PAST ICTAS RESEARCH AWARDS

RESEARCH AWARDS FROM 2019

EFO OPPORTUNITY SEED INVESTMENT GRANT FUNDS

"A Distributed Network of Bio-hybrid Micro-robots for Treatment of Unresectable Solid Tumors,"
Bahareh Behkam, Department of Mechanical Engineering

"VT Center for Reversing the Freshwater Salinization Syndrome in Urban Watersheds,"
Stanley Grant, Department of Civil and Environmental Engineering

"Multidisciplinary Studies to Improve Understanding of Influenza Transmission,"
Linsey Marr, Department of Civil and Environmental Engineering

"Materials Under Extreme Conditions," Kathy Lu, Materials Science Engineering

"Preparations of a UTC Proposal for Establishing National Center for Revitalization of Infrastructure Systems (NCRIS)."
Linbing Wang, Department of Civil and Environmental Engineering

Noise Produced by Small Unmanned Aerial Systems (sUAS) and Flight Path Planning to Minimize Population Annoyance

Principal Investigator: W. Nathan Alexander
Co-Principal Investigator: Antonio Trani

Abstract:

Commercial and military use of sUAS is increasing rapidly, but these systems produce significant noise. The community impact of flight operations needs to be studied so procedures can be developed to minimize community annoyance or to operate these platforms in acoustic stealth. The proposed project will conduct a comprehensive assessment of sUAS noise to produce predictive tools that can characterize the noise through all phases of flight. These results will be used to generate Noise Power Distance curves which will be input into flight planning software originally developed to estimate community noise from civil air transportation. This software will be modified to include distinct features of sUAS operations including low altitude maneuvers which produce transient increases in noise and appropriate noise metrics that account for the annoyance qualities of sUAS. The developed software will be used to investigate flight path planning procedures designed to minimize community impact. Also, effects of operational maneuvering limits and noise reducing sUAS designs and technologies on population noise exposure will be evaluated. This work aligns with the Intelligent Infrastructure for Human-Centered Communities and Integrated Security Destination Areas by providing guidance to policy makers regarding safe, secure, and effective integration of sUAS technology into society. Future funding will target government organizations including NASA, FAA, ARO, and AFOSR as well as industrial partners such as Aurora Flight Sciences, Google, and Amazon.

Developing a novel platform for generating flavivirus vaccines

Principal Investigator: Jonathan Auguste

Abstract:

Safe and effective FDA approved vaccines for mosquito-borne viruses continue to remain elusive. Recently a new approach was developed for generating vaccines against mosquito-borne alphaviruses using a host restricted (i.e. mosquito-specific) alphavirus, Eilat virus (EILV), as a vector. EILV's structural proteins were substituted with those from chikungunya virus, an important pandemic human pathogen. The major advantages of this insect-specific virus-based platform for vaccine development include the safety of the chimeric virus by virtue of its complete defect for replication in vertebrate cells, and increased immunogenicity due to lack of inactivation requirements that typically result in antigenic degradation using traditional methods. These chimeras are highly immunogenic and protect against all aspects of disease after a lethal challenge. Herein, I propose to develop an analogous platform for flaviviruses. The genus Flavivirus contains several important human pathogens such as dengue, yellow fever, West Nile (WNV), and the recently emergent Zika virus (ZIKV). The foundation for this new platform will be a recently discovered, mosquito-specific flavivirus, tentatively designated Aripo virus (ARPV). This platform has even greater commercial potential than Eilat due to the vast abundance of medically important flaviviruses worldwide, and the multi-billion-dollar market associated with vaccine development for these pathogens. To generate proof-of-principle data and attract funding and commercial interest, we propose to: 1) characterize developed Aripo/Zika and Aripo/West Nile chimeric viruses, and confirm their inability to replicate in vertebrate cells; 2) identify and insert adaptive mutations into the infectious clones of both chimeras to optimize their replication in mosquito cells; 3) evaluate the safety and efficacy of the Aripo/Zika and Aripo/West Nile chimera as vaccine candidates using established mouse models; and lastly 4) characterize the immunological effects of both chimeras in vivo. Demonstrating the efficacy of this platform will be extremely attractive not only for commercial human and veterinary flavivirus vaccines, but for other viruses in the family such as hepatitis C virus. To ensure the successful completion of this project, a multi-departmental team was assembled to combine the expertise of an immunologist, vaccinologist and veterinarian, and a medical entomologist and molecular virologist.

Leveraging Metagenomic "Big Data" for the Discovery of Novel Microbial Diversity in the Biosphere

Principal Investigator: Frank O. Aylward

Co-Principal Investigator: Liqing Zhang

Abstract:

Advancing our knowledge of the extent and nature of biodiversity on Earth is a fundamental challenge in Biology. The largest uncharacterized reservoir of phylogenetic diversity on the planet resides in cryptic lineages of Bacteria and Archaea, often referred to as "microbial dark matter", that cannot be cultivated in the laboratory and are only known to exist from cultivation-independent molecular methods. Understanding the physiology, evolutionary history, and environmental impact of these groups is a major frontier for future research, and studies in this area have already led to the discovery of new antibiotics1,2, transformative revelations regarding the evolution of complex life3, and the characterization of previously unknown forms of cellular metabolism that shape global elemental cycles4. Advances in high-throughput DNA sequencing together with other developments in the field of metagenomics over the last ten years have provided an unprecedented amount of "'omic" data that can now be mined to discover microbial lineages with novel and cryptic physiologies, but novel computational methods are required for leveraging this "big data" to achieve these biological insights. Here we propose to develop a novel computational methodology to assess microbial diversity in metagenomic data through analysis of sequences of RNA polymerase, a high-resolution phylogenetic marker gene that provides accurate taxonomic assignments for Bacteria and Archaea and can be leveraged to identify and classify cryptic microbial lineages in the biosphere. Our method combines sophisticated gene neighborhood and machine learning algorithms, and we anticipate it will be highly impactful in uncovering novel microbial diversity in massive 'omic sequencing datasets.

Macroscopic Synthetic Trees for Water Extraction and Energy Harvesting

Principal Investigator: Jonathan Boreyko

Abstract:

We propose to develop large-scale synthetic trees that can spontaneously extract and elevate water from a lower reservoir for water and energy harvesting applications. The passive pumping mechanism of our synthetic tree system is quite simple: by using wetted nanoporous media that mimic leaf tissue, nanoscale concave menisci are formed at the evaporating interface which generates a highly negative water pressure by virtue of the Laplace equation. Our preliminary results have already shown that by connecting an array of macroscopic tubes to a nanoporous disk, this negative pressure can extend all the way down to the free end of the tubes, turning them into super-powerful "straws" capable of continuously extracting and elevating water from a lower reservoir. Over the past decade, other groups have made primitive synthetic trees, but they have always been micro- scale in size and typically focused purely on the nanoporous "leaf" material and the thermodynamics of the negative pressure water contained within. Here, our unprecedented novelty is to couple arrays of long, millimetric tubing to a macroscopically large nanoporous film to probe the upper limits of a synthetic tree's ability to lift water high off the ground with a large throughput. Specifically, we will show two concepts for the first time: (1) That a synthetic tree can extract water from soil and elevate it above-ground for water harvesting applications, and (2) That a sufficiently tall synthetic tree can elevate water in an upper reservoir for pumped storage hydropower applications. The PI, Assistant Professor Jonathan Boreyko, has already spent four years developing a scale- model prototype synthetic tree system that is already showing excellent stability. The co-PI, Professor David Schmale III, has access to Conviron "growth chambers" that are two stories tall with environmental control, which will be used to test 10m tall synthetic trees needed to secure follow-up external funding.

Scalable Nano-integrated Fiber Arrays for Multifunctional Neural Interfacing

Principal Investigator: Xiaoting Jia

Abstract:

The objective of the proposed project is to address a key challenge in utilizing advanced nanotechnology in scalable neural interface applications, using a non-conventional multimaterial fiber drawing and patterning platform. The methods to be employed include thermal drawing of multimaterial multifunctional fibers, nanomaterials processing, optical, electrical and microfluidic characterization, femtosecond laser 3D micromachining, in vivo neural stimulation and recording, as well as theoretical modeling. The proposed research will extend current knowledge on the following key areas: (1) Nanomaterials: How do nanomaterials behave under high temperature, stress, and shear flow during thermal drawing? (2) Micro/nanofabrication: How can we manufacture nanomaterials in a scalable manner in order to create high spatial resolution and multiplexing devices? (3) Opto-electro-microfluidics: How can we fabricate and characterize multifunctional fibers, and extend the fiber functionality from conventional 1D probes to 3D devices? (4) Neuroscience and neural engineering: How can we detect and interpret seizure onset signals, and use optical, electrical, or microfluidic methods to intervene in the seizure event? If successful, this project will enable the next generation neural interface devices with high flexibility, biocompatibility, high spatiotemporal resolution, and multifunctional capabilities, and facilitate our understanding of complex brain functions as well as the treatment of neurological diseases.

Designing High Energy Anode Materials for Long Life and Safe All-Solid-State Batteries

Principal Investigator: Feng Lin

Abstract:

The large and growing lithium-ion battery market (recently projected to reach $46.21 billion by 2022) provides strong incentives to continue development, especially as new opportunities in vehicular applications and large-scale energy storage emerge. All-solid-state batteries, in particular those utilizing the lithium metal anode (specific capacity of 3,829 mAh/g and 2,061 mAh/cm3, electrochemical potential of -3.04 V vs the standard hydrogen electrode), are considered the “Holy Grail” of the battery future and are intensively studied for the next-generation battery technology. However, all- solid-state batteries encounter significant fundamental challenges, including lithium dendritic growth, low Coloumbic efficiency, and high interfacial impedance at the lithium-solid electrolyte interface. To resolve these challenges, integrating experiments and theoretical modeling, we propose to design function- gradient lithium/carbon composite anodes that consist of a lithiophobic surface layer and a lithiophilic three-dimensional (3D) carbon host. During the charging and discharging of an all-solid-state battery, the lithium plating and stripping take place in the lithiophilic 3D carbon host with minimal volume change, and the stable solid-electrolyte interphase (SEI) forms between the lithiophobic surface layer and the solid electrolyte. This new anode design is conceptually distinct from those reported in the literature and can potentially lay the foundation for high current density (>2 mA/cm2) and high areal capacity (>6 mAh/cm2) all-solid-state batteries. The proposed research will overcome the lithium challenges listed by the Department of Energy ARPA-E’s Perspective article [Nature Energy 3, 16-21 (2018)] and can potentially lead to a revolutionary advancement of high energy anode materials for all-solid-state batteries. Finally, our proposed fundamental research aligns with the basic research needs for next generation electrical energy storage identified by DOE/BES [DOE Workshop and Report, Mar 27-29, 2017].

Augmenting Computer Vision with Crowdsourcing to Identify People in Historical and Modern Photographs

Principal Investigator: Kurt Luther

Abstract:

Identifying people in photographs is a critical task in a wide variety of domains, from national security to journalism to human rights investigations. Yet, this task is challenging for both state- of-the-art computer vision approaches and expert human investigators. Automated face recognition technologies are powerful tools, but can be limited by real-world constraints such as poor quality imagery, exclusion of relevant distinguishing features, and high false positives.

We propose an innovative solution to overcome these constraints by augmenting face recognition with crowdsourced human visual capabilities, aiming to improve “last mile” analysis where users must carefully analyze many high-quality candidates. In Year 1, we will develop and test our approach in the context of identifying people in historical photographs, specifically American Civil War soldier portraits, which offer rich visual clues and compelling motivations for identification, but with relatively lower risk than living subjects. Our proposed solution is a novel five-step software pipeline, built on the foundation of a website called Civil War Photo Sleuth, that leverages the complementary strengths of crowdsourcing and computer vision. A user seeking to identify a soldier portrait categorizes visual clues with tags that are linked to a reference database of 15,000 identified soldier photos and corresponding military service records. These tags serve as filters to narrow the search results, which are further narrowed and sorted by face recognition. Finally, a crowdsourcing workflow searches the most similar candidate photos for distinctive features identified by the user, who can review a shortlist and confirm the identification.

In Year 2, we will evaluate the benefits of our novel pipeline with three studies. The first experiment will compare our crowdsourced approach to two computer vision-based techniques, while the second experiment will compare expert usage of our system versus experts’ current, largely manual investigation methods. A third, longitudinal study will shed light on our software’s real-world impact on professional researchers over a one-month usage period.

Our proposed research promises to transform historical research of visual material and build the foundation for significantly more effective techniques for modern person identification in national security and law enforcement contexts.

The Language of Online Extremism - Computational Models for Discovery and Analysis of Framing around Extremists' Narratives

Principal Investigator: Tanushree Mitra

Co-Principal Investigator: James Hawdon

Abstract:

This project studies framing in the context of social movements, specifically online collective action movements advocating for extremism, hate speech, and xenophobic ideologies. Framing is a central concept in social sciences that refers to how an issue is portrayed, how the problem is defined, what solution is offered, how it is offered and to what people it is linked to, etc. From a social movements' perspective, the appeal of extremist messages to potential recruits, rests in part how the message is framed, that is, whether it aligns with the individual's ideology and identity, and whether it is strong enough to persuade the individual to join the movement. This process of frame construction, interpretation, amplification and transformation to mobilize potential adherents, garner bystander support, and demobilize antagonists, often happen online through popular social media platforms, like Twitter, Facebook and Reddit. How do these frames form and then evolve over time to set a hateful agenda in motion? How can we study their characteristics, and how can we do that at scale, without the overhead of labor intensive content annotation? Can we devise new models and analytical frameworks that automatically identify the underlying frames from online content? By empirically investigating social media content from known extremist groups, this proposal addresses these key questions through three phases. In phase 1, we will develop novel methods for semi-automated frame discovery and annotation of social media posts from popular U.S. nationalist groups. This phase will lead to development of FrameBank dataset and the analytic scheme to generate this dataset. Next, in phase 2, we will develop and adapt a range of linguistic models to capture the thematic structures underlying these frames. Finally, in phase 3, we will put the results from phase 1 and 2 into action. We will apply our developed models and FrameBank scheme to study frame dynamics of international extremist movements. The goal is to test generalizability and adaptability of our developed annotation scheme and computational models.

Mitigation and Adaption: Using Silvopasture to Sequestor Carbon and Keep Cows Cool

Principal Investigator: Gabriel Pent

Abstract:

The intentional integration of trees into forage-livestock systems - known as silvopasture - has been proposed as a means of increasing the carbon sink capacity of grazinglands. Silvopastures also provide shade for livestock during periods of thermal stress, thereby increasing productivity and improving animal welfare. However, silvopasture adoption largely has been overlooked as a strategy for simultaneously mitigating climate change and adapting to its effects. Our objectives are to measure and model gain efficiency and carbon accretion when livestock are managed in silvopasture systems and to determine the value of creating silvopastures as a climate change adaptation strategy. Despite decades of pasture research, the capacity to measure intake of grazing animals still remains a key limitation in pasture research. Using novel, wearable acoustic-based systems that we are developing, we will measure and compare intake of animals managed in silvopastures and open pastures. Intake measures, coupled with measures of weight gain, will allow us to predict gain efficiency of these systems and to make preliminary calculations of methane emissions - the primary greenhouse gas emitted by ruminants. As we advocate the financial, environmental, and animal welfare benefits of silvopasture, we expect that more livestock producers will adopt silvopastoral systems, thereby increasing the resiliency of livestock production systems while reducing their net greenhouse gas emissions. We will determine the implications of land use change by evaluating a potential climate change mitigation strategy using novel technologies, while promoting the value of managing for resiliency in agroecosystems.

Designing Interactive Human-Aware Academic Spaces to Enhance User Experience Through Ubiquitous Information Management

Principal Investigator: Nazila Roofigari-Esfahan

Abstract:

Millions of devices powered by intelligent computation are becoming seamlessly integrated into the spaces in which people live and work. Spaces including buildings are becoming ever smarter through the incorporation of various sensors, actuators, and wireless networks, where a massive amount of data is collected for different purposes. However, the integration attempted so far has mainly concentrated on the data acquisition and data analysis processes. The interpretation of the collected data and context-aware delivery of the acquired knowledge to the targeted space users as well as users' interaction with these smart spaces has been largely neglected. Academic building spaces are one the most information-intensive environments that are designed for enhancing the knowledge quality of the community. In addition, as a result of the type of users of academic spaces (mainly students), these spaces are more vulnerable in emergency situations. As such, building emergencies create more concerns regarding threats they impose to the safety of their inhabitants. Despite its importance, the issue of context-aware information transmission in academic spaces has not yet been investigated. To address the aforementioned needs, we propose a framework for building a context-aware information system to augment current academic spaces into human-aware spaces that facilitate seamless information transmission. The proposed framework supports data acquisition, aggregation, interpretation and delivery, customized to specific requirements of various academic-space users. The outcomes of the proposed system are twofold. First, we present strategies that facilitate the multi-level diffusion of information into academic buildings and develop a framework for data acquisition, aggregation and knowledge discovery. Then, a user-interactive demonstration framework will be designed that enables access to the acquired knowledge for different levels of users including students, professors, visitors and security personnel. We specifically aim at developing a system that provides "Academic Data Sharing," "Occupancy Security Data Sharing" and "Public Service Information" without invading personal privacy. The proposed system will be evaluated through initial building-size experiments in Goodwin Hall on the Virginia Tech campus. The results of the research can be extended to develop a campus-wide, smart, context-aware, information management system that can further be used in settings other than academic environments.

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Song learning in birds as a model for understanding the consequences of childhood lead exposure

Principal Investigator: Kendra Sewall

Abstract:

Lead is an environmental contaminant that poses health risks to children throughout the world, and recent revelations about poor water quality in Flint, MI and in other U.S. cities have renewed concern about childhood lead exposure in the U.S. Any lead exposure is now considered dangerous to children by the Centers for Disease Control and World Health Organizations because even very low levels of lead can cause significant neurobehavioral impairments. Language in humans is particularly vulnerable to lead exposure, presumably because this form of learning depends upon an especially protracted period of brain plasticity. However, few animals share a protracted, post-natal, period of learning and brain plasticity with humans, limiting our understanding of the effects of lead on the development of brain circuits underlying cognition. Song learning in birds is an exception because it relies upon an extended period of learning and neuroplasticity within a well-defined neural circuit. Examining the effects of lead exposure in songbirds will provide important new information about how lead impacts learning and underlying brain circuitry because birds share the trait of "critical period vocal learning" with humans. Extending this model system for studies relevant to human health, however, requires determining if birds metabolize lead in the same way human children do, by measuring lead in blood and brain tissue. Collaboration among faculty from Biological Sciences (PI Sewall), the School of Neuroscience (Co-PI Thompson), and Geosciences (Co-PI Schreiber) will achieve these criteria to establish this study system for future work identifying therapies for children exposed to lead. The data generated will also be essential for future research proposals; an NIH R21 on this topic submitted by PI Sewall and Co-PI Thompson was scored a 35 and we believe collecting sufficient preliminary data with the assistance of Co-PI Schreiber will transform that proposal into a competitive R01.

Balancing Collaboration and Autonomy for Multi-Robot Multi-Human Search and Rescue

Principal Investigator: Ryan Williams

Abstract:

Each year, thousands of people go missing in the United States. Coordinated search and rescue (SAR) operations provide the best chance to locate a missing individual alive. In remote areas, challenging terrain and other search constraints represent a barrier to human searchers. Robots are subject to different constraints than humans. Unmanned aerial vehicles (UAVs) can explore areas where humans cannot easily go, and gather information on scales that can inform the overall SAR strategy beyond human capability. Multi-robot teams thereby have the potential to transform SAR by augmenting the capabilities of human teams and providing information that would otherwise be inaccessible. Our proposed work addresses fundamental challenges that must be overcome to scalably deploy autonomous UAV teams in SAR.

UAV flight optimization for SAR is based upon knowing the right place to look. Lost Person Behavior is the statistical approach which uses several different spatial models, subject categories, and terrain to put search resources in the right place. The different spatial models can be difficult for human planners to visualize and hence fully utilize. Indeed, search planning and management is one of the most demanding spatial tasks. Where to send a UAV, choosing the best sensor to put on the UAV, creating the flight plan, tracking flight plans, tracking potential clues, and applying search theory are difficult challenges faced by SAR volunteers. Our effort will develop new theory and technologies that enable field deployment of autonomous UAV systems and facilitate the process of managing multi-robot teams working in concert with multi-human search teams for SAR.

This project will focus on the following objectives of developing: (1) a minimally in- vasive, adaptive, multi-UAV control system leveraging risk-aware multi-robot planning for human-in-the-loop (HITL) control; (2) ubiq- uitous computing that opportunistically ex- ploits and balances multi-robot interaction, communication, computation, and decision- making; and (3) extensive testing and evalu- ation via large-scale prototyping in Virginia Tech's UAV facility, mock automated SAR with support from active SAR veterans, and oversight from leaders in the SAR community.

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Study of the Effects of Human-Induced Subsurface Fractures on Surface Water-Groundwater Interaction

Principal Investigator: Dr. Cheng Chen

Abstract:

Water exchange between stream and subsurface water across multiple spatial and temporal scales is referred to as hyporheic exchange. Subsurface fractures can be initiated or reactivated by various human activities. Our understanding of the effect of subsurface fractures on hyporheic exchange has been greatly limited by the complex flow coupling between fractures and surrounding porous media. Detailed pore-scale fracture information is usually highly localized and contains significant uncertainties. The objective of this work is to develop a coupled, multiscale model to account for heterogeneity at all spatial scales in order to advance our understanding of the effects of near-surface fractures on hyporheic exchange and obtain an empirical correlation to relate fracture size, direction, and fractal dimension to hydraulic fracturing related contaminant transport. The upscaling process includes pore- to continuum-scale coupling (millimeter- to centimeter-scale), continuum- to continuum-scale coupling (10 to 100 centimeters), and surface-subsurface coupling (1 to 10 meters). The numerical results of the upscaling workflow will be compared to results of laboratory-scale flume experiments. Scale-invariant parameters, such as the fractal dimension of the fracture, will be extracted to account for mass transfer across the pore- and continuum-scale domains and used in the formulation and parameterization of upscaling equations. The multiscale model will be applied in field testing in Buchanan County, Virginia. A microseismic monitoring system will characterize the CO2 induced fractures and the data will be used in the multiscale numerical model. The results of this study will advance our understanding of the environmental and hydrogeological impacts of hydraulic fracturing.

Expedite System-Level Knowledge Discovery through Metamodel-based Sensitivity Analysis: An Application to Large-Scale Agent-based Model of Immune Responses to H. pylori Infection

Principal Investigator: Xi Chen

Abstract:

Helicobacter pylori (H. pylori) is the dominant member of the gastric microbiota in more than 50% of the world's population. The presence of H. pylori in the stomach has been associated with various gastric diseases. However, there is a limited mechanistic understanding regarding H. pylori infection, disease and the associated gastric immunopathology. Enteric Immunity Simulator (ENISI) is an agent-based modeling (ABM) tool developed for modeling immune responses to H. pylori colonization of the gastric mucosa. ABMs such as ENISI are very powerful to study large-scale interactive systems, but they typically have complex structures and consist of a large number of model parameters. Determining the key model parameters which govern the outcomes of the system is very challenging. Existing sensitivity analysis techniques either lack a global perspective or are computationally expensive. We propose to develop an efficient metamodel-based experimental design and analysis approach to perform global and detailed individual parameter sensitivity analyses of large-scale ABMs. We will apply the proposed approach to ENISI and quantify the temporal significance of the model parameters. The new hypotheses generated will be validated through simulation and biological experiments by our collaborators at Biocomplexity Institute of VT. We anticipate that the research computational tool that can perform analysis that would otherwise be impossible for ENISI. The project is highly interdisciplinary and involves immunology, bioinformatics and operations research. Furthermore, the proposed approach is general in nature, and it can be broadly applied to study complex ABMs built for many other purposes

3D Colloidal Devices Fabricated through Digitally Programmable Electrowetting Dosing and Holographic Guiding

Principal Investigator: Jiangtao Cheng

Abstract:

Mother Nature can accomplish and build complex structures using more fundamental nanocomponents such as DNA molecules by molecular self-assembly. Well controlled self-assembly with great precision, flexibility, reversibility, and error-correction capacity remains as a challenge in this field. There are also limited approaches to fabricating three dimensional (3D) photonic structures with designed defects for function enhancement. The objective of this proposal is to address these challenges by incorporating electrowetting-based fluidic operations for precise colloidal microparticle dosing with designated stoichiometric ratios and reconfigurable holographic guiding in the colloidal formation for 2D and 3D functional devices. Proposed research tasks include: (a) both experimental and modeling methods will be used to study the advantages of using electrowetting dosing and holography guiding in realizing colloidal structures and photonic devices; (b) electrowetting will provide quantitative dosing control of the layer-by-layer deposition of colloid particles during colloidal crystallization. The precise and quantitative control will be demonstrated and tested by producing binary photonic crystals and cavity resonance devices; (c) the digital hologram will be incorporated with the electrowetting-driven flow for in-situ monitoring of particle flux; (d) the holographic guiding of colloids will be used to achieve advanced transformation-optics devices through a spatially reconfigurable hologram during the electrowetting-based fluidic process. The proposed project is interdisciplinary and consistent with the ICTAS mission of engaging innovative multifunctional materials, devices and systems to enhance energy generation, storage, and distribution.

CrowdWireless: Crowdsourcing-Based Content-Centric Design for Wireless Networks

Principal Investigator: Dr. Harpreet S. Dhillon

Abstract:

This project proposes a disruptive new idea of crowdsourcing-based design of wireless networks, where the spare storage capacity of the edge devices (mobile phones and cellular base stations) is used to cache popular content which can then be asynchronously delivered to the other users on demand. This idea is particularly relevant for the video-based traffic, which forms the largest fraction (by far) of the total mobile data traffic, and is known to exhibit a high degree of spatiotemporal correlation. The intellectual merit of this project is in developing a synergistic data-driven approach to the design, analysis, and optimization of crowdsourcing-based wireless networks that will, for the first time, bring together concepts from communications and information theories, big data, crowdsourcing, point process theory, and stochastic geometry. The proposed research will be performed through two main thrusts. The first thrust will extract synthetic statistical models for the features of interest from the data traces that will be collected as a part of this project. The second thrust will use these statistical models for the design and analysis of the proposed network architecture. Specific tasks in this thrust include: (i) using statistical mobility models extracted in Thrust 1 to design mobility-aware optimal caching strategies, (ii) optimal mode selection strategies (e.g., when to access content from a cache nearby and when directly from the Internet), and (iii) analysis of the energy efficiency with emphasis on the energy consumption of the user handsets, which will now form an active part of the network design.

CFPS-On-A-Chip: Development of A Microfluidic Platform for Engineered Therapeutic Proteins

Principal Investigator: Xueyang Feng

Abstract:

Cell free protein synthesis (CFPS) is a promising technology for modifying and producing therapeutic proteins, which have a >$100-billion market annually. To optimize protein production in CFPS, we will develop a microfluidic platform to simultaneously label target proteins with a fluorescent unnatural amino acid (fUAA) and evaluate the effects of multiple factors on CFPS in a high-throughput manner. This proposed platform, “CFPS-on-achip”, will harness the power of microfluidics and the fUAA-based protein labeling for highthroughput, customized optimization of in vitro protein expression. To achieve this, we will (1) develop a CFPS system to integrate a fUAA into a target protein and recognize the key effectors of the CFPS system; and (2) design a microfluidic chip for the CFPS system and optimize multiple effectors on in vitro protein expression using “CF-PSon-a-chip”. This proposal builds upon our existing success on integrating unnatural amino acids in target proteins and fabricating a prototype multi-channel microfluidic chips to generate concentration gradients for various fluids used in CFPS. Our proposed “CFPS-on-a-chip” system promotes the ideas on directly applying the CFPS system for high-throughput protein production and chemical modification of therapeutic proteins to develop novel solutions in drug delivery and vaccine design. The success of the proposed project will stimulate multidisciplinary collaborations on research related to vaccine development, drug delivery, and metabolic diseases, and eventually lead to the development of “Health-on-a-chip”, an up-graded, engineered platform to develop, optimize, and produce a wide range of therapeutic proteins for broad applications, including drug delivery, diseases treatment, and early diagnosis.

Data-driven climate change adaptation for riverine and coastal transportation infrastructure

Principal Investigator: Madeleine Flint

Abstract:

Recent research efforts led by PIs Flint, Ashfaq, and Diffenbaugh have produced data that, if integrated, have the potential to increase the accuracy of every aspect of the assessment of the impact of climate change on transportation infrastructure and adaptation planning. In particular, a database of hydraulic bridge failures, high-resolution coupled regional climate and hydrological re-analyses and projections, and methods for bias correction have the potential to greatly increase the accuracy of data used to assess the impact of climate change on bridge failures and their associated economic, social, and environmental impacts. When paired with strategies for robust decision-making, these data and methods offer a truly data-driven approach for adapting bridges to climate change and increasing the resilience of the US transportation infrastructure. Given that the total cost to maintain the current (poor) condition of US surface transportation infrastructure is estimated in the trillions of dollars, and that climate impacts on transportation infrastructure are expected to cost billions of dollars annually, it is critical that decision-making and adaptation planning be informed by sound science and engineering. The proposed project would be the first ever to integrate cutting-edge climate science and hydrological modeling with data-driven predictions of bridge failures and robust decision-making and optimization approaches. The result will be a solutions-driven technology that will transform transportation asset management at both the policy and local levels.

Non-Genetic Approach to Enhance Tolerance to Precipitation Extremes in Crops

Principal Investigator: Takeshi Fukao

Abstract:

Both high and low extremes in precipitation increasingly damage food, fiber, and bioenergy production worldwide. To meet glowing demand for plant-based products under changing climates, it is crucial to improve tolerance to flooding and drought in major crop species. Generally, improvement of crop stress tolerance has been attempted through conventional breeding and genetic engineering. However, these approaches necessitate labor-intensive processes such as hybridization, gene transfer, and selection in individual species and varieties. Here, we propose to enhance crop tolerance to flooding and drought by chemical application, instead of crossbreeding and genetic modification. To achieve this goal, we will identify small molecules that inhibit the action of a negative regulator for tolerance to water extremes in plant, PRT6, through high-throughput chemical screening (Aim 1). The effect of promising inhibitors on stress tolerance will be validated in soybean and maize, major crops susceptible to both stresses (Aim 2). PRT6 is an E3 ubiquitin ligase involved in targeted proteolysis of key transcription factors that regulate acclimation responses to flooding and drought. Based on the genetic evidence previously published, it is anticipated that inhibition of PRT6 activity by chemical application will stabilize the stress tolerance transcription factors, thereby enhancing crop adaptability to precipitation extremes. The outcome of this project will facilitate the development of a novel management practice that can increase yields of various crops under changing climates. The inhibitors identified in this project will be beneficial tools to characterize the regulatory mechanisms underlying crop tolerance to flooding and drought at posttranslational level.

Correlating Thermodynamics and Kinetics for the Design of Colloidal Metal Nanoparticles

Principal Investigator: Ayman M. Karim

Abstract:

The precise control of nanoparticles size and shape is of extreme importance because of their influence on the optical, catalytic and electrical properties of the nanoparticles. While there have been tremendous advances on the synthesis of transition metal nanoparticles, the ability to a priori design their size/shape is lacking, and a trial-and-error approach is still employed. This is due to a limited understating of the overarching principles governing the synthesis and most importantly the role of ligands. Therefore, in situ characterization is necessary to reveal the exact role of ligands in affecting the synthesis mechanisms and final structures. The proposed work leverages the complementary, interdisciplinary expertise of two faculty members to transform the synthesis of colloidal nanoparticles from an art into a predictive science using a novel combination of in situ thermodynamics/kinetics measurements and kinetic modeling. The research will focus on investigating the colloidal synthesis of Au and Pd nanoparticles in the presence of diverse capping agents. We will use in-situ kinetics (SAXS/XAFS) and thermodynamics measurements (isothermal titration calorimetry) to provide insights on the effect of ligand-precursor and ligand-nanoparticle binding structure and strength on the size and shape of the nanoparticles. The results will demonstrate if indeed there is a simple correlation between the kinetics and thermodynamics interactions and final nanoparticle size/shape. Additionally, we will develop a kinetic model capable of describing and eventually predicting the in situ characterization results. The correlations and kinetic model from this work are expected to enable the design colloidal nanoparticles of any arbitrary size/shape.

Novel quantitative imaging-based biomarkers for assessing quality of gametes and embryos

Principal Investigator: Kiho Lee

Abstract:

In vitro fertilization (IVF) has been widely applied in modern life due to an increased incidents of infertility. However, outcome of IVF is highly unpredictable as embryo and gamete quality cannot be reliably evaluated without an invasive approach. We propose here to develop new biomarkers of embryo viability and sperm quality, based on novel optical imaging techniques. Our hypothesis is that biomarkers identified by the novel imaging system can reflect viability of embryos and gametes and quantify their qualities. We will address our hypothesis by the two specific aims: (1) assess embryo quality using 3D tomographic imaging, and (2) assess sperm quality using 2D phase and birefringence imaging. For comparison, the embryo quality will be evaluated via traditional embryology standards and molecular biology technique based gene expression analysis. Our long-term goal is to establish effective and efficient approach to non-invasively evaluate sperm and embryo quality using a novel imaging system. Our model species is swine due to availability of sperm/oocytes/embryos for mass screening processes. Once we identify key biomarkers that can represent embryo/sperm quality in swine, we intend to apply this knowledge in different species including humans in the future. The ability to effectively and quickly identify viable embryos/sperm can be used in human IVF clinics to help couples who suffer from infertility.

pH Responsive-Nanoprobes: A novel therapeutic approach for brain injury

Principal Investigator: Michelle Theus

Abstract:

Traumatic brain injury (TBI) is the most common acquired central nervous system injury in the U.S. Due to the limited ability of the brain to heal, survivors are left with persistent motor and cognitive deficits that substantially reduce their quality of life. To date there are no safe and effective therapies to prevent neural tissue loss in the 1.7 million Americans who sustain head trauma each year. The complex nature of drug delivery via the blood-brain barrier following TBI supports the need for a more targeted approach, which poses minimal risk of side effects to the patient. We propose utilizing the intranasal pathway to deliver a novel fluorescein labeled nanoparticle crosslinked with a pH-responsive peptide (Nanoprobe) targeting EphA4 receptor signaling after TBI. The labeled Nanoprobes will be used to image/track the intranasal route of delivery as well as establish a bi-phasic release of an EphA4 blocking peptide after head trauma. Using this Nanoprobe system, we hypothesize that suppressing the activation of EphA4 receptor in the early phase of brain injury via the intranasal route of administration, can be achieved by establishing a bi-phasic release profile resulting in maximal tissue sparing. The EphA4 pathway represents an enormously attractive new neuroprotective target, as demonstrated by strong preliminary evidence generated in the PIs lab. We anticipate that Nanoprobe delivery will provide significant neuroprotection following head trauma. Our overall goal is to implement new, innovative treatment strategies to greatly improve the health and quality of life for TBI-injured patients.

Computation-guided Design of Plasmonic Nanoassemblies for Solar Water Splitting

Principal Investigator: Hongliang Xin

Abstract:

The objective of the proposed research is to advance mechanistic understanding of plasmonenhanced photochemistry at metal/semiconductor interfaces and to develop predictive models that can facilitate the discovery of plasmonic photocatalysts for efficient solar water splitting. The proposed research addresses one of the principal technological barriers to finding high-performance photoanodes that absorb sunlight over a broad range of wavelengths and transfer photogenerated holes near surface sites to drive water oxidation. We propose to use well-controlled nanostructure assemblies of medium bandgap hematite (a-Fe2O3) nanospheres selectively attached to the hot spots (geometric features characterized with strong plasmon-induced local fields) of gold (Au) nanostructures as a platform for probing plasmonic enhancement mechanism and as a promising photoelectrocatalyst for solar water splitting. Photoabsorption cross-section and local field distribution of metal/semiconductor systems will be computed using electromagnetic simulations for guiding the selection of size/shape of Au nanoparticles and the structure pattern of nanoassemblies. Density functional theory calculations will be employed to probe dynamics of photoinduced charge carriers and kinetics in water oxidation at the interface of metal oxides and surface modifiers, providing knowledge base for surface functionalization with beneficial organic linkers. While the concept of nanostructure assembling for desired structure features has been demonstrated, predictive models are needed for rational design of this novel class of materials. Model-predicted nanoassemblies will be fabricated using the plasmon-directed assembling techniques, and their transient photoabsorption properties and photoelectrochemical performance will be measured to validate and further fine-tune the model. By studying precisely defined nanostructures with state-of-the-art modeling tools and characterization techniques, this project could create the opportunity to usher in a new paradigm in photoelectrocatalyst design based on fundamental understanding of properties of nanostructure assemblies rather than trial-and-error.

3D Colloidal Devices Fabricated through Digitally Programmable Electrowetting

Dosing and Holographic Guiding

Principal Investigator: Jiangtao Cheng

Abstract:

Mother Nature can accomplish and build complex structures using more fundamental nanocomponents such as DNA molecules by molecular self-assembly. Well controlled self-assembly with great precision, flexibility, reversibility, and error-correction capacity remains as a challenge in this field. There are also limited approaches to fabricating three dimensional (3D) photonic structures with designed defects for function enhancement. The objective of this proposal is to address these challenges by incorporating electrowetting-based fluidic operations for precise colloidal microparticle dosing with designated stoichiometric ratios and reconfigurable holographic guiding in the colloidal formation for 2D and 3D functional devices. Proposed research tasks include: (a) both experimental and modeling methods will be used to study the advantages of using electrowetting dosing and holography guiding in realizing colloidal structures and photonic devices; (b) electrowetting will provide quantitative dosing control of the layer-by-layer deposition of colloid particles during colloidal crystallization. The precise and quantitative control will be demonstrated and tested by producing binary photonic crystals and cavity resonance devices; (c) the digital hologram will be incorporated with the electrowetting-driven flow for in-situ monitoring of particle flux; (d) the holographic guiding of colloids will be used to achieve advanced transformation-optics devices through a spatially reconfigurable hologram during the electrowetting-based fluidic process. The proposed project is interdisciplinary and consistent with the ICTAS mission of engaging innovative multifunctional materials, devices and systems to enhance energy generation, storage, and distribution.

CFPS-On-A-Chip: Development of A Microfluidic Platform for Engineered Therapeutic Proteins

Principal Investigator: Xueyang Feng

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CrowdWireless: Crowdsourcing-Based Content-Centric Design for Wireless Networks

Principal Investigator: Dr. Harpreet S. Dhillon

Abstract:

This project proposes a disruptive new idea of crowdsourcing-based design of wireless networks, where the spare storage capacity of the edge devices (mobile phones and cellular base stations) is used to cache popular content which can then be asynchronously delivered to the other users on demand. This idea is particularly relevant for the video-based traffic, which forms the largest fraction (by far) of the total mobile data traffic, and is known to exhibit a high degree of spatiotemporal correlation. The intellectual merit of this project is in developing a synergistic data-driven approach to the design, analysis, and optimization of crowdsourcing-based wireless networks that will, for the first time, bring together concepts from communications and information theories, big data, crowdsourcing, point process theory, and stochastic geometry. The proposed research will be performed through two main thrusts. The first thrust will extract synthetic statistical models for the features of interest from the data traces that will be collected as a part of this project. The second thrust will use these statistical models for the design and analysis of the proposed network architecture. Specific tasks in this thrust include: (i) using statistical mobility models extracted in Thrust 1 to design mobility-aware optimal caching strategies, (ii) optimal mode selection strategies (e.g., when to access content from a cache nearby and when directly from the Internet), and (iii) analysis of the energy efficiency with emphasis on the energy consumption of the user handsets, which will now form an active part of the network design.

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Principal Investigator: Madeleine Flint

Abstract:

Recent research efforts led by PIs Flint, Ashfaq, and Diffenbaugh have produced data that, if integrated, have the potential to increase the accuracy of every aspect of the assessment of the impact of climate change on transportation infrastructure and adaptation planning. In particular, a database of hydraulic bridge failures, high-resolution coupled regional climate and hydrological re-analyses and projections, and methods for bias correction have the potential to greatly increase the accuracy of data used to assess the impact of climate change on bridge failures and their associated economic, social, and environmental impacts. When paired with strategies for robust decision-making, these data and methods offer a truly data-driven approach for adapting bridges to climate change and increasing the resilience of the US transportation infrastructure. Given that the total cost to maintain the current (poor) condition of US surface transportation infrastructure is estimated in the trillions of dollars, and that climate impacts on transportation infrastructure are expected to cost billions of dollars annually, it is critical that decision-making and adaptation planning be informed by sound science and engineering. The proposed project would be the first ever to integrate cutting-edge climate science and hydrological modeling with data-driven predictions of bridge failures and robust decision-making and optimization approaches. The result will be a solutions-driven technology that will transform transportation asset management at both the policy and local levels.

Expedite System-Level Knowledge Discovery through Metamodel-based Sensitivity Analysis: An Application to Large-Scale Agent-based Model of Immune Responses to H. pylori Infection

Principal Investigator: Xi Chen

Abstract:

Helicobacter pylori (H. pylori) is the dominant member of the gastric microbiota in more than 50% of the world's population. The presence of H. pylori in the stomach has been associated with various gastric diseases. However, there is a limited mechanistic understanding regarding H. pylori infection, disease and the associated gastric immunopathology. Enteric Immunity Simulator (ENISI) is an agent-based modeling (ABM) tool developed for modeling immune responses to H. pylori colonization of the gastric mucosa. ABMs such as ENISI are very powerful to study large-scale interactive systems, but they typically have complex structures and consist of a large number of model parameters. Determining the key model parameters which govern the outcomes of the system is very challenging. Existing sensitivity analysis techniques either lack a global perspective or are computationally expensive. We propose to develop an efficient metamodel-based experimental design and analysis approach to perform global and detailed individual parameter sensitivity analyses of large-scale ABMs. We will apply the proposed approach to ENISI and quantify the temporal significance of the model parameters. The new hypotheses generated will be validated through simulation and biological experiments by our collaborators at Biocomplexity Institute of VT. We anticipate that the research will deliver an unprecedented metamodel-based computational tool that can perform analysis that would otherwise be impossible for ENISI. The project is highly interdisciplinary and involves immunology, bioinformatics and operations research. Furthermore, the proposed approach is general in nature, and it can be broadly applied to study complex ABMs built for many other purposes.

Non-Genetic Approach to Enhance Tolerance to Precipitation Extremes in Crops

Principal Investigator: Takeshi Fukao

Abstract:

Both high and low extremes in precipitation increasingly damage food, fiber, and bioenergy production worldwide. To meet glowing demand for plant-based products under changing climates, it is crucial to improve tolerance to flooding and drought in major crop species. Generally, improvement of crop stress tolerance has been attempted through conventional breeding and genetic engineering. However, these approaches necessitate labor-intensive processes such as hybridization, gene transfer, and selection in individual species and varieties. Here, we propose to enhance crop tolerance to flooding and drought by chemical application, instead of crossbreeding and genetic modification. To achieve this goal, we will identify small molecules that inhibit the action of a negative regulator for tolerance to water extremes in plant, PRT6, through high-throughput chemical screening (Aim 1). The effect of promising inhibitors on stress tolerance will be validated in soybean and maize, major crops susceptible to both stresses (Aim 2). PRT6 is an E3 ubiquitin ligase involved in targeted proteolysis of key transcription factors that regulate acclimation responses to flooding and drought. Based on the genetic evidence previously published, it is anticipated that inhibition of PRT6 activity by chemical application will stabilize the stress tolerance transcription factors, thereby enhancing crop adaptability to precipitation extremes. The outcome of this project will facilitate the development of a novel management practice that can increase yields of various crops under changing climates. The inhibitors identified in this project will be beneficial tools to characterize the regulatory mechanisms underlying crop tolerance to flooding and drought at posttranslational level.

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Study of the Effects of Human-Induced Subsurface Fractures on Surface Water-Groundwater Interaction

Principal Investigator: Dr. Cheng Chen

Abstract:

Water exchange between stream and subsurface water across multiple spatial and temporal scales is referred to as hyporheic exchange. Subsurface fractures can be initiated or reactivated by various human activities. Our understanding of the effect of subsurface fractures on hyporheic exchange has been greatly limited by the complex flow coupling between fractures and surrounding porous media. Detailed pore-scale fracture information is usually highly localized and contains significant uncertainties. The objective of this work is to develop a coupled, multiscale model to account for heterogeneity at all spatial scales in order to advance our understanding of the effects of near-surface fractures on hyporheic exchange and obtain an empirical correlation to relate fracture size, direction, and fractal dimension to hydraulic fracturing related contaminant transport. The upscaling process includes pore- to continuum-scale coupling (millimeter- to centimeter-scale), continuum- to continuum-scale coupling (10 to 100 centimeters), and surface-subsurface coupling (1 to 10 meters). The numerical results of the upscaling workflow will be compared to results of laboratory-scale flume experiments. Scale-invariant parameters, such as the fractal dimension of the fracture, will be extracted to account for mass transfer across the pore- and continuum-scale domains and used in the formulation and parameterization of upscaling equations. The multiscale model will be applied in field testing in Buchanan County, Virginia. A microseismic monitoring system will characterize the CO2 induced fractures and the data will be used in the multiscale numerical model. The results of this study will advance our understanding of the environmental and hydrogeological impacts of hydraulic fracturing.

RESEARCH AWARDS FROM 2015

A Nanotechnology Approach to Overcome the Barriers of Cancer Drug Delivery

Principal Investigator: David G. I. Kingston

Abstract:

This proposal addresses the critical need for more effective cancer chemotherapeutic agents by development of the disruptive nanomedicine we have named Doxtaunif, which will deliver the potent but toxic drug doxorubicin (DOX)13 and the toxic cytokine tumor necrosis factor (TNF) to tumors on a gold nanoparticle (AuNP) platform that drastically reduces toxicity. The natural product DOX (1) is an important anticancer drug that is used both as a single agent and in over 100 different drug combination regimens.13 It does however have a major dose-limiting side effect of cardiotoxicity at cumulative doses higher than 400 mg/m2, and this side effect has prevented it from being curative in many treatments.14 In addition, in common with other systemically administered chemotherapies, it faces the barrier of elevated tumor interstitial fluid pressure (IFP), resulting from a leaky tumor neovasculature and a collapsed lymphatic system.15-17 This inability of chemotherapy to reach the cancer cell reduces anti-tumor efficacy, and requires the use of high doses of toxic drugs to achieve clinically meaningful responses. The overall objective of the proposed work is to prepare AuNPs loaded with DOX, TNF, and PEG-thiol, and to evaluate them rigorously for chemical stability, for drug release under tumor conditions, and for toxicity to mice. These results are expected to lead to submission of a patent application and the development of a new and effective nanodrug for cancer treatment.

A Pilot Study for Augmenting Situational Awareness and Real-Time Risk Analysis for Construction Workers through Smart Safety Glasses

Principal Investigator: Tanyel Bulbul

Abstract:

This project aims to conduct a pilot study to investigate methods to convert head wearable display (HWD) systems, to Smart Safety Glasses (SSG) and explore the usability of this technology to augment situational awareness of construction workers. By its nature, a construction site houses various safety risks for workers. The high rates of occupational safety risks are partly caused by the dynamic nature of the profession. A construction site is a complex work environment that involves various trades working concurrently, using numerous tools of different sizes and changing resources. Construction workers also need to process large amounts of sensory input to be aware of their constantly changing environment which is often noisy, dusty and directly exposed to the weather. Under these circumstances, many safety procedures are missed, overlooked or ignored mostly because the construction workers do not have the cognitive bandwidth needed to process risks around them alongside the potential long-term consequences of certain actions or inaction. The specific aim of this research is to explore the usability of a light weight and hands-free wearable technology for supporting occupational health and safety procedures in a large scale building or infrastructure construction project. Two main tasks that will be performed in this pilot study will focus on defining the user interfaces (UI) at different levels of visual fidelity, and modeling construction workers can interaction with these UI mainly for hazard warning scenarios.

An Efficient and Scalable Ocean Thermal Energy Harvesting System for Autonomous Underwater Vehicles

Principal Investigator: Kevin G. Wang

Abstract:

A major shortcoming of autonomous underwater vehicles (AUVs) is short operation time, which is caused by the limited capacity of onboard batteries. Currently, battery technology is rapidly maturing, and the energy density of batteries is projected to improve only incrementally in the near future. In view of this technical barrier, as well as the worldwide demand for renewable and sustainable energy, we propose to harvest the thermal energy associated with the vertical temperature variation in the ocean thermocline to continuously power AUVs. In this regard, existing approaches are limited to low energy conversion efficiency (<10%) and poor scalability (restricted to very large size). Our objective is to design and demonstrate an efficient and scalable system that can be integrated into several categories of AUVs as their primary power supply, leading to a disruptive improvement in their mission endurance. To accomplish this objective, we will combine several energy conversion mechanisms and devices, including phase-change materials, thermoelectric generators, piezoelectric stacks, and electromagnetic generators, which have been successfully applied in many other energy harvesting applications characterized by low temperature variation and small size. Specifically, we will develop a prototype system to demonstrate the high efficiency, and develop a physics-based computational model to predict the scalability of power output with respect to size. This approach is promising and completely new. The successful execution of the proposal will position us to attract large external grants from various programs on energy, power, and autonomous systems from ONR, NSF, DOE, and other agencies.

An innovative approach for recovering ammonia and high-quality water from wastewater

Principal Investigator: Rui Qiao

Abstract:

Wastewater treatment consumes nearly 3% of the electricity in the U.S. Recovering valuable chemicals such as ammonia from wastewater will make its treatment more sustainable but has received scant attention. In fact, ammonia in wastewater is often converted into N2 at significant energy cost despite that synthesizing ammonia from N2 consumes about 1% of the world's electricity. We propose a new wastewater treatment technology that integrates ammonia recovery using bioelectrochemical systems (BES) and water recovery using forward osmosis (FO). Such a BES+FO technology can generate significant energy benefit for both wastewater treatment and ammonia industries. Our initial study confirmed the feasibility of this technology but also revealed that its ammonia recovery efficiency must be improved to enable mass deployment. In this integrated computational and experimental project, we seek to (1) develop computational tools for the simulation of coupled ammonia, ion, and water transport in BES+FO systems, (2) delineate the coupled ion, ammonia, and water transport in the BES+FO systems, (3) investigate how these transport can be manipulated to maximize the ammonia recovery efficiency, and (4) develop and validate new designs of BES+FO system to improve the ammonia recovery efficiency. If successful, this project will lead to an efficient prototype BES+FO system and design rules for scaling it up to large systems. The computational tools developed in this project can be adapted to simulate diverse bioelectrochemical systems to serve the need of other VT groups working on BES-related sustainable water/energy technologies.

Bio-inspired solutions for quieter wind turbines and better wildlife preservation

Principal Investigator: Lin Ma

Abstract:

This proposal seeks seed funding with a view to initiate an externally funded research program to tackle two problems associated with wind turbines: reduction of their noise and prevention of wildlife death caused by their blades. Both problems are significant obstacles to the expansive implementation of wind turbines, and they seem to be independent on the surface. Here we propose to initiate a study that is expected to reveal the relationship between these problems and provide solutions to both of them. The key component of the proposed approach involves high speed optical measurements (up to 20 kHz) of flying animals (including bats and birds) in VT's Stability Wind Tunnel. Combining state-of-art hardware and software recently developed by our team, these measurements are expected to enable data long desired but unattainable thus far to reveal the creature's motion and of the flow fields caused by such motion simultaneously. These measurements will then be analyzed by our multidisciplinary team to provide critical insight into fundamental questions that cannot be answered by existing data. The data, and the capabilities they demonstrate, are expected to serve as a powerful catalyst to a new and comprehensive, externally funded, interdisciplinary research program in this area. It is expected to draw substantial sponsorship not just from the wind energy industry, but also from the agencies supporting fundamental research (such as NSF and the defense department), the propulsion community, and other bio-relevant areas.

Harnessing CRISPR Technology for Gene Therapy Applications

Principal Investigator: Dr. Irving Coy Allen

Abstract:

Over 4000 human diseases are associated with single gene mutations, including Huntington

Disease and Duchene muscular dystrophy. These monogenetic disorders are logical targets for genome engineering, which seeks to correct the underlying genetic mutations and cure the disease. Our laboratory studies Muckle Wells Syndrome (MWS), which is a monogenetic autoinflammatory disorder associated with an A352V mutation in the NLRP3 gene that results in constitutive IL-1βhyper-production. The corresponding mouse model of this disease carries an

A350V mutation. Earlier this year, a series of high profile genome engineering studies demonstrated for the first time that CRISPR-Cas9 could be harnessed to modify the mouse genome in adult animals. However, for this system to evolve from proof-of-principle to therapeutic application, several major limitations associated with cell delivery must be overcome. The overarching objective of this project is to develop a nanoparticle based delivery strategy for the CRISPR-Cas9 system that is suitable for in vivo applications and conduct proof-of-principle studies using mouse models. Our first Aim is to optimize a PLGA based nanoparticle system for the effective encapsulation and in situ release of the CRISPR-Cas9 system. We will validate this approach in mouse primary cells. Our second Aim will move beyond in vitro characterization by utilizing the CRISPR-Cas9 nanoparticles to correct the Nlrp3 A350V mutation in adult mice and attenuate disease pathogenesis. We believe that combining the CRISPR-Cas9 system with nanoparticle delivery has the potential to significantly alter research and therapeutic paradigms and completion of this proposal will provide us with critical proof-

Identifying the Effects of Climate Change on Irrigated Agriculture using Remote Sensing and Geospatial Water Rights Data

Principal Investigator: Kelly M. Cobourn

Abstract:

Understanding the effects of climate change on water use by irrigated agriculture is critical to ensuring the sustainability of scarce water resources. However, quantitative estimates of these impacts have proven elusive for two reasons: 1) water rights complicate the relationship between climate signals and irrigator behavior, making it difficult to characterize how irrigators adapt to changes in water availability; and 2) there is a dearth of data on water-use decisions at the spatial resolution of the irrigator and over a time series long enough to capture changes in climate. We propose to overcome these challenges by merging remote sensing science and economics to generate new insight into the ways in which irrigators respond to changes in water availability over the short and long run. We will do so by leveraging an extensive repository of remote sensing data from NASA, recently developed big data classification algorithms, and unique geospatial data on water rights to conduct micro-econometric analyses of irrigator adaptation to climate change. The results of these analyses will be combined with climate change projections to generate novel visualizations that capture the effect of water rights on changes in resource use and economic welfare across space and time. These results will form the basis for future external funding proposals that combine remote sensing and econometric methods to examine broad questions about the societal impacts of climate change. Our findings will support effective and efficient policy making to maintain agricultural productivity and protect water resources in the face of changing natural conditions.

Location via Vibration Tracking - An Indoor Location Tracking System for Smart Buildings

Principal Investigator: Pablo Tarazaga

Abstract:

According to the DOE, United States buildings sector accounted for about 41% of primary energy consumption in 2010, 44% more than the transportation sector and 36% more than the industrial sector. Consequently, a recent DOE report [1] suggests that advanced occupancy sensors (as proposed herein) could increase efficiency by 18%, as opposed to 5.9% using common occupancy sensors yielding a considerable reduction in energy usage. We believe that the localization of vibration events in buildings is a capability that can realize these efficiency improvements. Specifically, we believe that the vibrations induced by building occupants can be measured and used for localization, identification and tracking of individuals. This unprecedented and detailed level of knowledge of building occupancy can (among other things) lead to the development of highly customizable energy systems in the built environment (HVAC, Lighting, maintenance scheduling, etc.). Leveraging the most instrumented building in the world for vibrations, Goodwin Hall, the work proposed here will develop novel methods of extracting information from the building's sensor network that can be used to accurately calculate occupancy and traffic and consequently used as feedback for an energy control system. Additionally, such a system will also facilitate many other applications including the localization of E911 callers, building evacuation, and emergency response. The ultimate objective of this project is the development of a system that is capable of localizing and tracking individuals in a building without requiring the individuals to wear or carry any device or sensor dedicated to localization. In other words, we wish to be able to localize the individuals in a building using only the building infrastructure. We believe that this can be done using a network of vibration sensors. The immediate goal of this project is to demonstrate the basic technologies required to develop such a system. The results of this demonstration would then be used to obtain the funding necessary to fully develop a prototype of the envisioned system.

Precision Nanomedicine: Heteromultivalent Scaffolds for Fundamental Studies in Cancer Biology & Theranostics

Principal Investigator: Jatinder Josan

Abstract:

Nanoparticles (NPs) are heralded as the next generation diagnostics and therapeutics for cancer. However, there are multiple hindrances to bring them to the clinic. Most NPs are coated with high density of ligands against a cell-surface "good target" (i.e., overexpressed in cancer), leading to side effects. This can be resolved with heteromultivalent approaches. Taking metastatic melanoma as the case study, we will use Protease Activated Receptor (PAR1) and Melanocortin Receptor 1 (MC1R) as the model system to study heteromultivalency. The expression and activity of both receptors get de-regulated with tumor progression and metastatic potential. We will investigate whether a true hetero-multivalent effect can be gained with NP targeting by constructing NPs that contain low and precise density of ligands on the NPs. In this context, endohedral fullerenes allow precise modification with only 2 or 3 orthogonal handles for attachment of ligands, while containing the imaging motif (such as Gd) inside the cage. Alternatively, a liposome-based system will be used to investigate the targeting efficacy of NPs functionalized with varying density of two different receptor-specific ligands, decorated separately or as heterobivalent complex.

Novel strategies for breaking down platelet-mediated extravasation of cancer cells

Principal Investigator: Daniel Capelluto

Abstract:

Chemotherapy, radiotherapy, and surgical treatments non-specifically target a large number of cancer cells leading to severe side effects and toxicities that compromise the quality of life of the patient. Peptide-driven cancer therapy has emerged as an alternative approach that specifically targets cancer cells. Sulfatides are highly expressed at the surface of platelet and cancer cells, favoring platelet-cancer cell interactions. Preliminary data show that Dab2 N-PTB inhibits the association of platelets to leukemia U937 cells. While the results are encouraging, the size of N-PTB limits its usefulness as a drug. We propose to generate a nanodelivered peptide, with similar or higher inhibitory properties to NPTB, by chemically reworking its structure to generate a stable artificial peptide containing the minimal sulfatide-binding region that can block platelet association to cancer cells. We previously demonstrated that Dab2 SBM, a region of 35 amino acids within N-PTB, mimics the inhibitory effects of N-PTB (17). NMR structural studies further showed that the last 20 residues of SBM, containing the BxBxBx sequence (B, basic; x, any residue) are functionally relevant for sulfatide interactions. We propose to generate synthetic Dab2-derived peptides, varying the distance between motifs, increasing hydrophobic interactions (i.e., removing residues 24-38 in SBM, introducing alanine mutations in Asp36 and Asp46; see Fig. 1), reducing the number of 'spurious' Arg and Lys residues around the BxBxBx motif (i.e., replacing Lys44 by Ala; see Fig. 1), and containing tandems of BxBxBx. We will apply unrestrained and steered molecular dynamics (MD) simulations to examine interactions between peptides and lipid bilayers enriched with sulfatides. The best candidates will be selected for structural and sulfatide-binding analyses. Peptides will be further evaluated for inhibition of platelet interaction with leukemia cells. Peptides with the highest IC50 will be encapsulated in nanoparticles (NP) comprised of poly(lactic-co-glycolic acid) (PLGA) to increase peptide uptake efficiency and to protect them from proteolysis. Fig. 3 summarizes the proposed strategy. NPs can also be coated with poly(ethylene glycol) (PEG) chains for improved biocompatibility and longer circulation times in vivo. Dynamic light scattering and NP tracking analysis will be used to characterize the NP size distribution, whereas zeta potential will measure their surface charge. Once optimized, encapsulated peptides will be evaluated in endothelial cell-coated microfluidic devices as we previously reported (17, 18).

Precision Nanomedicine: Heteromultivalent Scaffolds for Fundamental Studies in Cancer Biology & Theranostics

Principal Investigator: Jatinder Josan

Abstract:

Nanoparticles (NPs) are heralded as the next generation diagnostics and therapeutics for cancer. However, there are multiple hindrances to bring them to the clinic. Most NPs are coated with high density of ligands against a cell-surface "good target" (i.e., overexpressed in cancer), leading to side effects. This can be resolved with heteromultivalent approaches. Taking metastatic melanoma as the case study, we will use Protease Activated Receptor (PAR1) and Melanocortin Receptor 1 (MC1R) as the model system to study heteromultivalency. The expression and activity of both receptors get de-regulated with tumor progression and metastatic potential. We will investigate whether a true hetero-multivalent effect can be gained with NP targeting by constructing NPs that contain low and precise density of ligands on the NPs. In this context, endohedral fullerenes allow precise modification with only 2 or 3 orthogonal handles for attachment of ligands, while containing the imaging motif (such as Gd) inside the cage. Alternatively, a liposome-based system will be used to investigate the targeting efficacy of NPs functionalized with varying density of two different receptor-specific ligands, decorated separately or as heterobivalent complex.

Probing Novel Mechanisms of Nanoparticle Crystallization In Situ

Principal Investigator: F. Marc Michel

Abstract:

Our ability to control crystallization is behind untold trillions of dollars of annual technology, as well as a key to interpreting the past, present, and future evolution of our planet. Yet our scientific understanding of crystallization - the transformation of dissolved species into solids - is drastically incomplete. Recent research is revealing a diversity of new “nonclassical” pathways and mechanisms by which crystals, particularly nanocrystals, form and grow through attachment of precursor particles. However, immense gaps remain in our understanding of these processes.

With this understanding, it could very well unlock new ways to stimulate and innovate current technology and even the understanding of nature, which would have fundamental and applied applications from the behavior of the planet to better control of our environment (e.g., climate).

Key to unlocking this potential is developing new ways to study crystallization in situ. The challenge lies in observing and accurately measuring the atomic structural, chemical, and physical properties of a system as it continuously evolves from initial reactant species to intermediate products (i.e., polymers, clusters, and smallest nanoparticles) to final solids. In the proposed collaborative effort we will revolutionize real-time crystallization research by using additive manufacturing (3D printing) and multilayer soft lithography to fabricate ‘reactionware’ devices that are ideal for use with synchrotron techniques. This pioneering approach to crystallization research - using unique crystallization chamber fabrication techniques with stateof-the-art synchrotron science - has a very high probability of success and promises advances in nanomaterials design and synthesis for diverse applications in nanoscience and beyond.

Recovering environmentally distributed pollutants using dynamic bacterial biofilms controlled by synthetic biology

Principal Investigator: Warren C. Ruder, Ph.D.

Abstract:

The natural environment continues to be infiltrated with damaging anthropogenic materials. As a result, methods to recover these substances from waste streams would enable greater sustainability of water quality. A sustainable approach for seek-and-recovery of environmental contaminants will be critical in the future. We propose to engineer control of complex behavior in bacteria with an eventual goal of programming them to target and then aggregate environmental substances as biofilms at key locations. Biofilms (e.g., dental plaque) are composed of embedded bacteria and bacterially produced material matrix. As a result, bacteria that sequester contaminants could be easily recovered by removing macroscopic biofilms. We will use synthetic biology to first program bacteria to sequester environmental contaminants. Next, we will program biofilm locations by using synthetic biology to genetically engineer the bacterial response to the surrounding fluid flow structure. Bacteria represent an ideal technology platform for materials recovery as multiple species already bind contaminants like heavy metals and organic toxins. Furthermore, the biology underlying their propensity to form biofilms in fluid flows is now sufficiently understood to allow us to design genetic programs that control this process. Ultimately, our engineered, pollutant-laden bacteria will aggregate and be recovered at specific locations in moving fluids.

The Development of Thermal Diodes and Transistors for Sustainable Energy

Principal Investigator: Prof. Scott Huxtable

Abstract:

Over half of the energy consumed in the world is ultimately lost as waste heat. Thus tremendous opportunities exist to improve energy sustainability and efficiency through better control of thermal transport. Here we propose to engineer nanoscale interfaces that will underpin the development of novel heat transfer systems. Modern electronic devices benefit from precise control of electrons with fundamental building blocks such as transistors (controlled currents) and diodes (one-way current). Analogues for controlling heat are theoretically possible, but lacking in reality. Systems where heat flow is controlled with thermal transistors and/or diodes would revolutionize our use of energy as otherwise-wasted heat could be stored or routed for further usage. Our limited understanding and control of nanoscale heat transport has hindered the development of these devices. This project will initially focus on elucidating fundamental mechanisms that control heat transfer through interfaces via systematic nanoscale measurements of thermal transport as a function of chemical structure and temperature at an interface. The vibrational spectra of the components will be examined to determine the relationship between vibrational interactions and heat transfer at the nanoscale. By designing molecules with asymmetric vibrational and thermal properties, we will build the foundations for thermal diodes and transistors. This project is fundamentally interdisciplinary as it combines efforts in heat transfer (Huxtable) with preparation and spectroscopy of interfacial films (Ducker). Once the mechanisms of interfacial heat transfer are understood, the team will be well poised to design and fabricate proof-of-concept thermal diodes and transistors.

Turbulence in real environments: performance and impact on large scale wind energy

Principal Investigator: K. Todd Lowe

Abstract:

We propose an interdisciplinary study of multi-scale wind turbine blade interaction to improve the understanding and prediction of wind farm-scale performance and acoustic emissions. A pressing need in utility-scale wind turbine research is physics-motivated methods for modeling groups of wind turbines. The challenge is daunting, requiring resolution far beyond current computing capabilities if one were to directly model the entire problem. Current approaches are either 1) much too low fidelity to correctly predict the interactions among atmospheric turbulence, upstream blade wakes and local blade loading or 2) naïve in implementing multi-scale resolution switching in attempts to capture some details of flow and acoustics. The approach we propose is to computationally and experimentally study a new model problem that captures the entire range of pertinent space and time scales while also containing many key physics including transitory stall, unsteady transition, dynamic loading, and amplitude modulated noise sources. An experiment involving two turbine blades, one in the wake of the first, is to be designed using resolved simulations for the VT Stability Wind Tunnel and later studied using high speed particle image velocimetry (PIV). Our core hypothesis is that the microscale and macroscale of unsteady flows is coupled in important ways that result in impacts on blade performance and acoustic emissions. Full testing of this hypothesis will extend beyond the scope of the JFC; however, the work proposed is critical for establishing the groundwork needed to seek follow-on funding from NSF (Fluid Dynamics, Energy for Sustainability, Major Research Instrumentation programs) and DOE (Atmosphere to electrons program).

VQA: Visual Question Answering

Principal Investigator: Devi Parikh

Abstract:

We are witnessing an excitement in the research community and frenzy in the media today regarding deep learning, computer vision, and automatic image understanding technology. In fact, nearly two months ago (November 2014), The New York Times heralded the arrival of a new generation of image recognition technology. It takes in as input an image, and outputs a description in natural language (English). While often accurate, the descriptions produced by these systems are quite generic. This is not surprising because the task “describe an image” is ill-defined. One primary motivation behind such image description approaches is to provide analysts or people with impaired eyesight a mechanism to extract relevant information from images and videos. However, usability research and testimonials from disabled have shown that users do not want rambling generic descriptions constantly blaring in their ears. What they want is to be able to poll an intelligent device and ask specific goal-driven questions. What they want is to be able to elicit situationally relevant information - Can I cross the street? Is there a car about to hit me? Is there something sharp in the scene that I should avoid? The overarching goal of this project is to create **VQA: A visual question answering system that given an input image can answer natural language free-form questions**

Well-defined Nanoscale Carbon Electrode from Block Copolymer Thin Films for Energy Conversion and Storage

Principal Investigator: Guoliang (Greg) Liu

Abstract:

Simultaneously achieving three properties - a large surface area, a high conductivity of electrons, and efficient transport of ions/molecules - is a grand challenge in high performance modern nanoelectrodes for energy conversion and storage. Most conventional materials can achieve the first two properties but often miss the third one and thus have limited performance as electrodes in energy conversion and storage. Herein we propose to synthesize and fabricate thin films of nanoporous carbon structures from block copolymers that can self-assemble into welldefined nanoscale morphologies. We hypothesize that the self-assembled block copolymer thin films can be used as precursors to create nanoporous carbon electrodes with well-controlled morphologies and pore sizes. The resulting nanoporous carbon electrodes 1) inherit from block copolymers their well-defined porous morphologies and molecule-controlled dimensions, 2) gain a high conductivity through high-temperature pyrolysis of polymers into carbon, and 3) allow for fast transport of electrons, ions, and reactants across the thin-film electrodes. We will 1) synthesize novel block copolymers with various compositions for efficient conversion into carbon, 2) pyrolize block copolymers into well-defined nanoporous carbon structures, and 3) functionalize nanoporous carbon with molecules and nanoparticles and test the performance as nanoelectrodes. We anticipate that these nanoporous carbon electrodes can be used in various applications for energy conversion and storage including fuel cells, batteries, and supercapacitors, as well as other applications such as water purification membranes, sensors, and actuators.

Wireless Cognition: A Prototype Multi-User Brain-Computer Interface System

Principal Investigator: John A. Richey

Abstract:

The purpose of the current proposal is to use the principles of brain-computer interface (BCI) to link the brains of multiple humans in real-time, for the purposes of exchanging data about cognitive states in a way that has potential to facilitate communication and problem solving. Broadly speaking, BCI is a system that 1) classifies and 2) reports patterns of brain activity to a device for the purposes of control depending on the distinctive cognitive state of the user. All prior BCI implementations have one feature in common: a single human interacting with a single processor. This is appropriate for scenarios in which a human has no other options for communication (e.g. paralysis). However, many normal aspects of communication could be dramatically accelerated by using a computer as an intermediary. In this project, we will develop and alpha test a prototype multi-user BCI, which will allow users (wearing EEG caps) to communicate simple information extremely rapidly over cellular or Wi-Fi networks. The utility in adding a computer as an intermediary between humans is revealed when considering that there are critical parameters of an interaction that a human 1) is not capable of computing or 2) does not compute for practical reasons (i.e. unreasonable increase in cognitive load), or 3) cannot compute fast enough to be practically useful. A computer could facilitate an interaction by assuming the computational burden. This is useful when verbal communication is impossible such as battlefield conditions or undesirable as in conditions requiring silent communication.

RESEARCH AWARDS FROM 2014

A Unified Computational-Experimental Investigation of Biotransport of Self-Propelled Drug Nanoparticles
Principal Investigator: Bahareh Behkam

Additive Manufacturing of Magnetic Components for Next-level Power Electronics Integration
Principal Investigator: Guo-Quan Lu

Amorphous polysaccharide matrices: a novel strategy to improve delivery and anti-diabetic effectiveness of dietary procyanidins
Principal Investigator: Andrew P. Neilson

Analytical Capacity Enhancement to Support and Expend Research Activities of USDA-Funded and Other Federally Funded Projects on Environmental Fate and Impact of Emerging Contaminants
Principal Investigator: Kang Xia

Automated Synthesis of Software Countermeasures to Defend against Side-Channel Attacks
Principal Investigator: Chao Wang

Bio-Inspired Technique for the Reduction of Wind Turbine Trailing Edge Noise
Principal Investigator: William Devenport

Bioinspired Artificial Reefs for Coastal Protection
Principal Investigator: Anne Staples

Breaking Boundaries on Information Encoding in Sonar and Radar
Principal Investigator: Hongxiao Zhu

Clean water from complex natural systems: Soil and hydrological controls
Principal Investigator: Brian Strahm

CloudCV: Large-Scale Distributed Computer Vision as a Cloud Service
Principal Investigator: Dhruv Batra

Composite Delamination Prevention and Detection via Sustainable, Tough and Smart Nanocellulose/Carbon Nanotube Fibers
Principal Investigator: Gary Seidel

Dynamics of coupled P-Fe-Mn cycling in drinking water reservoirs and implications for water quality
Principal Investigator: Cayelan Carey

Food sustainability using cavitation micro-bubbles: mechanical sanitization
Principal Investigator: Sunghwan Jung

Geotechnical Survey Strategies for Cost-efficient Ocean Renewable Energy Early Site Characterization
Principal Investigator: Nina Stark

Greenhouse gas emissions and stream restoration
Principal Investigator: Durelle Scott

Improving biofuel crop growth and photosynthesis through the use of non-transgenic genome editing technology
Principal Investigator: Zachary Nimchuk

Instructive biomaterials: a multimodal nano-engineered scaffold platform to examine 3D tissue development
Principal Investigator: Aaron Goldstein

Morphodynamic and Ecological Impacts of Marine Hydrokinetic Energy Extraction: A Multiscale, Interdisciplinary Approach
Principal Investigator: Heng Xiao

Nanofiber-based Cardiac Tissue Regeneration: integrating drug delivery, cells and 4D in situ imaging
Principal Investigator: Jia-Qiang He

Novel Solutions for Cognitive Radio Ad Hoc Networks in Tactical Communications
Principal Investigator: Thomas Hou

Opening the 'black box' in bioretention cells: how does understanding of microbial ecology translate to improved performance?
Principal Investigator: Brian Badgley

Self-Powered Structural Health Monitoring System for Fiber Reinforced Composites
Principal Investigator: Michael Philen

Ultrasensitive microfluidic ChIP technology for probing epigenetic dynamics during inflammation
Principal Investigator: Chang Lu

Understanding the distortion of atmospheric turbulence approaching a wind turbine
Principal Investigator: William Devenport

Use of fecal source-tracking techniques in groundwater quality management to reduce waterborne disease outbreaks
Principal Investigator: Leigh-Anne Krometis

Why is cancer so smart? Breaking through at the intersection of tumor engineering and microbiology
Principal Investigator: Scott S. Verbridge

RESEARCH AWARDS FROM 2013

"Filming" Biomolecules in Action with Terahertz Spectroscopy
Principal Investigator: Vinh Nguyen
Co-Principal Investigator: Daniel Capelluto

Bat Swarming as a Model System for Novel Air Traffic Control
Principal Investigator: Nicole Abaid
Co-Principal Investigator: Rolf Mueller

Cardiovascular Computed Tomography with Stationary Carbon Nanotube X-ray Sources
Principal Investigator: Guohua Cao
Co-Principal Investigator: John L. Robertson

Coherent Polarization Microscopy - A Quantitative, Label-free Approach to Understanding the Inflammatory Mechanism of Atherosclerosis
Principal Investigator: Yizheng Zhu
Co-Principal Investigator: Liwu Li

Giant Thermoelectric Performance through Combinatory Computation Modeling and Microstructural Engineering
Principal Investigator: Celine Hin
Co-Principal Investigator: Shashank Priya

H2S-Releasing Nanoparticles for Cancer Therapy
Principal Investigator: John Matson
Co-Principal Investigator: Carla Finkielstein

Nanoscale Structural/Chemical Characterization of Manganese Oxide Nanoparticles in Drinking Water Systems
Principal Investigator: Mitsuhiro Murayama
Co-Principal Investigator: Michael Hochella, William Knocke

Paper-Based Sensors and Bicycle Pumps for Airborne Pathogen Detection
Principal Investigator: Linsey Marr
Co-Principal Investigator: Elankumaran Subbiah, Peter Vikesland

Polymer-Supported Light-Activated Supramolecular Complexes in Catalysis
Principal Investigator: Karen Brewer
Co-Principal Investigator: John L. Robertson

Tailoring Metal Oxide Morphology and Interfacial Energetics for High Efficiency Hybrid Bulk-Heterojunction Solar Cells
Principal Investigator: Amanda Morris
Co-Principal Investigator: Harry Gibson

Uncovering the Role of the Tumor Microenvironment in Cancer Progression and Therapeutic Intervention using a Multi-Disciplinary Tumor Engineering Platform
Principal Investigator: Nicole Rylander
Co-Principal Investigator: Carla Finkielstein, John L. Robertson, Pavlos Vlachos

Unmanned Aerial System Airworthiness: A Case Study in Safety Certification for Complex, Non-Deterministic Systems
Principal Investigator: Craig Woolsey
Co-Principal Investigator: Mazen Farhood, Mayuresh Patil, Patrick Roberts, Christopher Roy

Using High Sensitivity Transcriptomics and Metabolomics to Develop New Strategies against Plant Pathogens
Principal Investigator: Guillaume Pilot
Co-Principal Investigator: John M. McDowell

RESEARCH AWARDS FROM 2012

Carbon Nanohorn Theranostic Cancer Agents
Principal Investigator: M. Nichole Rylander, Mechanical Engineering
Co-Principal Investigator: Timothy Long, Chemistry; Ge Wang, School of Biomedical Engineering and Sciences; John Robertson, Biomedical Sciences and Pathobiology; Chris Rylander, Mechanical Engineering

A New Approach to Low-Power Design of Radios for Wireless Devices
Principal Investigator: Dr. Kwang-Jin Koh (Electrical and Computer Engineering)
Co-Principal Investigator: Dr. Dong S. Ha (Electrical and Computer Engineering)
Thrust Area: Cognition and Communication

Artificial Hair Cells as the Basis for New Methods of Treating Hearing Loss and Balance Disorders
Principal Investigator: Dr. Donald J. Leo (Mechanical Engineering)
Co-Principal Investigator: Dr. John W. Grant (Biomedical Engineering), Dr. Rolf Mueller (Mechanical Engineering), and Dr. Pablo Tarazaga (Mechanical Engineering)
Thrust Area: Emerging Technologies

Biodiscerned© Flight Kinematics for Articulated Flapping Systems
Principal Investigator: Dr. Javid Bayandor (Mechanical Engineering)
Co-Principal Investigator: Dr. Andrew Kurdila (Mechanical Engineering)
Thrust Area: Emerging Technologies

Carbon Footprint Monitoring of Earthmoving Construction Operations using Networks of Existing Cameras and Inventories of Greenhouse Gas Emissions
Principal Investigator: Dr. Mani Golparvar-Fard (Civil and Environmental Engineering)
Co-Principal Investigator: Dr. Linsey C. Marr (Civil and Environmental Engineering)
Thrust Area: Emerging Technologies

Co-verification of Critical Cyber-Physical Systems: A Formal Approach
Principal Investigator: Dr. Chao Wang (Electrical and Computer Engineering)
Co-Principal Investigator: Dr. Michael S. Hsiao (Electrical and Computer Engineering)
Thrust Area: Emerging Technologies

Sustainable Plant-microbial Interactomes to Feed an Impoverished World: Exploiting Gene Diversity for Fe and Zn Accumulation in Tubers of Potato and Its Interaction with Helper Microbes
Principal Investigator: Dr. Mark A. Williams (Horticulture)
Co-Principal Investigator: Dr. Richard Vellieux (Horticulture)
Thrust Area: Emerging Technologies

Using the Generalized Langevin Equation Formalism to Reconstruct Dynamic Equations from Time Series Data
Principal Investigator: Dr. Jianhua Xing (Biological Sciences)
Co-Principal Investigator: Dr. Michel Pleimling (Physics)
Thrust Area: Emerging Technologies

A Novel Fiberoptic Microneedle Device for Therapeutic Cancer Vaccine Delivery
Principal Investigator: Dr. Chris Rylander (Mechanical Engineering)
Co-Principal Investigator: Dr. Elankumaran Subbiah (Veterinary Medicine)
Thrust Area: Nano-Bio Interface

Modular Biotemplates for Assembly and Patterning of Bio-inspired, Nanostructured Materials
Principal Investigator: Dr. Tijana Grove (Chemistry)
Co-Principal Investigator: Dr. Robert Moore (Chemistry)
Thrust Area: Nano-Bio Interface

Tissue Scaffold Fabrication via Micro-Stereolithography
Principal Investigator: Dr. Chris Williams (Mechanical Engineering)
Co-Principal Investigator: Dr. Timothy E. Long (Chemistry)
Thrust Area: Nano-Bio Interface

Design of Multiscale Heterostructures with Enhanced Energy Harvesting
Principal Investigator: Dr. Marwan Al-Haik (Engineering Science and Mechanics)
Co-Principal Investigator: Dr. Donald J. Leo (Mechanical Engineering)
Thrust Area: Nanoscale Science and Engineering

Magneto-optical Studies of Carbonaceous Nanostructures for Quantum Information and Other Applications
Principal Investigator: Dr. Hans Robinson (Physics)
Co-Principal Investigator: Dr. Giti Khodaparast (Physics)
Thrust Area: Nanoscale Science and Engineering

A Multi-Disciplinary Approach for Co-Design of the Cyber and Physical Components of Autonomous Miniature Air Vehicles
Principal Investigator: Dr. Mazen Farhood (Aerospace and Ocean Engineering)
Co-Principal Investigator: Dr. Sandeep Shukla (Electrical and Computer Engineering)
Thrust Area: National Security

A New Approach to Lightweight Armor Applications: Metal-Ceramic Composite Castings
Principal Investigator: Dr. Alan P. Druschitz (Materials Science and Engineering)
Co-Principal Investigator: Dr. Christopher B. Williams (Mechanical Engineering) and Dr. Romesh C. Batra (Engineering Science and Mechanics)
Thrust Area: National Security

Next Generation Data-to-Decision Systems for Disaster Response
Principal Investigator: Dr. Christian Wernz (Industrial and Systems Engineering)
Co-Principal Investigator: Dr. Naren Ramakrishnan (Computer Science)
Thrust Area: National Security

Model-Guided Metabolic Engineering of Plants
Principal Investigator: Dr. Ryan Senger (Biological Systems Engineering)
Co-Principal Investigator: Dr. Glenda Gillaspy (Biochemistry)
Thrust Area: Renewable Materials

Electrocatalytic Flow-Through Metal Organic Framework Membranes for Sustainable Fuel Generation from a CO2 Feedstock
Principal Investigator: Dr. Amanda Morris (Chemistry) Dr. Eva Marand (Chemical Engineering)
Thrust Area: Sustainable Energy

A Coupled Biochemical/Biophysical System to Remediate Diffuse Nitrate in Shallow Groundwater
Principal Investigator: Dr. Mark S. Reiter (Crop and Soil Environmental Sciences) and Dr. Zachary M. Easton (Biological Systems Engineering)
Co-Principal Investigator: Dr. Wade E. Thomason (Crop and Soil Environmental Sciences) and Dr. Brian L. Benham (Biological Systems Engineering)
Thrust Area: Sustainable Water

Physicochemical Effects of Temperature and Water Chemistry on Streambank Erosion
Principal Investigator: Dr. Theresa Wynn-Thompson (Biological Systems Engineering)
Co-Principal Investigator: Dr. Matthew Eick (Crop and Soil Environmental Sciences)
Thrust Area: Sustainable Water

StREAM Lab Examination of Critical Watershed Processes Governing Dissemination of Agricultural Sources of Antibiotic Resistance
Principal Investigator: Dr. Amy Pruden-Bagchi (Civil and Environmental Engineering)
Co-Principal Investigator: Dr. W. Cully Hession (Biological Systems Engineering), Dr. Leigh Anne Krometis **(Biological Systems Engineering), Dr. Kang Xia (Crop and Soil Environmental Sciences), and Dr. Katherine F. Knowlton (Dairy Science)**
Thrust Area: Sustainable Water

RESEARCH AWARDS FROM 2011

3D Printing with Nano-inks for Physical Cryptography
Principal Investigator: Christopher Williams, Aerospace and Ocean Engineering
Co-Principal Investigator: Kathy Lu, Materials Science and Engineering; Thomas A. Campbell, Institute for Critical Technology and Applied Science

3D Reconstruction and Recognition for Enhanced Highway Condition Assessment
Principal Investigator: Mani Golparvar-Fard, Civil and Environmental Engineering
Co-Principal Investigator: Jesus M. de la Garza, Electrical and Computer Engineering

A New Approach for Targeted Drug Delivery and Controlled Release
Principal Investigator: Mike Zhang, Biological Systems Engineering
Co-Principal Investigator: Harry Dorn, Chemistry

A Pathway to Generating High Performance Thermoplastic Nano-Composites
Principal Investigator: Donald Baird, Chemical Engineering
Co-Principal Investigator: Stephen M. Martin, Chemical Engineering

A Theranostic Approach to Tuberculosis
Principal Investigator: Elankumaran Subbiah, Biomedical Sciences and Pathobiology
Co-Principal Investigator: Judy Riffle, Chemistry; Nammalwar Sriranganathan, Biomedical Sciences and Pathobiology

Chipless RFID
Principal Investigator: Majid Manteghi, Electrical and Computer Engineering
Co-Principal Investigator: Tamal Bose, Electrical and Computer Engineering

Damping and Piezoresistive Response of Nanocomposite Structural Health Monitoring Sensors: Multi-scale Modeling and Characterization
Principal Investigator: Gary Seidel, Aerospace and Ocean Engineering
Co-Principal Investigator: Daniel Inman, Mechanical Engineering

Design Optimization and Fabrication of Nanocomposite MAV Wings
Principal Investigator: Mayuresh Patil, Aerospace and Ocean Engineering
Co-Principal Investigator: Gary Seidel, Aerosapce and Ocean Engineering; Robert Canfield, Aerospace and Ocean Engineering

Elucidating the Regulatory Roles of MicroRNAs in Switchgrass Biomass Production
Principal Investigator: Bingyu Zhao, Horticulture
Co-Principal Investigator: Richard Veilleux, Horticulture

Generating Environmentally-Friendly Novel Biofuel Molecules with Synthetic Biology
Principal Investigator: Ryan Senger, Biology Systems Engineering
Co-Principal Investigator: David Bevan, Biochemistry

Helping Streams Help Themselves: Developing a Sustainable Water Pollution Mitigation Technique
Principal Investigator: Erich Hester, Civil and Environmental Engineering
Co-Principal Investigator: W. Cully Hession, Biological Systems Engineering

High Performance Sorbents for Carbon Capture
Principal Investigator: Richard Gandour, Chemistry
Co-Principal Investigator: Roe-Hoan Yoon, Mining and Minerals Engineering; S. Richard Turner, Chemistry; Diego Troya, Chemistry

Integrating Soil and Vegetation Performance into Complex Engineered Environments in Urban Watersheds
Principal Investigator: Susan Day, Forest Research and Environmental Conservation
Co-Principal Investigator: Glenn Moglen, Civil and Environmental Engineering; Stephen Schoenholtz, Virginia Water Resources Research Center

Multi-scale Modeling and Simulation of Geophysical Flows: A Numerical Laboratory
Principal Investigator: Anne Staples, Engineering Science and Mechanics
Co-Principal Investigator: Traian Iliescu, Mathematics

Novel Games for Analyzing Cyber-Security Behaviors: An Interdisciplinary Approach
Principal Investigator: Danfeng Yao, Computer Science
Co-Principal Investigator: Scott Geller, Psychology; Manuel Perez-Quinones, Computer Science

Probing Fundamental Material Constants of Polymeric Nanofibers
Principal Investigator: Amrinder Nain, Mechanical Engineering
Co-Principal Investigator: Robert B. Moore, Chemistry. David Schmale, Plant Pathology, Physiology and Weed Science; Craig Woolsey, Aerospace and Ocean Engineering

When Emotion Really Matters: Brain Computer Interfaces for the Masses
Principal Investigator: Denis Gracanin, Computer Science
Co-Principal Investigator: Joe Gabbard, Virginia Bioinformatics Institute; Karen Roberto, Institute for Society, Culture and Environment; Kirby Deater-Deckard, Psychology

StREAM Lab Examination of Critical Watershed Processes Governing Dissemination of Agricultural Sources of Antibiotic Resistance
Principal Investigator: Dr. Amy Pruden-Bagchi (Civil and Environmental Engineering)
Co-Principal Investigator: Dr. W. Cully Hession (Biological Systems Engineering), Dr. Leigh Anne Krometis (Biological Systems Engineering), Dr. Kang Xia (Crop and Soil Environmental Sciences), and Dr. Katherine F. Knowlton (Dairy Science)
Thrust Area: Sustainable Water

RESEARCH AWARDS FROM 2010

Contactless-AC-Modulated Insulator-Based Dielectrophoresis (CiDEP) for Rare Cancer Cell Separation
Principal Investigator: Masoud Agah, Electrical and Computer Engineering
Co-Principal Investigator: Rafael Davalos, School of Biomedical Engineering and Sciences; Eva Schmelz, Human Nutrition, Foods and Exercise

Design and Fabrication of a Biologically Accurate, Vascularized Artificial Bone Graft
Principal Investigator: Joseph W. Freeman, School of Biomedical Engineering and Sciences
Co-Principal Investigator: Aaron Goldstein, Chemical Engineering

Dynamic Mechanical Properties of Recombinant Elastomeric Proteins
Principal Investigator: Daniel M. Dudek, Engineering Science and Mechanics
Co-Principal Investigator: Chenming (Mike) Zhang, Biological Systems Engineering

Hemocompatibility of Drug-laden Nanomaterials
Principal Investigator: Elankumaran Subbiah, Center for Molecular Medicine and Infectious Diseases
Co-Principal Investigator: Nammalwar Sriranganathan, Biomedical Sciences and Pathobiology; Judy Riffle, Chemistry

Hierarchical Design and Assembly of Structures: Nano to Mesoscale
Principal Investigator: Amrinder S. Nain, Mechanical Engineering and School of Biomedical Engineering and Sciences
Co-Principal Investigator: Chris Cornelius, Chemical Engineering; Bahareh Behkam, Mechanical Engineering

Interdisciplinary Teaming and Graduate Education Study of ICTAS
Principal Investigator: Maura Borrego, Engineering Education
Co-Principal Investigator: Roseanne Foti, Psychology

Molecular Target of Soy Genistein for Potential Therapeutic Intervention of Inflammatory Induced Vascular Dysfunction
Principal Investigator: Zhenquan Jia, Division of Biomedical Sciences, Virginia College of Osteopathic Medicine
Co-Principal Investigator: Hara P. Misra, Virginia College of Osteopathic Medicine; Dongmin Liu, Human Nutrition, Foods and Exercise; S. Ansar Ahmed, Biomedical Sciences and Pathobiology

Nanofibers from Multi-layer Melt Electrospinning (MME)
Principal Investigator: Eugene G. Joseph, Chemical Engineering
Co-Principal Investigator: Abby W. Morgan, Chemical Engineering; J. Randy Heflin, Physics

Nanostructure III-V Multijunction Solar Cell on Germanium and Lattice Engineered Silicon Substrates
Principal Investigator: Mantu K. Hudait, Electrical and Computer Engineering

Novel Electrode Design to Increase Power Generation in Microbial Fuel Cells
Principal Investigator: Bahareh Behkam, Mechanical Engineering and School of Biomedical Engineering and Sciences
Co-Principal Investigator: Michael W. Ellis, Mechanical Engineering

Real-world Oriented Design for Dynamic Spectrum Access Systems
Principal Investigator: Yaling Yang, Electrical and Computer Engineering
Co-Principal Investigator: George Morgan, Finance; Dilip Shome, Finance; Tamal Bose, Electrical and Computer Engineering

The Origin of Nanoscale-derived Properties in Nanoparticles
Principal Investigator: M. Murayama, Nanoscale Characterization and Fabrication Laboratory (ICTAS) and Chemical Engineering
Co-Principal Investigator: William T. Reynolds, Materials Science and Engineering

Using Nanomaterials to Track Messenger RNA in Plants
Principal Investigator: James Westwood, Plant Pathology, Physiology and Weed Science
Co-Principal Investigator: Giti Khodaparast, Physics

Contactless-AC-Modulated Insulator-Based Dielectrophoresis (CiDEP) for Rare Cancer Cell Separation
Principal Investigator: Masoud Agah, Electrical and Computer Engineering
Co-Principal Investigator: Rafael Davalos, School of Biomedical Engineering and Sciences; Eva Schmelz, Human Nutrition, Foods and Exercise

RESEARCH AWARDS FROM 2009

A Design Framework for Thin-Walled Concrete Structures
Principal Investigator: Moen, Cris

A New Paradigm for Non-Equilibrium Dynamics
Principal Investigator: Schmittmann, Beatte

Algal Biodiesel Production: Breaking Barriers via Functional Genomics
Principal Investigator: Pereira, Andy

Bio-inspired Energy Harvesting
Principal Investigator: Sultan, Cornel

Biomimetic Microsystems Inspired by Physiological Networks in Insects
Principal Investigator: J. Socha-ESM
Co-Principal Investigator: S. Ross-ESM, P. Vlachos-ME, M. Stremler-ESM, A. Staples-ESM, I. Puri-ESM, R. De Vita-ESM, R. Davalos-Bio Engr., M. Agah-ECE

Challenges in the Fabrication of PEM Fuel Cell Membranes: Phase Separation Kinetics in Block Copolymer Systems During Solvent Removal
Principal Investigator: Martin, Stephen

Climate Change and Urban Growth: Development of a Sustainable and Resilient Water Management System Portfolio for the Greater Washington, DC Metropolitan Area
Principal Investigator: Moglen, Glenn

Cognitive Radio Network
Principal Investigator: Bose, Tamal

Conductive Biocompatible Nanoactuators
Principal Investigator: J. Freeman-SBES
Co-Principal Investigator: T. Long-Chem

Critical Programmatic Expansion of the ICTAS Environmental Nanosciences and Technology Research Theme: Nanoparticle/Cell Interactions and Nanotechnology-Enabled Sensor Development
Principal Investigator: Hochella, Mike

Development and Incorporation of a River-floodplain Metric into Regional Water Quality Models
Principal Investigator: Scott, Durelle

Dielectrophoretic microweaving: new technology platform for biofabrication of advanced nanomaterials
Principal Investigator: Davalos, Rafael

Enabling Sustainable Agriculture and Natural Resource Research and Education by Integrating Emerging Engineering Technology into Sustainable Practices
Principal Investigator: Gabbard, Joseph

Enhanced Performance in Bulk Heterojunction Solar cells via Endohedral Metallofullerenes and Morphological Control
Principal Investigator: Heflin, Randy

Exploiting Natural Genetic Variation to Improve Wood Properties and Biomass Yield in Poplar
Principal Investigator: J. Holliday-For Resources and Environ Consrv
Co-Principal Investigator: E. Beers-Hort, A. Brunner- For Resources & Environ Consrv

Holey Scaffolds
Principal Investigator: Xu, Yong

ICE - Advanced Fuel Gasification: A Coupled Experimental Computational Program
Principal Investigator: Lattimer, Brian

In-Situ NMR Investigation of Gas Hydrates-the future Energy Source and Storage
Principal Investigator: Wi, Sungsool

Inhibiting HIV-1 TAR RNA function using nanoparticle-delivered branched peptides
Principal Investigator: Santos, Webster

Magnetic and Optical Properties of Au Core/Oxide Shell Nanoparticles using Pulsed Laser Ablation
Principal Investigator: Abaide, Jeremiah

Nanopatterning and Quantitative Characterization of Nanostructured Materials
Principal Investigator: Lu, Kathy

Nanostructured Biomaterial Meshes with Gradient Properties for Tissue Engineering
Principal Investigator: Morgan, Abby

Near Real-time Monitoring and Adaptive Risk Assessment of the US National Levee Ssem Using Satellite-based Remote Sensing
Principal Investigator: Martin, James

Proof of Concept Study of Carbon Nanohorn Supported Virus Envelope-like Particles as Novel Vaccines
Principal Investigator: M. Zhang-BSE
Co-Principal Investigator: H. Dorn-Chem, X. Meng-Bio Med Sci

Selective Functionalization and Guided Assembly of Nanoparticle Molecules
Principal Investigator: Robinson, Hans

Sustainable Building Design Initiative
Principal Investigator: Boroyevich, Dushan

Sustainable Water Development: Water and Wastewater Treatment, Infrastructure Assessment and Repair, and Urban Watershed Management
Principal Investigator: Novak, John

Unique and Unclonable On-Chip Identifiers
Principal Investigator: Shaumont, Patrick

Water for Health ICTAS Center of Excellence
Principal Investigator: Dietrich, Andrea

RESEARCH AWARDS FROM 2008

A Visual Interface for Smart Vehicle Networks: A Flexible, User-Friendly Data Visualization Tool for Autonomous Vehicle Operators and Developers
Principal Investigator: N. Polys-CS
Co-Principal Investigator: C. Woolsey-AOE, D. Stilwell-ECE, A. Kurdila-ME

Cardiovascular Non-Invasive Diagnostics and Therapies
Principal Investigator: R. De Vita-ESM
Co-Principal Investigator: D. Leo-ME, T. Long-Chem, M. Paul-ME, M. Roan-ME, D. Tafti-ME, P. Vlachos-ME

Characterization and potential therapeutic intervention of human inflammatory network
Principal Investigator: L. Li -Biological Sciences
Co-Principal Investigator: J. Tyson-Biological Sciences, P. Carlier-Chem, H. Misra-VCOM, D. Capelluto-Chem, C. Lawrence-Biological Sciences, G. Wang-SBES, C. Rylander-SBES, N. Rylander-SBES

Cognitive Routing in Wireless Networks: Network Status Detection, Diagnosis and Response
Principal Investigator: Y. Yang-ECE
Co-Principal Investigator: A. Bell-ECE

Development of a Collaborative Laboratory for Hydrogen and Fuel Cell Research
Principal Investigator: M. Ellis-ME
Co-Principal Investigator: J. McGrath-Chem, R. Moore-Chem, D. Baird-CE, P. Zhang-BSE, M. von Spakovsky-ME, K. Lu-MSE, W. Reynolds-MSE

Development of Biosensors for Monitoring Engineered Nanomaterials in the Environment
Principal Investigator: P. Vikesland-CE
Co-Principal Investigator: M. Schreiber-Geosciences, M. Ehrich-Biomed, M. Hull-CE, B. Diesel-Geosciences

Integrated Analysis of Regulation by the Quorum-Sensing and CsrA Pathways in Bacteria
Principal Investigator: R. Kulkarni-Physics
Co-Principal Investigator: A. Stevens-Biological Sciences, A. Ritter-Physics

Non-Intrusive Monitoring for Gait and Posture for Fall Prevention for Telemedicine
Principal Investigator: T. Lockhart-ISE
Co-Principal Investigator: F. Quek-Computer Interaction and CS, M. Roan-ME, T. Martin-ECE, K. Roberto-Center for Gerontology, Y. Cao-CS

Positioning Virginia Tech to Significantly Enhance its External Grants and Activities in Water Quality and Urban Watersheds
Principal Investigator: J. Novak-CEE
Co-Principal Investigator: W. Hession-BSE , T. Grizzard-CEE, A. Godrej-CEE

SHOC Doc Mobil Unit- Safety and Health in Occupations Center (SHOC) Data in Occupations Collection (Doc) for on site research on occupational hazards
Principal Investigator: B. Kleiner-ICTAS and ISE
Co-Principal Investigator: M. Agnew-ISE. C. Evia-English, M. Madigan-ESM, T. Mills-Building Construction, A. Nieto-MME, M. Nussbaum-ISE, T. Smith-Jackson-ISE, T. Songer-CEE, W. Winchester III-ISE, D. Young-Myers-Lawson School of Construction

Smart Laboratories: Computer-Ready, Immediate Environments for the 21st Century Science
Principal Investigator: T. Kaur-VMRCVM
Co-Principal Investigator: J. Singh-VMRCVM, B. Schubert-College of Architecture and Urban Studies, R. Dunay-CAUS, N. King-CAUS, C. Clark-CAUS, C. Vorster, M. Gardener-CNS, B. Plymale-R & D Learning Technologies, W. Feng-CS

Turning Bytes to Knowledge Using Compositional Data Mining
Principal Investigator: N. Ramakrishnan-CS
Co-Principal Investigator: T. Murali-CS, L. Heath-CS, L. Watson-CS and Math, R. Helm-BioChem, C. Beattie-Math

VT-CogNet Virginia Tech Cognitive Radio Network
Principal Investigator: J. Reed-ECE
Co-Principal Investigator: T. Bose-ECE, C. Bostian-ECE, M. Buehrer-ECE, A. MacKenzie -ECE, M. Marathe-VBI and CS, S. Raman-_ECE, L. Da Silva-ECE, S. Sheetz-Acctg. Info. Sys., T. Smith-Jackson-ISE, C. Da Silva-ECE, W. Tranter-ECE, C. Zobel-Bus. Info. Tech

RESEARCH AWARDS FROM 2007

Autonomous Personal Transportation (APT)
Principal Investigator: Akshay Sharma School of Architecture and Design
Co-Principal Investigator: Robert Dunay School of Architecture and Design, Richard Goff Mechanical Engineering, and Michael Fleming TORC Technologies

Bio-based Materials Center (BBMC) at Virginia Tech
Principal Investigator: F. Agblevor-Biological Systems Engineering
Co-Principal Investigator: Justin Barone-Biological Systems Engineering, Kevin Edgar-Wood Science and Forest Products, Alan Esker-Chemistry, Paul Gatenholm-Materials Science and Engineering, Sean McGinnis-Materials Science and Engineering, Abby Morgan-Materials Science Engineering and Chemical Engineering, Scott Renneckar-Wood Science and Forest Products, Maren Roman-Wood Science and Forest Products, Zhiyou Wen-Biological Systems Engineering, Percival Zhang- Biological Systems Engineering

Bone Healing Grafts Fabricated by Nanoscale Assembly of Biological Building Blocks
Principal Investigator: P. Gatenholm-Materials Science and Engineering
Co-Principal Investigator: F. Agblevor-Biological Systems Engineering, J- H. Bohn-Mechanical Engineering, A. Esker-Chemistry, A. Goldstein-Chemical Engineering and Biomedical Engineering, K. Lu-Materials Science Engineering, L. O'Rourke-Biomedical Sciences and Pathobiology, I. Puri-Engineering Science and Mechanics, G. Wang-Biomedical Systems Engineering

Chemosensory Evaluation of Training and Oxidative Stress in Long-Distance Runners
Principal Investigator: P. Mallikarjunan-Biological Systems Engineering
Co-Principal Investigator: P. G. Brolinson-Virginia College of Osteopathic Medicine

Constructing Building Blocks (Recombinant Thermophilic Enzymes) and Investigating Their Interactions: A Novel Carbohydrate-Based Hydrogen Production by Synthetic Biology
Principal Investigator: P. Zhang-Biological Systems Engineering
Co-Principal Investigator: Liwu Li-Biological Sciences

Continuous Plasma Torch Production of Fullerenes and Trimetallic Nitride Endohedral Metallofullerenes
Principal Investigator: H. Dorn-Chemistry and CSAND
Co-Principal Investigator: W. O'Brien-Mechanical Engineering

Development of Trimetallic Nitride Templated Endohedral Metallofullerenes and Peapod Structures for Imaging Therapeutic Applications
Principal Investigator: N. Rylander-Mechanical Engineering and SBES
Co-Principal Investigator: H. Dorn-Chemistry, S. Huxtable-Mechanical Engineering, C. Rylander-Mechanical Engineering and SBES

Evaluation of a Nanoscale Targeted Antioxidant Delivery System in an Equine Model for Human Asthma and Pulmonary Inflammation
Principal Investigator: C. Thatcher-Biomedical and Veterinary Science
Co-Principal Investigator: B. Lepene-Biomedical and Veterinary Science

Implantable Oncologists
Principal Investigator: M. Agah-Electrical and Computer Engineering
Co-Principal Investigator: R. Davalos-Biomedical Engineering and Sciences, P. Gatenholm-Materials Science Engineering, I. Lazar-Virginia Bioinformatics Institute, L. Nazhandali- Electrical and Computer Engineering, S.Raman-Electrical and Computer Engineering, I. Puri-Engineering Science and Mechanics, G. Wang-Biomedical Systems Engineering

Interdisciplinary Design of Engineering Muscle Tissue
Principal Investigator: T. Long-Chemistry, D. Baird-Chemical Engineering
Co-Principal Investigator: J. Freeman-SBES, A. Goldstein-Chemical Engineering

Microbial-driven Electrical Currents in Nanobiofilms
Principal Investigator: J. Falkinham-Biological Sciences
Co-Principal Investigator: A. Dietrich-Civil and Environmental Engineering, I. Puri- Engineering Science and Mechanics

Nanoparticle Markers for High-Efficiency Non-Linear Microscopy: Combining Cancer Imaging and Treatment
Principal Investigator: H. Robinson-Physics
Co-Principal Investigator: R. Davis-Chemical Engineering, Y.W. Lee-SBES

Neural Tube Defects in Mice from Tap Water
Principal Investigator: T. C. Hrubec-Biomedical Sciences and Pathobiology
Co-Principal Investigator: VCOM, D. J. Blodgett-Biomedical Sciences and Pathobiology, College of Veterinary Medicine, F. A. Etzkorn-Chemistry

Newcastle Disease Virus Bionanoparticles for Tumor-Selective Targeting and Oncolysis
Principal Investigator: E. Subbiah-Biomedical Science
Co-Principal Investigator: J. Riffle-Chemistry

Synthesis and Characterization of New Reverse Osmosis and Nanofiltration Membranes for Water Purification
Principal Investigator: J. McGrath-Chemistry

RESEARCH AWARDS FROM 2006

Bioconjugated Cellulose Nanocrystals for Immunotargeting
Principal Investigator: Maren Roman (Wood)
Co-Principal Investigator: YongWoo Lee (DBSP)

Cognitive RAdio Front-end Technology (CRAFT)
Principal Investigator: Sanjay Raman (ECE)
Co-Principal Investigator: Charles Bostian (ECE), Allen MacKenzie (ECE), Jeff Reed (ECE)

Development of "Environmental Nanoscience and Technology" at Virginia Tech
Principal Investigator: Michael Hochella (Geosciences)
Co-Principal Investigator: Harry Dorn (Chem), Joerg Jinschek (MSE), Peter Vikesland (CEE), Linsey Marr (CEE)

Development of Bionano-Constructs with Tethered Lipid Bilayers
Principal Investigator: Amadeu Sum (ChemE)
Co-Principal Investigator: Richard Gandour (Chem), Alan Esker (Chem)

Engineered Nanoconstructs for Targeted Regulation of Intracellular Free Radical Concentration
Principal Investigator: Kathleen Meehan (ECE)
Co-Principal Investigator: Richey Davis (ChemE), David Cox (ChemE), Judy Riffle (Chem), Marion Ehrich (Biomedical Science and Pathobiology/VetMed), Bev Rzigalinski (Biomedical Science and Pathobiology/VetMed)

Environmentally Beneficial Energy Science and Technology (E-BEST) PEM Fuel Cell Program
Principal Investigator: Scott Case (ESM)
Co-Principal Investigator: Michael Ellis (ME), Nancy Love (CEE/BS)

Getting the Tooth Fairy to Give Back:Bone Tissue Engineering from Voluntary Tooth Extractions
Principal Investigator: Brian Love (MSE)
Co-Principal Investigator: Aaron Goldstein (ChemE), Mark Van Dyke (Biomedical Engineering/Wake Forest), James Wampler (Biomedical Engineering/Wake Forest)

Micro Injection of Nanoparticles and Real-time Spectroscopy in Biological Systems
Principal Investigator: Giti A. Khodaparast (Physics)

Sensor and Wireless Network Design For Ultra Lightweight Inflatable Structures Health Monitoring (SHM) Research
Principal Investigator: Rakesh K. Kapania (AE)
Co-Principal Investigator: Ron Moffitt (IALR), Amitabh Mishra (ECE), Nakhiah Goulbourne (ME)

Super Resolution in Scanning Holographic Microscopy of 3D Fluorescent Biological Specimens
Principal Investigator: Guy Indebetouw (Physics)

Systems Biology of in vitro 3D Hepatic Architectures
Principal Investigator: Padma Rajagopalan (ChemE)
Co-Principal Investigator: T.M. Murali (CS)

Targeted Drug Delivery to Treat Diseases Due to Intracellular Bacterial Pathogens and Cancer
Principal Investigator: Nammalwar Sriranganathan (DBSP)
Co-Principal Investigator: Gary Pickrell (MSE), Randy Heflin (Physics), Ramanathan Kasimanickam (Large Animal Clinical Sciences)