts: the expected Kullback-Leibler (KL) divergence, which makes the sensor to explore and learn the most uncertain part of the DP-GP mixture model; and the expected mutual information, which guides the sensor to exploit the learnt model for tracking the targets. A greedy algorithm is designed utilizing the hybrid information value function as the objective function. Simulation results show that the error and uncertainty in describing the target behaviors decrease faster via the greedy algorithm than algorithms that only consider target tracking.

Author(s) Biography: Hongchuan Wei received the BS degree from the Department of Automotive Engineering, Tsinghua University, Beijing, China. Currently, he works with the Laboratory for Intelligent Systems and Controls, Duke University, Durham, NC. His research interests include sensor network deployment and motion planning, human pilot controller design, and nonparametric Bayesian model.

Dr. Thomas Wettergren, United States Navy

"Field Design Considerations for Distributed Undersea Acoustic Sensor Networks"

Author(s): Thomas A. Wettergren

Abstract: Distributed acoustic sensor networks present an opportunity for underwater surveillance at an affordable cost with limited manning. While much work goes into the detailed design of specific nodes for such systems, there is another layer of design consideration in examining how the distributed nodes relate to one another in placement, communication, and decision making. In this talk, we describe a set of analytical techniques that have been developed to assist with these field-level design considerations for underwater acoustic sensor networks. Specifically, we illustrate a node-size vs. node-density calculus for determining the number of required sensors, and then illustrate how different levels of collaboration and mobility affect those considerations. We also show how adaptive control techniques can be used to autonomously manage these networks to efficiently manage battery usage and extend the system-level longevity. Finally, we discuss the intersection of these methods with the science of autonomy for the examination of groups of unmanned vehicles performing cooperative sensing.

Author(s) Biography: Thomas Wettergren received the B.S. degree in electrical engineering and the Ph.D. degree in applied mathematics, both from Rensselaer Polytechnic Institute in Troy, NY, USA. He joined the Naval Undersea Warfare Center in Newport, RI, in 1995, where he has served as a Research Scientist at the Torpedo Systems, Sonar Systems, and Undersea Combat Systems Departments. Dr. Wettergren currently holds the position of the US Navy Senior Technologist in operational and information science, in which he leads and performs on a variety of basic and applied research projects. He also serves as an Adjunct Professor of Mechanical Engineering at Pennsylvania State University. His personal research interests are in the mathematical modeling, analysis, optimization, and control of undersea sensing systems. His professional awards include the NAVSEA Scientist of the Year, the Assistant Secretary of the Navy Etter Award, and the IEEE-USA Harry Diamond Award.

Ms. Tiffany Wilson, IGERT WISeNet Trainee, Duke University

"Seasonal Signals in Rainfall Depth Distributions Based on Wet and Dry Period Transition Probabilities"

Author(s): Tiffany G. Wilson and John D. Albertson

Abstract: Hydrologic models typically require meteorological data on scales finer than one day to accurately predict hydrological response to precipitation events. Accordingly, it is desirable to be able to generate rainfall time series on the hourly scale based on existing data. One of the methods used to generate hourly rainfall is to create a stochastic model based on the conditional probabilities for transitions from wet to dry periods, then to randomly select a rainfall depth from a known distribution. This work focuses on the rainfall depth distributions, namely if different distributions should be selected based on whether the previous period is wet or dry. We analyze existing records of both 30- and 60-minute precipitation for stations in varying climates to learn about the seasonal signals of these transition-based precipitation distributions with the ultimate goal of using these characteristics for fine-scale rainfall generation.

Author(s) Biography: Tiffany Wilson is in the fifth year of PhD studies in the Civil and Environmental Engineering Department at Duke University. She is a James B. Duke Fellow and Pratt-Gardner Fellow. Tiffany has been a WISeNet Trainee for 2012-2013 and 2013-2014, will participate in the Bass Online Apprentice Fellowship program in Summer 2014, and is earning a Certificate in College Teaching. Tiffany plans to graduate in December 2014.

Mr. Xu Zhang, IGERT WISeNet Associate, Duke University

"Spike-Based Indirect Training of a Spiking Neural Network-Controlled Virtual Insect"

Author(s): X. Zhang, Z. Xu, C. Henriquez, and S. Ferrari

Abstract: Because of the capability of spiking neural network on replicating the spike patterns, learning via biologically-plausible mechanisms, such as synaptic time dependent plasticity (STDP), they are commonly utilized to model cultured neural network, and memristor-based neuromorphic computer chips that aim at replicating the scalability and functionalities of biological circuitries. These applications do not allow for the direct manipulation of the synaptic strength as required by existing algorithms. Therefore, an indirect training approach is developed by Laboratory for Intelligent Systems and controls (LISC) for application in real biological neural culture. The method is founded on using extra light to force the neurons to fire so that the synaptic strength can be modified based on the Spike Timing-Dependent Plasticity (STDP). So in place of the weights, the algorithm manipulates the input stimulus used to stimulate the input neurons by determining a sequence of spike timings that minimize a desired objective function and, indirectly induce the desired synaptic plasticity in the network. The training algorithm is tested in training a spiking neural network-controlled virtual insect for navigating in an unknown terrain by avoiding rough terrain and finding its food.

Author(s) Biography: Xu Zhang received the B.S. degree in Mechanical Engineering and Material Science from the University of Shanghai for Science and Technology. He is now a Ph.D. student working with Dr. Silvia Ferrari in the Laboratory of Intelligent System and Control (LISC), in the department of Mechanical Engineering and Material Science at Duke University. His research interests include indirect training method for spiking neural network, function approximation, application of indirect training method on robot path planning, machine learning, and computational neuroscience.

Mr. Xiaochi (Joe) Zhou, IGERT WISeNet Associate, Duke University

"Development of Wireless Air-Monitoring Sensor Package for Aerial-Sampled Emissions from Open Burning"

Author(s): Xiaochi Zhou

Abstract: Air sampling of open-area emissions can be used to determine the pollutant source strength, and predict the downwind human and environmental risk using atmospheric dispersion modeling. During emission events, ground based sampling methods will often face sensor placement problems due to changes in wind direction and the need to optimize measurement accuracy without compromising the safety of sensors and the operating personnel. In contrast, aerial sampling methods can overcome this problem with high maneuverability. However, pilot-controlled airplanes and helicopters are not ideal for quick and near-plume air sampling mainly due to high operating cost and high safety risk when flying at low altitude under limited visibility and strong near-ground turbulence. The use of pilotless remote-controlled helicopters/multicopters could be a cost-effective and reliable candidate for air sampling. However, the limited payload capacity on these systems prevents the use of big and heavy onboard batteries, sensors, and data loggers.

To overcome this problem, a small, light-weight, and power-efficient air monitoring sensor package, which includes low-cost air quality sensors, a microcontroller (Arduino), and a wireless communication network (Zigbee), is under development at the Environmental Protection Agency (EPA). As a first step, a nondispersive infrared carbon dioxide gas sensor (DX6220) and a carbon monoxide electrochemical sensor (EC4-500) are rigorously tested in the lab and the field to quantify their performance, including accuracy, noise, delay, and zero-drift. Meanwhile, Arduino-based data logging and wireless communication programs are being developed to obtain real-time data and help position the remote-controlled aerial system. In the future, this sensor package will be loaded in an unmanned air vehicle for monitoring of open burning emissions.

Author(s) Biography: Xiaochi Zhou is a Ph.D. student at Civil and Environmental Engineering department at Duke University. His research interest includes: remote sensing retrieval of coastal water quality, wireless sensor network for air quality and hydrological measurement.

Mr. Xiaochi (Joe) Zhou, IGERT WISeNet Associate, Duke University

"Hillslope Scale Soil Moisture Monitoring Using a Wireless Sensor Network: A Case Study in Sardinia, Italy"

Author(s): Xiaochi Zhou and John D. Albertson

Abstract: At hillslope scale, the temporal dynamics of mean and variance of soil moisture and their relationship under steep topography and strong rainfall seasonality is poorly understood. In this study, we use a wireless sensor network (WSN) to monitor soil moisture and soil matric potential along a hillslope in Sardinia Island, Italy, which has a Mediterranean climate featured by dry summer and wet winter. This WSN includes three remote stations and a base station. Each remote station is equipped with 16 soil moisture sensors, which are placed on the top soil layer (30 cm below ground) horizontally in a 4-by-4 matrix with a sensor-to-sensor spacing of 2 meters, and 2 soil matric potential sensors which are placed at 0.3 and 1 meter below ground, respectively. These three remote stations are placed on the top, backslope, and the foot of a hillslope-to-channel transition, respectively. The base station wirelessly receives data from remote stations at every 10 minutes and periodically upload them to an online database. Based on this dataset, we will first develop a physical-based model to explore the influence of local (topographic and vegetative) and regional (climate) factors in the evolution of soil moisture mean and variance in a semiarid Mediterranean hillslope. In addition, the impact of spatial scale will be studied by comparing model results at patch scale (individual remote station) with hillslope scale (integrating all stations), which could be associated with the wetness index derived from hillslope DEM.

Author(s) Biography: Xiaochi Zhou is a Ph.D. student at Civil and Environmental Engineering department of Duke University. His research interest includes: remote sensing retrieval of coastal water quality, wireless sensor network for air quality and hydrological measurement.

Dr. Albertson's research interests include surface hydrology and boundary layer meteorology; semi-arid vegetation dynamics; Large eddy simulation of turbulence and turbulent transport; urban air quality; hydroclimatic controls on infectious disease dynamics.

Mr. David Zielinski, Duke University

"ML2VR: Providing MATLAB Users an Easy Transition to Virtual Reality and Immersive Interactivity"

Author(s): David J. Zielinski, Ryan P. McMahan, Wenjie Lu, and Silvia Ferrari

Abstract: MATLAB is a popular computational system and programming environment that is used in numerous engineering and science programs in the United States. One feature of MATLAB is the capability to generate 3D visualizations, which can be used to visualize scientific data or even to simulate engineering models and processes. Unfortunately, MATLAB provides only limited interactivity for these visualizations. As a solution to this problem, we have developed a software system that easily integrates with MATLAB scripts to provide the capability to view visualizations and interact with them in virtual reality (VR) systems. We call this system 'ML2VR' and expect it will introduce more users to VR by enabling a large population of MATLAB programmers to easily transition to immersive systems. We will describe the system architecture of ML2VR and report on a successful case study of robot path planning involving the use of ML2VR.

Author(s) Biography: David J. Zielinski is a research and development engineer at Duke University in the Pratt School of Engineering. He is a member of the DiVE Virtual Reality Lab, under the direction of Regis Kopper (2013-present) and previously Rachael Brady (2004-2012). He is an experienced software engineer who received his bachelors (2002) and masters (2004) degrees in Computer Science from the University of Illinois at Urbana-Champaign. He has experience in the design and implementation of virtual reality experiences. He is also experienced in the hardware configuration and systems integration issues of virtual reality systems. His virtual reality research interests include: software systems, interaction techniques, tracking systems, and domain specific applications. He has additional interests in audio synthesis and physical computing via Arduino.