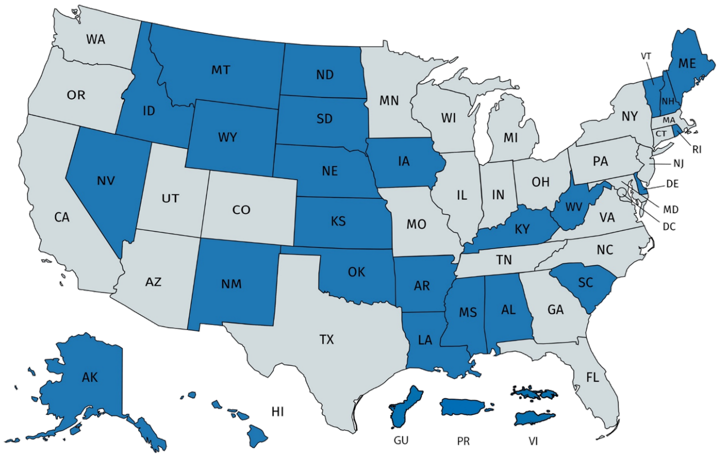
EPSCoR Jurisdiction Research Programs
aligned with
NASA Ames Research Center Priorities

A Companion Booklet created for NASA Ames Researchers in conjunction with the “NASA EPSCoR Research discussions with ARC” Virtual Meeting held on Thursday, June 22, 2022, 1:00 pm EST



Thursday, June 22, 2023 | 1:00 pm – 2:30 pm Eastern

Virtual participation via Microsoft Teams

Meeting Link

Meeting ID: 264 389 037 700 Passcode: UrAuc4

Collected Researcher Slides and Bios are available here

Agenda

All times are EASTERN U.S. time zone

1:00 pm **Welcome and Summary of Meeting Objectives** **T. G. Guzik**
1:02 pm **Overview of Ames Research Center** **Harry Partridge**
1:07 pm **Introduction to EPSCoR and the NASA EPSCoR Program** **T. G. Guzik**

The remainder agenda items are two-minute flash talk presentations by jurisdiction researchers to illustrate capability and relevance to ARC research priorities.

1:25 pm Researcher Presentation Part 1:

Recent tests of gas-surface reaction products for carbon samples in air and oxygen plasmas **Douglas G. Fletcher (VT)**

Unleashing the potential of quantum algorithms for the simulations correlated quantum materials **Ka-Ming Tam (LA)**

Dynamic Adaptive Mesh Refinement for Wall Modeled LES of Complex Aero-Configurations **Andrew Kirby (WY)**

Machine learning and deep learning models for hyperspectral unmixing of waterbodies **Vidya Manian (PR)**

AI-enabled Joint Air Traffic and Aviation Spectrum Management **Hongxiang Li (KY)**

Autonomous Structural Composites (AutoCom) for Autonomous Damage Detection and Healing **Donghyeon Ryu (NM)**

Energy Efficient and Rapid Composite Manufacturing via Frontal Polymerization **Xiang Zhang (WY)**

Q&A (9 minutes)

1:48 pm Ten-minute break in virtual meeting. Resume at 1:58 pm.

1:58 pm Researcher Presentation Part 1:

Advancements in Gene Sampling Technology: Unveiling Transcriptomic and Proteomic Biomarkers of Ionizing Radiation Exposure through Exosomal Liquid Biopsy **Gergana G. Nestorova (LA)**

Biogeography and ecophysiology of extremophiles in the deep biosphere **Anirban Chakraborty (ID)**

Identification of Prebiotic Molecules and Exploration of Astrochemistry through High-Resolution Laser Spectroscopy **Jinjun Liu (KY)**

Cracking the Histone Code **Karen C. Glass (VT)**

Stitching the Surface to the Sky: Surface & Drone-Borne Martian Boundary Layer Science **Brian Jackson (ID)**

Space Systems Operations Research and Next Generation Space Systems **Hang Woon Lee (WV)**

Semi-supervised Machine Learning for Anomaly/Rare Category Detection **Rohan Loveland (SD)**

Electro-spun polymer nanofibers for use as sensors and in low power consumption devices **Nicholas J. Pinto (PR)**

Big Data & Multi-Source Data Fusion/Integration and Analysis of Global Land Use/Cover Change in the Pacific Islands **Jose Edgardo L. Aban (GU)**

Methane Dynamics of Vegetation-Soil Interactions in Bald Cypress and Other Bottomland Hardwood Forests **Bassil El Masri (KY)**

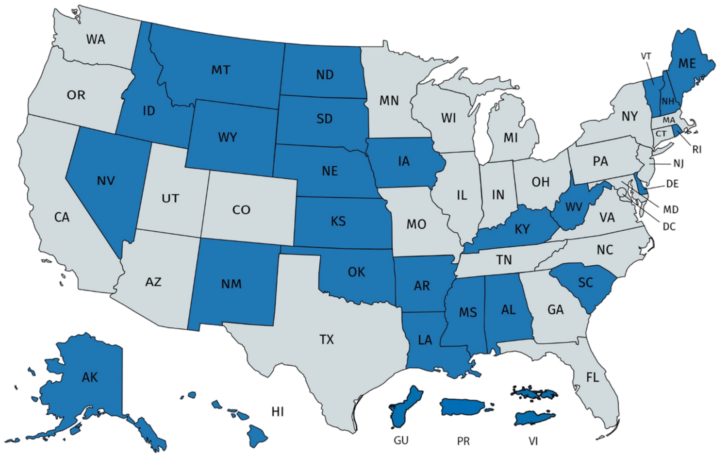
Measuring the line-of-sight distribution of potential exoplanet host microlenses with K2 Campaign 9 data **Matthew Penny (LA)**

Q&A (10 minutes)

4:30 pm Adjourn Meeting

Topic Area 1

Entry Systems: Safely Delivering Spacecraft to Earth and Other Celestial Bodies



NASA EPSCoR Research for ARC
June 22, 2023

Entry Systems: Safely Delivering Spacecraft to Earth and Other Celestial Bodies

Pulsed laser deposition with RHEED at Western Kentucky University

Dr. Ali Oguz Er

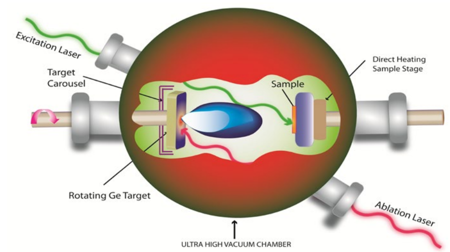
Western Kentucky University
Department of Physics & Astronomy
ali.er@wku.edu; (270) 745-6202

Ali Oguz Er is an Associate Professor of Physics at WKU. His research background includes pulsed laser deposition of quantum dot growth, time resolved x-ray diffraction, nanoscale heat transport in thin films, photodeactivation of pathogenic bacteria and viruses in human blood, optical discrimination of fluorescent proteins by using quantum control techniques, and selective bond breaking of semiconductor surfaces. Dr. Er has a state-of-the-art pulsed laser deposition (PLD) system in his lab at WKU. This PLD system incorporates multiple laser types (e.g., Nd:YAG, Kr-F excimer) and associated wavelengths, suitable for deposition of a wide array of materials onto various substrates in an UHV and reactive environment. Semiconductor, metal and multilayer coatings have been successfully deposited with this system.

Pulsed Laser Deposition with RHEED at WKU

<u>Advantages of PLD</u>

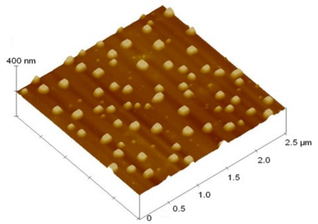
- Flexible, easy to implement
- Growth in any environment
- Exact transfer of complicated materials (YBCO)
- Epitaxy at low temperature
- Greater control of growth



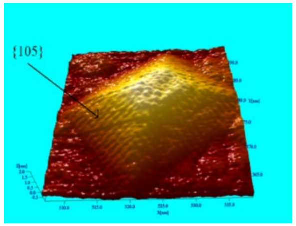
Typical PLD setup

<u>Advantages of RHEED</u>

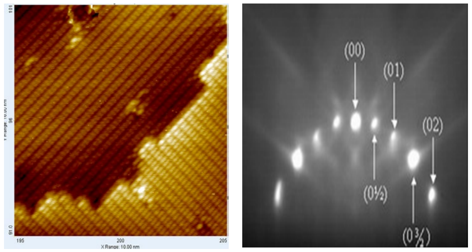
- Calibration of growth rates
- Observing removal of oxides from the surface
- Calibration of substrate temperature
- Monitoring arrangement of surface atoms
- Providing information on surface morphology and growth kinetics



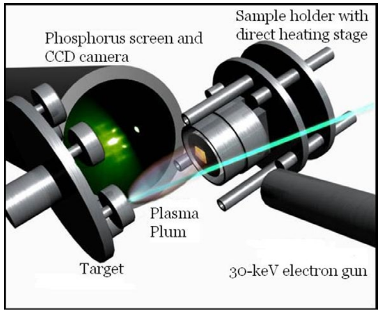
Ge quantum dots on Si(100)



Single Ge quantum dot



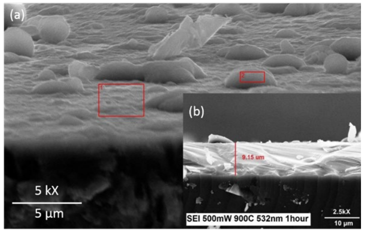
Clean Si(100)-2x1 and its RHEED image



Reflection High Energy Electron Diffraction (RHEED)

- **Target**: <u>Just about anything</u>! (metals, semiconductors, …)
- **Multilayer** coating capability
- **Laser**: WKU has two nanosecond (Nd:YAG and Excimer) and two picosecond lasers (Nd:YAG)
- **Vacuum**: Atmospheres to ultrahigh vacuum (down to 10^{-11} Torr)

WKU has the capacity to deposit any material with its PLD system, specifically ceramic coatings onto carbon/composite substrates, with application to heat shield technologies



Variable growth rate

Entry Systems: Safely Delivering Spacecraft to Earth and Other Celestial Bodies

Recent tests of gas-surface reaction products for carbon samples in air and oxygen plasmas

Prof. Douglas G Fletcher

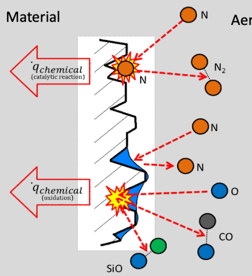
University of Vermont
Department of Mechanical Engineering
Plasma Test and Diagnostics Laboratory
dfletche@uvm.edu; (802) 233-8432

Dr. Fletcher is Professor and Chair of Mechanical Engineering at the University of Vermont, where he and his students have constructed 30 kW ICP Torch Facility for testing high temperature materials for aerospace applications and for quantifying the critical gas-surface interactions that control surface heating. Prior to his current position, Dr. Fletcher worked at NASA Ames Research Center from 1989-2000 and the von Karman Institute for Fluid Dynamics from 2000-2007 Dr. Fletcher's research interests also include the development and application of laser spectroscopic techniques to characterize non-equilibrium plasmas and to probe gas-surface interactions. He has experience testing in both arc-jet and ICP test facilities, and he has led numerous research projects in Europe (ESA and CNES) and in the US (NASA, AFOSR, ONR).

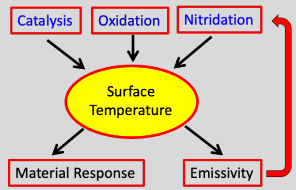
Quantitative Measurement of Gas-Surface Reaction Rates for Planetary Entry

Motivation

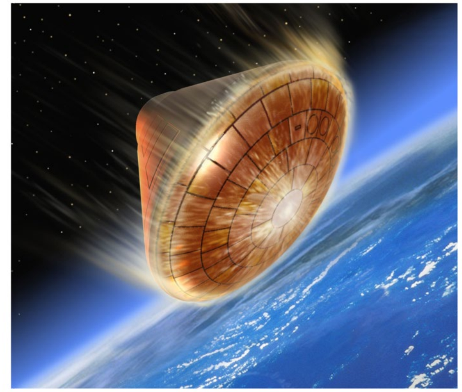
Material responds and surface evolves, changing the boundary condition



SiC gas/surface interactions



Material response feedback



Planetary entry on ballistic trajectory causes detached shock that creates a high temperature plasma – typically resolve with carbon based ablator

Hypersonic flight in earth atmosphere requires stable and sharp leading edges to minimize drag – high heat fluxes for non-ablators and transpirants

Our Research

Tools

- 30 kW ICP Torch Facility
- Nanosecond laser system
- Multi-component plasmas

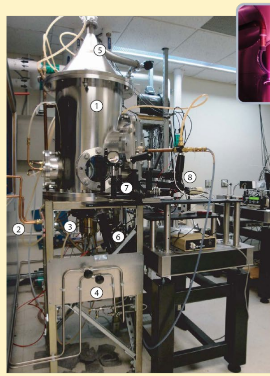
Applications

- Material screening
- Targeted reaction rates
- Material response characterization

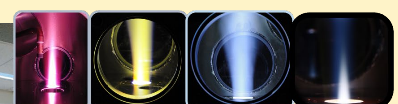
Outcomes

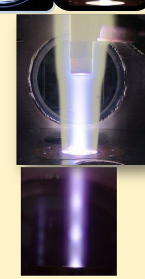
- Reaction rates
- Uncertainty estimates
- Improved material knowledge

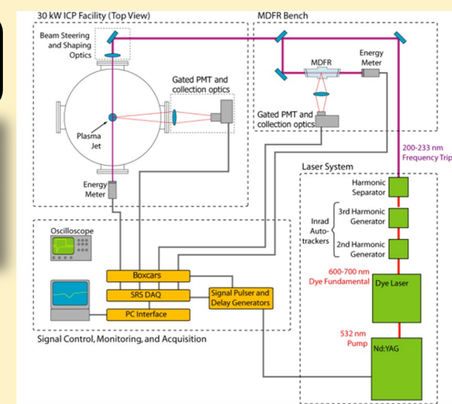
Experimentation

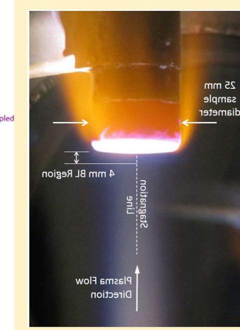


(1) Test chamber **(2)** Water cooled leads to coil from 30 kW RF power supply **(3)** Injector block with coil and quartz tube **(4)** Gas injector controls **(5)** Heat exchanger and vacuum system **(6)** 2-color pyrometer **(7)** Emission collection optics **(8)** TALIF collection optics Flow reactor optical table at rear right.









PLASMA TEST & DIAGNOSTICS LABORATORY

Dr. Douglas G. Fletcher

NASA EPSCoR Research for ARC
June 22, 2023

Entry Systems: Safely Delivering Spacecraft to Earth and Other Celestial Bodies

Multi-scale modeling of porous ablators for NASA missions

Dr. Savio J. Poovathingal

University of Kentucky
Department of Mechanical and Aerospace Engineering
Computational Thermophysics and Fluids Laboratory (CTFL)
saviopoovathingal@uky.edu; (859) 562-2854

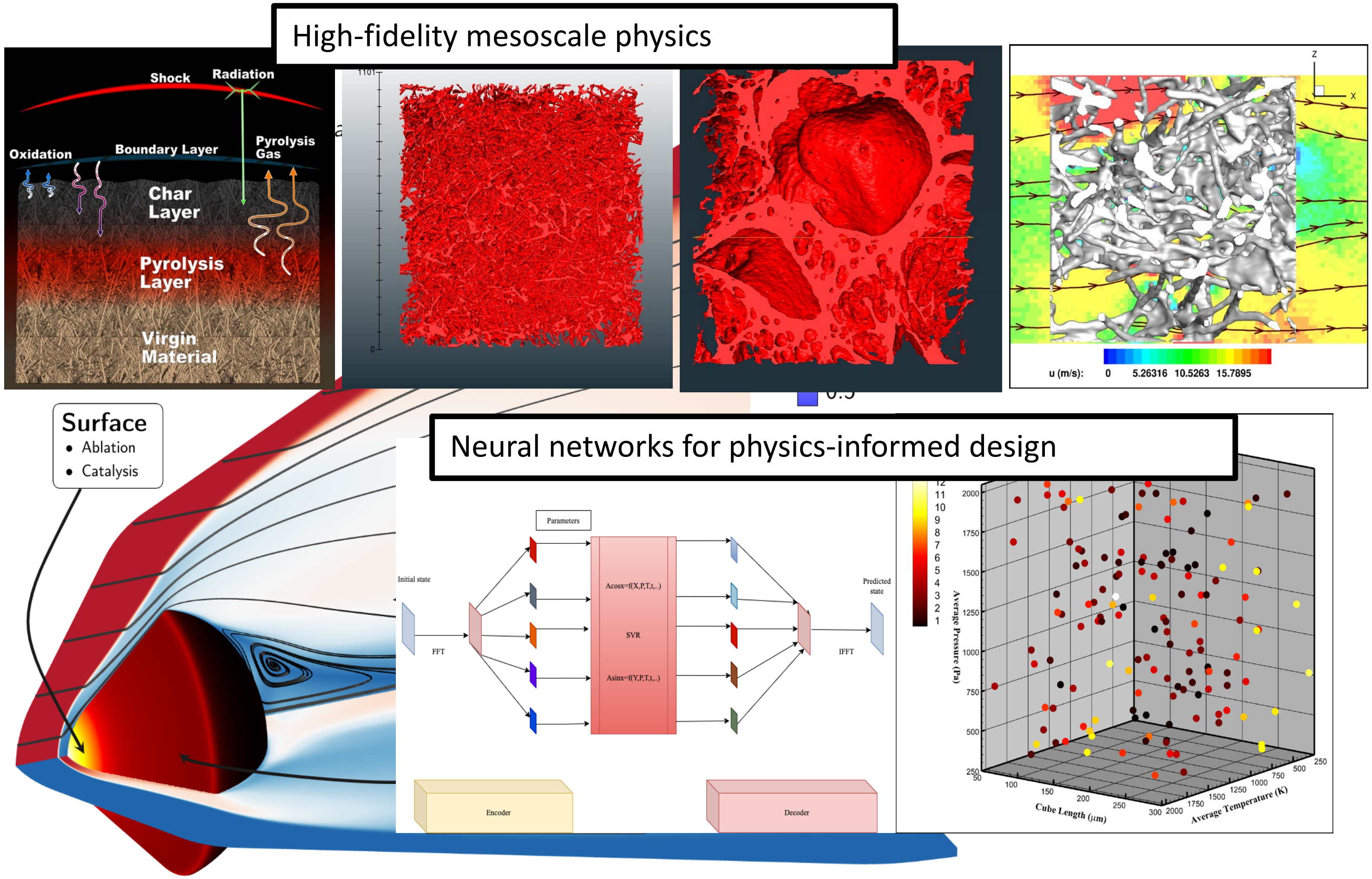
Dr. Savio Poovathingal specializes in developing computational tools to solve multi-scale problems in gas-surface interactions pertaining to hypersonic flows. During his career, he has developed numerical approaches for direct simulation Monte Carlo (DSMC) and large-scale molecular dynamics calculations. He is an expert in high-fidelity analysis of simulations and experiments to develop physics-based models for CFD and other continuum methods, most notably developing a finite rate ablation model for hypersonic conditions. His current interests lie in investigating the coupling of the microscale material architecture and aerothermodynamics. His most recent work includes the development of novel simulation capabilities to study momentum and radiative energy transport within microstructures of thermal protection systems, and the use of x-ray computed microtomography and digital microstructure generating tools to capture realistic microstructures. He has published 16 peer-reviewed archival journal articles and 18 full-length conference publications in diverse fields: chemistry, aerospace engineering, and computational development. In total, he has received over $3M in research grants and advises 10 Ph.D. students who are working on high-fidelity microscale and macroscale modeling of gas-material interactions.

University of Kentucky

Computational Thermophysics and Fluids Laboratory (CTFL)

Multi-scale modeling of porous ablators for NASA missions

- Develop numerical tools for flow, chemical, and radiative physics
- High-fidelity modeling of fluid flow and heat transfer in porous media at the microscale
- Build neural network models to enable physics-informed design of space capsules using information from the high-fidelity datasets



Savio Poovathingal, Ph.D., Mechanical and Aerospace Engineering, saviopoovathingal@uky.edu

NASA EPSCoR Research for ARC
June 22, 2023

Entry Systems: Safely Delivering Spacecraft to Earth and Other Celestial Bodies

Coating Porous Carbon Substrates via Self-Limiting Surface Growth of Nano-Oxides

Dr. Adarsh D. Radadia

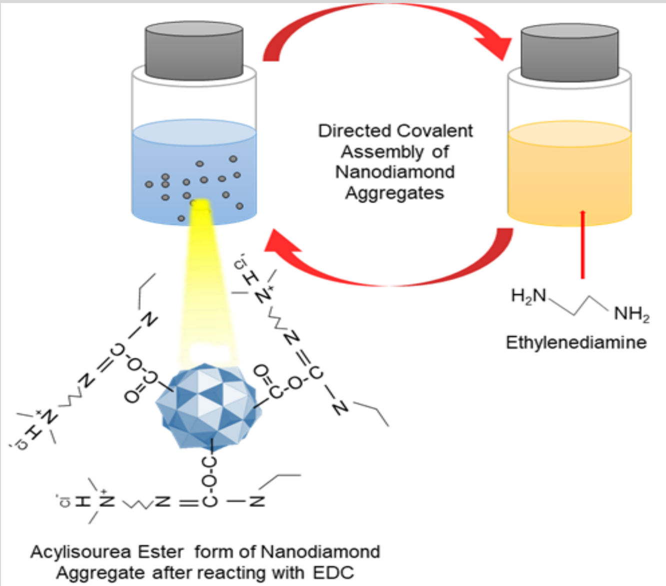
Louisiana Tech University
Chemical Engineering
radadia@latech.edu; (318) 257-5112

Adarsh D. Radadia is a Frank Earl Hogan Family Professor of Chemical Engineering at LaTech. His research expertise is at the intersection of surface machining, surface chemistry, and surface characterization. Since 2009, Dr. Radadia's research has primarily focused on carbon-based nanomaterials and their surface chemistry for thin film formation. Such films are necessary to realize improved chemical and biological sensors with long-term chemical and mechanical stability for continuous monitoring. The Radadia Lab has worked on two self-limiting surface growth methods - ultrasonication-assisted surface coating and more recently the method of directed covalent assembly of nanoparticles. These methods can be used to chemically bind a wide range of nano-oxides and -nitrides to the surface to yield thin films with tunable morphology and thermal conductivity.

Coating Porous Carbon Substrates via Self-Limiting Surface Growth of Nano-Oxides

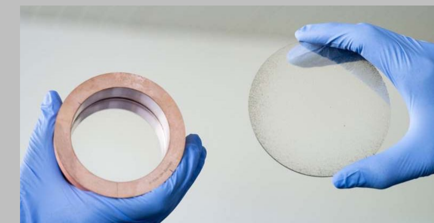
Motivation

New Process Developed:
Directed Covalent of Nanomaterials



Applications

Nanocrystalline Thin Films

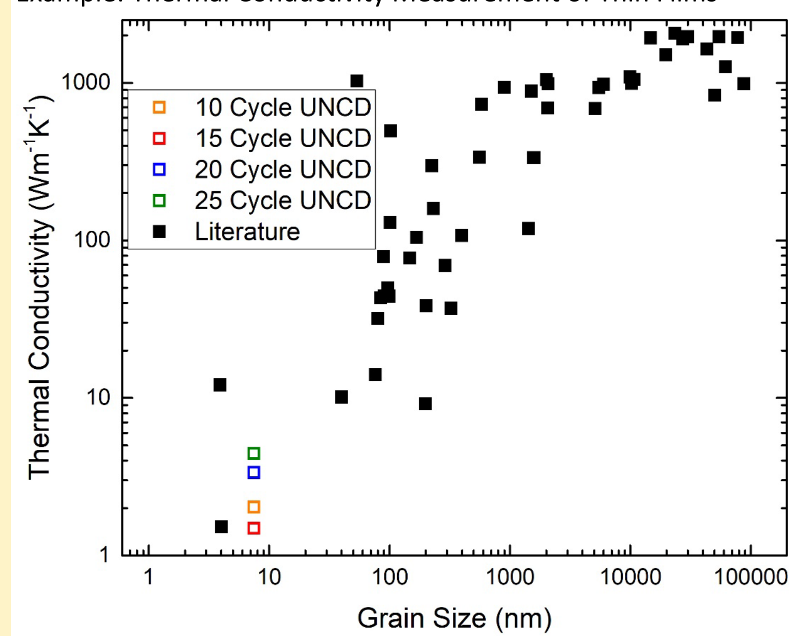


- Corrosion Resistance
- Biocompatibility
- Radiation Hardness

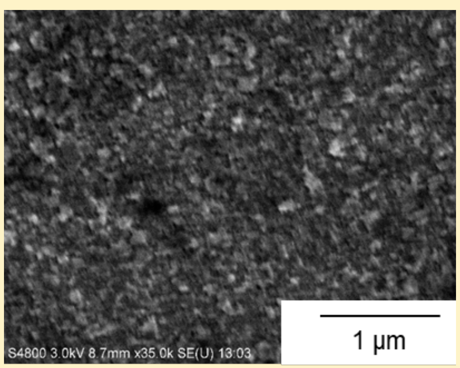
- Valve Seals and Coatings
- Optical Windows
- Thermally Conductive Coatings

Our Research

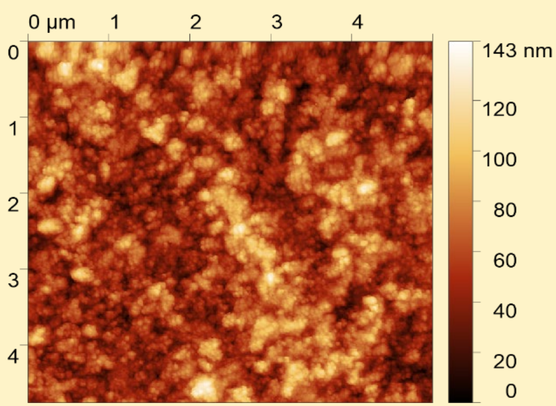
Example: Thermal Conductivity Measurement of Thin Films



Scanning Electron Microscopy



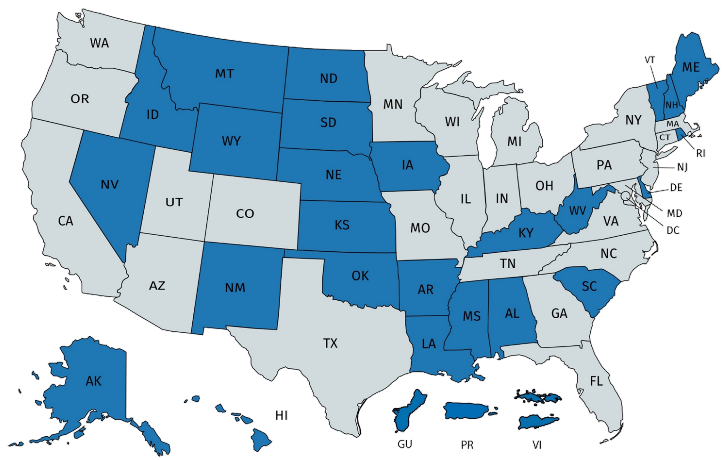
Atomic Force Microscopy



Dr. Adarsh D. Radadia @ Louisiana Tech

Topic Area 2

Advanced Computing and IT systems: Enabling NASA's advanced modeling and simulation



Advanced Computing and IT systems: Enabling NASA's Advanced Modeling and Simulation

Unleashing the potential of quantum algorithms for the simulations correlated quantum materials

Dr. Ka-Ming Tam

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Department of Physics and Astronomy
kmtam@lsu.edu; 225-907-0273

Ka-Ming Tam is a Research Assistant Professor at the Department of Physics and Astronomy, Louisiana State University. His research expertise is on the simulations of correlated materials by utilizing high performance computer simulations, quantum computing algorithms, and data science approaches. Dr. Tam has extensive experience in the development of computer codes for heterogeneous computing architectures. These include classical and quantum Monte Carlo for optimizing systems with complex energy landscapes, such as spin glass and random field systems. Starting in 2018, Dr. Tam has developed various new approaches based on machine learning and quantum computing algorithms for studying the properties of correlated materials. Such methods include variational autoencoder, generative adversarial network, variational quantum eigensolver, and quantum convolutional neural network. These previous works pave the way to creating a quantum database of correlated materials which will expand our current understanding of materials relevant to NASA mission.

Unleashing the potential of quantum algorithms for the simulation of correlated quantum materials

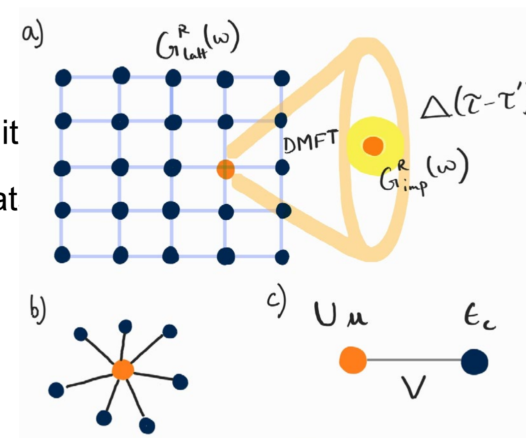
LSU
Department of Physics & Astronomy

Importance of Materials Design for Extreme Environments

- Designing materials and their mechanical structures for energy storage, propulsion, and space and planetary environments is critical for NASA mission

Limitations of current modeling

- Very small system sizes, often not representing the physical thermodynamic limit
- Quantum machine learning is being used for classical data not truly quantum dat



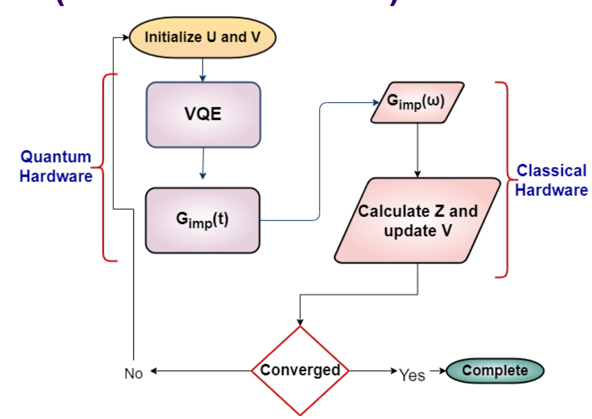
Our Proposal:

1. Studying the thermodynamic limit instead of a very small finite size

- Dynamical Mean Field Theory and Dynamical Cluster Approximation.
- Finding the Ground State by variational quantum eigensolver,
  Trotter propagation or variational quantum eigensolver for finding excited states and Green functions.

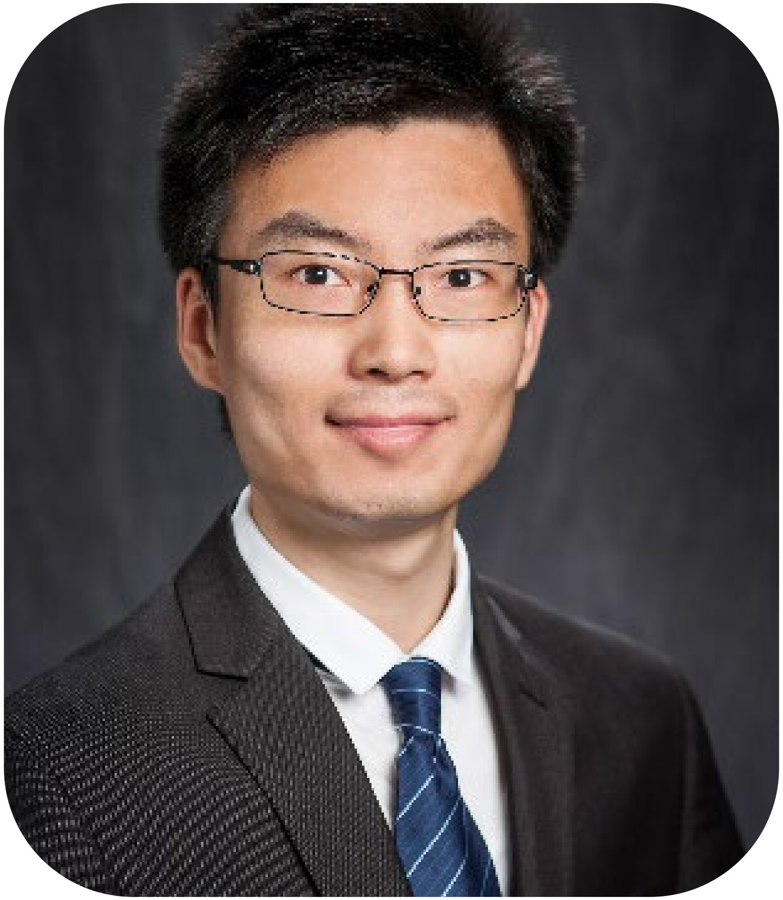
2. Utilizing Quantum Machine Learning approaches on Quantum Data (not classical data)

- Creating a Quantum Materials database for **TRULY** quantum data, that is the wavefunctions itself. (in term of variational wavefunctions or related ones).
- Demonstrate capability of detecting important physical quantities, such as transport and phase transitions.



Advanced Computing and IT systems: Enabling NASA's Advanced Modeling and Simulation

Physics-informed Artificial Intelligence-based Diagnostics



Dr. Chao Sun

Louisiana State University
Department of Civil & Environmental Engineering
Complex Dynamics and Smart Sensing (CDSS) Laboratory
csun@lsu.edu; (225) 578-8511

Chao Sun is an Associate Professor of the Department of Civil and Environmental Engineering at LSU. He's the director of the Complex Dynamics and Smart Sensing Laboratory. His research expertise lies in structural dynamics and control, computational fluid dynamics, and diagnostics of engineering structures. Since 2015, Dr. Sun has been focusing on the development of low-cost smart sensing and diagnostics methods for civil, mechanical, and aerospace structures, which aligns well with the first research priority of the Ames Research Center: Diagnostics for Arc Jet Characterization. Testing facilities (e.g., sensors, data acquisition system, and relevant programs) are available in the CDSS lab to develop smart sensing and diagnostics methods for Arc Jet. Also, Dr. Sun and his coworkers are developing multi-phase computational models to simulate extreme wind-wave flows and the complex dynamics of engineering structures (e.g., buildings and offshore wind turbines) under winds and waves. This research area aligns with the second research priority: Computational aerosciences.

Physics-informed Artificial Intelligence-based Diagnostics

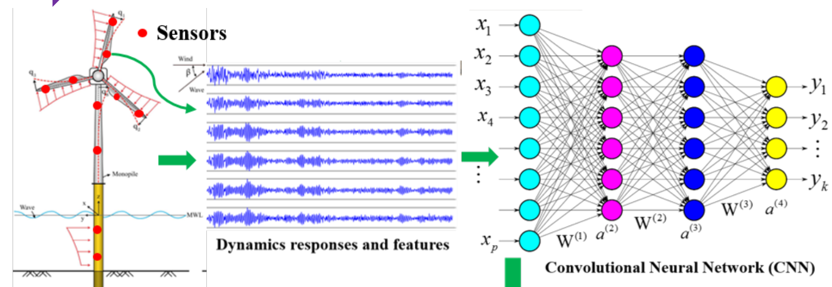
Dr. Chao Sun

LSU Department of Civil & Environmental Engineering

Motivation

Damages of aircraft and spacecraft structural components

Physics and AI-enabled damage diagnosis



- Physics models
- Structural nonlinearity
- Signal processing

Damage location and severity

- AI-based damage diagnosis

Turbine blade monitoring and diagnosis

responses/ features y

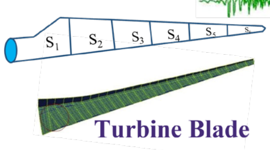
FE model updating

physics guidance

- damage severity: z_{mu}
- damage probability: p_{mu}
- most probable damage location: y_{mu}

Model $\mathcal{M}(\theta)$

extended features y



$$p^i_{mu} = \frac{\exp(z^i_{mu})}{\sum_{j=1}^{c} \exp(z^j_{mu})}$$

$$p^i_{f} = \frac{\exp(z^i_{f})}{\sum_{j=1}^{c} \exp(z^j_{f})}$$

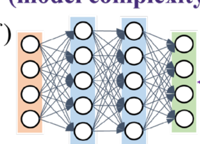
(soft max function)

L_{p1} (cross entropy), L_{p2} (mean squared error)

$$\lambda_p L_p = \lambda_{p1} L_{p1} + \lambda_{p2} L_{p2} \longrightarrow Loss = L_d(z_f, y) + \lambda_R R(W) + \lambda_p L_p$$

(data loss) (model complexity)

$$f = \arg\min_f \; Loss(z_f, y, f)$$



Damage location and severity

Inform maintenance

Our Research on Diagnostics

Applications

- Energy infrastructure, wind turbines, oil & gas pipelines
- Spacecraft structures
- Buildings and bridges

Outcomes

- Sensing data
- Algorithms to process data
- Damage diagnosis methodology

Research Tools

- Finite Element modeling
- Structural dynamics theory
- Bayesian model updating methods
- Machine learning models

Laboratory facilities

Structural dynamics testing, sensing, and data acquisition devices

NASA EPSCoR Research for ARC
June 22, 2023

Advanced Computing and IT systems: Enabling NASA's Advanced Modeling and Simulation

Dynamic Adaptive Mesh Refinement for Wall Modeled LES of Complex Aero-Configurations

Dr. Andrew Kirby

University of Wyoming
School of Computing
akirby@uwyo.edu; (307) 760-1059

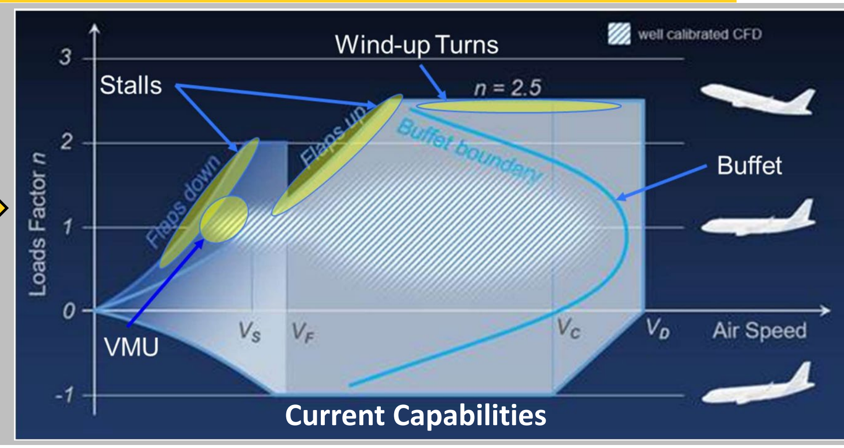
Andrew Kirby is a Research Scientist in the School of Computing at the University of Wyoming. His research expertise is at the intersection of aerodynamics, computational mathematics, and high performance computing. Since 2015, Dr. Kirby's primary area of activity has been the development of high-order numerical methods with dynamically adaptive mesh refinement for aerospace and wind energy aerodynamic simulations. Such systems are intrinsic to missions that involve air traffic management, search and rescue, area coverage, perimeter protection, or co-transportation of large objects. Additionally, his research is intersecting into Wall-Modeled Large Eddy Simulation (WMLES) with fully dynamic adaptive mesh refinement for unstructured mixed-element meshes. These areas of research are critical toward the aircraft certification by analysis and the grand challenges issued in the NASA CFD2030 report. Additionally, Dr. Kirby has extensive experience in the development of scientific software for next-generation heterogeneous computing systems including GPU-based platforms. He was PI for a NASA SBIR STTR project focused on the GPU acceleration of an adjoint enabled real gas hypersonic flow solver designed for simulating planetary atmospheric entry.

Dynamic Adaptive Mesh Refinement for Wall Modeled LES of Complex Aero-Configurations

Motivation

Aircraft Certification

Analysis



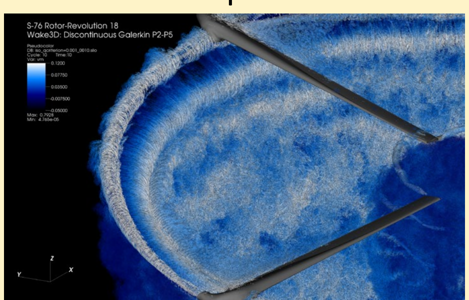
Our Research

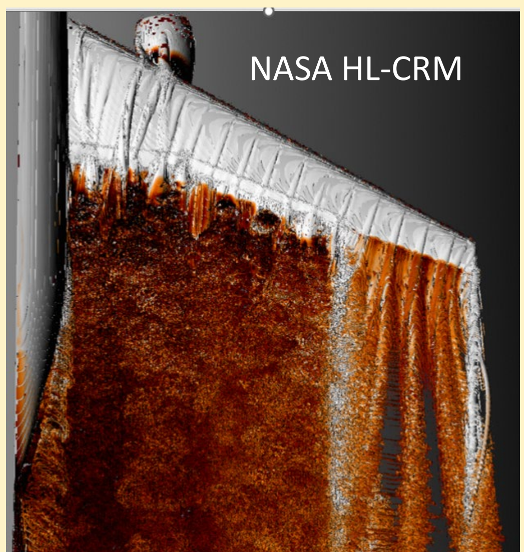
Tools
- High-fidelity CFD framework
- Heterogeneous computing

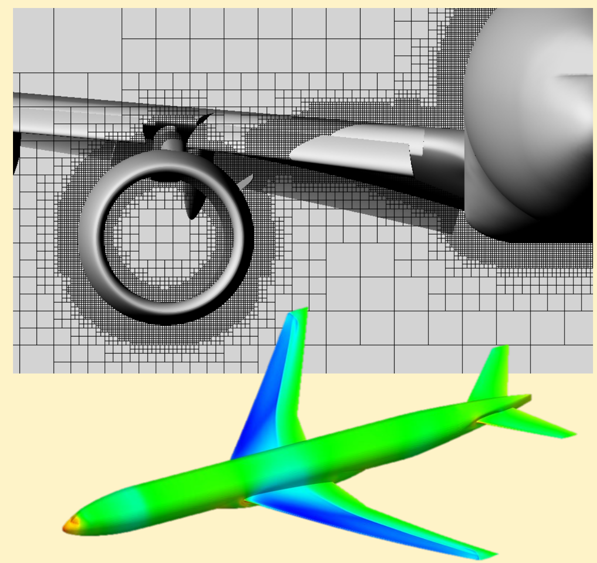
Applications
- Fixed-wind aircraft
- Rotorcraft
- Real gas hypersonics

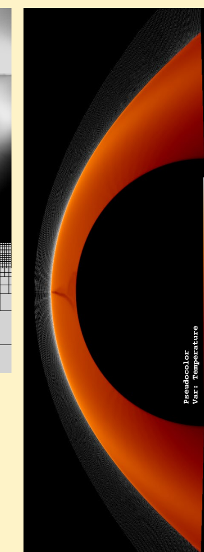
Outcomes
- More accurate predictions
- Faster time to solution
- Better aircraft designs

Sikorsky S-76
Helicopter Rotor









School of Computing

Dr. Andrew Kirby

UW

NASA EPSCoR Research for ARC
June 22, 2023

Advanced Computing and IT systems: Enabling NASA's Advanced Modeling and Simulation

Collaborative Digital Twin with Edge Computing for Autonomous and Semi-autonomous Cyber-Physical Systems

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Sabur Baidya is an Assistant Professor of Computer Science and Engineering at University of Louisville. He's the director of the Autonomous Intelligent Mobile Systems Laboratory (AIMSLab) and an affiliated faculty at the Louisville Automation and Robotics Research Institute (LARRI). His research areas include autonomous and cyber-physical systems in the domain of the Internet-of-Things (IoT) and Robotics, including Unmanned Aerial Vehicles (UAV), Connected and Autonomous Vehicles (CAV), and Tactile based robotic systems. On the technical side, his research employs multi-modal sensing, efficient computing systems and architecture (e.g. Edge/Fog Computing, Device-mapping, Virtualization), advanced communications, developing innovative distributed intelligence using optimizations and deep learning based AI-driven approaches. He has been involved in research with real-world autonomous systems since his participation at the DARPA SDR Hackfest at the NASA Ames Research Center in 2017, working with drones and software-defined radios. Subsequently, he had developed an advanced UAV-Network integrated simulator called 'FlyNetSim' which has been widely used by researchers. His research group has been working with Digital Twin Simulation for the last couple of years. On the computing side, his group is working on optimizing the neural networks and reconfigurable computing for accelerating the performance of the system.

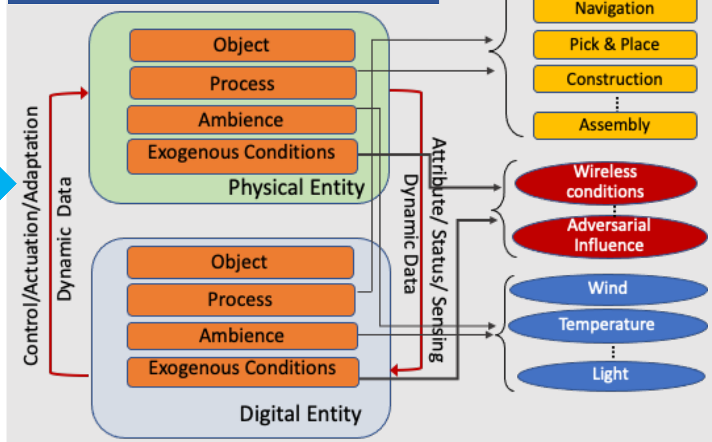
Collaborative Digital Twin with Edge Computing for Autonomous and Semi-autonomous Cyber-Physical Systems

Motivation

Uncertainties in the Autonomous Operations

- mission-critical and safety-critical Operations
- Digital Twin (DT) enables safe operations through remote monitoring and bi-directional data exchanges.

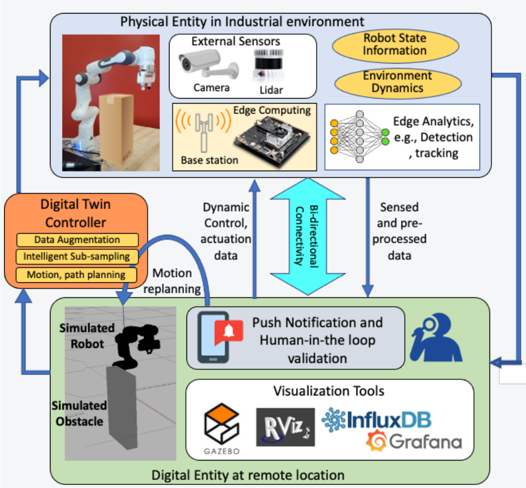
Digital Twin Framework



Challenges

- Accurately modeling the digital twin framework that can replicate the uncertainty of the physical robot in the virtual environment.
- process the sensed data in real-time for the digital twin.
- Dynamic Adaptation both in the physical and digital environment without expensive model tuning.

Collaborative Architecture



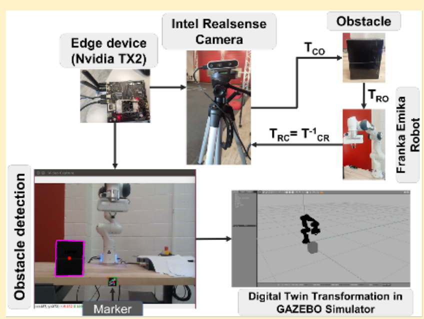
Autonomous Intelligent Mobile Systems
A I M S LAB

Experimentation

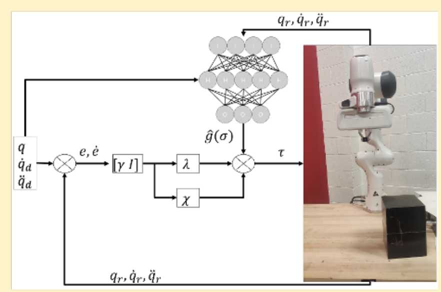
Tools
- Edge/Fog Computing
- Neural Compression
- Device mapping and reconfigurable Computing
- Neuro-Adaptive Control

Applications
- Robotic Manipulation
- Drone Navigation
- Autonomous Vehicles

Outcomes
- Low Latency
- Safety guarantees
- Collision/obstacle avoidance



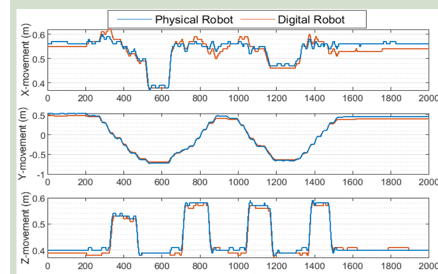
External Scene Monitoring and Obstacle Detection with Edge Computing

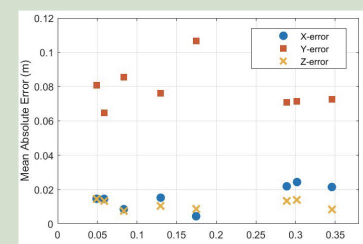


NAC Structure for On-Line Dynamic Control of Robot System

Results

Comparison of the Physical & Digital Robot





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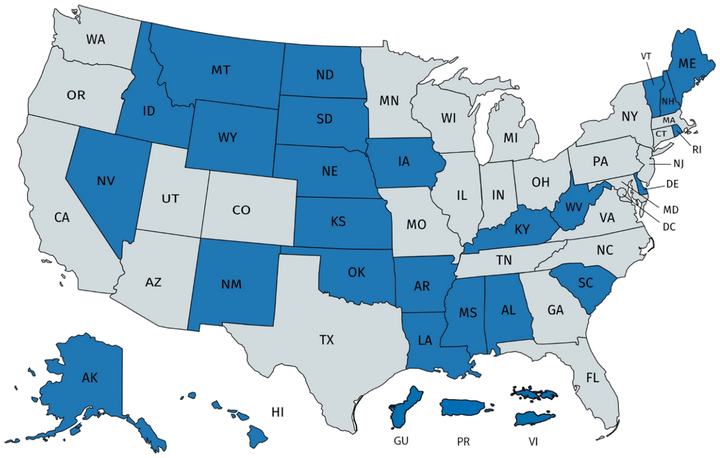
LOUISVILLE AUTOMATION & ROBOTICS RESEARCH INSTITUTE

Dr. Sabur Baidya

Topic Area 3

Aerosciences and Airborne Science



Aerosciences and Airborne Science

Functionalization of lightweight composites for aerospace parts and structures

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Materials Science & Engineering (MSE) Laboratory
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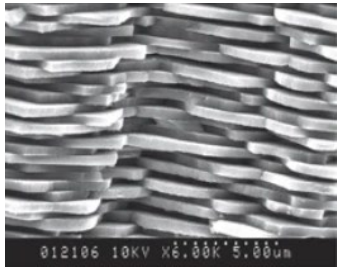
O. Marcelo Suárez is a Professor of Materials Science & Engineering (MSE) and the Bioengineering Program at UPRM. He has coordinated the MSE graduate program (created in 2016) and is responsible for his home institution's five MSE research laboratories. He coordinates the MSE curricular sequence, a unique undergraduate instructional endeavor in a Hispanic-serving institution. His research expertise ranges from solidifying light metals and metal matrix composites to synthesizing, functionalizing, and applying biopolymeric composites. Prof. Suárez is a Fellow of ASM International and a 2020 Univ. of Wisconsin Distinguished Engineering Alumnus. He has received numerous grants from NSF, DoD, Dept. of Education, and other agencies to support his research totaling more than $25,000,000. Of particular interest to NASA, there are two instrumentation awards. The DoD Contract Nº W911NF-17-1-0494 allowed defraying of the cost of a Renishaw AM 400 additive manufacturing unit with a 70 µm spot size for metallic powder bed fusion. The NSF award 1531755 permitted acquiring two pieces of equipment from Edmund Bühler GmbH: an ultra-rapid splat quencher and a melt spinner for ribbons. Both instruments can melt refractory metals via RF levitation. Prof. Suárez's team also has a G200 nanoindentation unit, thermal characterization equipment, and mechanical testing units. He and his graduate students have produced, functionalized, and characterized aluminum-based composites and nanocomposites for structural and wear-resistant applications (like parts subject to lunar and Mars regolith abrasion).

Aerosciences and Airborne Science: Functionalization of lightweight composites for aerospace parts and structures

Nature



Inspiration

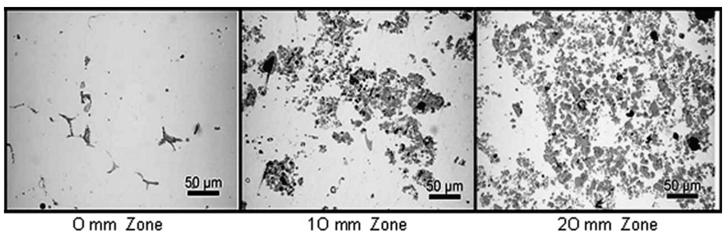
- Molsk shells are functional, lightweight, ceramic-reinforced composites

Lunar and Mars exploration needs

- Regolith is very abrasive
- Regolith can wreak havoc on machines and equipment

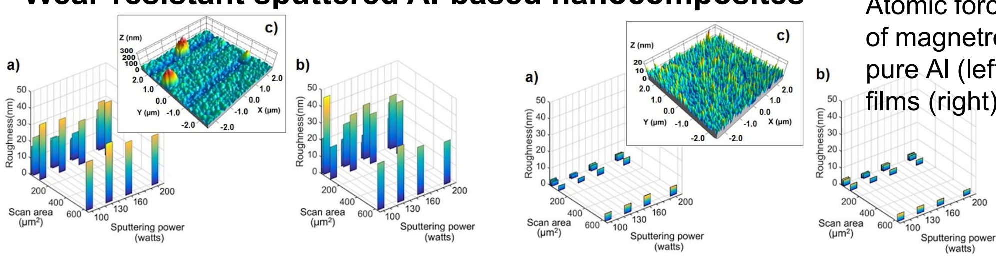
- Regolith could affect orbiting spacecraft
- Lightweight abrasion-resistant materials are mandatory

Functionally-graded aluminum-based composites



Functionally-graded Al-AlB_2 composite prepared via centrifugal casting [1]

Wear-resistant sputtered Al-based nanocomposites



Atomic force microscopy of magnetron sputtered pure Al (left) and Al-B thin films (right) [2]

[1] Z. H. Melgarejo, O. M. Suárez, and K. Sridharan, “Microstructure and properties of functionally graded Al–Mg–B composites fabricated by centrifugal casting,” *Compos. Part A Appl. Sci. Manuf.*, vol. 39, no. 7, pp. 1150–1158, Jul. 2008, doi: 10.1016/j.compositesa.2008.04.002.

[2] U. Barajas-Valdes and O. M. Suárez, “Morphological and Structural Characterization of Magnetron-Sputtered Aluminum and Aluminum-Boron Thin Films,” *Crystals*, vol. 11, no. 5. MDPI, Basil, Switzerland, p. 492, 2021, doi: 10.3390/cryst11050492.

Our Research

Applications

- Lunar and Mars rovers
- Lunar and Mars machinery
- Habitats

Outcomes

- High strength, high wear resistant composites
- Lightweight materials containing nanoparticles

New instrumentation

Left: Ultra rapid splat quencher and melt spinner. Right: Rapidly solidified Al-Ce ribbon.

Materials Science & Engineering Research Labs

Dr. O. Marcelo Suárez

UPRM Dept. of Engineering Sciences & Materials

Aerosciences and Airborne Science

Machine learning and deep learning models for hyperspectral unmixing of waterbodies

Dr. Vidya Manian

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Vidya Manian is a Professor in the department of electrical and computer engineering at the University of Puerto Rico, Mayagüez (UPRM). She is also a faculty in the Bioengineering graduate program. She is a research faculty in the Laboratory for applied remote sensing, imaging, and photonics. Her research involves development of deep learning architectures for processing airborne and satellite multispectral and hyperspectral images for unmixing and endmember extraction in coastal and inland waters, quantifying algal blooms, and water quality assessment. She has published 15 refereed journal articles in machine learning and artificial intelligence, and hyperspectral image processing, and currently applies artificial intelligence to modeling of remote sensing observations of waterbodies. She teaches the machine learning and pattern recognition course in the college of engineering. Her capability is in the development of physics informed machine learning models with uncertainty quantization to improve predictions from multidimensional and noisy datasets. She works with novel methods such as optimal transport for improving anomaly detection using autoencoders. Her research interests are in development of bio-inspired learning approaches such as reinforcement learning, and meta learning to improve performance of deep learning architectures and their application to Earth sciences.

Aerosciences and Airborne Science: Machine Learning and deep learning models for hyperspectral unmixing of waterbodies

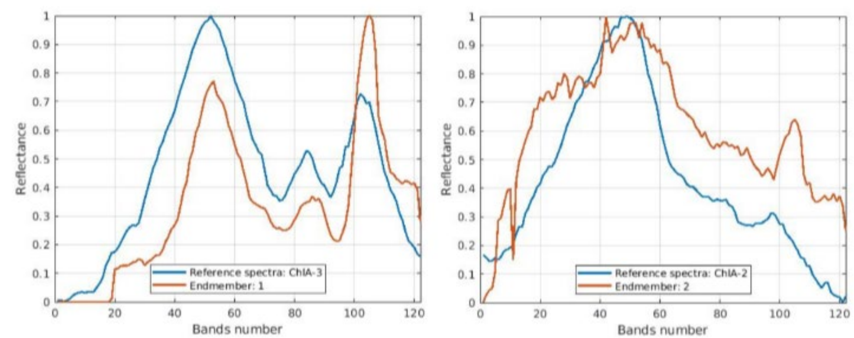
ARC research / development priority: Airborne Science for examining our own world & beyond from the sky, including air quality, smoke observations and modeling, coral reefs, coastal aquatic quality, ocean carbon, and current observations and modeling

Anticipated ARC focused research / development project

- Development of deep learning autoencoder architecture for spectral unmixing of water constituent spectra from airborne hyperspectral / multispectral images
- Development of ensemble machine learning models for unsupervised labeling of pixels in airborne images from unlabeled airborne image data
- Improving detection /prediction of coral reefs using physics informed machine learning with uncertainty quantization from airborne images
- Sparse dictionary learning and graph embeddings by sensor image data fusion from airborne hyperspectral / multispectral images for improved water quality assessment

Research capability

- Physics informed machine learning models with uncertainty quantization to improve predictions from multidimensional and noisy datasets
- Novel methods such as optimal transport for improving anomaly detection using autoencoders and generative adversarial networks
- Bio-inspired learning approaches such as reinforcement learning, and transfer learning to improve performance of deep learning architectures in classification and prediction, and their application to airborne science



Blind deconvolution non-symmetric autoencoder extraction of endmembers spectra from Lake Erie hyperspectral image

LARSIP
Laboratory for Applied Remote Sensing Imaging and Photonics

https://uprm.edu/aiig

Dr. Vidya Manian

Department of Electrical & Computer Engineering
University of Puerto Rico, Mayaguez

Aerosciences and Airborne Science

AI-enabled Joint Air Traffic and Aviation Spectrum Management

Dr. Hongxiang Li

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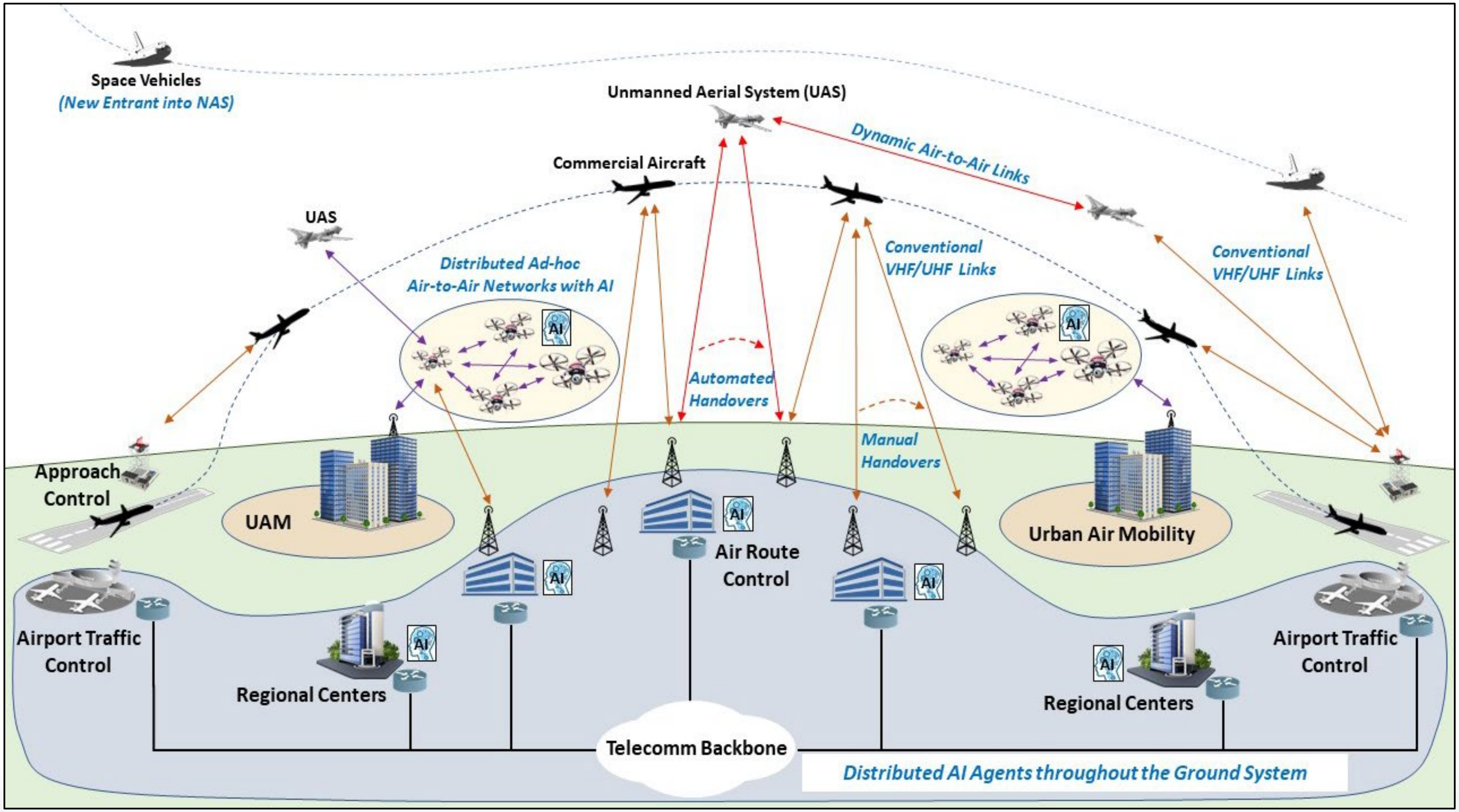
Hongxiang Li is an Associate Professor of Electrical and Computer Engineering at UofL. He has over 20 years of experience in the research and development of wireless communication and networking systems. He was the NASA Glenn Faculty Fellowship Program (NGFFP) awardee in 2013, 2018 and 2019, working on various topics including small UAS transceiver design, MIMO based interference mitigation, and delay sensitive aerial V2V communications. In recent years, his research interests include big data analytics and the application of machine learning to communication systems and spectrum optimization. Since 2019, Dr. Li has partnered with the Communications and Intelligent System Division of NASA Glenn Research Center (GRC) on autonomous spectrum allocation for aeronautical communications, where he co-invented the Air Traffic and Spectrum Modeling and Simulation Testbed consisting of environment visualization and various computational tools for sensing, scheduling and communications. Using live air traffic data accessible through FAA's SWIM Flight Data Publication Service and ADS-B data, the testbed enables real-time assessment of future air traffic and spectrum management solutions.

AI-enabled Joint Air Traffic and Aviation Spectrum Management

Dr. Hongxiang Li, Electrical and Computer Engineering



The objective is to ensure safe and efficient air operations by jointly maximizing the national air space and aviation spectrum utilization efficiency.

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Aerosciences and Airborne Science

A Breath of Fresh Air: Evaluating Environmental Quality in Lunar Habitats

Arup Bhattacharya, Ph.D.

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Arup Bhattacharya is an Assistant Professor at the Bert S. Turner Department of Construction Management, Louisiana State University. His research expertise is in airflow dynamics and transient system modeling, broadly covering the assessment of Indoor Environmental Quality and how it impacts occupant health, well-being, and productivity. As an early career researcher, Dr. Bhattacharya is setting up his research to diversify the applications of computational fluid dynamics in extraterrestrial environments, especially the sustainable environmental control in Lunar habitats, depending on the materials and methods of construction of the habitats. Dr. Bhattacharya's lab is developing a co-simulation framework using V-HAB and COMSOL to study the environmental properties inside Lunar habitats. Dr. Bhattacharya leads the Research Subcommittee of TG 9.Space, a Technical Committee of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), responsible for driving the research to establish standards for Environmental Systems design for deep space and extraterrestrial environments.

A Breath of Fresh Air: Evaluating Environmental Quality in Lunar Habitats

LRO Data for Lunar South Pole

Boundary Conditions

COMSOL MULTIPHYSICS®

ECLSS

VHAB

MATLAB

Arup Bhattacharya, Ph.D.

LSU
Bert S. Turner Department of Construction Management

Aerosciences and Airborne Science

Autonomous Structural Composites (AutoCom) for Autonomous Damage Detection and Healing

Donghyeon Ryu, Ph.D., P.E.

New Mexico Tech
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Lab for Smart Materials and Structures (LaSMaS)
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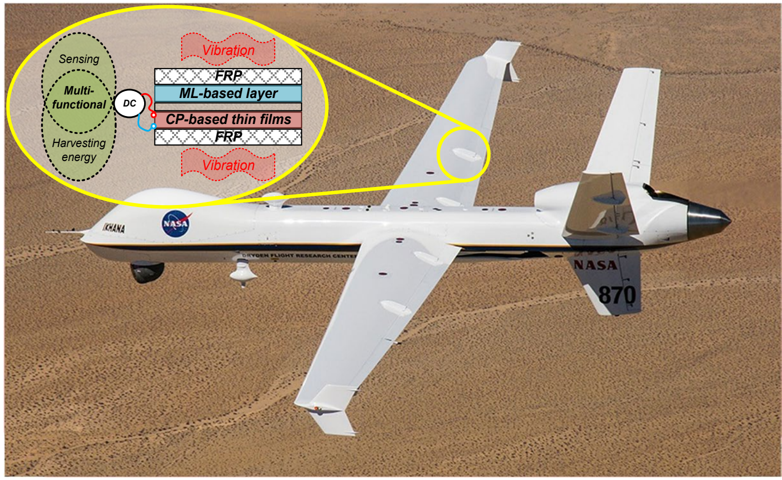
Dr. Donghyeon Ryu is an associate professor in the Department of Mechanical Engineering at New Mexico Tech (August 2014 – present) and a co-founder and Chief Scientific Officer of RD Health Sensing (November 2020 – present). He obtained a Ph.D. in the Department of Civil and Environmental Engineering in September 2014 and M.S. in the Department of Mechanical and Aerospace Engineering in March 2014 from the University of California, Davis. Before then, he obtained M.S. (2008) and B.S. (2004) in the Department of Civil and Environmental Engineering at Yonsei University in Seoul, South Korea. Dr. Ryu is active in research involving multifunctional materials, nanocomposites, and metamaterials for health monitoring of structural and biological systems; advanced sensor technologies; and energy harvesting. His research has been sponsored by NASA, Sandia National Labs, Office of Naval Research, Federal Aviation Administration, and others. He received New Mexico Space Grant Consortium Faculty Research Award and three best paper awards from ASME (America Society of Mechanical Engineers), 9IWSHM (9th International Workshop on Structural Health Monitoring), and DAMAS (10th International Conference on Damage Assessment of Structures).

Lab for Smart Materials and Structures
LaSMaS

PI: Donghyeon Ryu, Ph.D., P.E.

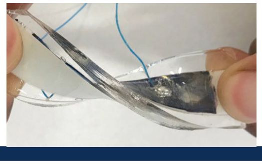
1. Target ARC research/development priority: **3.d. Unmanned Aerial Systems**
   a. Autonomous structural composites (AutoCom) can be used to encode self-powered sensing in fiber reinforced polymer (FRP) structural composites.
   b. AutoCom can be a solution to build next generation UAS that is self-sustainable by generating electricity via mechanical-radiant-electrical (MRE) energy conversion of mechano-luminescence-optoelectronic (MLO) composites.
2. Key aspects of the anticipated ARC focused research/development project:
   a. Novel design of MLO to generate direct current (DC) using mechanical vibration.
   b. DC varies with strain (i.e., DC-based strain sensing) and can be an energy source.
   c. Strain (via self-powered sensing)-based global structural health monitoring approach is used for detecting damage in UAS.
3. Research capabilities of the researcher:
   a. Multi-physics and multi-scale design of novel materials and composites
   b. Advanced sensor technologies for anthropogenic and biological structural
   c. Materials processing and functionalizations



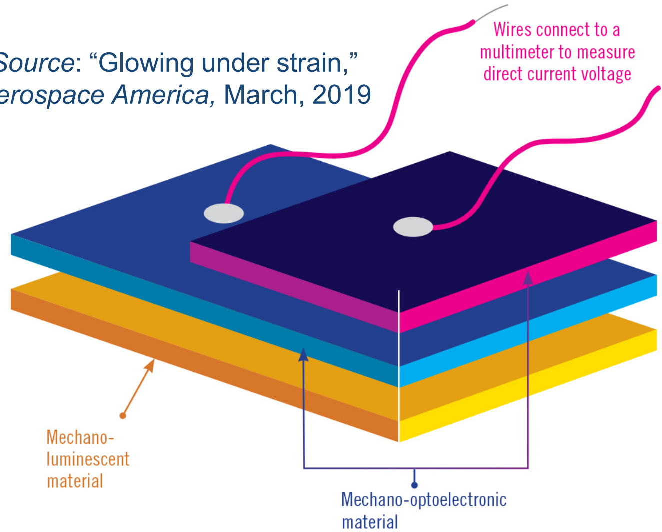
AutoCom-UAS capable of autonomous damage detection and mechanical-radiant-electrical energy harvesting

The layers of a strain-sensing material

A mechano-luminescent-optoelectronic, MLO, composite combines a mechano-luminescent material, which glows under strain, with a mechano-optoelectronic material, which generates current when exposed to light.



Source: "Glowing under strain," *Aerospace America*, March, 2019



Aerosciences and Airborne Science

Energy Efficient and Rapid Composite Manufacturing via Frontal Polymerization

Dr. Xiang Zhang

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Computations for Advanced Materials and Manufacturing Laboratory
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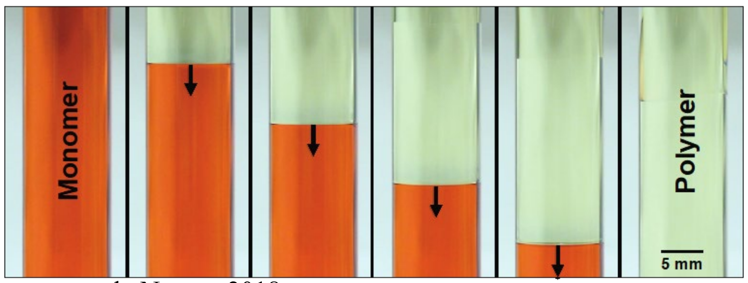
Dr. Xiang Zhang is an assistant professor in the Mechanical Engineering Department at the University of Wyoming, where he leads the Computations for Advanced Materials and Manufacturing Laboratory. Before joining UW in 2019, he conducted his postdoctoral research in the Aerospace Engineering Department at University of Illinois at Urbana-Champaign and earned his Ph.D. from the Civil Engineering Department at Vanderbilt University.

Dr. Zhang's group focus on developing computational tools to understand how materials response and evolve during their lifespan, from manufacturing to service and eventually failure. In the area of advanced manufacturing, his group has been developing multiphysics modeling approach to simulate the thermo-chemo-mechanical process associated with composite manufacturing, including additive manufacturing process, to provide insights and guidance for optimizing processing parameters. Recently, his group is building a customized 3D printer for composite 3D printing and aim to develop an augmented reality environment to use real-time analysis and optimization to optimize the printing process on the fly. His group also has access to various 3D printers at the UW Innovation Wyrkshop, including a state-of-the-art metal 3D printer, where one of his students is currently printing and testing 3D printed Titanium parts.

Manufacturing Thermoset Polymer and Polymer Composites via Frontal Polymerization

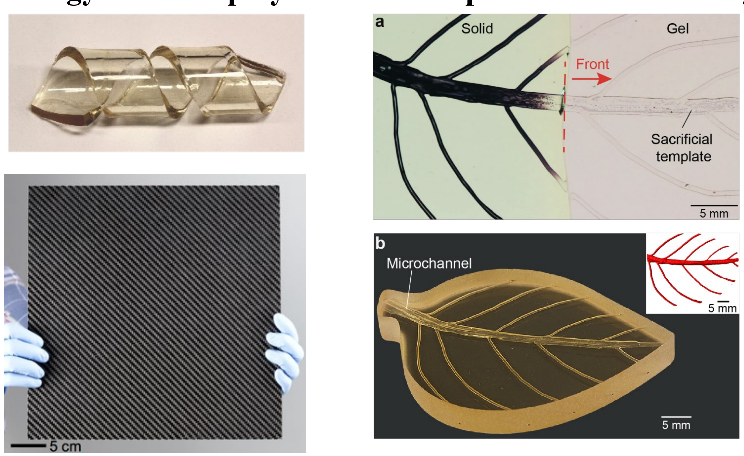
- ARC Research priority: Aerosciences and Airborne Science; novel approaches for composite materials manufacturing to advance urban air mobility
- Energy efficient: self-propagating reaction front driven by exothermic heat

Self-propagating polymerization front for fast curing



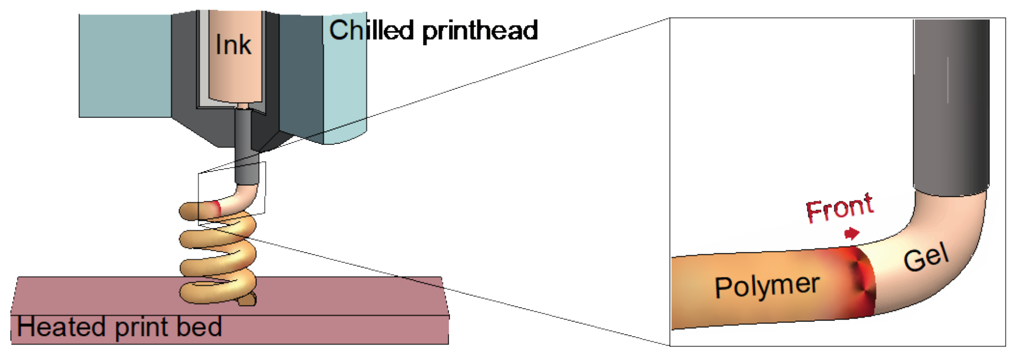
Robertson et al., Nature, 2018

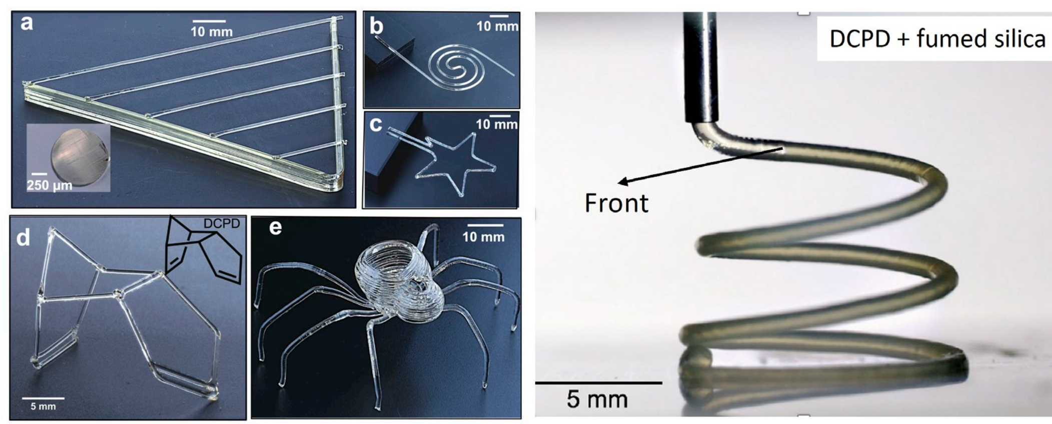
Energy-efficient polymer and composite manufacturing



Garg et al., Nature Communications, 2021

3D printing application

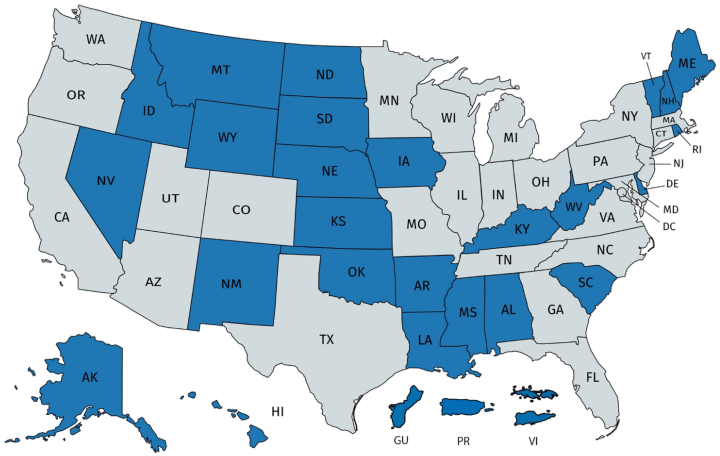




Aw et al., Advanced Materials Technologies, 2022

Topic Area 4

Astrobiology and Life Science: Understanding Life on Earth - and in Space



Astrobiology and Life Science: Understanding Life on Earth - and in Space

Advancements in Gene Sampling Technology: Unveiling Transcriptomic and Proteomic Biomarkers of Ionizing Radiation Exposure through Exosomal Liquid Biopsy

Dr. Gergana G. Nestorova

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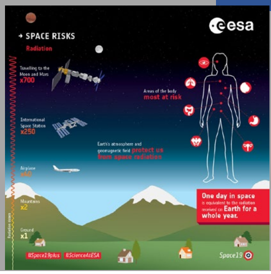
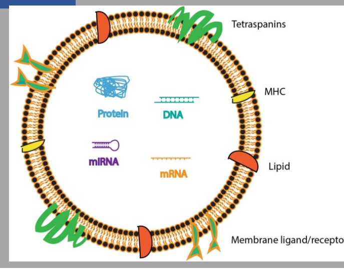
Dr. Gergana G. Nestorova is an Associate Professor of Biology at Louisiana Tech University and the director of the Applied Genomics and Biotechnology Lab. She serves as the Program Chair for the MS and Ph.D. Programs in Molecular Sciences and Nanotechnology. Dr. Nestorova's research expertise lies at the dynamic intersection of technology development for nucleic acid and extracellular vesicle purification for the detection of genomic and proteomic biomarkers of ionizing radiation response. Dr. Nestorova's lab developed a micro-probe-based tool, which facilitates the rapid purification of RNA and exosomes. This technology enables precise and high-resolution sampling of specimens, enabling sensitive genotyping of various organisms, including plants, 3D spheroids, and bacteria. The Gene Sampling technology was successfully tested on the International Space Station in 2021 for plant genotyping in collaboration with the Wet Lab-2 team. Utilizing human astrocytes as a biological model, Dr. Nestorova's lab has identified exosome-derived microRNA biomarkers for neurological radiation injury. These studies are crucial for deepening the understanding of the impacts of radiation on the nervous system during spaceflight that may lead to the development of targeted biomarkers for diagnostic and therapeutic applications. In her most recent projects, Dr. Nestorova has focused on employing state-of-the-art TimsTOF mass spectrometry analysis to identify exosome-derived protein biomarkers using human astrocytes, neurons, and endothelial brain cells. The results from this work will provide new insights into the exosome-derived proteomic biomarkers including response to ionizing radiation.

Advancements in Gene Sampling Technology: Unveiling Transcriptomic and Proteomic Biomarkers of Ionizing Radiation Exposure through Exosomal Liquid Biopsy

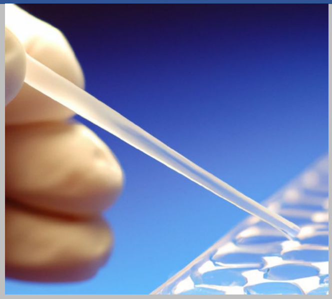
Motivation





Inspiration

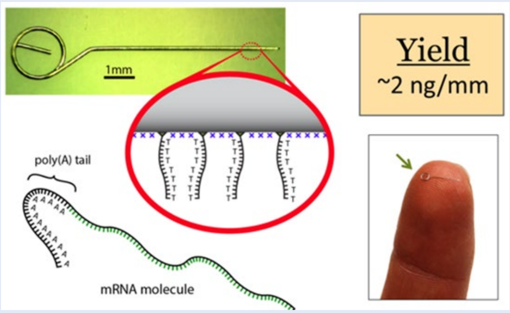
- Biological countermeasures
- Liquid biopsy
- Monitoring astronaut health



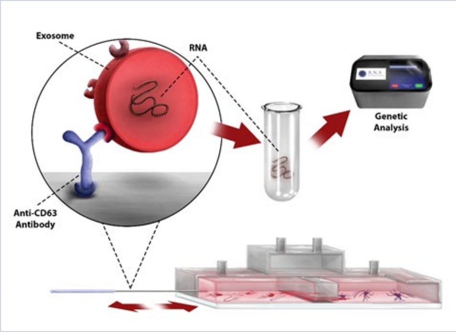
- Mitigation of radiation exposure
- Biomarkers discovery

Gene Sampling Tool

RNA purification



Exosomes purification



Our Research

Tools

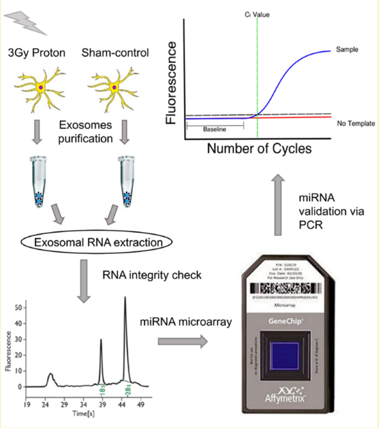
- Gene Sampling Tool for purification, genomic, and proteomics analysis of exosome
- Mass spectrometry proteomic analysis of exosomes

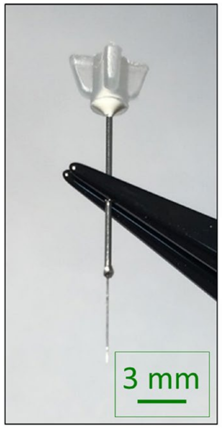
Applications

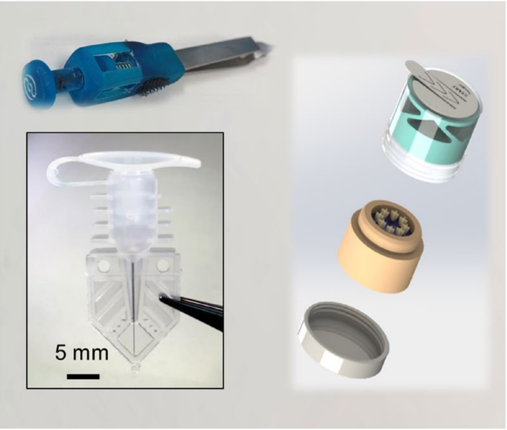
- Biomarkers discovery
- Non invasive assessment of astronaut health

Outcomes

- Rapid genotyping of exosomal biomarkers
- Integration with a microfluidics platform for sample-in/results-out







The Applied Genomics and Biotechnology Lab

Dr. Gergana G. Nestorova

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Building an extreme microbial toolkit – insights from the Great Salt Lake

Dr. Caryn Evilia

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Caryn Evilia is a Professor of Biochemistry at Idaho State University. Her research expertise is in extremophilic organisms and their biochemistry. More specifically, her specialties include protein structure and stability (using NMR, fluorescence and CD spectroscopy, and protein computational modeling), extremophile microbiology (culturing extreme halophiles, experience with extreme thermophiles), and molecular biology and metagenomics (next-generation DNA sequencing, gene cloning and protein expression). With institutional access to next-generation DNA sequencers and high-performance computers, Dr. Evilia has been working on DNA sequence data processing using gene family (OTU) and sequence variant (ASV) analysis via bioinformatics tools (MOTHUR, DADA2, DECIPHER, etc) in the R programming language. Extreme microbes aren't well represented in current DNA reference databases and Dr. Evilia's laboratory is working to increase the sensitivity of these databases to unusual organisms.

Building an extreme microbial toolkit – insights from the Great Salt Lake

Dr. Caryn Evilia, Department of Chemistry, Idaho State University

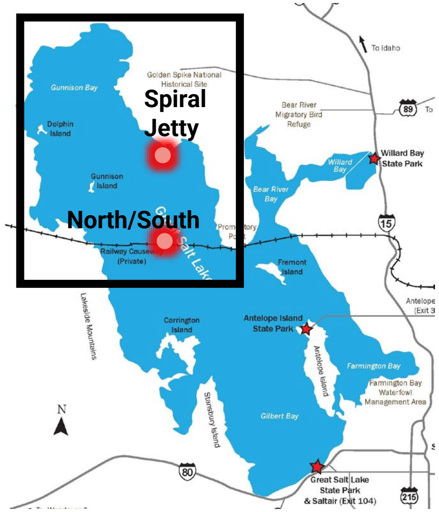
ARC Research Topic 4: Astrobiology and Life Science: Understanding life on Earth - and in space

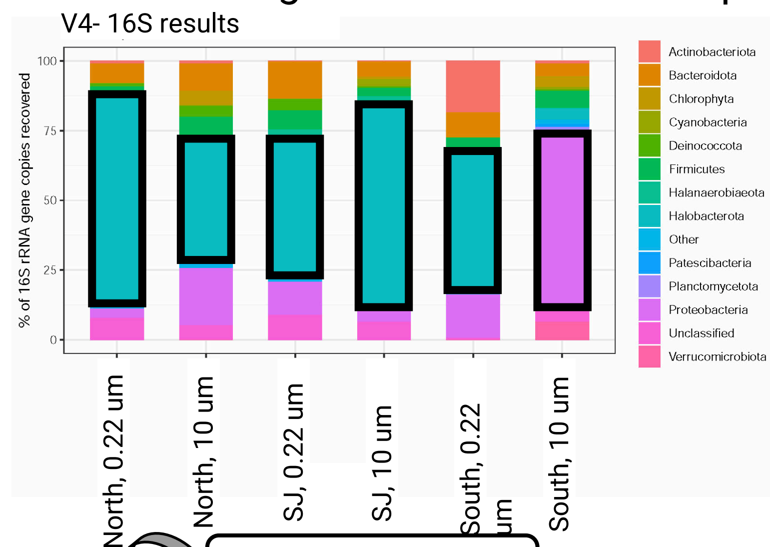
My Research

Our environment:
The Great Salt Lake

Our microbes:
Halobacterium salinarum
Pseudomonas aeruginosa
E. coli and more

Our tools:
Next-gen DNA sequencing
Bioinformatics
ICP, AAS
Fluorescence & CD spectroscopy
Microbiology methods
Biochemistry methods





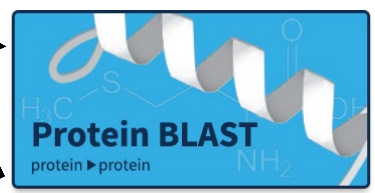
Metal Analysis

Metagenomics

Who lives here? How extreme is the environment? Can we predict what these organisms need to survive?

Selected anti-oxidant genes/proteins

Top organisms with sequenced genomes selected



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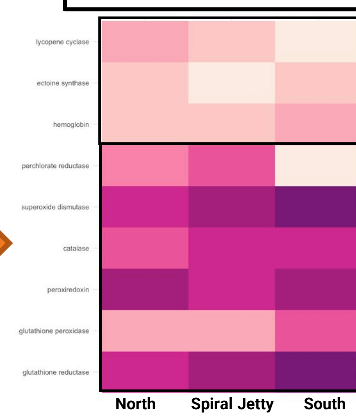


Potential detoxifiers

Enzymes that target radicals

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Biogeography and ecophysiology of extremophiles in the deep biosphere

Dr. Anirban Chakraborty

Idaho State University
Department of Biological Sciences
Email:anirbanc@isu.edu; Phone: (208) 282-1217

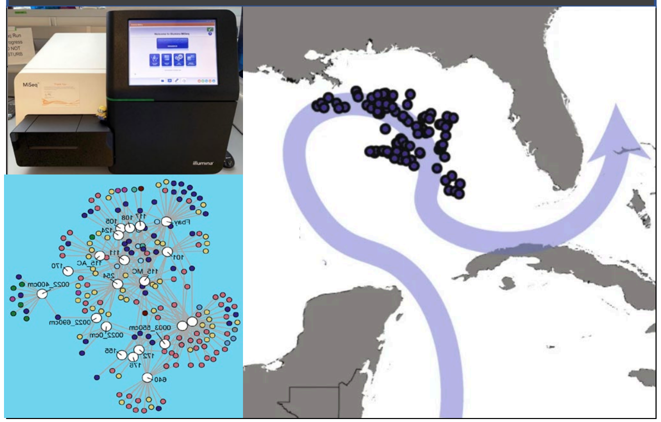
Anirban Chakraborty is an Assistant Professor of Environmental Microbiology at ISU. His research expertise includes interactions of microbial life with the lithosphere and the hydrosphere at physiological, organism and community levels. He frequently employs field- and laboratory-based approaches that integrate molecular diversity surveillance and meta-omics tools with traditional microbiological and geochemical techniques. Primary research areas in his lab include 1) microbial dispersal and its impact on biomass circulation and community assembly in the deep marine biosphere using subsurface extremophiles as model organisms, 2) activity of anaerobic thermophiles associated with biogeochemical cycling of elements in the continental subsurface, and 3) microbial metabolic diversity in contaminated groundwater and soil in relation to developing efficient pollutant cleanup strategies. His laboratory is equipped with anoxic cultivation facilities and is on the same floor as ISU's Molecular Research Core Facility which houses several state-of-the art equipment including an Illumina MiSeq benchtop sequencer, a quantitative PCR instrument, a newly acquainted FACSMelody flow cytometer, several microscopes, and a TEM. He uses ISU's high performance computing cluster for his research.

Biogeography and ecophysiology of extremophiles in the deep biosphere

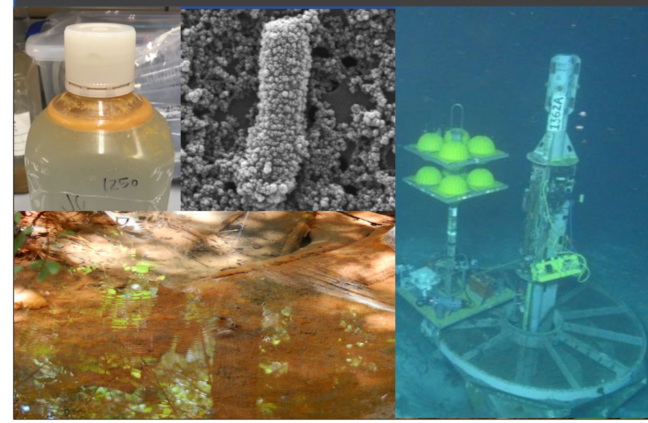
Idaho State University

Dr. Anirban Chakraborty

Microbial biogeography



Ecophysiology of extremophiles



Central Questions:

- How does the microbial ecology of the deep biosphere inform the habitability of life in other planets?
- How do biogeography and dispersal impact the subsurface microbial life?
- What physiological and metabolic traits are crucial for subsurface extremophiles to thrive in their natural habitats?

Habitats of interest

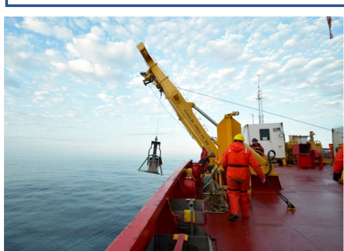
- Deep ocean hydrocarbon seeps
- Oceanic crustal biosphere
- Marine hydrothermal vents
- Deep groundwater systems

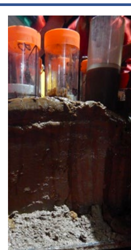
Tools

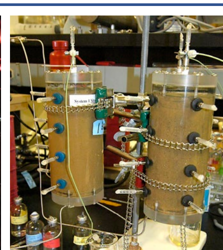
- Field sampling
- Cultivation of extremophiles
- Biogeochemical assays
- Molecular and –omic analyses

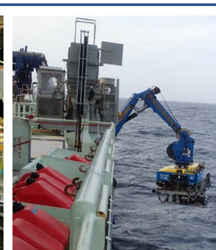
Outcomes

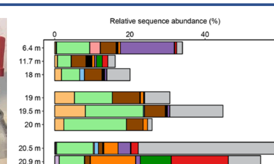
- Exploring novel physiology
- Discovering diverse microbes
- Genomic sequence data











ROAR

NASA EPSCoR Research for ARC
June 22, 2023

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Agnostic detection of alien and novel life forms: a planetary immune system

Greg Hampikian, Ph.D.

Boise State University
Department of Biology
Wastewater Virus Laboratory
greghampikian@boisestate.edu; (208) 781-0438

Greg Hampikian is molecular biologist whose lab focusses on sequence detection and analysis. He has published research on identification and evolution of sequences including the evolution of mammalian testis-determining genes, and the first paper on Nullomers and Primes. Nullomers are the shortest absent sequences in a species or group of species, and primes are those sequences absent from the known biome. The lab is currently working on using absent sequences to develop synthetic immune systems. His lab uses its expertise in sequence analysis and evolution to study human populations such as the Basque diaspora, and forensic issues such as bias in complex DNA mixture interpretation. The lab is active in outreach, legislative advisement, and the courts, and has been responsible for more than 40 DNA exonerations.

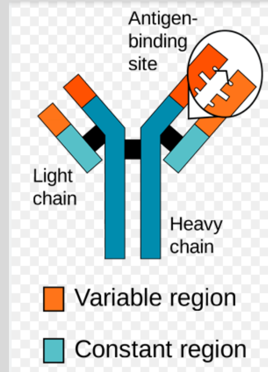
Planetary immune system and the detection of novel sequences.

Space and Earth Science: Understanding our planet, our solar system, and everything beyond

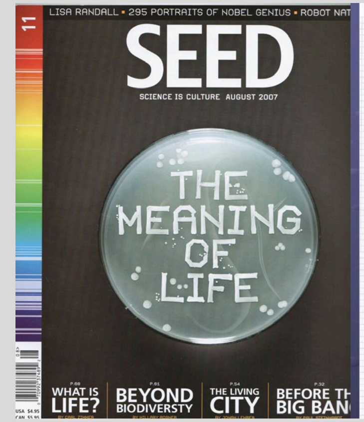
Goal

Planetary Immune System based on the detection of Nullomers, the shortest sequences absent from "self."

Bio-Inspired



Aha!



NOMENCLATURE

Nullomer

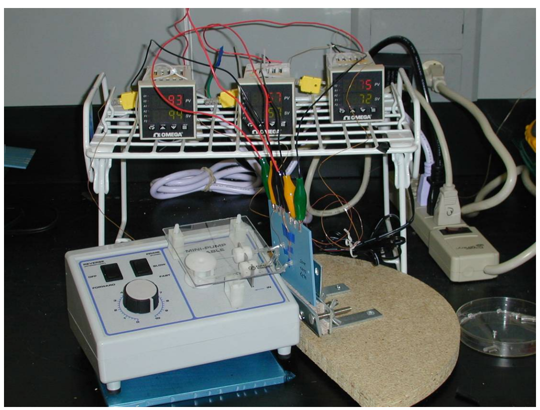
\nə́-lə-mər\ *n.*: A SEQUENCE OF NUCLEOTIDES THAT APPEARS NOWHERE IN THE GENOME OF A SPECIES.

Biologist Greg Hampikian and computer scientist Tim Anderson, both at Boise State University, have developed software that scans genomic databases to find short DNA sequences that aren't present in any genetic sample on record, though straightforward statistics predict they should be. The team coined a new term for a nucleotide sequence absent from the genome of a particular species, "nullomer."

So far, the researchers have identified 80 nullomers in humans that are 11 nucleotides long, as well as several thousand longer sequences. They have also identified tens of thousands of "primes," sequences that don't exist in the genomes of any species, all over 15 nucleotides in length.

The researchers believe that nullomers and primes could code for amino-acid sequences that would be lethal to an organism. Therefore, identifying nonexistent DNA could further the understanding of dead ends in DNA evolution and also help create a last defense against virulent diseases. —*Emily Anthes*

Our 3 prototype components



1. Cold-fired Ceramic PCR Bioterror Detection device, Blue plate in the center.

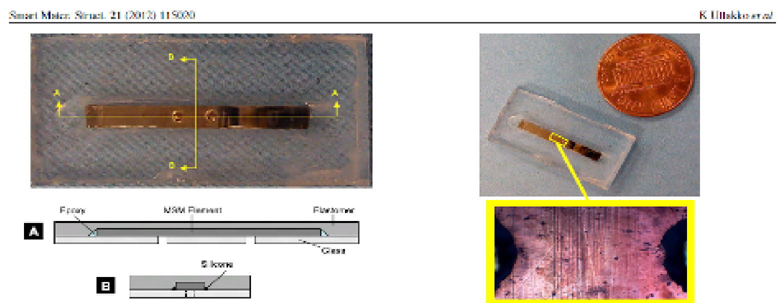


Figure 1. Construction details of the MSM micropump. (A) Epoxy is used to constrain both ends of the MSM element, and elastomer provides a sealing base (shown on top here, during construction). (B) Minimal silicone is applied to the corner between the MSM element and the glass slide.

Figure 2. MSM pump relative dimensions. The working mechanism of the MSM micropump is within the yellow box. The inset is a close up of the MSM element as it pumps a red aqueous solution.

Single-crystal Pump for Miniaturized DNA Forensics Developed

Tue, 10/16/2012 - 8:00pm

Get today's news and top headlines for forensics professionals – Sign up now!

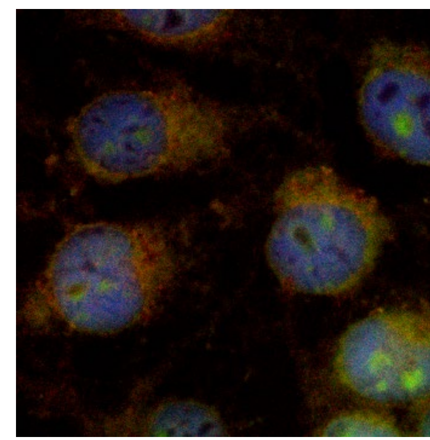
A Boise State Univ. research team has developed a new type of micro pump that can be used in forensic DNA profiling. Their results are being published in the journal *Smart Materials and Structures*.

"The pump represents a giant leap in miniaturization," said biology professor Greg Hampikian, who leads the team along with materials science professor Peter Müllner.

In the race for rapid DNA profiling, a large impediment has been that

2. Magnetic Shape Memory micropump

3. Nullomer detection probes



Greg Hampikian, Ph.D.

BOISE STATE

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Genetic dissection of “Space Brain” and conferring radioresistance for deep space exploration and colonization

Dr. Xiao-Hong Lu

Associate Professor
Department of Pharmacology, Toxicology & Neuroscience
Louisiana State University Health Shreveport
1501 Kings Highway
Shreveport, LA 71130-3932
Tel: 318.675.4276 (Office)
Email: xiaohong.lu@lsuhs.edu

Dr. Lu’s research focuses on the molecular pathogenesis of genotoxic stress in brain aging, neurodegeneration, and deep space radiation exposure, as well as developing novel neurogenetic technologies. With a background in psychiatry, Dr. Lu was trained in molecular genetics at the Center for Neurobehavioral Genetics of UCLA. Dr. Lu revealed the pathogenic role of genotoxic stress in Parkinson’s disease using the first BAC transgenic Parkinson’s disease (PD) mouse model that recapitulates the cardinal features of the disease. His translational study in a transgenic mouse model of Huntington’s disease (HD) identified a novel therapeutic strategy targeting genotoxic stress for neurodegeneration. Dr. Lu co-invented single-cell transgenic technology (MORF, Mosaicism with Repeat Frameshift) for cell-type specific single-neuron genetic labeling and perturbation. Funded by NARSAD, Dr. Lu generated a VIPR2 duplication mouse model of schizophrenia. His recent work focuses on developing novel genetic engineering technologies and genetically modified animal models, including an in vivo genetic sensor of genotoxic stress, PRISM, to evaluate spaceflight hazards and confer human radioresistance. Dr. Lu is funded by grants from NASA, NIEHS, and NIGMS.

Genetic dissection of “Space Brain” and conferring radioresistance for deep space exploration and colonization

NASA Ames Research Center – Research Priorities for NASA EPSCoR

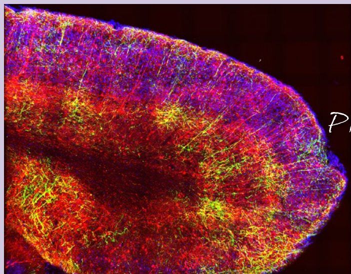
Astrobiology and Life Science: Understanding life on Earth - and in space: Space Radiation and limits of habitability

INSPIRATION: ***Can we learn from the resilience of extremophiles such as tardigrades to safeguard nervous system against space radiation and enhance human habitability for deep space exploration and colonization?***

A P P R O A C H

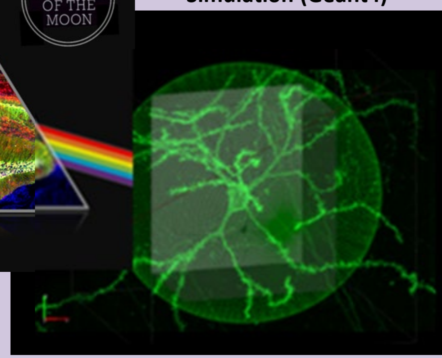
Genetic Sensor of Deep Space Radiation

Genetic sensor revealed accelerated brain aging in mice exposed to simulated GCR accompanied by long-lasting sensorimotor deficits



PRISM labeling after simulated GCR exposure

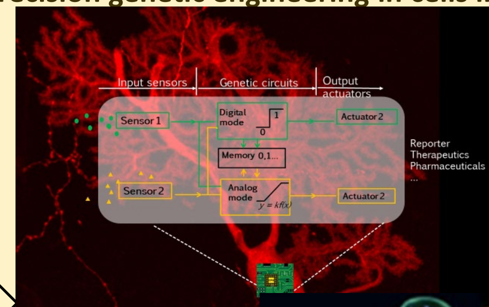
Computational modeling of neuron irradiation with Monte Carlo Simulation (Geant4)



El-Saadi, et al, Science Advances, 2022

Synthetic sensor-actuator circuit (“Cellular Robot”)

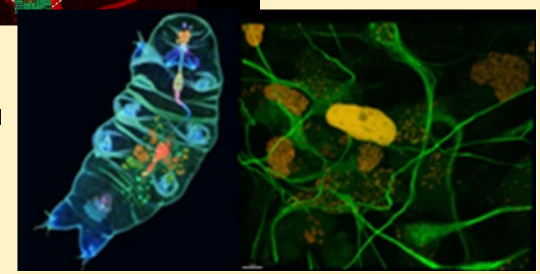
Precision genetic engineering in cells injured by space radiation



Genetic interrogation of DNA damage response, senescence, autophagy /lysosome, and neuroinflammation pathways in cells injured by space radiation

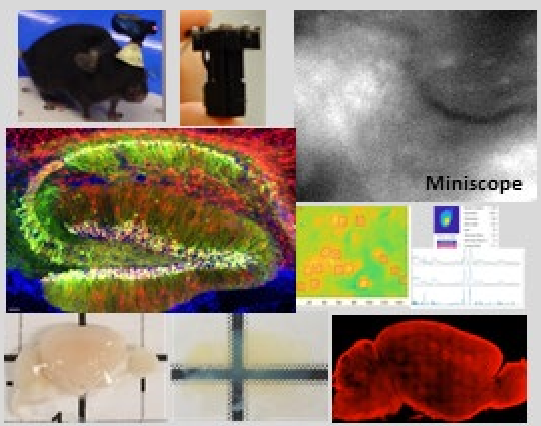
Lu, et al, Science Translational Medicine, 2014

Tardigrade gene modified human iPSCs differentiated neurons and transgenic mice after exposure to radiation mimic, Lu lab data



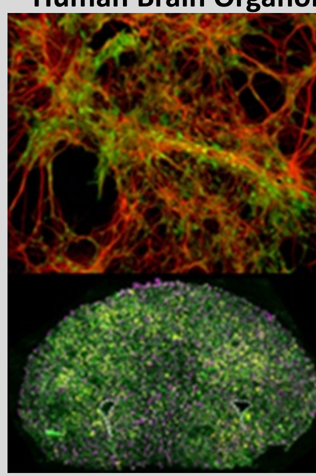
M O D E L S

Mouse

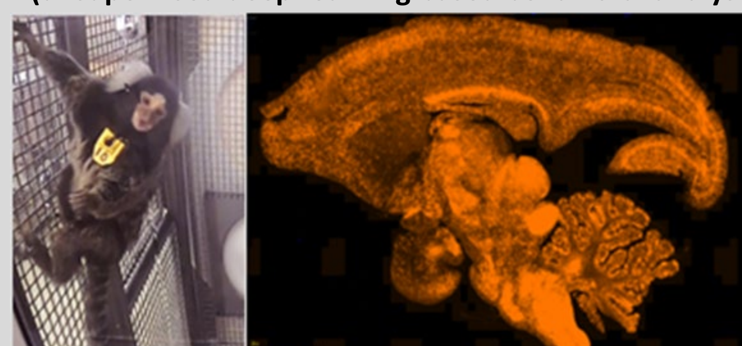


Tissue cleared brain and volume imaging

Human Brain Organoid



Non-human primate (unsupervised deep-learning based behavioral analysis)



Transgenic marmoset: Athena and a genetically modified marmoset brain
Simulation of cumulative dose, high complex lesion , and dose rate related to high Linear energy transfer (LET) using CRISPR and anti-CRISPR system.

BRAIN

Brain Research through Advanced and Innovative Neurogenetics

Dr. Xiao-Hong Lu
www.luneurolab.org

LSU Health SHREVEPORT

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Identification of Prebiotic Molecules and Exploration of Astrochemistry through High-Resolution Laser Spectroscopy

Dr. Jinjun Liu

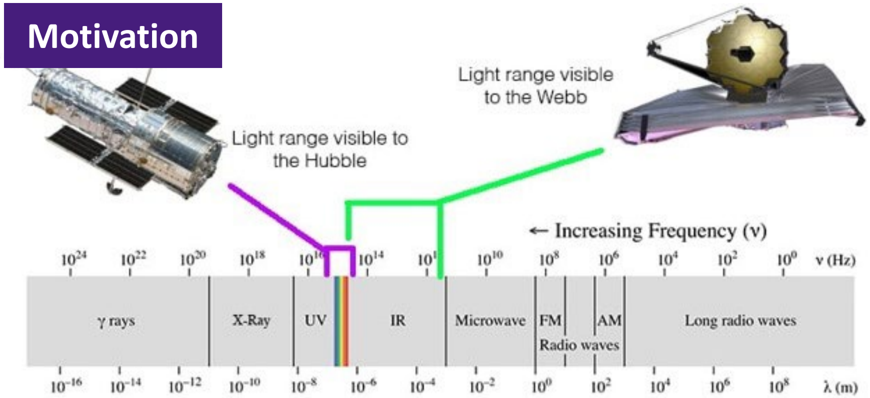
University of Louisville
Department of Chemistry and Department of Physics
Conn Center for Renewable Energy Research
j.liu@louisville.edu; (502) 852-1223

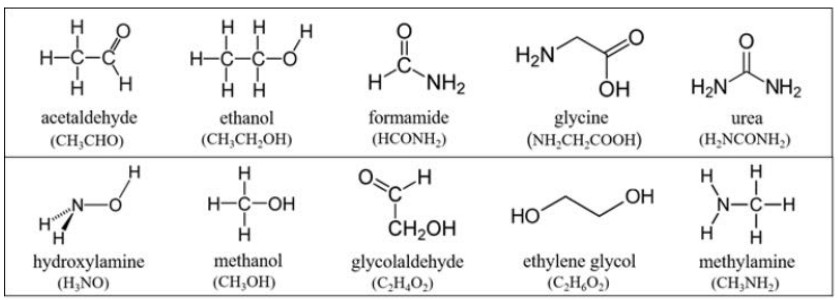
Dr. Jinjun Liu is a Professor of Chemistry and Adjunct Professor of Physics at the University of Louisville (UofL). He is also the Spectroscopy Theme Leader of the Conn Center for Renewable Energy Research of the Speed School of Engineering at UofL. Research in Dr. Liu's group consists of high-resolution laser spectroscopy of gas-phase molecules, many of which can be found in space, through combined experimental, theoretical, and computational investigations. The experimental investigations center on the detection and characterization of stable molecules and transient species, including free-radical chemical intermediates and molecules in excited electronic states. The research lab is equipped with more than ten narrow-linewidth, widely tunable lasers that cover the spectral range from mid-IR to UV. The high-resolution, high-sensitivity laser spectroscopic techniques used by the Liu Group include laser-induced fluorescence/dispersed fluorescence (LIF/DF), cavity ring-down (CRD) spectroscopy, Doppler-free saturation absorption spectroscopy, and two-photon spectroscopy techniques. These studies provide a quantitative understanding of energy-level structure and intramolecular dynamics. Unambiguous identification and assignment of experimentally obtained spectra is often a prerequisite to subsequent work on chemical reactions. Dr. Liu's group also develops pectroscopic models and implement quantum chemistry calculations to predict and analyze the complex structure and dynamics of molecules embedded in their experimental spectra.

UNIVERSITY OF LOUISVILLE

Identification of Prebiotic Molecules and Exploration of Astrochemistry through High-Resolution Laser Spectroscopy

Motivation



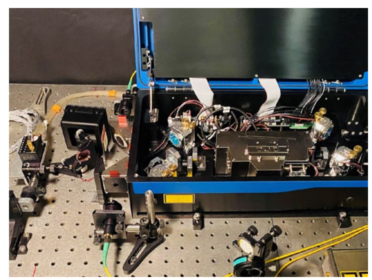


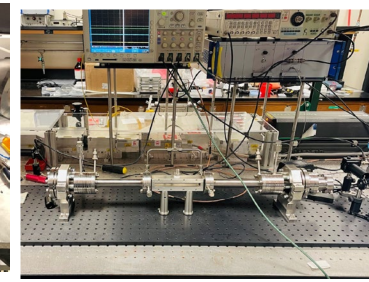
Resources

- Narrow-linewidth, widely tunable lasers covering mid-IR to UV.
- Flow cells.
- Vacuum chambers and molecular-beam sources.
- Laser-spectroscopic apparatuses.

Techniques

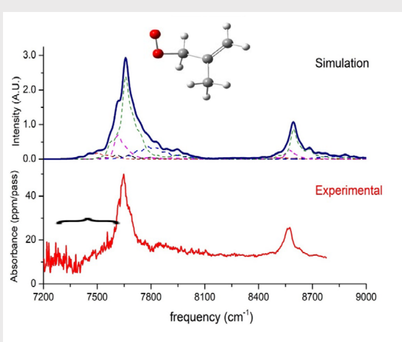
- Laser-induced fluorescence/dispersed fluorescence (LIF/DF).
- Cavity ring-down (CRD) spectroscopy.
- Doppler-free saturation absorption spectroscopy.
- Two-photon spectroscopy techniques.



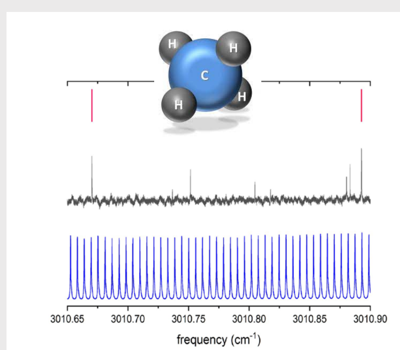


Outcomes

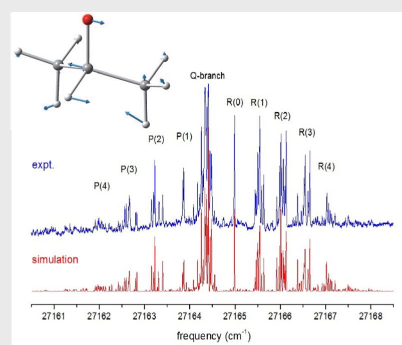
Detection and identification of reaction Intermediates

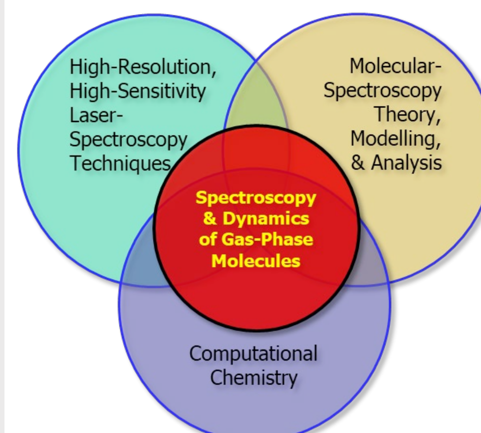


High-resolution high precision spectra of gas-phase molecules



Simulating and understanding experimental spectra





NASA EPSCoR Research for ARC
June 22, 2023

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Novel method for 3D printing metalized halloysite nanotube and lunar simulant regolith nanocomposites for radiation shielding

Dr. David K Mills

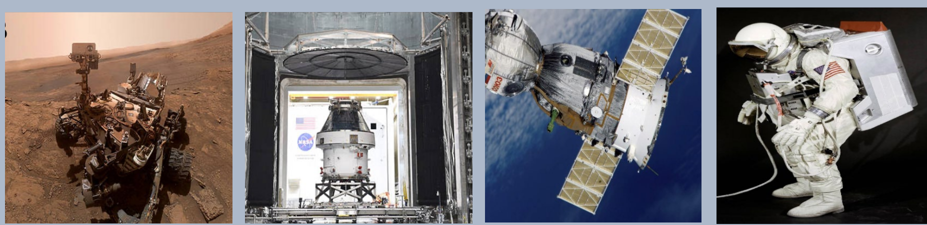
Louisiana Tech University
School of Biological Sciences
The BioMorpH Laboratory
dkmills@latech.edu; (318) 267-5644

I am on the ‘road less traveled and have met a few fellow travelers. I have a BA degree in Ancient History, another in Classics from Indiana University, an MA in Biological Anthropology, and a PhD. in Anatomy and Cell Biology from the University of Illinois. I am a professor of Biology and Biomedical Engineering at Louisiana Tech. I am a Professor of Biological Science (College of Applied and Natural Sciences). I have a strong background in bioengineering, cell and molecular biology, histology, and material science. My research groups are focused on the design of bioactive nanofilms and coatings, scaffolds for dental and orthopedic implants, the application of nanoscale topographic and chemical cues for controlling osteogenesis, 3D printing of biomedical devices, implants, and advanced parts and tools. Current projects are focused on supporting future Lunar and Mars missions through developing antimicrobial/viral filtration systems, nanoceramic materials for enhanced plant growth and protection, and radiation shielding materials for planetary habitats. One of my research groups won the NASA Ignite the Night Competition (April 2020), and we were a finalist in this October’s NASA’s iTECH Cycle II Innovation challenge.

Novel method for 3D printing metalized halloysite nanotube and Lunar simulant regolith nanocomposites for radiation shielding

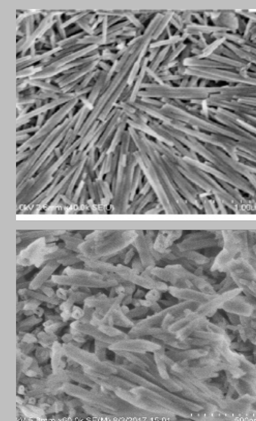
Motivation

What is vulnerable in space?



Key shielding components

Halloysite

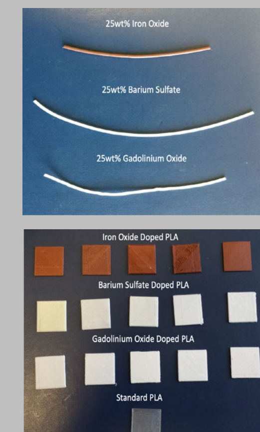


Bi_2O_3/Halloysite

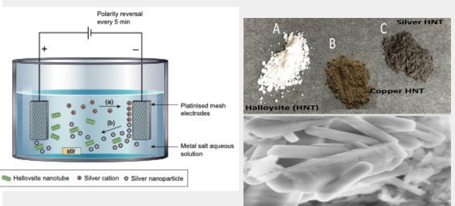
Native Halloysite

Bi_2O_3/Halloysite

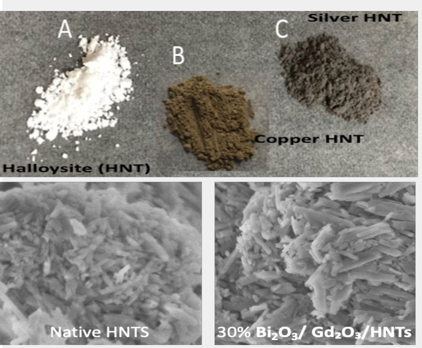
Printer Filaments



Fabrication Methods

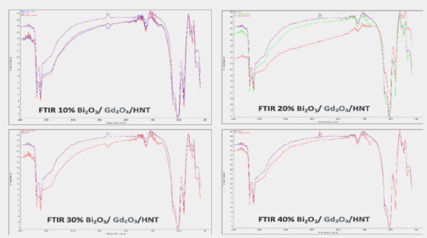


Coating HNTs by electrodeposition

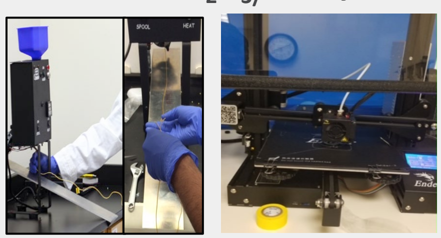


Coating HNTs of metal oxides

Current Research

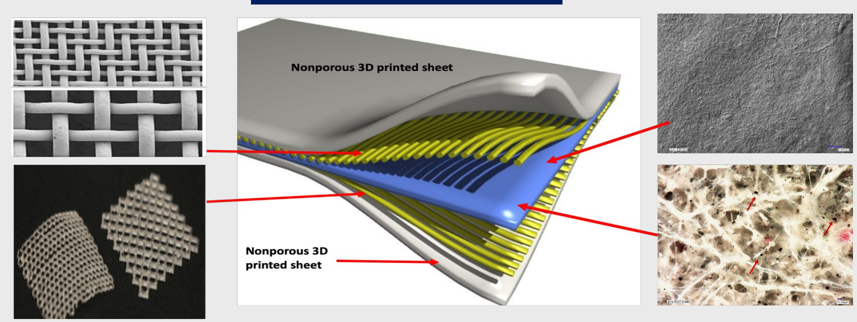


FTIR of Bi_2O_3/Halloysite



3D printing of Bi_2O_3/ Gd_2O_3/HNT constructs

Future Research



Multilayered 3D printed Bi_2O_3/ Gd_2O_3/HNT composites

BioMorph louisiana tech university

Dr. David K. Mills

School of Biological Sciences

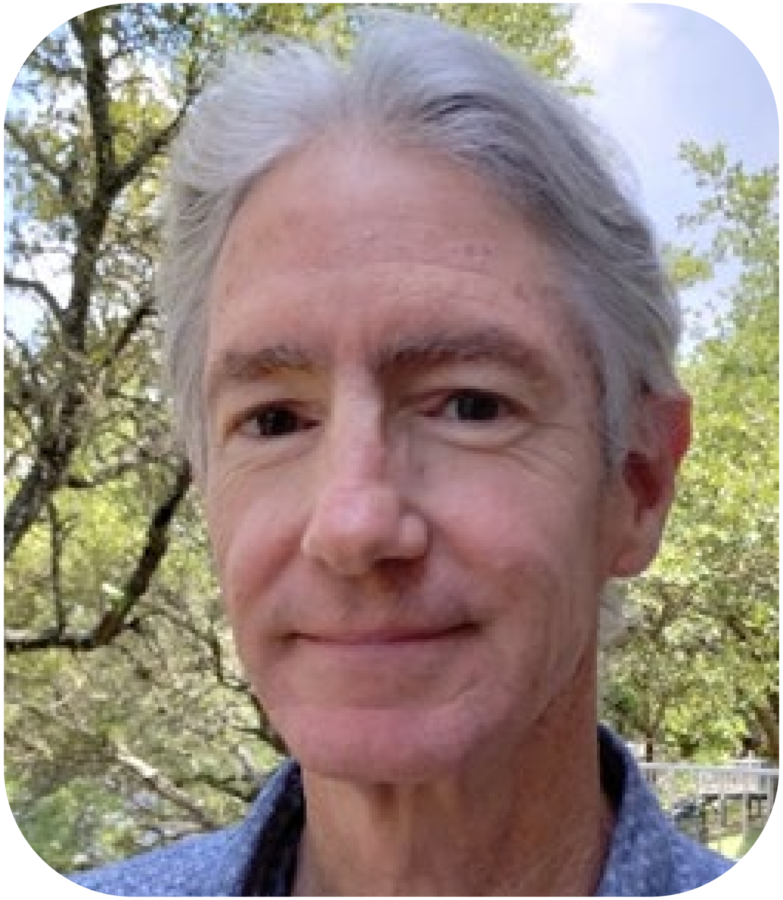
NASA EPSCoR Research for ARC
June 22, 2023

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Radiation Resistance of Isolated Proteins

Dr. Vince LiCata

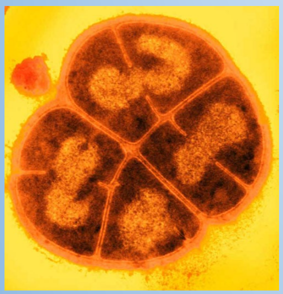
Louisiana State University
Departments of Biological Sciences and Chemistry
licata@lsu.edu
(225) 578-5233



Vince LiCata is the Louis S. Flowers Professor in the Department of Biological Sciences, with a joint appointment in the Department of Chemistry, at Louisiana State University. His laboratory focuses on the thermodynamics and kinetics of function and stability of isolated proteins from organisms that live in extreme environments. One of the focal organisms for the lab is Deinococcus radiodurans, which is widely studied as one of the most radiation resistant organisms ever identified – able to survive thousands of times the dose that would kill E. coli or humans. We have isolated several DNA-binding proteins from D. radiodurans: DNA polymerase I, recombinase A (RecA), and single-stranded binding protein (SSB), with plans to add several others. We have begun examining the effects of both UV and ionizing radiation on the structural and functional integrity of the isolated proteins, with the hypothesis that, similar to other extremophiles, radiation resistant proteins have also evolved within radiation resistant organisms. Understanding the limits and potential bio-engineerability of radiation resistant proteins will have long-range impact and implications for the survivability and possible presence of Earth-like proteins on exoplanets, and on potential countermeasures for space radiation exposure. Our lab's experimental approaches/capabilities include: protein chemical and thermal stability determinations (using calorimetric, fluorescence, and circular dichroism based techniques), DNA-binding quantification (thermodynamics and kinetics; using fluorescence anisotropy, gel-shift, and calorimetric techniques), and selected functional assays (nucleotide incorporation and primer extension, ATP hydrolysis, and several enzymatic assays).

Radiation Resistance of Isolated Proteins

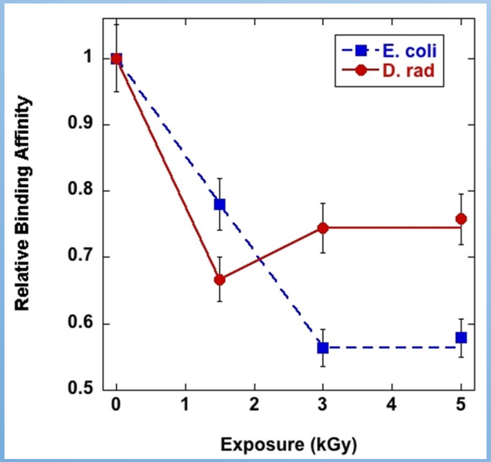
Vince LiCata, Departments of Biological Sciences and Chemistry, Louisiana State University, Baton Rouge, LA



DNA binding proteins are isolated from *Deinococcus radiodurans* – including DNA polymerase, RecA, and single-stranded binding protein (SSB)

Modeled structure of DNA polymerase from *D. radiodurans*

Proteins are assayed for structure, stability, and function after exposure to radiation. The graph below shows that DNA-binding activity of RecA from *D. radiodurans* is more resistant to ionizing radiation than RecA from *E. coli*.



Central Hypothesis: Proteins from radiation resistant organisms have also evolved to be either intrinsically more radiation resistant or to associate with ROS scavengers.

Experimental approaches/capabilities: protein purification, protein stability (ΔG, ΔH, Tm), protein structure and oligomerization (CD, DLS, GPC), protein function (binding and enzymatic activity).

LSU
LOUISIANA STATE UNIVERSITY

Astrobiology and Life Science:
Understanding Life on Earth - and in Space

Cracking the Histone Code

Dr. Karen C. Glass

University of Vermont, College of Medicine
Department of Pharmacology
Karen.Glass@uvm.edu; (802) 656-5760

Dr. Karen C. Glass is an Associate Professor in the Department of Pharmacology at the University of Vermont College of Medicine. She received her Ph.D. in Microbiology and Molecular Genetics from the University of Vermont in 2005, and completed her postdoctoral training in Pharmacology at the University of Colorado Denver.

Dr. Glass's research interests focus on understanding how epigenetic signaling regulates gene expression, and how alterations in these pathways are involved in disease development, particularly cancer and cardiovascular disease. She is interested in the molecular mechanisms driving the recognition of histone post-translational modifications, which are chemical changes that can be added to histone proteins in the nucleosome, the spools around which DNA is wrapped. Histone modifications play a role in regulating gene expression by controlling how tightly DNA is packed, which affects how accessible it is to transcription factors, the proteins that control which genes are turned on and off.

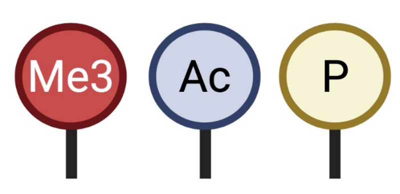
Dr. Glass uses a variety of techniques, including X-ray crystallography, nuclear magnetic resonance spectroscopy, and cryo-electron microscopy, to determine the three-dimensional structures of proteins. Protein structure is important for understanding how proteins function and how they interact with other molecules. Dr. Glass also has a strong background in molecular biology, genomics, biochemistry, biophysics, and proteomic techniques to study the function of proteins and other biological molecules. Dr. Glass's research has been published in leading scientific journals, including Nature, Molecular Cell, and the Journal of Medicinal Chemistry. She is currently conducting two research projects funded by the National Institutes of Health (NIH) to study how bromodomain-containing proteins recognize the histone code, and how the activity of these proteins influences the response to estrogen therapy in ER+ breast cancer. Dr. Glass is also a member of the American Society for Biochemistry and Molecular Biology, the American Crystallography Association, and the American Association for Cancer Research.

Dr. Glass is very excited about extending her research to NASA areas of interest. Particularly, regarding how radiation exposure during space flight may disrupt epigenetic regulatory responses and trigger uncontrolled inflammation, promoting disease development. Establishing new collaborations with NASA scientists has the potential to lead to new therapeutic strategies to extend our ability for space travel.

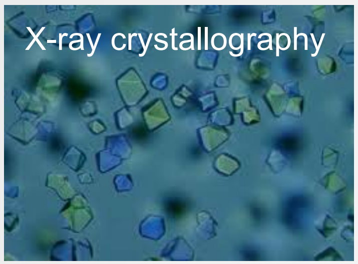
Cracking the Histone Code

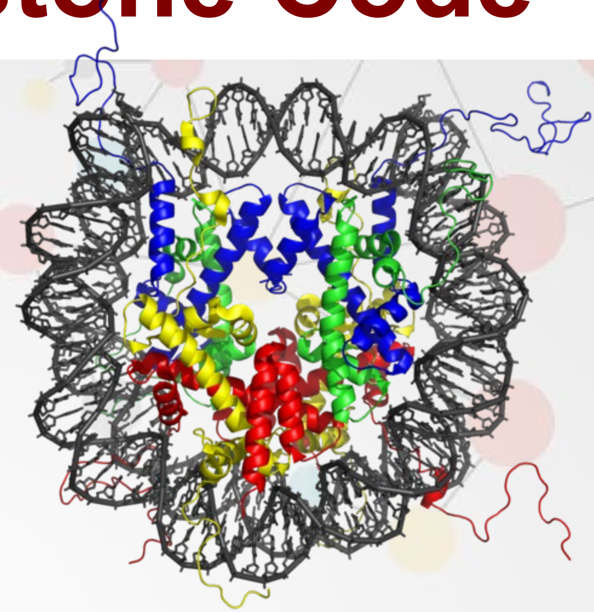
The Glass Laboratory

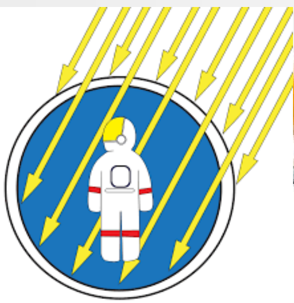
- Department of Pharmacology

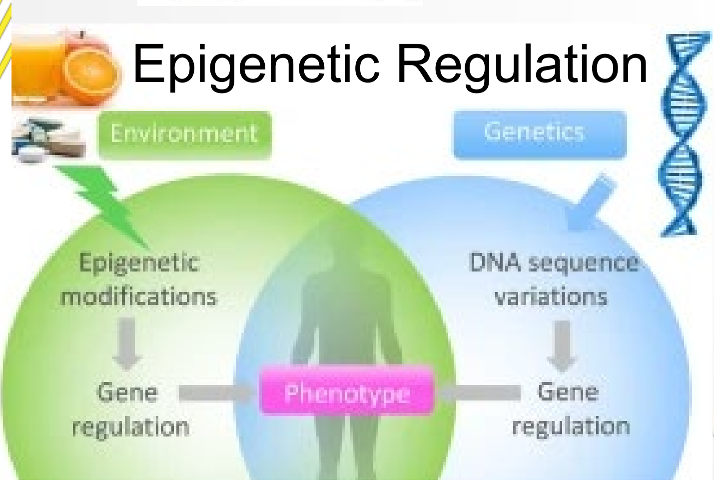


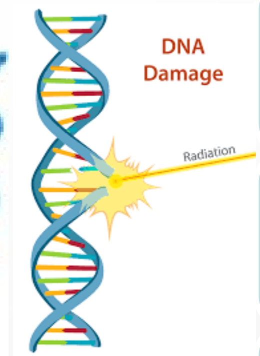
Histone modifications form a complex molecular language











How does SP100-C recognize histone modifications?

Connect DNA damage response to inflammation/apoptosis via CARD

Develop therapeutics to extend space travel

NASA VTSGC

The University of Vermont
LARNER COLLEGE OF MEDICINE

Astrobiology and Life Science: Understanding Life on Earth - and in Space

Noise-Induced Hearing Loss and Health Effects of Regolith Exposure

Dr. Danny Xu

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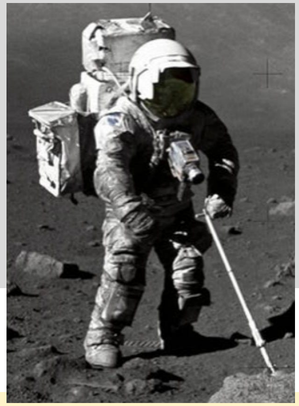
Department of Biomedical and Pharmaceutical Sciences
College of Pharmacy
xudong@isu.edu; (208) 373-1832

Dr. Danny Xu a Associated Professor of Biomedical Sciences and Pharmacy at ISU. He’s the director of the Graduate Programs and Zebrafish and Computational Core Research Facilities. His research expertise is at the intersection of molecular biology, drug discovery, and computational data science. Dr. Xu’s primary area of activity has been to identify novel systemic toxicity and ototoxicity of approved medications, environmental substances, and toxicants, and develop preventive strategies and pharmacological interventions to mitigate these toxicities. He has intense interests in preventing noise-induced hearing loss and characterizing the health effects of space stressors, including Lunar and Martian regolith, and other toxic substances. His research aims to protect NASA crew from these stressors to ensure the safety and success of deep space exploration.

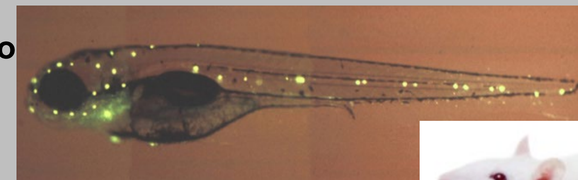
Noise-Induced Hearing Loss and Health Effects of Regolith Exposure

Motivation

Stressors During Space Missions



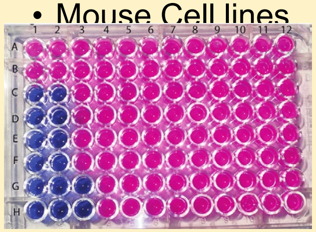
Characterization

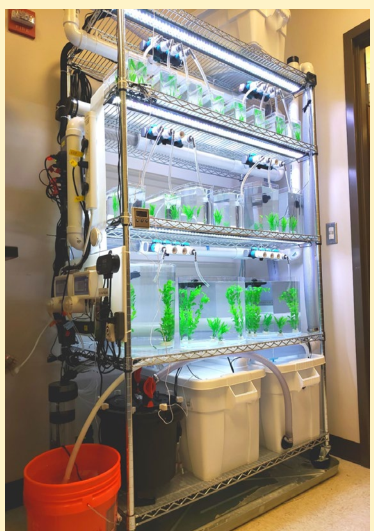


Pharmacological Intervention

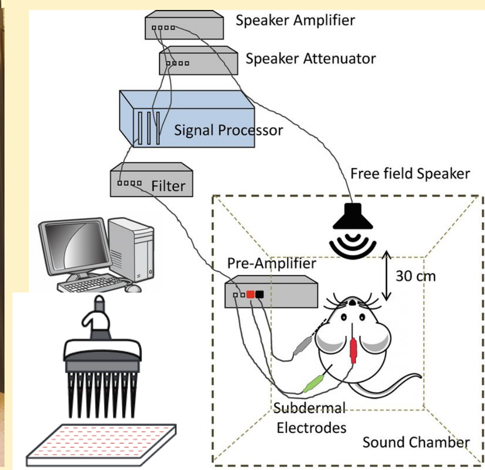
Our Research

In Vitro
- Human cell lines
- Mouse Cell lines



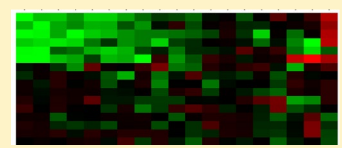


In Vivo
- Zebrafish Model
- Rodent Model

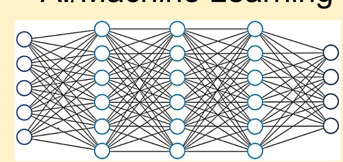


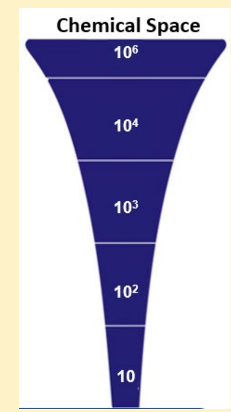
In Silico
- Clinical Data

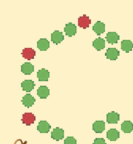
- Gene Expression Data



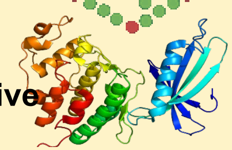
- AI/Machine Learning







Novel Protective Agents

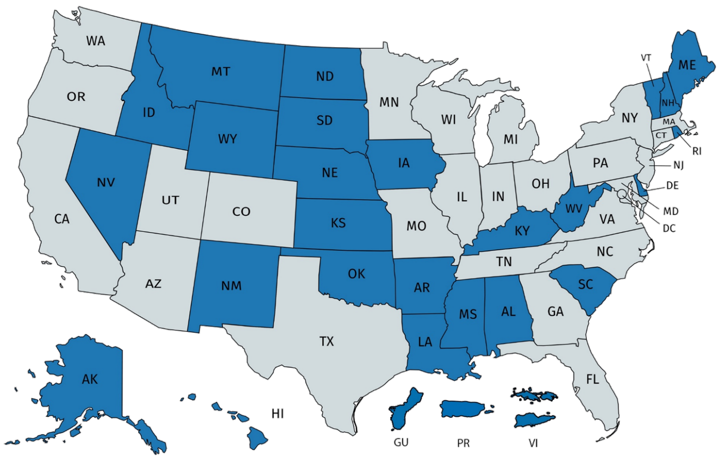


Dr. Danny Xu

Idaho State University
College of Pharmacy

Topic Area 5

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon



NASA EPSCoR Research for ARC
June 22, 2023

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

Stitching the Surface to the Sky: Surface & Drone-Borne Martian Boundary Layer Science

Prof. Brian Jackson

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Dept. of Physics
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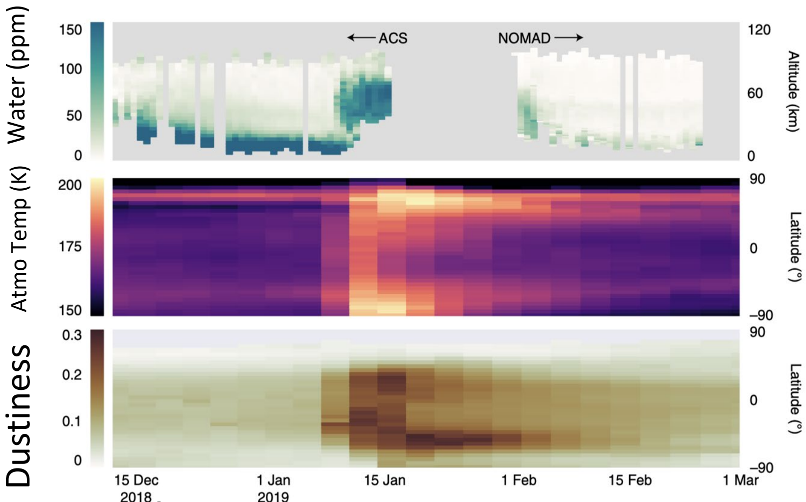
Brian Jackson is a professor of physics and planetary science at Boise State. His research expertise involves boundary-layer processes including aeolian transport. Since 2015, his group at Boise State has conducted field studies using miniature ground-based and drone-borne meteorological instrumentation to understand the connections between planetary surfaces and atmospheres as moderated by the boundary layer. His group has also used data collected by instruments on Mars and Saturn's moon Titan to extrapolate terrestrial field studies to better understand boundary layer processes on those distant worlds. Recent work includes exploring approaches to use drones as wind probes to determine wind speed and direction from only aircraft attitude without the need for additional instrumentation. Such an approach would be ideally suited for aerial exploration of Mars where drone-borne payloads will be severely mass-limited. In addition to research, Jackson has supported planetary exploration in several ways, including serving on the 2019 Discovery Mission Program review panel, participating in the selection of NASA's VERITAS and DAVINCI missions, on the Mars Exploration Program Analysis Group's Mars Concurrent Exploration panel, and as a member of the American Astronomical Society (AAS) Division for Planetary Science (DPS) Executive Committee.

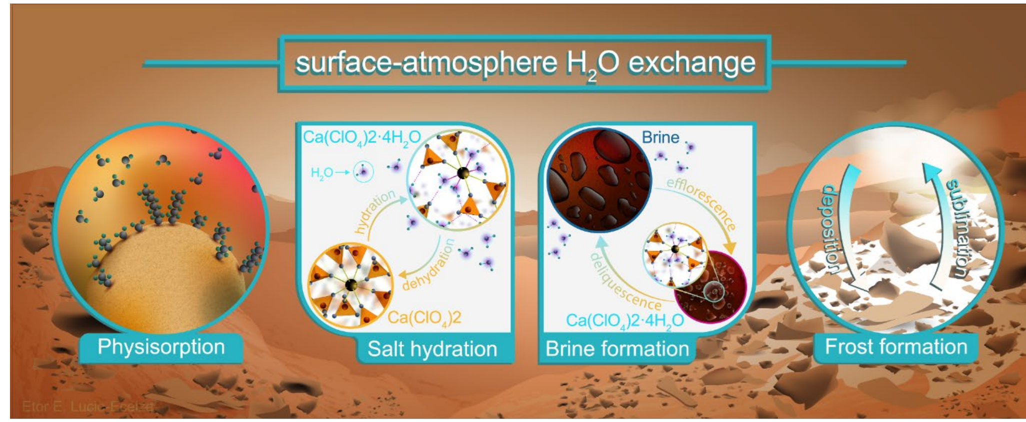
Cost-Effective Space Missions: Mars aero-explorer support & Network exploration with Aeolus

Boundary layer processes profoundly impact the martian environment.

Dust enhances water loss.

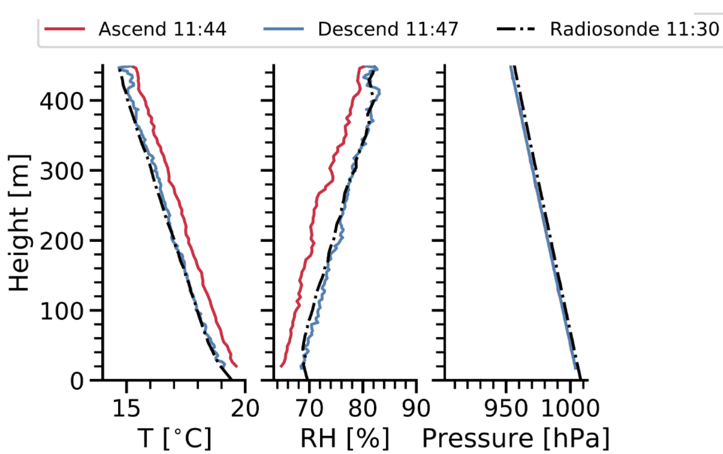


Atmo-surf water exchange de/stabilizes ice.

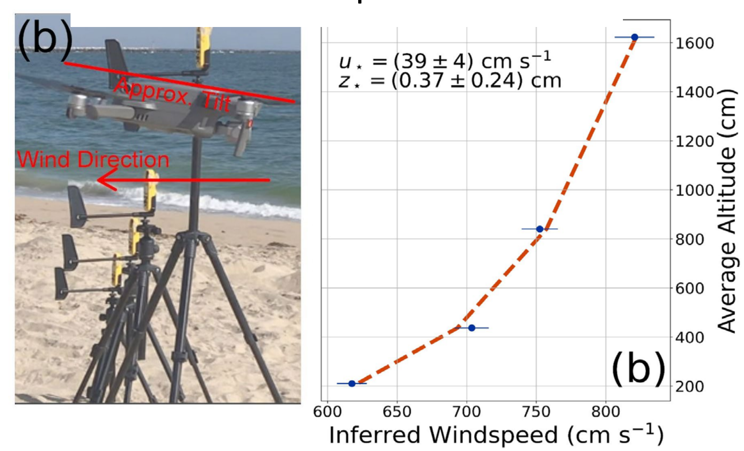


Drone-borne measurements can revolutionize boundary layer science.

Drones can profile near-surface water.



Drones can also profile wind.



BOISE STATE UNIVERSITY

Prof. Brian Jackson - bjackson@boisestate.edu

NASA EPSCoR Research for ARC
June 22, 2023

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

Fiber-reinforced Geopolymer Composites for Application in Extreme Environment

Dr. Ernesto J. Guades

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School of Engineering
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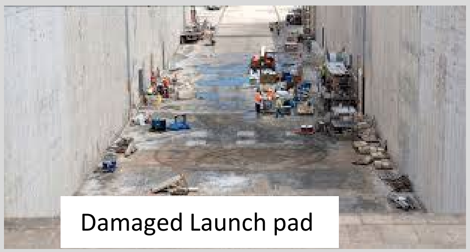
Ernesto J. Guades is an Assistant Professor of Structural Engineering at the University of Guam (UOG). He is the Lab in-charge of the Materials and Structural Laboratory (MSL) at UOG. The MSL is just recently established and is undergoing improvement to house additional equipment and research facilities. Dr. Guades's research expertise is in fiber-reinforced polymer (FRP) composites, fiber-reinforced cementitious composites, geopolymer concrete and construction materials under extreme condition. In the last 10 years, his primary area of research activity is focused on fiber-reinforced composites with application in civil infrastructures under corrosive environment and strengthening of existing structural elements.

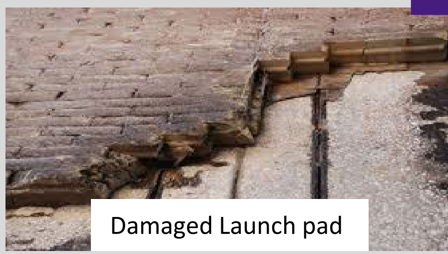
Fiber-reinforced Geopolymer Composites for Application in Extreme Environment

Motivation


Space shuttle launch pad


House built from lunar soil (regolith)

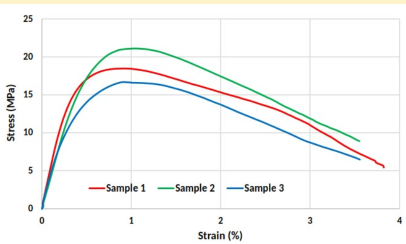

Damaged Launch pad

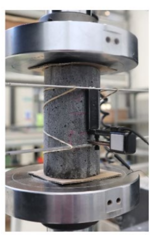

Damaged Launch pad

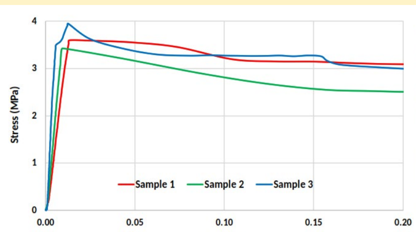
Proposed Research: Fiber-reinforced Geopolymer Composites

- Excellent fire and heat resistance (durability at elevated temperature)
- Superior corrosion resistance
- Lower creep and shrinkage characteristics
- Improved tensile and flexural performance, high toughness and ductility
- Good bond strength to concrete/cementitious substrate
- Closely resembles the oxide and phase composition of lunar regolith

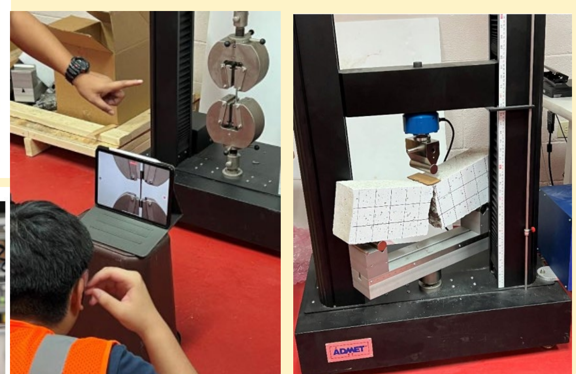
Experimentation



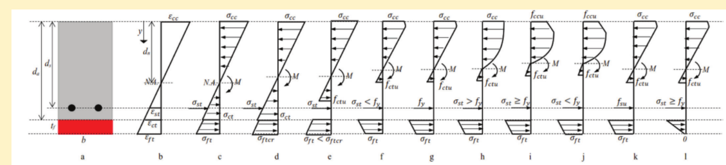




Our Research



Analytical Process



Neutral axis depth, d_n

$$\frac{2f_c'}{3}\left[\frac{2\varepsilon_{ft}}{\varepsilon_{cc0}}\left(\frac{d_n}{d_a-d_n+t_f}\right)-\left(\frac{\varepsilon_{ft}}{\varepsilon_{cc0}}\left(\frac{d_n}{d_a-d_n+t_f}\right)\right)^2\right]bd_n-\left(\frac{\sigma_{ft0}}{\varepsilon_{ftu}-\varepsilon_{ft0}}\right)\left[(\varepsilon_{ftu}-\varepsilon_{ft})+\left(\frac{\varepsilon_{ft}t_f}{2(d_a-d_n+t_f)}\right)\right]b\,t_f - f_y\left(\frac{\varepsilon_{ft}}{\varepsilon_{sy}}\right)\left(\frac{d_s-d_n}{d_a-d_n+t_f}\right)A_s-\left(\frac{f_{ctu}}{2}\right)(d_a-d_n+t_f)\left(\frac{\varepsilon_{ctu}}{\varepsilon_{ft}}\right)b=0$$

Moment, M

$$=\frac{2f_c'}{5}\left[\frac{2\varepsilon_{ft}}{\varepsilon_{cc0}}\left(\frac{d_n}{d_a-d_n+t_f}\right)-\left(\frac{\varepsilon_{ft}}{\varepsilon_{cc0}}\left(\frac{d_n}{d_a-d_n+t_f}\right)\right)^2\right]bd_n^{\,2}+\left(\frac{\sigma_{ft0}}{\varepsilon_{ftu}-\varepsilon_{ft0}}\right)\left[(\varepsilon_{ftu}-\varepsilon_{ft})\left(d_a-d_n+\frac{t_f}{2}\right)+\left(\frac{\varepsilon_{ft}t_f}{2(d_a-d_n+t_f)}\right)\left(d_a-d_n+\frac{t_f}{3}\right)\right]b\,t_f+f_y\left(\frac{\varepsilon_{ft}}{\varepsilon_{sy}}\right)\left(\frac{(d_s-d_n)^2}{d_a-d_n+t_f}\right)A_s+\left(\frac{f_{ctu}}{3}\right)\left[(d_a-d_n+t_f)\left(\frac{\varepsilon_{ctu}}{\varepsilon_{ft}}\right)\right]^2 b$$

Dr. Ernesto J. Guades

UNIVERSITY OF GUAM
UNIBETSEDÅT GUÅHAN

SCHOOL OF ENGINEERING
UNIVERSITY OF GUAM

NASA EPSCoR Research for ARC
June 22, 2023

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

Characterization of Heat, Mass and Charge Transport in Spontaneous Electrokinetic Energy Conversion Devices

Dr. Debashis Dutta

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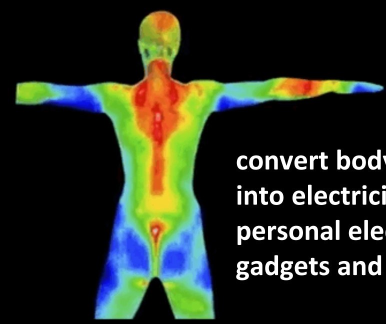
Department of Chemistry
ddutta@uwyo.edu; (307) 766-4318

Debashis Dutta is a Professor in the department of Chemistry at the University of Wyoming. His research expertise is in the areas of micro- and nanofluidic transport and their utilization in sensing and energy conversion applications. Recently, Dr. Dutta has been working on characterizing evaporation-driven spontaneous capillary flows for electrokinetic energy conversion employing glass nanochannels and Nafion® membranes as the evaporating media. This is a promising method for small-scale electricity production from low-grade heat that is largely unexplored. Dr. Dutta's laboratory is currently involved in developing experimental tools for characterizing heat, mass and charge transport in these systems to identify their scaling laws for electricity generation. He holds a US patent on the method of electrokinetic energy conversion using evaporation-driven spontaneous electrolyte flow through nanoporous media, and has just published a journal article on the characterization of solvent flow and evaporation rates in a glass channel based spontaneous electrokinetic energy conversion device.

Characterization of Heat, Mass and Charge Transport in Spontaneous Electrokinetic Energy Conversion Devices

Motivation

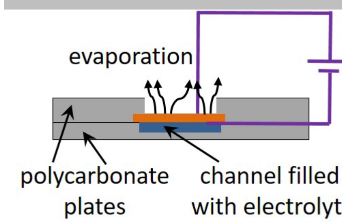
convert waste heat from propulsion system, air friction, onboard electronics, etc., into electricity

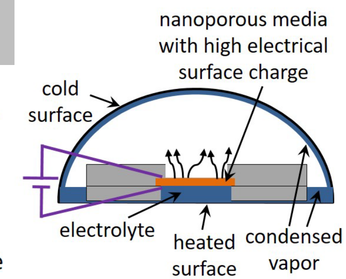


convert body heat into electricity to run personal electronic gadgets and sensors

Proposed solution

Open and Closed Evaporation-Driven Electrokinetic Energy Conversion Devices





Gaps in Knowledge and Technology

- Understanding of solvent evaporation rates from electrically charged nanopores
- Understanding of heat, mass and charge transport through nanoporous media with an evaporating surface
- Understanding of scaling laws for electricity generation with respect to design and operating parameters

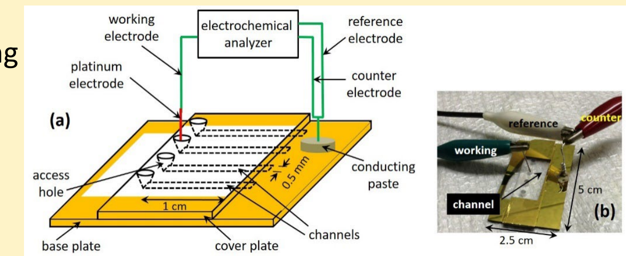
Research Opportunities

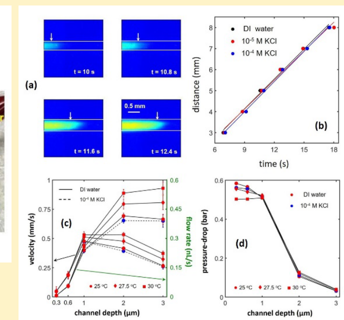
- Identify materials, e.g., nanoporous media, solvent, electrodes, etc., that maximize electricity generation
- Develop surface modification strategies to promote solvent evaporation
- Develop device architecture for improved heat, mass and charge transport
- Utilize external factors, e.g., solar radiation, force fields, etc., to improve heat, mass and charge transport

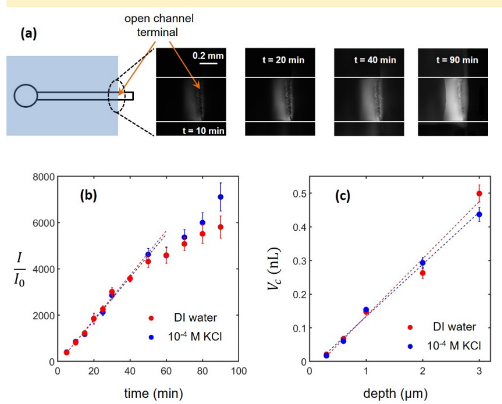
Our Research

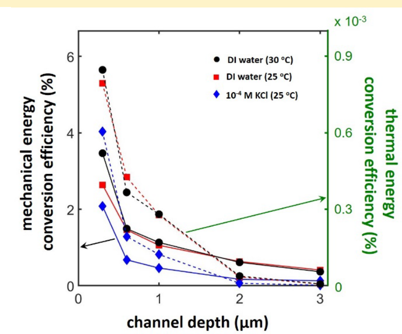
Tools

- fluorescence imaging
- gravimetry
- calorimetry
- electrochemical measurements









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Dr. Debashis Dutta

UNIVERSITY of WYOMING

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

Space Systems Operations Research and Next Generation Space Systems

Dr. Hang Woon Lee

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Space Systems Operations Research Group
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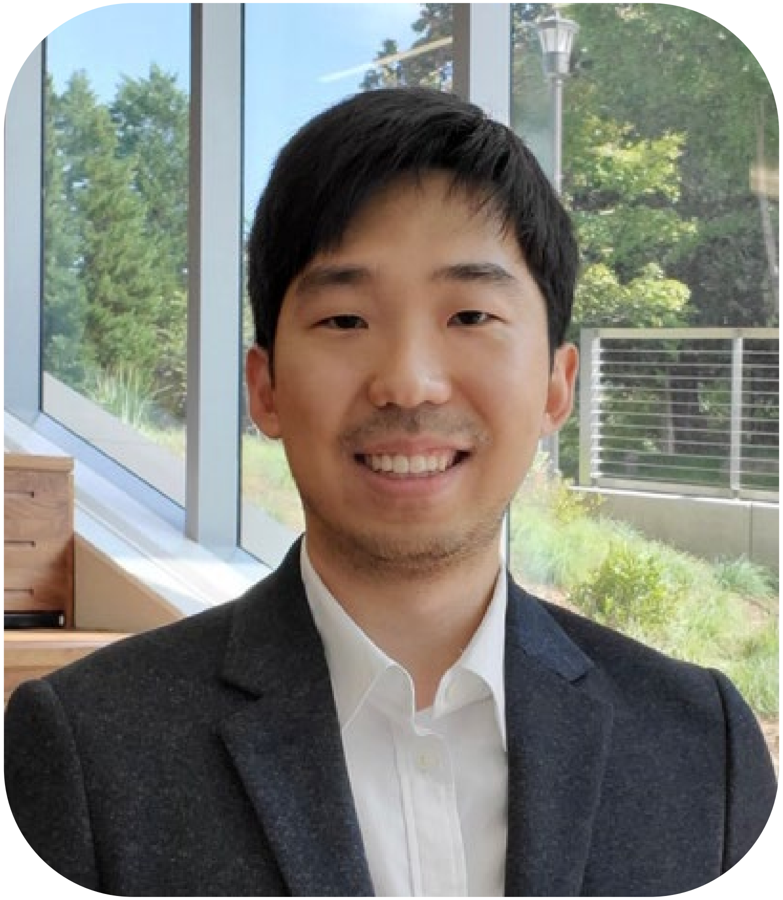
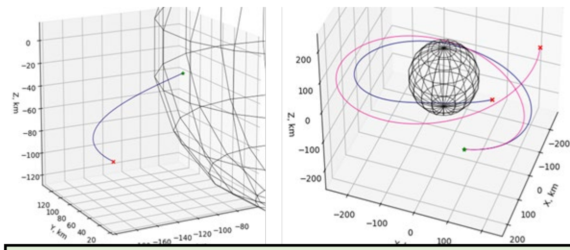
Hang Woon Lee is an Assistant Professor of Space Systems at West Virginia University. He is the director of the Space Systems Operations Research Group. His research interest lies at the intersection of space systems engineering, operations research, and astrodynamics. He is dedicated to the development of innovative mathematical modeling techniques and optimization methods for tackling complex decision-making problems that arise during the life cycle of a space system. Applications include the design and operations of earth observation satellite constellations, space domain awareness in cislunar space, and space logistics. Hang Woon is a faculty member of the newly founded West Virginia Small Satellite Center of Excellence.



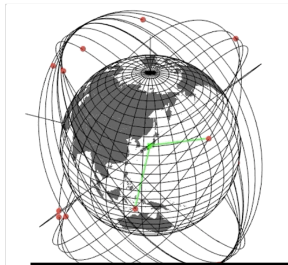
Space Systems Operations Research and Next Generation Space Systems

Mission Design and Operations

- Autonomous operations under uncertainty
- Mission design and scheduling
- Network fault detection & resilience



Asteroid exploration using reinforcement learning

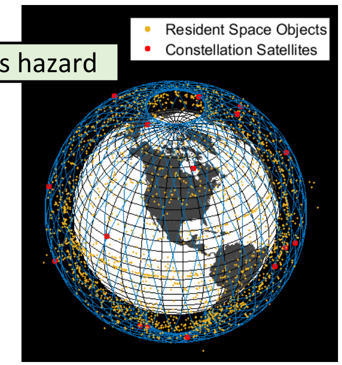


Earth observations

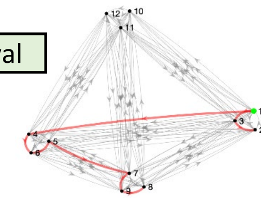
Space Traffic Management & Space Domain Awareness

- Post-mission disposal
- Active debris removal
- Space-based SDA
  - Cislunar space

Space debris hazard



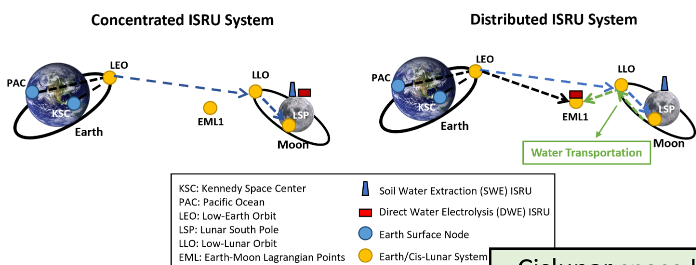
Active debris removal



Distributed Satellite Systems

On-orbit Servicing & Space Logistics

- *Where do we locate gas stations in space?*
- *In-situ* resource utilization
- Campaign-level mission design & supply chain mng.



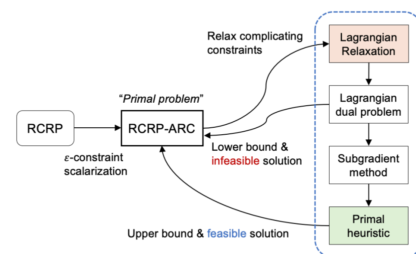
Cislunar space logistics

Operations Research

- ***The science of making "good" decisions.***

Tools

- Modeling & Simulation
  - Graph-theoretic
  - Network analysis
- Mathematical Optimization
  - NLP, large-scale, decomposition-based
- Artificial intelligence



Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

In-Space Servicing and Assembly with Electromagnetic Small Satellites

Dr. Hasan A. Poonawala

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Hasan A. Poonawala is an Assistant Professor of Mechanical & Aerospace Engineering at UK. His research expertise is at the intersection of robotics, nonlinear control theory, and data-driven models. Since 2016, he has focused on analysis and synthesis of data-driven controllers with performance guarantees. A primary application area has been in robotic navigation under uncertainty. He is part of the UK Autonomy, Robotics & Controls (ARC) group which has tested small satellite control algorithms on custom hardware on board the international space station. The group has a 20ft by 20 ft flat floor facility that enables relevant-environment experiments.

In-Space Servicing and Assembly with Electromagnetic Small Satellites

Motivation

Topic 5: Cost-Effective Space Missions

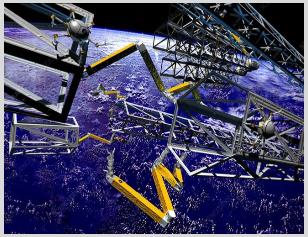


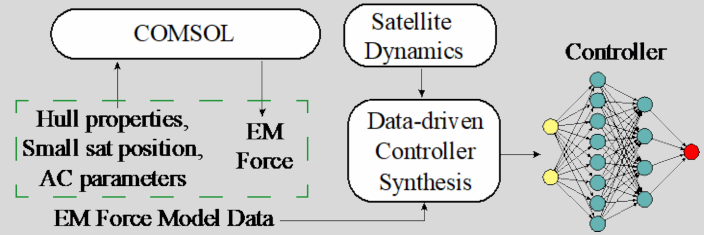
Image credit: NASA

Small Satellites for ISA

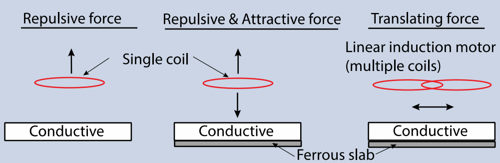
- Low-cost
- Replenishable actuation
- Robust / Modular

Goals

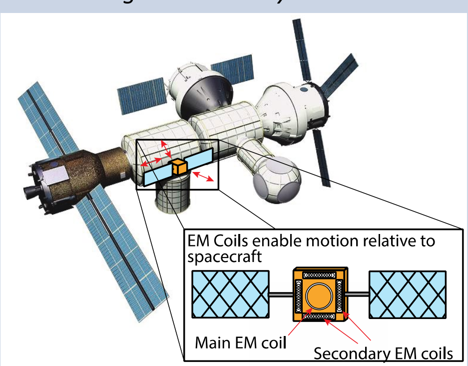
- Challenge: lack of closed-form EM force models for small sat position control
- Approach: data-driven controller synthesis using COMSOL



Electromagnetic Small Satellites



- *EM coils can generate forces relative to space craft hull*
- *Suitable design enables small sat motion relative to spacecraft for servicing and assembly*



Research Capabilities

Tools

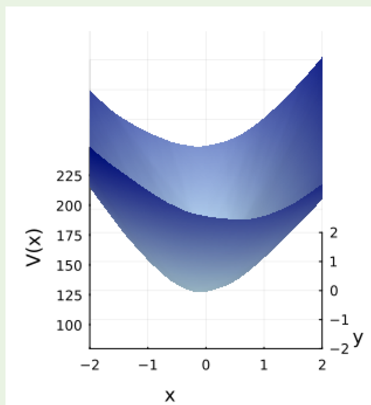
- Hybrid systems theory
- Mathematical Optimization
- Machine learning

Applications

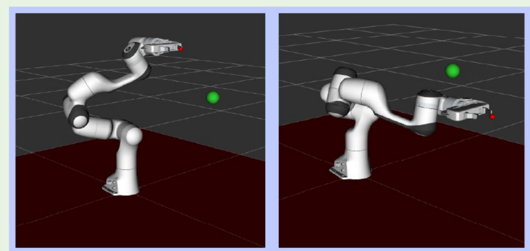
- Sensor-driven path following
- Contact-rich manipulation

UK ARC Facilities

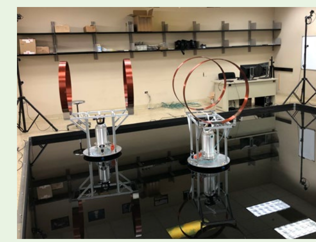
- Flat floor
- Small satellite fabrication



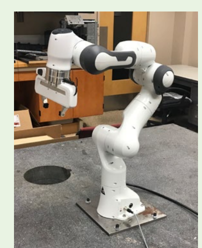
Lyapunov functions for data-driven controllers



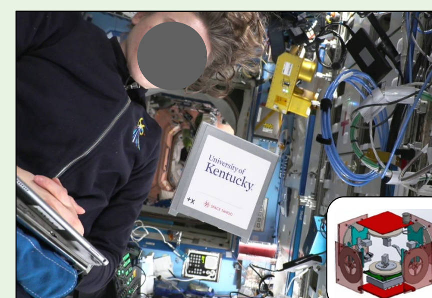
Learning-based planning and control



20 ft x 20 ft Flat Floor



Robot platforms



Small sat on ISSS (courtesy: UK ARC)

Dr. Hasan A. Poonawala

Pigman College of Engineering
Department of Mechanical and Aerospace Engineering

NASA EPSCoR Research for ARC
June 22, 2023

Cost-Effective Space Missions: Enabling High Value Science to Low Earth Orbit and the Moon

ODeSEUS: A Orbit Decaying Smallsat for atmospheric Entry Unit Shooting experiments

Dr. Dae Young Lee

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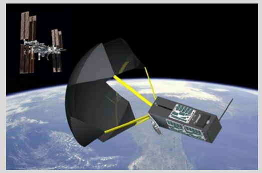
Dr. Dae Young Lee received B.S. and M.S. degrees in mechanical engineering from Pusan National University, Pusan, South Korea. In 2016, he acquired M.S. and Ph.D. degrees in aerospace engineering from the University of Michigan, Ann Arbor, MI, USA. Before his Ph.D., he worked as a Research Engineer at Hyundai Heavy Industry and LS Industrial Systems from 2000 to 2009. He was also a Postdoctoral Researcher at the Center of Space Research of the University of Texas at Austin, TX, USA, from 2016 to 2018, then currently working as an Assistant Professor of aerospace engineering at Iowa State University, Ames, IA, USA. He is also the Director of Cardinal Space Laboratory and researching space missions based on a CubeSat platform, attitude determination and control (ADCS), and entry, descent, and landing (EDL) of a spacecraft. His research interests include nonlinear model predictive control of the car, drone, and spacecraft feet with various constraints and extended tracking of 3D targets using their point clouds.

ODeSEUS: Orbit Decaying Smallsat for atmospheric Entry Unit Shooting experiments

Motivation

Dragon / Soyuz

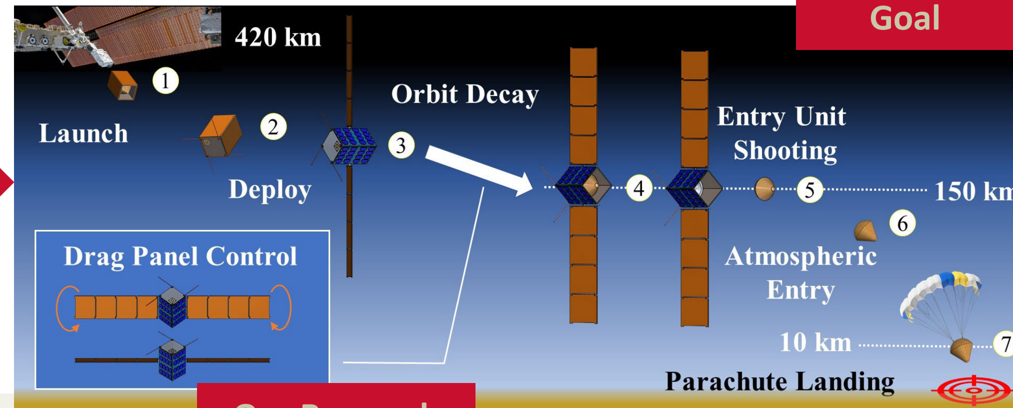
Small Payload Quick Return (SPQR)



CubeSat platform

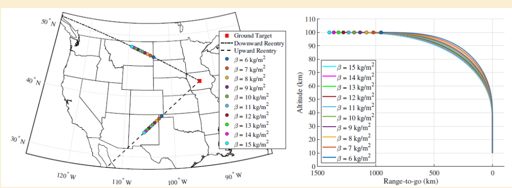
- Experimental sample delivery from International Space Station (ISS) to the ground is limited (Not frequent and expensive)
- Small Payload Quick Return (SPQR) system is in-development

Goal

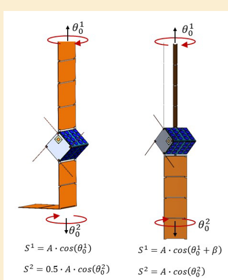


Key concepts

- ***Onboard optimal entry interface calculation***



- ***Drag-based orbit decaying***
- ***On-orbit ballistic coefficient estimation***



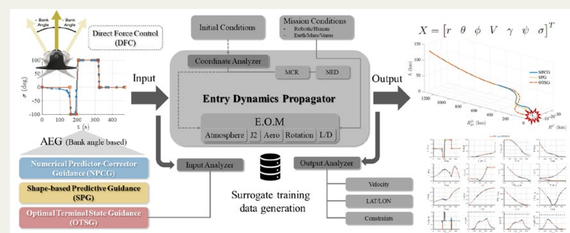
- ***CubeSat mission design and development***

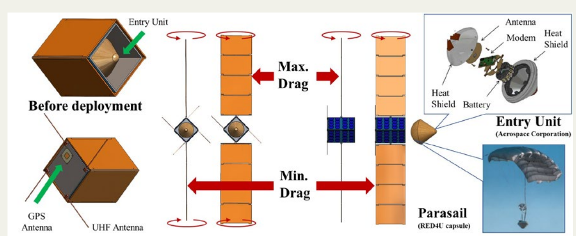
Our Research

Tools

- CubeSat development experience and facilities

- Atmospheric entry simulation framework





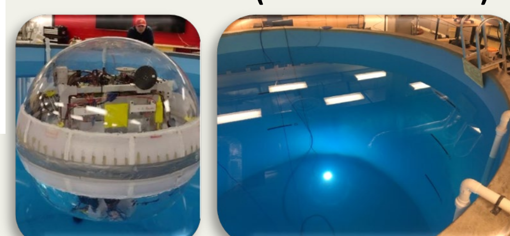
Outcomes

- Atmospheric entry guidance algorithms development
- On-orbit optimal guidance based on surrogate training.

Applications

- Earth/Mars/Venus entry GNC simulation framework
- Aero capturing demonstration using Small Satellites

Water tank test (Attitude Control)



Collaborating with the University of Kentucky for entry unit development

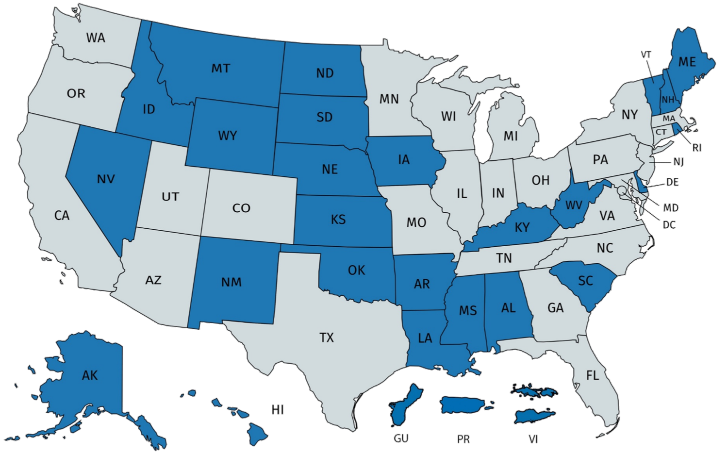
Iowa State University
College of Engineering

Dr. Dae Young Lee
Aerospace Engineering

Cardinal Space Laboratory

Topic Area 6

Intelligent/Adaptive Systems: Complementing Humans In Space



Intelligent/Adaptive Systems: Complementing Humans In Space

Coordinated mobility of teams of autonomous agents

Dr. Marcio de Queiroz

Louisiana State University
Department of Mechanical & Industrial Engineering
Innovation in Control & Robotics Engineering (iCORE) Laboratory
mdeque1@lsu.edu; (225) 578-8770

Marcio de Queiroz is a Professor of Mechanical Engineering at LSU and a fellow of the American Society of Mechanical Engineering. He is the director of the iCORE Lab and coordinator for the Robotics Engineering minor. His research expertise is at the intersection of systems theory, control engineering, and robotics. Since 2011, Dr. Queiroz's primary area of activity has been coordination control of multiple autonomous robotic vehicles with decentralized or centralized sensing, communication, and control. Such systems are intrinsic to missions that involve air traffic management, search and rescue, area coverage, perimeter protection, or co-transportation of large objects. His work in this area involves algorithm development, computer simulations, and experimentation on proof-of-concept testbeds.

Coordinated Mobility of Teams of Autonomous Agents

Motivation

Nature

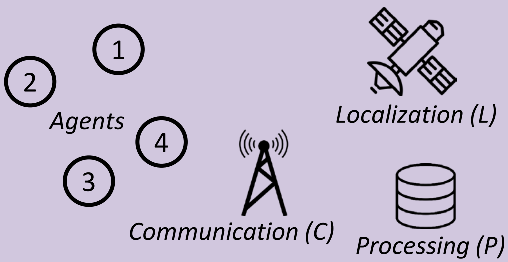
Inspiration

Engineered Systems

- Air traffic management
- Search and rescue
- Area coverage
- Perimeter protection
- Co-transportation of large objects

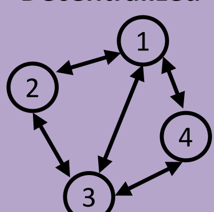
Autonomy Modes

Centralized



- Unified L/C/P
- ***Critical points-of-failure***

Decentralized



- Distributed, onboard L/C/P
- ***Robust and versatile (e.g., GPS-denied environments)***

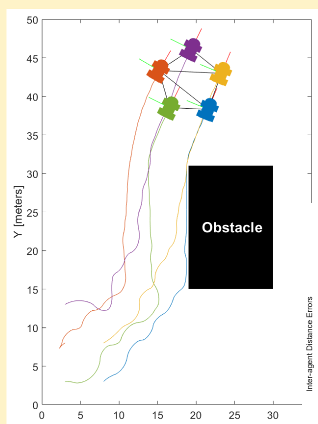
Our Research

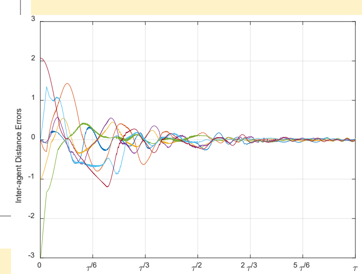
Tools
- Rigid graph theory
- Nonlinear systems theory
- Distance-based control

Applications
- Formation maneuvering
- Target interception
- Splitting and merging

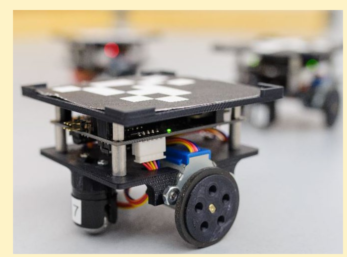
Outcomes
- Switched autonomy
- Stability guarantees
- Collision/obstacle avoidance

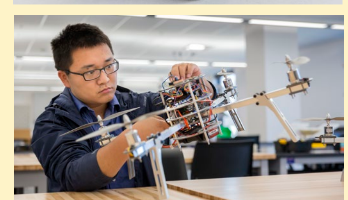
Computer Simulations

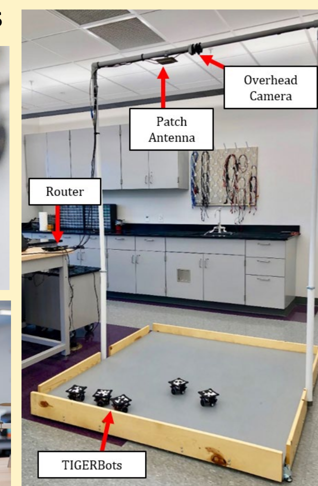




Proof-of-Concept Experiments







iCORE Innovation in Control and Robotics Engineering Lab

Dr. Marcio de Queiroz

LSU College of Engineering
Department of Mechanical & Industrial Engineering

NASA EPSCoR Research for ARC
June 22, 2023

Intelligent/Adaptive Systems: Complementing Humans In Space

Energy-efficient adaptive locomotion using muscle-driven limbless robots

Dr. Mahdi Haghshenas-Jaryani

New Mexico State University
Department of Mechanical & Aerospace Engineering
Bioinspired and Biomimetic Robotics (Bio2Robotics) Laboratory
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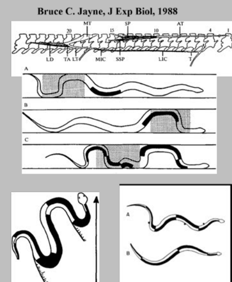
Mahdi Haghshenas-Jaryani, Ph.D., is an Assistant Professor of Mechanical and Aerospace Engineering and the director of the Bioinspired and Biomimetic Robotics (Bio2Robotics) Laboratory at New Mexico State University (NMSU). His research focuses on the dynamics and morphological control of bioinspired and shape-morphing soft and soft-and-rigid hybrid robots for mobility, manipulation, and physical human-robot interaction. Some recent research activities have focused on studying artificial muscle-driven limbless robots for achieving adaptive and energetically-efficient locomotion for surface and subsurface navigation. Such systems facilitate navigation of extreme access environments, steep slopes, and terrains with loose soil, long-range coverage, and self-burrowing for space exploration applications. The Bio2Robotics Lab has computational resources, fabrication prototyping capabilities, and robotic platforms for space exploration, mobility, and manipulation research. As experimental testbeds, a series of custom-built soft and rigid snake-like robots have been designed and developed to test and validate our dynamic models and control algorithms. Additionally, Dr. Haghshenas has active collaborations with research facilities related to space surface technology research, including NM Tech Lunar Arena and NMSU Advancing Regolith Technologies and Education (ARTE) Lab.

Energy-efficient adaptive locomotion using muscle-driven limbless robots

Motivation

Snakes and their musculoskeletal system



Inspiration

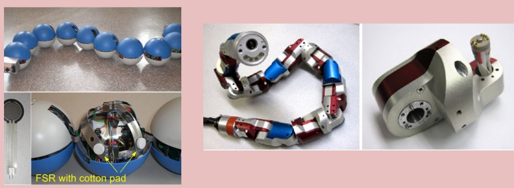
Snake-like robots

- Extreme Access Navigation
- Adapt to different environments
- Self-burrowing

- Space Inspection and Monitoring
- Terradynamics characterization
- Improve traversability

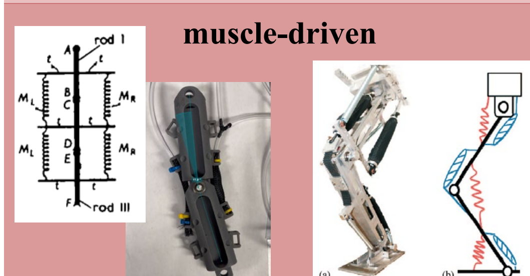
Artificial muscle-driven

Conventional



Heavy, bulky size, complex mechanism for compliance/stiffness control, and more net transportation cost

muscle-driven



- ***High force-to-weight ratio***
- ***Inherited compliance & stiffness control***

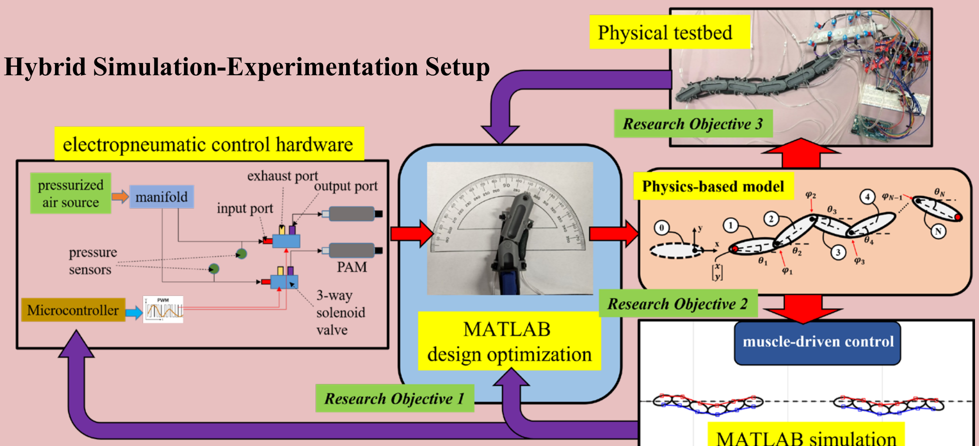
Our Research

Tools
- Rigid-soft multibody dynamics
- Compliance control
- Morphological computation & physical reservoir computing

Outcomes
- Energetically efficient & adaptive limbless locomotion
- Long range navigation/traversability
- Morphological learning/control framework

Applications
- Extreme Access Navigation
- Subsurface self-burrowing

Hybrid Simulation-Experimentation Setup



Bio[2]Robotics Laboratory

Dr. Mahdi Haghshenas-Jaryani

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NASA EPSCoR Research for ARC
June 22, 2023

Intelligent/Adaptive Systems: Complementing Humans In Space

Autonomous Odor Source Localization with Artificial Intelligence Methods

Dr. Lingxiao Wang

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Department of Electrical Engineering
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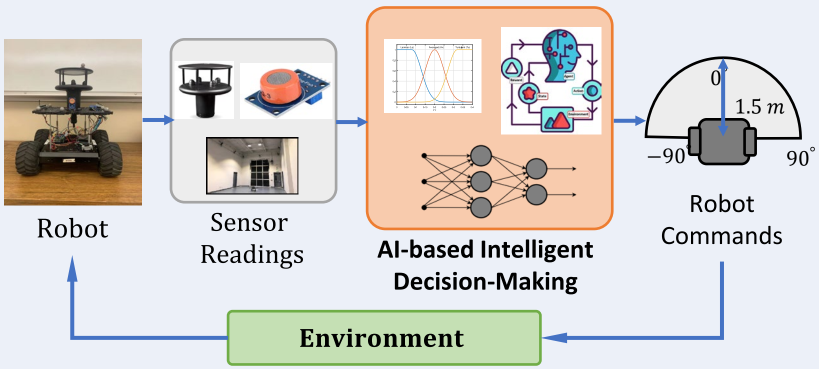
Lingxiao Wang is an Assistant Professor of Electrical Engineering at Louisiana Tech University (LaTech). His research work brings artificial intelligence (AI) and robotics closely together, aiming to develop a methodology for intelligent real-time decision-making in robotic systems to solve challenging real-world problems. His current research projects include autonomous odor source localization, map-less robot navigation, and dynamic path planning in autonomous vehicles. The applications of his research span a broad spectrum, ranging from the development of intelligent house robots capable of detecting/locating peculiar odors or gases (e.g., carbon monoxide), to the employment of uncrewed aerial systems for wildfire localization, as well as path and mission planning in autonomous driving vehicles. At LaTech, he supervises two graduate students and runs a robotic laboratory equipped with multiple high-performance computing stations and ground mobile robots, which are served as the testing platform for implementing/evaluating the intelligent navigation and path-planning algorithms in both simulation and real-world environments.

Develop Intelligent Robotic Systems via Artificial Intelligence Methods

1. Introduction

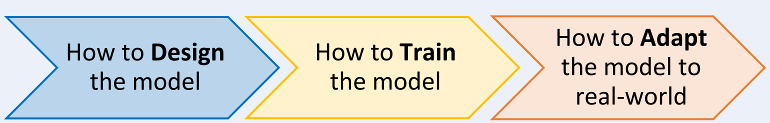
- ARC Research / Development Priority:
  - **Intelligent/Adaptive Systems**
- Research Objective:
  - Develop an intelligent robotic system that is capable of completing predefined tasks autonomously.
  - Integrate Artificial Intelligence (AI) to achieve intelligent decision-making in a robotic system.



The Framework of an Intelligent Robotic System

2. Key Aspects

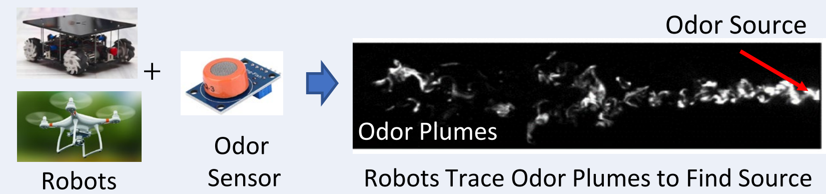
- To obtain an AI-based intelligent decision-making model, we need to consider three key aspects:



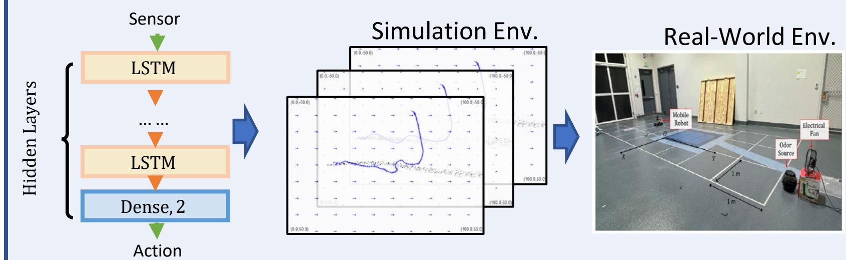
- We address these key aspects through an example robotic application: robotic odor source localization.

3. Research Capability: Robotic Odor Source Localization

- We aim to develop a robotic system to find odor sources in unknown environments autonomously.



- The key to success is the design of a plume tracing algorithm. Our algorithm integrates various AI methods:



Model Design:	Model Training:	Model Adaptation:
Deep Neural Networks	Reinforcement Learning; Supervised Learning	Transfer Learning

- Outcomes (compared to traditional search methods):
  - High success rate; Reduced search time; Robust to new environments.
- Related Applications:
  - Wildfire Monitoring
  - Finding Hydrothermal Vents
  - Adapting to other robotic systems, e.g., autonomous driving, house robots, delivery drones, etc.

LOUISIANA TECH UNIVERSITY

Dr. Lingxiao Wang

COLLEGE OF ENGINEERING & SCIENCE

Intelligent/Adaptive Systems: Complementing Humans In Space

Decentralized formation control of teams of autonomous agents

Dr. Zhangxian (Dan) Deng

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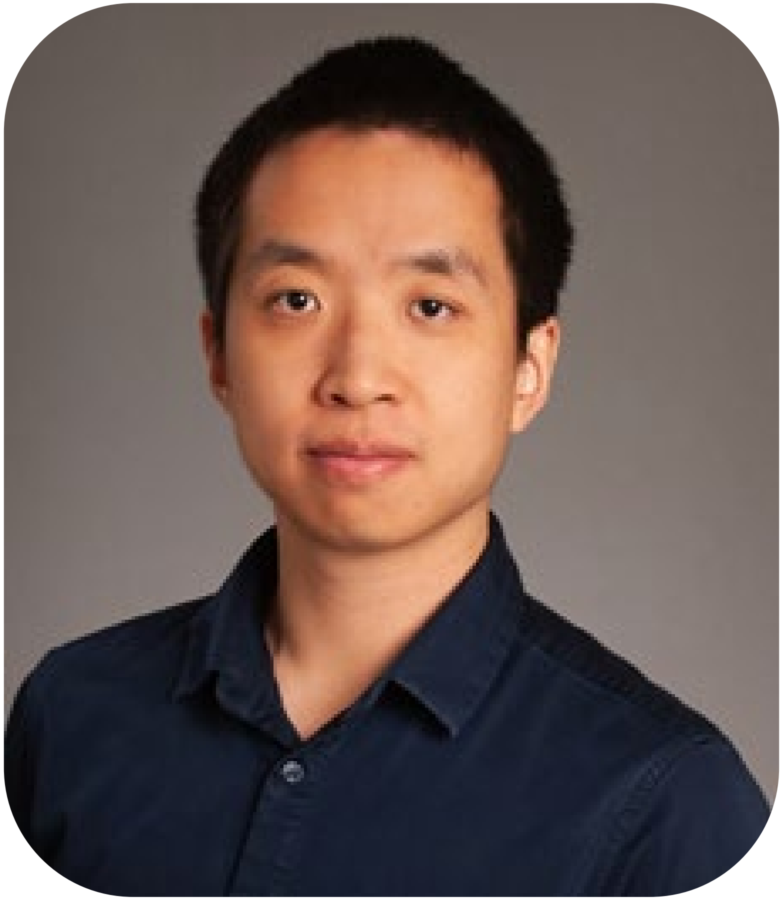


Zhangxian Deng is currently an assistant professor in the department of mechanical and biomedical engineering at Boise State University. Before joining Boise State in July 2018, Dr. Deng was a postdoctoral researcher with National Science Foundation (NSF) Industry-University Collaborative Research Center (IUCRC) Smart Vehicle Concepts Center. He received the Bachelor's degree in mechatronics from Zhejiang University (Hangzhou, China) and the Ph.D. degree in mechanical engineering from the Ohio State University (Columbus, OH) in 2010 and 2015, respectively. His expertise is at the intersection of additive manufacturing and smart materials. His research group specifically focuses on three types of smart materials: (1) magnetostrictive materials that deform in response to a magnetic field or demonstrate magnetization variations when subjected to mechanical loads, (2) piezoelectric materials that deform in response to an electrical voltage or produce electrical charges when stressed, and (3) shape memory polymers that exhibit temperature-driven deformation. The additive manufacturing techniques of his research interest include direct ink writing, fused filament fabrication, and aerosol jet printing.

Intelligent Adaptive Systems Enabled by Additive Manufacturing

Smart Materials

- Piezoelectric materials
- Magnetostrictive materials
- Shape memory polymers (SMP)

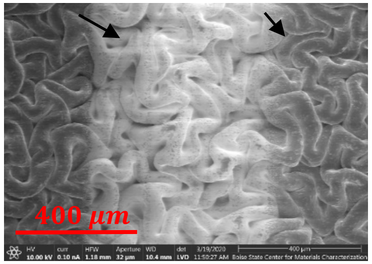
Additive Manufacturing

- Direct ink writing
- Fused filament printing
- Aerosol-jet printing

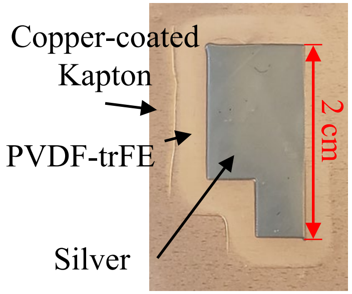
Human Systems Integration

Wrinkled electrodes

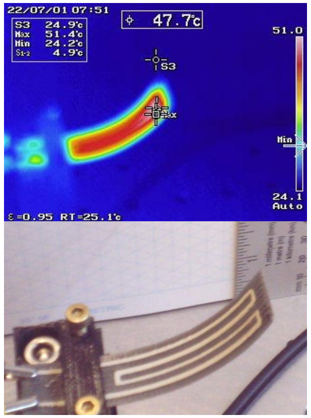
Printed silver Shrunken SMP



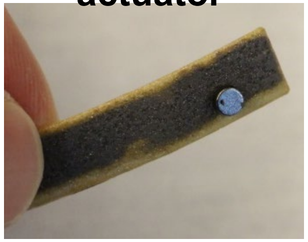
Flexible piezo force sensors



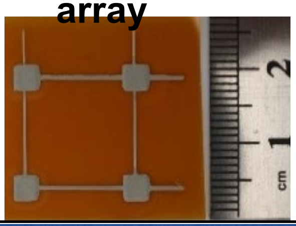
Morphing electronics



Magnetically-driven actuator



Piezo force sensor array



Lab Capabilities

- Smart material nanosynthesis
- Ink synthesis
- Multiphysics material characterization and modeling

Potential Applications

- Distributed sensing
- Structural health monitoring
- Energy harvesting
- Wireless charging
- Electrochemical sensing

NASA EPSCoR Research for ARC
June 22, 2023

Intelligent/Adaptive Systems: Complementing Humans In Space

Semi-supervised Machine Learning for Anomaly/Rare Category Detection

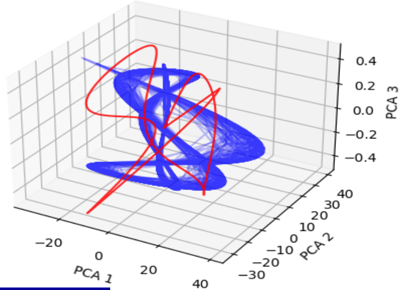
Rohan Loveland

South Dakota School of Mines and Technology
Department of Electrical Engineering and Computer Science
Anomalous/Relevant Event Detection (A/RED) Institute
rohan.loveland@sdsmt.edu; (505) 695-0188

Rohan Loveland is an Asst. Professor of Computer Science at South Dakota Mines. He's the founder of the Anomaly/Relevant Event Detection Institute as well as Faculty Co-Advisor for the Data Mining Club. His research expertise is in machine learning and data science, specifically in the development and application of semi-supervised active learning for anomalous and rare category and event detection. Dr. Loveland has applied his algorithms successfully to several NASA datasets in the past, including LIBS data from the Mars ChemCam, asteroid data from the ATLAS project, and most recently LROC high-resolution lunar imagery data. The goal of the current research is to develop algorithms that will help to identify anthropogenic activity sites on the moon, including crashed probes that remain unlocated at present. More generally the tools he's working on have potential application for augmenting human data analysis capabilities in a broad variety of areas, including system and human health monitoring, by providing real-time flagging of anomalous events. Beyond application to streaming data, these algorithms can also be used to facilitate exploration of massive imbalanced datasets where the classes of interest are not known in advance, thus providing a foundation for detecting technosignatures and Lunar and Martian resource exploration. Dr. Loveland makes it a priority to involve undergraduates in his research and is currently conducting research with them in Mountain View, CA.

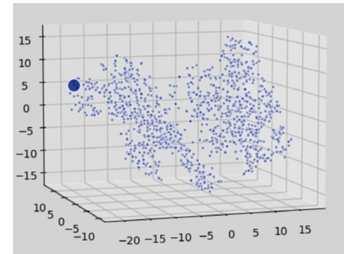
ML for Anomaly/Rare Category Detection – Topic 6: Intelligent/Adaptive Systems

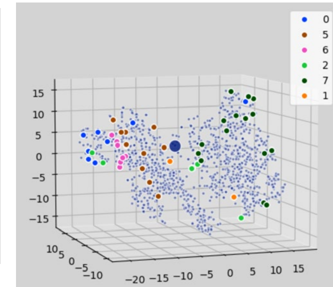
Massive Datasets / Streaming Sensors



Finding Information Buried in Data/Noise

Tools for Augmenting Human Data Analysis

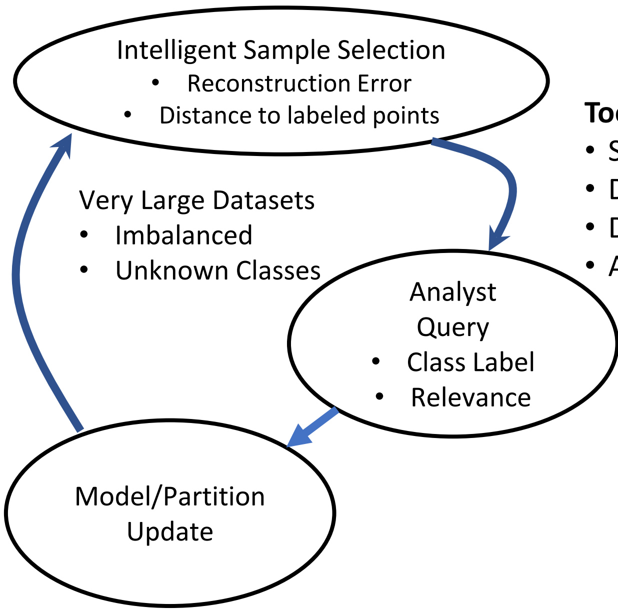




- Image Analysis
  - Finding Lunar Probes
  - Unusual Geographic Features

- Detecting System Failures
  - Instrument Artifacts
  - Health Monitoring
- Mineral Resource Identification

Active Machine Learning Loop



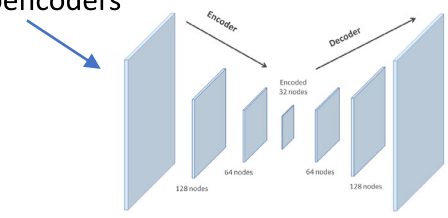
- Unlabeled points used to infer class boundaries
- ***Optimized for new class discovery***

Our Research

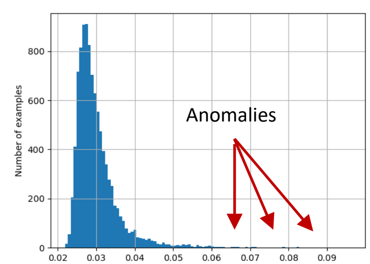
Tools
- Semi-supervised ML
- Dimensionality Reduction
- Deep Neural Networks
- Autoencoders

Applications
- Rare category discovery
- System health monitoring
- Failure detection

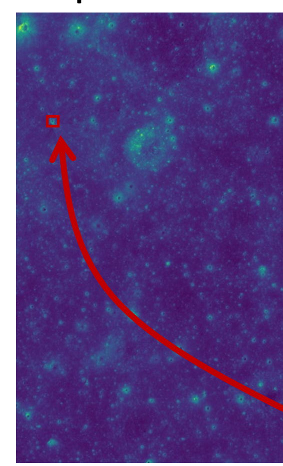
Outcomes
- 1,000x+ analyst productivity multiplier
- Preventative measure identification
- Proactive decision making



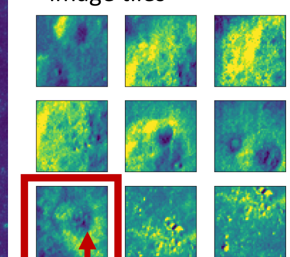
Ranking Anomalies by Reconstruction Loss



Experimentation



Ranger 6 crash autonomously ranked in top 10 out of 9,801 image tiles



Ranger 6 crash site

A / R E D Institute

Anomaly/Relevant Event Detection Institute

Dr. Rohan Loveland

SOUTH DAKOTA MINES
An engineering, science and technology university

Intelligent/Adaptive Systems: Complementing Humans In Space

Development of Cobots for Enhanced Perception and Exploration

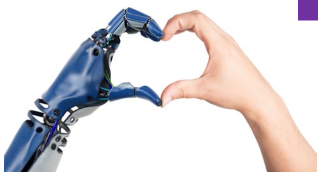
Dr. Xiangyu Meng

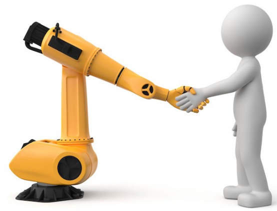
Department of Electrical and Computer Engineering
Louisiana State University
xmeng5@lsu.edu; (225) 578-8961

Xiangyu Meng is an Assistant Professor in the Division of Electrical and Computer Engineering at LSU. His research expertise is at the intersection of control theory, computer vision, learning and robotics. Since 2017, Dr. Meng's primary area of activity has been centered around perception, planning and control of connected and autonomous vehicles. Autonomous vehicle technology developed for vehicles on Earth also improves the technology used for robotic vehicles for space exploration. The economical approaching and departure algorithm developed by Dr. Meng was tested on autonomous vehicles in the Mcity Test Facility.

Development of Cobots for Enhanced Perception and Exploration

Cobots

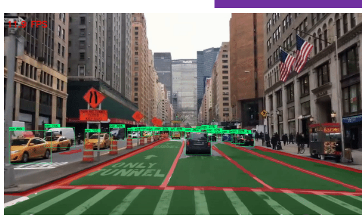


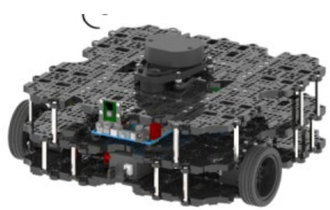


Theoretical Foundations

- ➢ Computer vision: image segmentation and classification
- ➢ Safety: control barrier function
- ➢ Shared vision and remote control
- ➢ Path planning, obstacle avoidance

Research Works





Proposed Works

- ➢ Shared vision between human and robots
- ➢ Remote control via augmented reality

Dr. Xiangyu Meng

LSU College of Engineering
Division of Electrical & Computer Engineering

Intelligent/Adaptive Systems: Complementing Humans In Space

Electro-spun polymer nanofibers for use as sensors and in low power consumption devices

Dr. Nicholas J. Pinto

University of Puerto Rico at Humacao
Department of Physics and Electronics
Humacao, PR 00791
nicholas.pinto@upr.edu; (787) 850-9381

Nicholas Pinto is a Professor of Physics at UPRH. He is the Director of the NSF sponsored Research at Undergraduate Institutions (RUI) grant at UPRH. He is interested in studying charge transport in conducting polymers, carbon nanotubes, graphene, and 2-D transition metal dichalcogenides. His research focusses on fabricating devices and organic electronics at the nanoscale. Pinto is the co-author of 120 refereed publications and holds four US patents. His primary interest is to motivate students into STEM fields by giving them hands on research experience in an undergraduate lab setting. He is also engaged in efforts to integrate research grade experiments into the undergraduate curriculum in the Physics and Electronics Department at UPRH.
https://sites.google.com/a/upr.edu/nicholas-j-pinto/

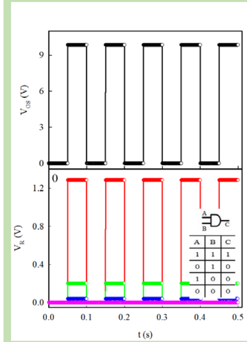
Intelligent/Adaptive Systems: Complementing humans in space: Electro-spun polymer nanofibers for devices and sensors

Motivation

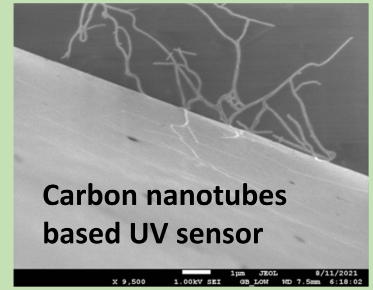
Workforce Training

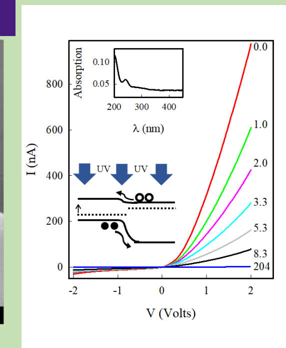
Tight space, Harsh environment

Logic gates



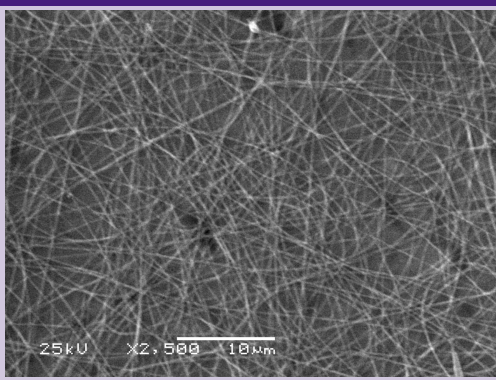
Robust electronics



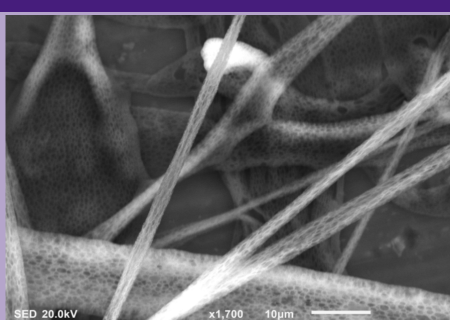


Small, Light weight, Low power consumption, Sensitive, Reusable

Electro-spun nanofibers



E-spun fibers with surface nanopores



Research at a glance

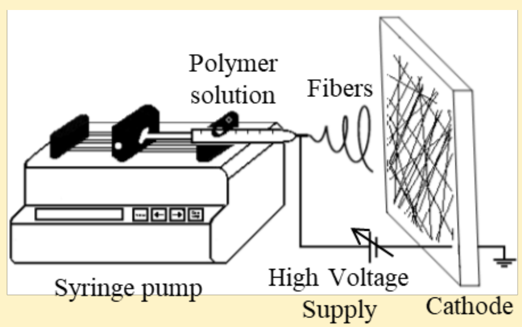
Laboratory Activities

Materials
- Conducting polymers
- Graphene
- Carbon nanotubes
- Ionic liquids

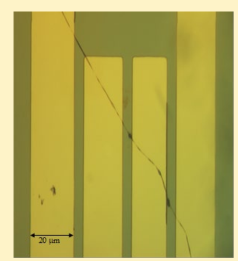
Material shapes
- Nanofibers
- Thin films
- Pressed pellets
- Gels

Results
- Binary switches
- Logic gates
- UV/Gas sensors
- Read/Write Memory Chips

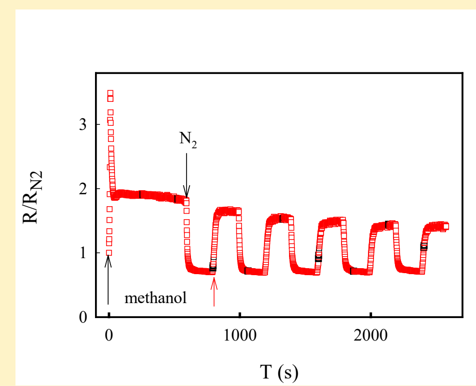
Electrospinning



Single polymer nanofiber

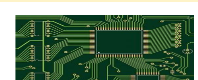


Gas sensing



Department of Physics and Electronics

Dr. Nicholas J Pinto



UPR HUMACAO

Intelligent/Adaptive Systems: Complementing Humans In Space

Development of an autonomous system for farm work

Dr. Duke M Bulanon

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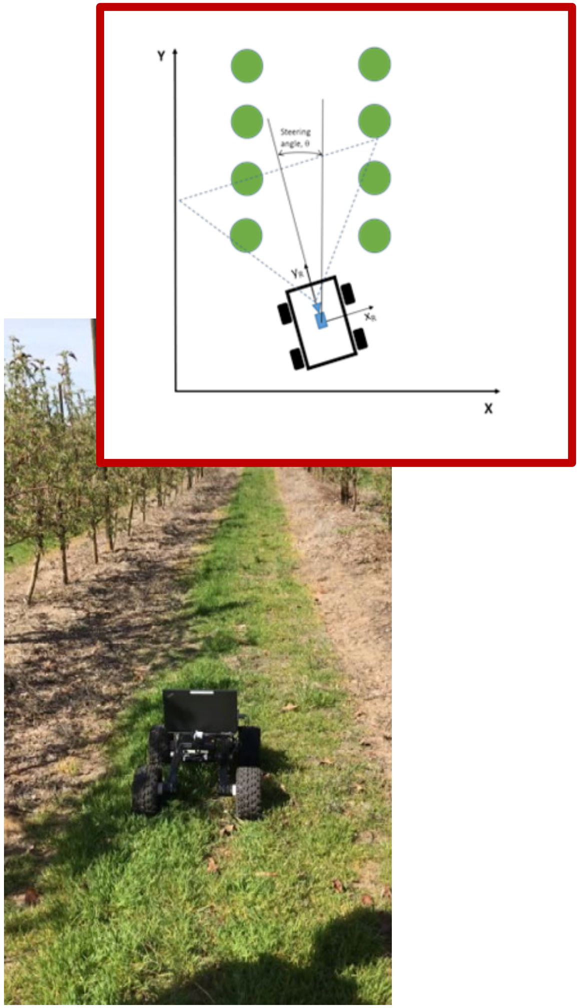
Department of Engineering & Physics
Robotics Vision Laboratory
dbulanon@nnu.edu; (352)-682-7449

Duke M Bulanon earned his BS Mechanical Engineering degree from the University of San Carlos (Philippines) in 1995. He earned his MS and PhD in Agricultural Engineering from Iwate University (Japan) in 1999 and 2003, respectively. He was a postdoctoral fellow in Hokkaido University (Japan) doing research in robotic fruit harvesting and precision agriculture in 2003 through the Japan Society for the Promotion of Science Fellowship. He continued his research in robotic fruit harvesting, for oranges, as a Research Associate in the University of Florida in 2006. Currently, he is an Associate Professor of the Engineering & Physics Department at Northwest Nazarene University (Nampa, Idaho). His current research involves the development of sensing technologies for orchard management and the use of robots in the orchards which are funded by the Specialty Crop Research Block Grant by the Idaho State Department of Agriculture, MJ Murdock Charitable Trust, and NASA Idaho Space Grant Consortium. Dr. Bulanon is a licensed Professional Engineer in the State of Idaho.

Development of Autonomous Systems for Farm Work

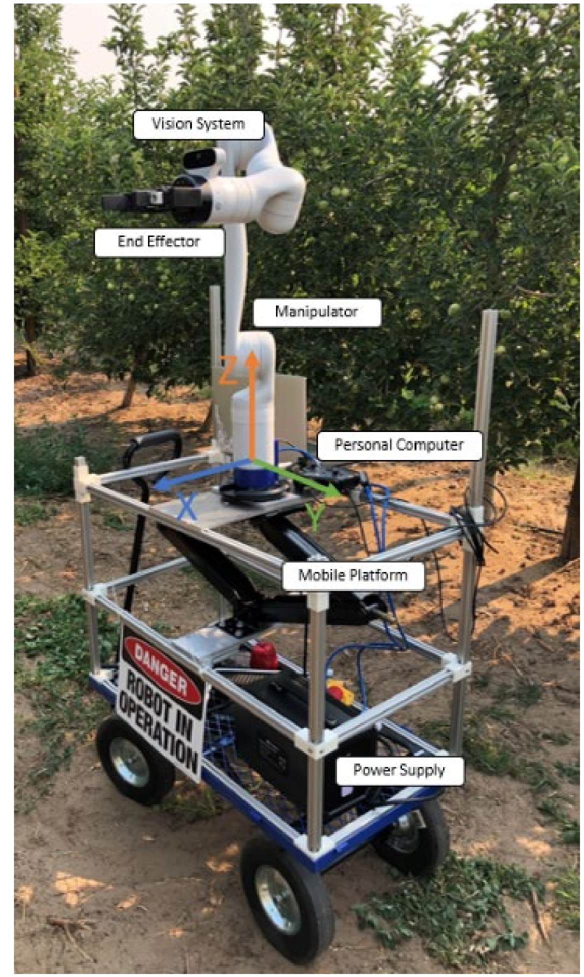
(Intelligent/Adaptive Systems: Complementing humans in space)

Autonomous Navigation



Remote Sensing

Orchard Robot



Research Objective: To develop systems that will augment human farm labor

Engineering and Physics Department
Northwest Nazarene University

Duke M Bulanon
Robotics Vision Laboratory

Intelligent/Adaptive Systems: Complementing Humans In Space

Foldable Robotic Arm with Automatic Tool Changing Mechanism for the Space Rover

Dr. Taher Deemyad

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Department of Mechanical Engineering
ISU Robotics Laboratory
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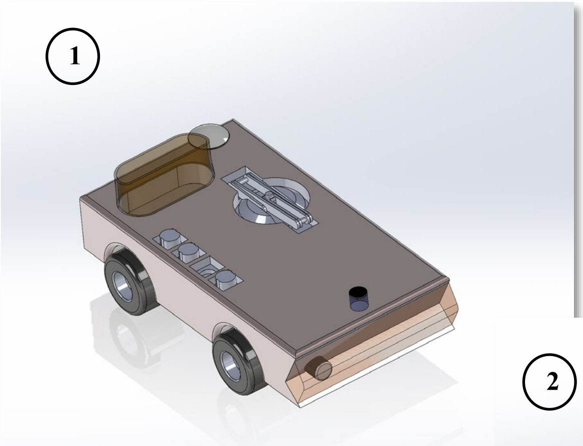
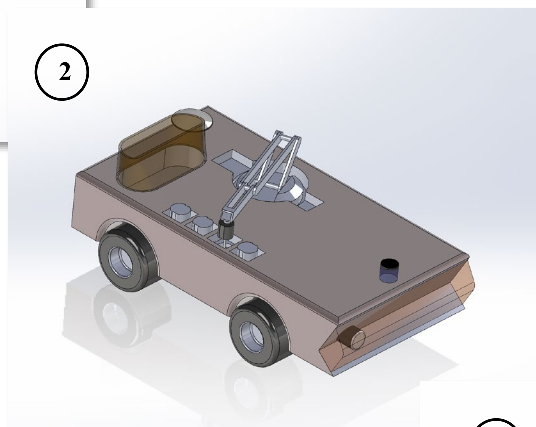
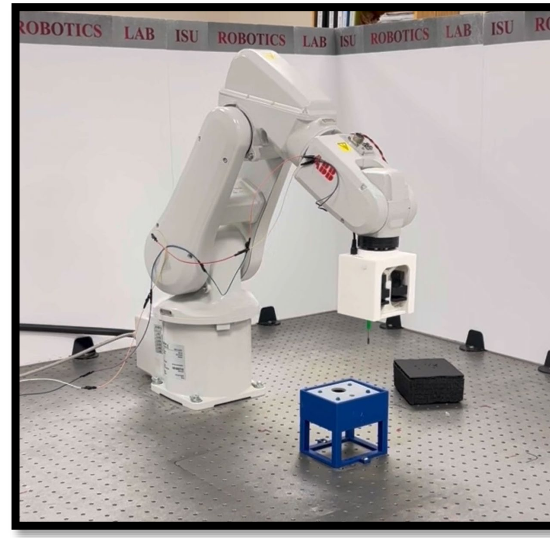
Taher Deemyad is an Assistant Professor & Robotic Lab Director at Idaho State University. Dr. Deemyad got his Ph.D. in Mechanical Engineering with a focus on Robotics and autonomous systems. His research interests include the Design of Novel Robotic Grippers, Kinematics and Dynamics of Serial and Parallel Manipulators, Autonomous Systems, Navigation, Obstacle Avoidance Systems, Image Processing, Automation, Optimization, and Singularity Analysis of the Mechanisms.

Foldable Robotic Arm with Automatic Tool Changing Mechanism for the Space Rover



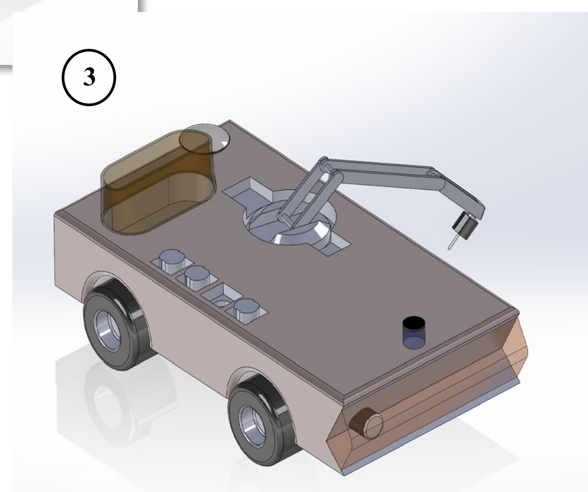
The innovative robotic arm, uniquely designed with a 6-axis configuration, possesses the remarkable ability to be retracted within the rover's body, thereby optimizing spatial utilization.





Automatic Tool Changing System for Robotic Arm

The development of an automated tool-changing system for the robotic arm, enabling it to automatically interchange tools, demonstrates its inherent versatility in accomplishing a diverse range of tasks in an unknown environment.



TAHER DEEMYAD, PhD
ISU Robotics Laboratory
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Intelligent/Adaptive Systems: Complementing Humans In Space

Resilient Distributed Machine Learning and Optimization for Autonomous Systems

Dr. Duong Nguyen

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Duong.Nguyen@uwyo.edu.
https://duongnn.github.io

Duong Nguyen is an Assistant Professor in the Department of Electrical Engineering and Computer Science at the University of Wyoming. He obtained his B.S., M.S. and Ph.D. degrees in Computer Science from Hanoi University of Science and Technology, Purdue University, and Michigan State University, respectively. He was also a postdoctoral fellow at Georgetown University under the supervision of Professor Nitin H. Vaidya.

He is interested in both theoretical and implementation aspects of distributed computing. His research focuses on improving the reliability and performance of large-scale distributed computations such as distributed graph processing, distributed machine learning, cloud computing, using techniques/tools such as self-stabilization, distributed predicate detection and monitoring, formal methods.

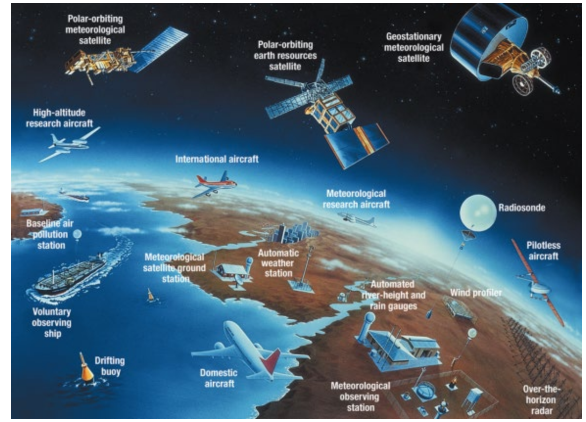
Resilient Distributed Machine Learning and Optimization for Autonomous Systems

Motivation

Focus topic: Use of system autonomy and robotics

Motivation: Learning and operation of autonomous systems

- Analyzing/Learning on large amount of data exceeds the capacity of a single machine $\Rightarrow$ distribute the learning tasks across multiple workers.
- Some applications (robotic swarms, astronomical observatories, global climate monitoring, geospatial information systems, etc.) are naturally distributed.
- Failures of some components (hardware, software, attacks) are expected.



Integrated Global Observing System. Source: WMO

Centralized architecture (server-based)

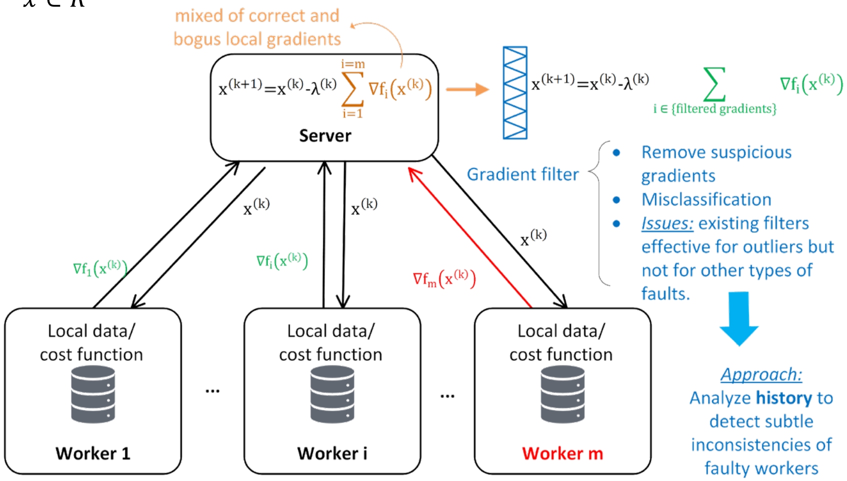
Resilient Distributed Optimization/Learning: Architectures, Issues, and Approaches (both theory and experiment)

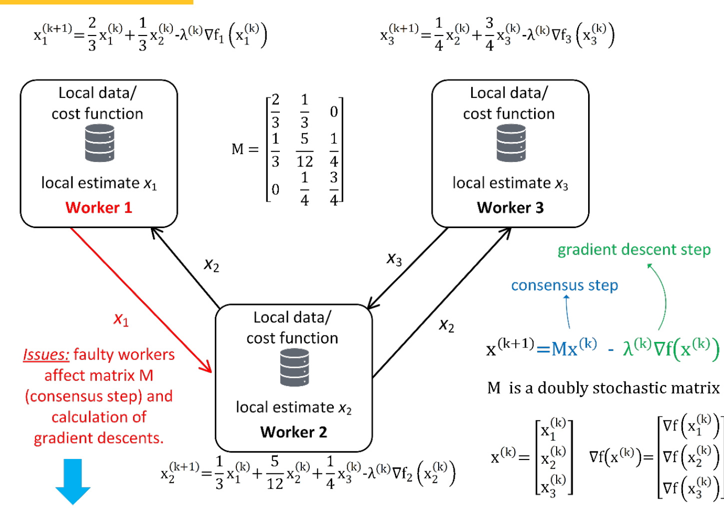
Decentralized architecture (peer-to-peer, serverless)

n: # of optimization variables / learning parameters

m: # of workers

$x \in R^n$





Approach: Use **matrix analysis** and **statistical inference** to identify and mask adverse effect of faulty workers

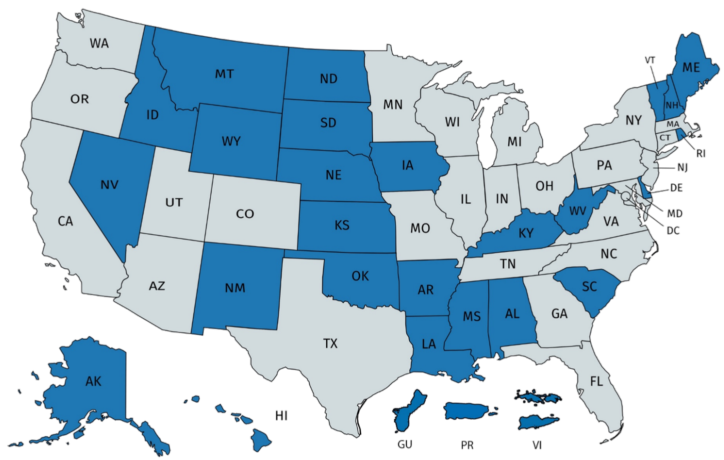
NASA Ames Researcher Virtual Discussion

Duong Nguyen
Department of Electrical Engineering and Computer Science
University of Wyoming

University of Wyoming

Topic Area 7

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond



Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Automatic Analysis of Spectral Data Using Genetic Algorithms

Dr. Min Long

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Department of Computer Science
minlong@boisestate.edu; (607) 342-3095 (c)

Dr. Long is an assistant professor of Computer Science at Boise State University. Prof. Long and his Computing and AI Lab for Physical Sciences focus on applying Computing and AI methods to the basic science that involves interdisciplinary research of scientific computing, data science, and computational physics. He has extensive experience in areas like full-star MHD simulation of disk accretion, simulations of Type Ia supernovae, and developing AI algorithms for automated analysis of large quantities of spectroscopic data with minimal human intervention but high efficiency and reproducibility. His recent work includes developing and releasing an open-source framework Neo, and its two Python-based toolkits: EXAFS-Neo and Astro-Neo for automated spectral analysis in materials science and astrophysics. He received his Ph.D. in astrophysics from Cornell University and later worked as a postdoc fellow in computational astrophysics at the University of Illinois and the University of Chicago before joining BSU.

Automatic Analysis of Spectral Data Using Genetic Algorithms

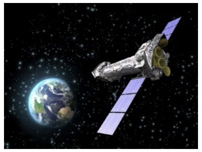
Min Long

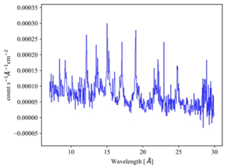
Department of Computer Science, Boise State University, Boise, ID 83725

Introduction

Abstract

We developed an automated spectral analysis tool based on genetic algorithms (GA) to accelerate spectral fitting with reduced human intervention but improved efficiency and reproducibility. This automation is vital in the era when current and upcoming detectors acquire massive data at rates orders of magnitude greater than current collection rates Our GA method has been applied to X-ray data of starburst galaxies like NGC 253 from XMM-Newton reflection grating spectrometer, and compared with manual fitting using Xspec. Our results demonstrated good fitness scores with minimal human intervention. The modular design also makes the software extensible for other applications.





Background

The existing and the next generation of X-ray observatories are capable of observing a large number of point and extended sources in real time and thus create enormous amounts of data. The massive data set are produced by multiple reasons.

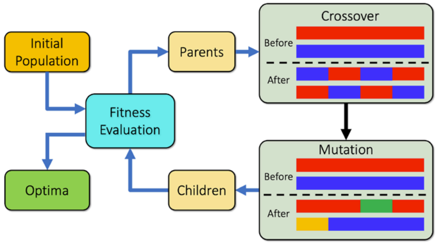
Methodology

Generic Algorithms

GA is a class of metaheuristic methods inspired by the Darwinian theory of evolution to study natural systems but has been extended and mainly applied to solve optimization problems in biology, economics, finance, material science, and other domains.

Pipeline

GA starts with a selection of population consisting of a number of temporary solutions. Each solution is considered as a chromosome consisting of the model parameters and each parameter represents a gene of the chromosome. The GA evaluates the fitness value of each solution using an objective/fitness function to determine the evolution of the next generation.



Advantages

The major advantage of using GA is that it can explore large and complex spaces and locate promising solutions for models without human intervention and domain knowledge.

Implementation

Evolution Operators

To improve the accuracy of the final solution and the convergence rate of the involved iterations, a number of evolutionary-inspired operators (e.g., crossover, mutation) are applied on each solution throughout subsequent generations.

Crossover

Crossover or Recombination is described as the operation of combining parental materials of two or more solutions during which the information is inherited. We implemented 3 crossover methods: uniform random, AND crossover, and OR crossover to more efficiently steer the evolution.

Mutation

Mutation operators modify existing solution by disturbing them by random chance. We implemented an algorithm based on the Rechenberg 1/5 success rule, which increases the mutation probability (σ) based on the "success ratio" at the current generation.

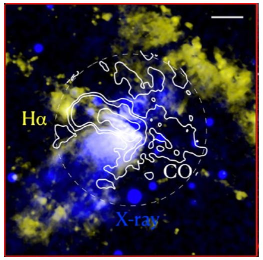
Algorithm 1 Rechenberg Adaptive Mutation

Input: Success Probability at generation i: (S_i)
Output: Mutation Probability at generation i: (σ_i)
for number of generations **do**
  if $(S_i \geq 1/5)$ **then**
    $\sigma_{n+1} = \sigma_n \times 1.2$
  else
    $\sigma_{n+1} = \sigma_n \times 1.2^{-1/4}$
  end if
end for

Results

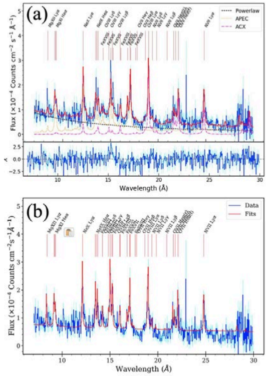
Fitting X-ray Spectra from NGC253

We applied the GA method to a high-resolution X-ray spectrum from a starburst galaxy NGC 253.



Manual Fitting vs Auto Fitting

Manual and GA fittings match quite well except peaks around 22 Å. This is because the GA fitting was only a verification test and doesn't consider charge exchange process dominating features around 22 Å.



NASA EPSCoR Research for ARC
June 22, 2023

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Hybrid Laser Induced Spectroscopy for Characterization, Extraction and Processing of Off-Earth Regolith

Dr. Rudrajit Mitra

South Dakota School of Mines & Technology
Department of Mining Engineering & Management
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Rudrajit Mitra is an Associate Professor and Syd & Felicia Peng Professor in Mining Engineering at the South Dakota Mines. Prior to joining the School of Mines, he was Head of Research at the Institute for Advanced Mining Technologies (AMT) at RWTH Aachen University, Germany. He is also a Visiting Associate Professor at the School of Mining Engineering at the University of Witwatersrand (Wits), South Africa. He has been a faculty member at Wits from 2017 – 2020 as Associate Professor and Centennial Chair of Rock Engineering and at UNSW Sydney, Australia from 2006 – 2016. His area of expertise includes rock mechanics, mining systems engineering focusing on resource efficiency through use of digitalization, mine ventilation, virtual reality/augmented reality and innovation in learning & teaching. He has over 130 research publications in book chapters, journals, peer-reviewed conferences and reports and has been involved in various projects for the mining industry across different countries. Dr Mitra is an active member of the Society of Mining Professors (SOMP). He is also a member of the AusIMM, SME, SAIMM, MMSA and is in the Editorial Board for multiple journals and has been responsible for organizing various international conferences. He is currently member of two of the ISRM sub-commissions – Planetary Rock Mechanics and Deep Mining.

Hybrid Laser Induced Spectroscopy for Characterization, Extraction and Processing of Off-Earth Regolith

Characterization of regolith is highly complex and challenging due to uncertainties associated with the inherent sample variabilities, measurement errors, and statistical limitations in harsh environments.

Our research:
Develop a novel hybrid methodology for simultaneous melting, characterization and extraction of regolith, followed by separation and concentration of water ice by using novel hybrid machine learning assisted laser ablation, laser spectroscopy in conjunction with electrostatic separation (MALA-ES).

Utilization of laser ablation has the potential to determine composition of regolith prior to processing, with the possibility of pre-sorting material that contains significant water ice to be selectively mined for further processing

Proposed work will help lay the groundwork for future successful lunar habitation operations and improve the capabilities to design effective in-situ resource utilization (ISRU) techniques

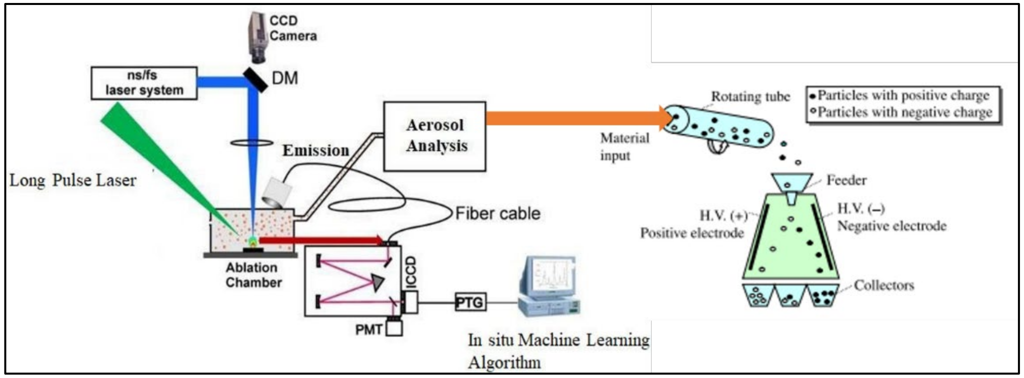

Figure: Schematic for the proposed MALA-ES

Project Team:

- Dr Prasoon Diwakar – Department of Mechanical Engineering
- Drs Bharat Jasthi & Brett Carlson – Department of Materials and Metallurgical Engineering
- Drs Rudrajit Mitra & Purushotham Tukkaraja – Department of Mining Engineering & Management

SOUTH DAKOTA MINES
An engineering, science and technology university

NASA EPSCoR Research for ARC
June 22, 2023

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Citizen Science in Astronomy: GalaxyZOO

Dr. Benne Willem Holwerda

University of Louisville
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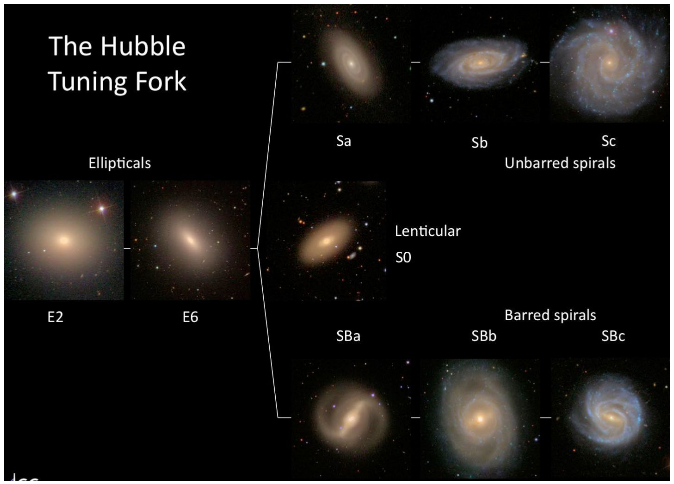
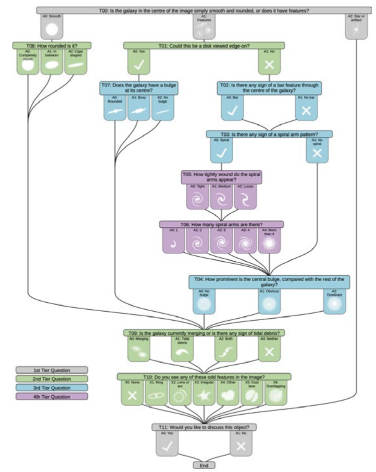
Prof. B.W. Holwerda is a professor at the University of Louisville. He has gotten involved in a variety of galaxy morphology studies in a large part because he originally had to pick out distant galaxies during his thesis. He has been involved in a number of galaxy collaborations that study galaxy morphology, spectral energy distributions, and evolution. He is an expert in galaxy morphology measures now working on both the analysis of archival NASA data and new JWST observations. He is the author of the book ``Galaxy Morphology'' (IOP 2021) and his research is in part on the use of machine learning in the area of galaxy morphology.

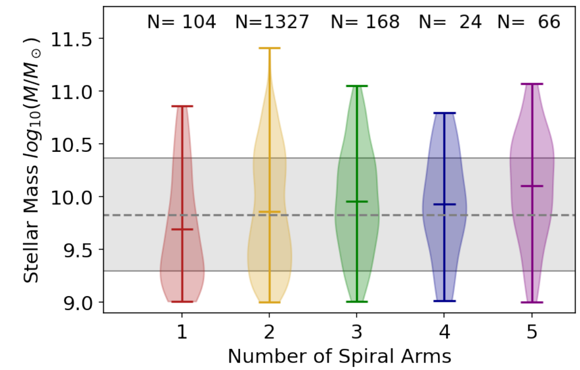
Citizen Science in Astronomy: GalaxyZOO

Benne W. Holwerda (University of Louisville)





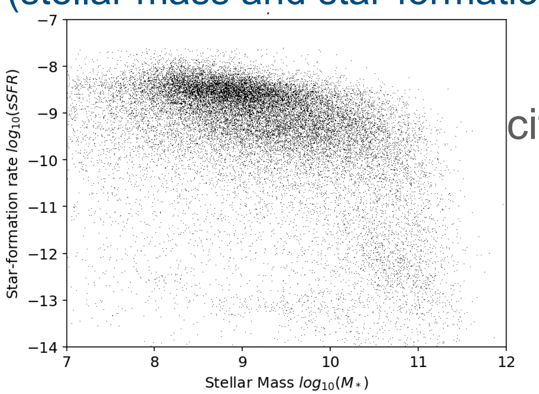
Stellar mass



How many spiral arms do you see?

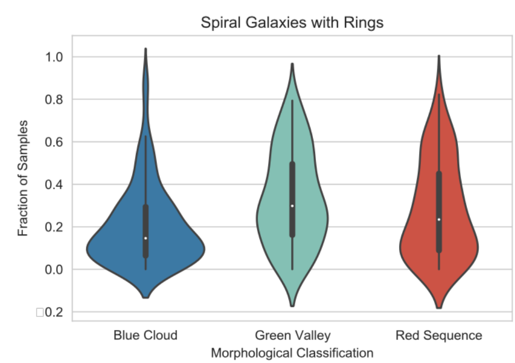
Citizen Scientist answer questions about galaxy appearances

Measures from astronomers
(stellar mass and star-formation)



Improving direct measures or citizen science statistics allows us to infer subtle morphological relations to other galaxy properties

Do you see a ring?



Galaxy Color

NASA EPSCoR Research for ARC
June 22, 2023

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Measuring Aerosol Chlorides for Atmospheric Corrosion Studies in Artic Climate

Dr. Raghu Srinivasan

Associate Professor and Department chair, Mechanical Engineering,
College of Engineering, University of Alaska Anchorage,
3211 Providence Drive, ECB 301F, Anchorage, AK 99508-4614;
Phone: 907 786 4815; Email: rsrinivasan2@alaska.edu

Dr. Raghu Srinivasan is an associate professor and department chair in the Mechanical Engineering Department at UAA's College of Engineering. He established, and currently serves as the director of the Environmental Degradation lab at UAA where he developed and deployed atmospheric corrosion test racks across the state of Alaska. He grew up in India and moved to Hawaii to do Ph.D. in atmospheric corrosion before landing here in Alaska. His research interests include atmospheric corrosion of light alloys, materials compatibility, and materials selection.

Measuring Aerosol Chlorides for Atmospheric Corrosion Studies in Arctic Climate

ARC Research Topic: ***Measurements of aerosols, cloud properties, water vapor, trace gases, and radiation budget***

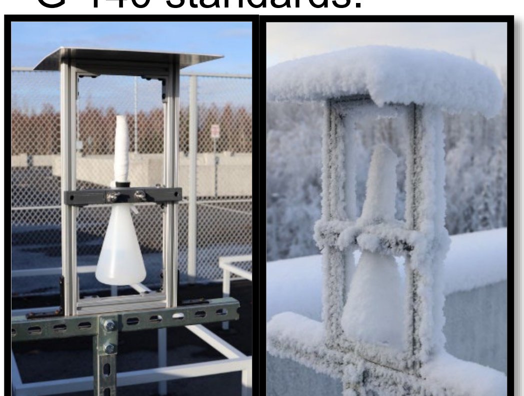
PI: Raghu Srinivasan (rsrinivasan2@alaska.edu), University of Alaska Anchorage

Need

- Corrosion continues to be a major problem for NASA since its inception in 1962 and it is included in NASA's Space Technology Roadmap to reduce the cost and improve the sustainability and efficiency of its ground operations.
- One of the major parameters that affects atmospheric corrosion of metals is aerosol chlorides.
- Measuring aerosol chlorides in cold freezing climate is challenging using the existing measuring standards.

Approach

- Wet chloride candle method are used to measure the aerosol chloride following ASTM G-140 standards.



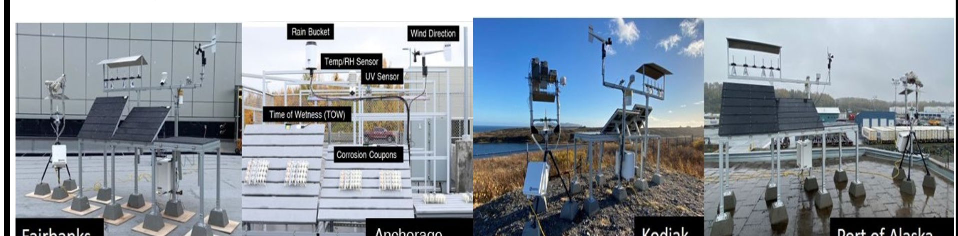
Frozen candle during winter months make it difficult to measure aerosol chlorides and other particles in the atmosphere.

Benefit

- The proposed collaboration with NASA ARC Space and Earth Science team will enhance the aerosol measurement techniques in cold arctic climate.
- This will lead to a better understanding of atmospheric corrosion and to develop a corrosivity map for the state of Alaska based on aerosol and weather data.

Competition

- Test sites along the Trans-Alaska Pipeline and marine transportation sectors are already established using NASA EPSCoR CAN project.
- The combination of urbanization and proximity to marine environments make arctic and sub-arctic regions in North America, particularly Alaska, an important natural laboratory to study atmospheric corrosion.



Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Applications of Small Uncrewed Aerial Systems towards Atmospheric Research

Dr. Sean C. C. Bailey

University of Kentucky
Department of Mechanical & Aerospace Engineering
Uncrewed Aerial Vehicles Laboratory (UAVLAB)
Sean.Bailey@uky.edu; (859) 218-0648

Dr. Bailey earned a doctorate at the University of Ottawa funded by both national and provincial scholarships to study the turbulent interactions between rotating flows and turbulence. This was followed by a post-doctoral fellowship and associate research scholarship at Princeton University contributing to research on high Reynolds number turbulence in wall-bounded flows. He joined the Department of Mechanical Engineering at the University of Kentucky in 2010 where he has continued his research in the experimental study of turbulent flows with focus on the role of coherent structures in boundary layers, unsteady vortex flows, interaction between coherent structures and homogeneous turbulence, scaling of wall-bounded flows at high Reynolds numbers and the development of experimental methods. In 2014 he received an NSF CAREER award to fund research into using autonomous unmanned aerial vehicles (UAVs) to measure turbulence in the atmospheric boundary layer and has since deployed UAVs in studies addressing a broad range of atmospheric flows including boundary layer turbulence, drainage flows, wind turbine wakes, and stratospheric turbulence.

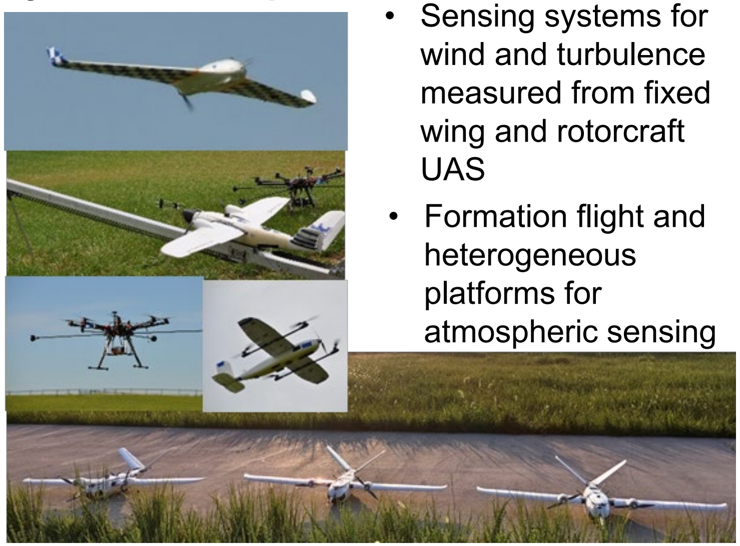
UAVLAB
UNCREWED AERIAL VEHICLES MOBILE LABORATORY

Sean C. C. Bailey

Pigman College of Engineering
Department of Mechanical and Aerospace Engineering

Uncrewed Aerial Systems → Applications

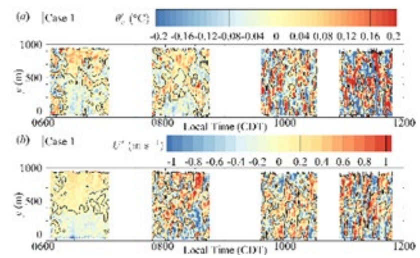
System Development



- Sensing systems for wind and turbulence measured from fixed wing and rotorcraft UAS
- Formation flight and heterogeneous platforms for atmospheric sensing

Field Deployments

Atmospheric boundary layer turbulence

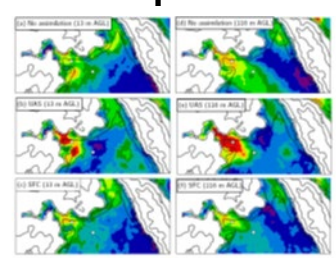


- Studies of topographic modification of the coupling between surface and atmosphere
- Turbulent transport in the atmosphere (e.g., smoke, aerosols)

Stratospheric environment

- Sensing approaches for turbulence detection in the stratosphere
- Elucidate atmospheric dynamics such as stratospheric turbulence structure, gravity wave detection and analysis

Assimilation of UAS data into numerical weather prediction



- Identify approaches and benefit of coupling UAS observations and NWP to improve prediction of micro-meteorological events (drainage flows, fog, dispersion)

NASA NSF FEDERAL AVIATION ADMINISTRATION NASA Kentucky Space Grant Consortium and EPSCoR Programs STRATODYNAMICS AVIATION INC.

NASA EPSCoR Research for ARC
June 22, 2023

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Big Data and Multi-Source Data Fusion/Integration and Analysis of Global Land Use/Cover Change in the Pacific Islands

Dr. Jose Edgardo L. Aban

University of Guam (UOG)
Geography Program
College of Liberal Arts and Social Sciences
abanj@triton.uog.edu; +1(671) 483-2408

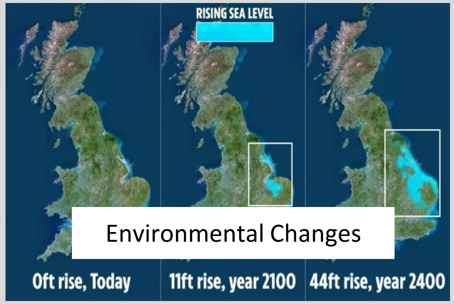
Jose Edgardo L. Aban is a seasoned research and project manager and an advocate of satellite remote sensing education. He served for almost two decades at the Department of Science and Technology of the Philippines and has taught as a senior lecturer in the Department of Geography, Development, and Environmental Studies at the Universiti of Brunei Darussalam, where he was instrumental in the establishment of an image processing laboratory.

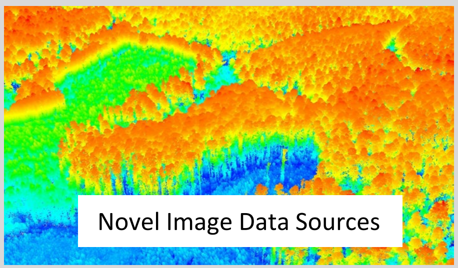
Dr. Aban teaches both introductory and advanced Remote Sensing and satellite image processing, Geographic Information Systems (GIS) as well as a host of Geography subjects such as World Regional Geography, Physical Geography, and Economic Geography.

Prior to joining UOG, Aban served as a technical consultant at the Asian Development Bank, as project manager of the GIS-based project dubbed “Communication and Information Systems for the Control of Avian Influenza” of the ASEAN Foundation, and as a consultant of a mapping unit of an agricultural company in Indonesia.

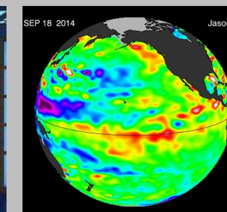
Big Data & Multi-Source Data Fusion/Integration & Analysis of Global Land Use/Cover Change in the Pacific Islands

Motivation





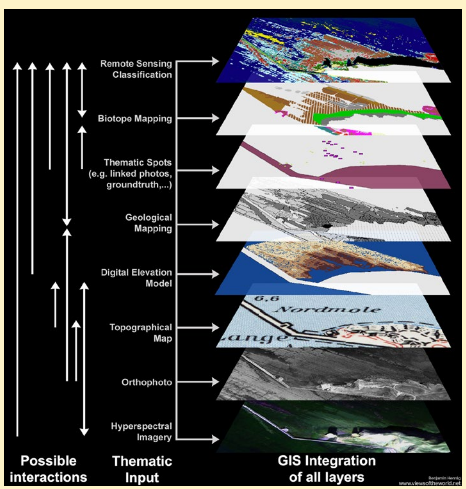
Proposed Research:



- Sourcing of Image data from different sources and platforms
- Integration of historical and contemporary *in situ* environmental data
- Data mining for nascent, novel and hidden environmental phenomenon(a)
- Big Data Analysis of multi-temporal, multi-point, multi-source, multi-level digital/image and environmental data
- Development of novel techniques of digital data processing and analysis
- Visualization of these phenomena

Our Research

Geospatial Data Integration & Processing



Dr. Jose Edgardo Aban

Visualization, Analysis & Interpretation

UNIVERSITY OF GUAM
UNIBETSEDÅT GUÅHAN

GEOGRAPHY PROGRAM
UNIVERSITY OF GUAM

NASA EPSCoR Research for ARC
June 22, 2023

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Leveraging remote sensing observations to build a more sustainable world

Dr. Meng Zhao

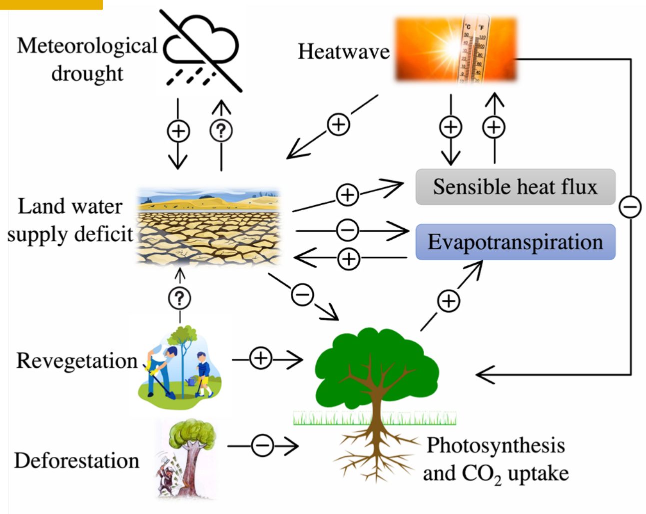
University of Idaho
Department of Earth and Spatial Science
mengz@uidaho.edu; (213) 509-6825

Dr. Meng Zhao is an Assistant Professor of Earth and Spatial Sciences at the University of Idaho. Dr. Zhao studies the intersection between hydrology and ecology, and their broader implications on climate, society, and policymaking. Dr. Zhao employs a variety of approaches, including satellite remote sensing (especially GRACE/GRACE-FO), GIS, Earth system modeling, and machine learning. Dr. Zhao aims to use what we discover to address challenges in the water-energy-food nexus.

Space and Earth Science: Understanding our planet, our solar system, and everything beyond

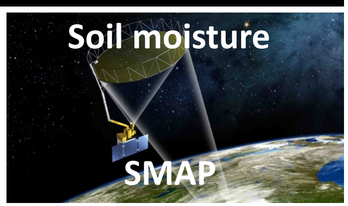
Leveraging remote sensing observations to build a more sustainable world

Motivation

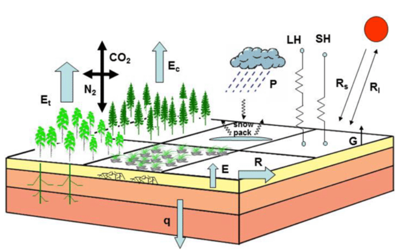


Approaches

Satellite observations

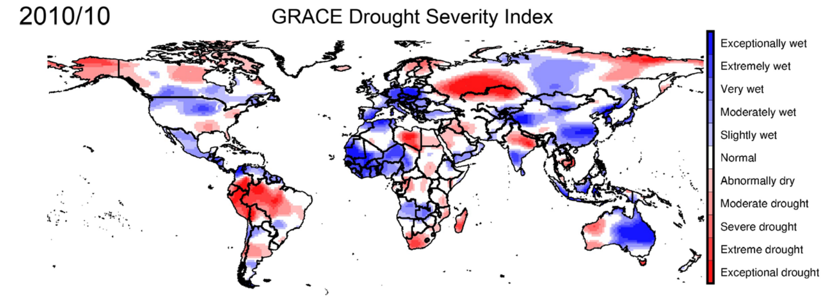


Land surface modeling



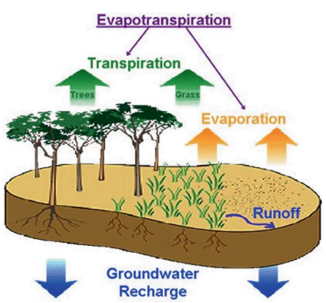
Our Research

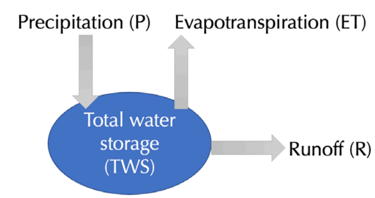
Drought characterization



Zhao et al.(2017) J. Hydrometeorol. DOI:10.1175/JHM-D-16-0182.1

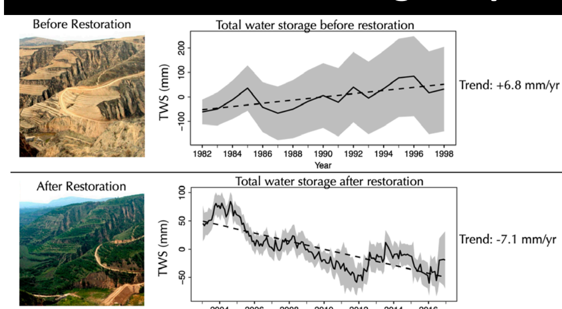
Evapotranspiration and ecosystem processes





$$ET = P - \frac{dTWS}{dt} - R$$

Land use change impact on water resources



Zhao et al. 2021 Nat. Sustain.

Dr. Meng Zhao

University of Idaho

Space and Earth Science: Understanding Our Planet, Our Solar System, and Everything Beyond

Methane Dynamics of Vegetation-Soil Interactions in Bald Cypress and Other Bottomland Hardwood Forests

Dr. Bassil El Masri

Murray State University
Department of Earth and Environmental Sciences
belmasri@murraystate.edu; 270-809-3110

Bassil El Masri is an Associate Professor in the Department of Earth and Environmental Sciences at Murray State University. His research focuses on investigating the soil-vegetation-atmosphere interactions and how these interactions are affected by the changing climate. He uses multi-sensors remotely sensed data for estimating terrestrial ecosystem carbon and water fluxes and for scaling up site measurements to the regional and global scales. He also uses land surface models to understand the terrestrial ecosystem carbon, water, and nitrogen fluxes responses to environmental change. The El Masri lab is home of trace gas analyzer and eddy covariance flux tower that can be used to measure ecosystem carbon and water fluxes. The trace gas analyzer is used to measure methane emissions from soil and woody structure of several bottomland hardwood species.

Methane Dynamics of Vegetation-Soil Interactions in Bald Cypress and Other Bottomland Hardwood Forests

MURRAY STATE UNIVERSITY

Dr. Bassil El Masri

ARC Research Topic:
Topic 7: Space and Earth Science

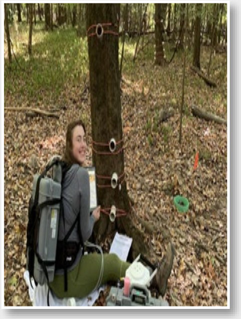
ARC Anticipated Research: Linking Satellite GHGs with in-situ data

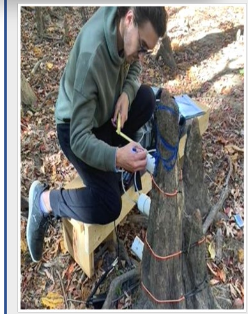
Current Research

Tools:
- ❑ LICOR gas analyzer
- ❑ Eddy Covariance Tower
- ❑ Process-based modeling

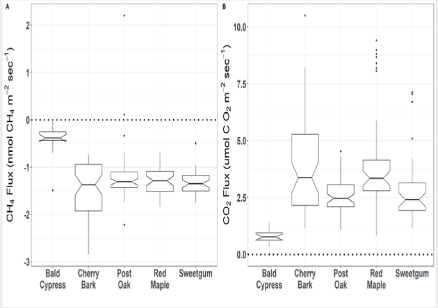
Applications:
- ❑ Soil vegetation interactions
- ❑ Woody structure CH_4 fluxes
- ❑ Soil CH_4 fluxes

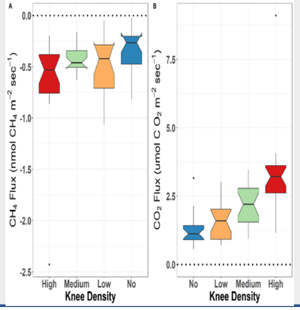
Site measurements





Results:





Site measurements

↓

Novel Hyperspectral Camera

↓

Satellite-based CH_4

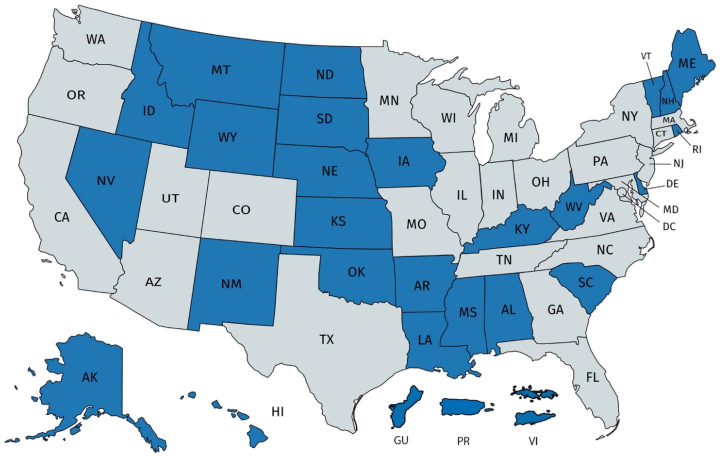
↓

Process-based model

Upscaling

Topic Area 8

Exoplanets: Finding Worlds Beyond Our Own



NASA EPSCoR Research for ARC
June 22, 2023

Exoplanets: Finding Worlds Beyond Our Own

Fueling the STEM Pipeline with NASA Exoplanet Watch

Dr. Wes Ryle

Thomas More University
Crestview Hills, KY
Professor, Department of Mathematics & Physics
Director, The Thomas More University Observatory
rylew@thomasmore.edu; (859) 344-3367

Wes Ryle is a Professor of Physics at Thomas More University (TMU), a small Catholic liberal arts institution in the greater Cincinnati area. Dr. Ryle has taught at TMU since 2008 and served as director of the on-campus Thomas More University Observatory during this time. While TMU is a primarily a teaching focused institution, Dr. Ryle has utilized the observatory to expand research opportunities for students and garner public interest and investment in astronomy and astrophysics. Related to this, the current presentation focuses on initiatives toward fueling the STEM pipeline via exoplanet transit observations supporting the NASA Exoplanet Watch program. Over the past year, Dr. Ryle has led a student research project on exoplanet transits with student funding provided by the NASA Kentucky Space Grant Consortium. Furthermore, the research project also served as catalyst for redesign of non-science major undergraduate astronomy laboratory courses with a greater emphasis on student led projects including target selection, data reduction, and analysis of exoplanet targets. These types of projects help to fulfill a career-long goal of diversifying the STEM workforce and informing the public of major STEM initiatives.

Fueling the STEM Pipeline with NASA Exoplanet Watch

THOMAS MORE UNIVERSITY

NASA Kentucky
Space Grant Consortium and EPSCoR Programs

Background & Motivation

Presented by: Dr. Wes Ryle

ARC Priority: Exoplanets: Finding worlds beyond our own

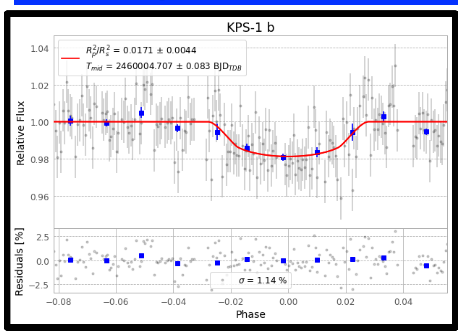
Key Aspects: Easily accessible projects with meaningful impact can act as an early STEM recruitment and public outreach tools. In this case, undergraduate student observations of transiting exoplanets can support the NASA Exoplanet Watch program.

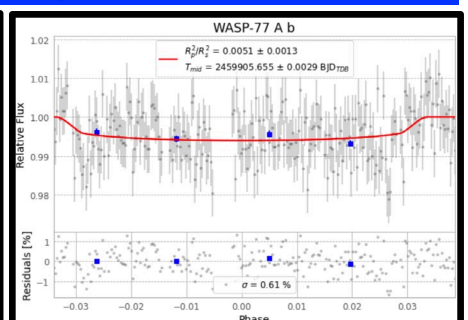
Research Capabilities

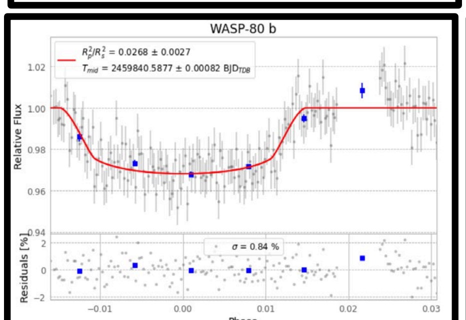
- On-campus Thomas More University Observatory
  - 11” (0.28m) Schmidt Cassegrain telescope
  - SBIG STT-8300m CCD camera
- NASA Exoplanet Watch EXOTIC Pipeline
  - Available via Google Colab
  - Raw images to lightcurve with model
- Growing statewide and regional collaborations
  - Access to the 0.7m Bell Observatory (WKU)
  - Possible access to the 1.83m Perkins Telescope (BU)

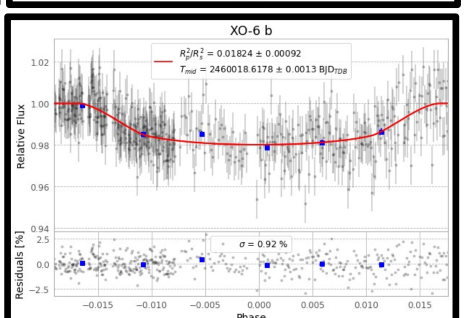
EXOTIC

Sample Transits Obtained by Student Researcher





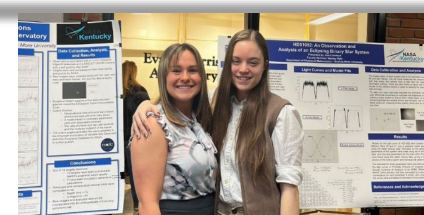




Fueling the STEM Pipeline

- Impactful astronomical research at the undergraduate level is rare at smaller institutions
- Early introduction to STEM research is key to greater retention
- These projects open the STEM pipeline to a wider and more diverse population
- Public outreach also possible through incorporation into non-science major laboratory courses

THOMAS MORE UNIVERSITY OBSERVATORY



EXOPLANET WATCH

NASA EPSCoR Research for ARC
June 22, 2023

Exoplanets: Finding Worlds Beyond Our Own

Thermal Habitability of Exoplanets

Prof. Abel Méndez

University of Puerto Rico at Arecibo
Department of Physics and Chemistry
Planetary Habitability Laboratory (PHL)
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Professor Abel Méndez is a planetary astrobiologist and Director of the Planetary Habitability Laboratory at the University of Puerto Rico at Arecibo. His research focuses on the habitability of Earth, the Solar System, and extrasolar planets. Prof. Méndez is a NASA MIRS Fellow with research experience at Fermilab, NASA Goddard, NASA Ames, and the Arecibo Observatory. He is best known for developing the Earth Similarity Index, the Visible Paleo-Earth Project, and maintaining the Habitable Exoplanets Catalog, a database of potentially habitable worlds. Prof. Méndez is currently working on theoretical models of the suitability for life of planetary environments, the impact of stellar activity on planets, and the characterization and detection of potentially habitable exoplanets. He is also a co-author of Searching for Habitable Worlds and Habitable Exoplanets in New Frontiers in Astrobiology.

Thermal Habitability of Exoplanets

Prof. Abel Méndez, PHL @ UPR Arecibo (abel.mendez@upr.edu)

NASA ARC Topic

Topic 8: Exoplanets: Finding worlds beyond our own (exoplanet theory & astrobiology)

Main Research Problem

How local and global surface temperatures impact the dynamic habitability of Earth-like exoplanets.

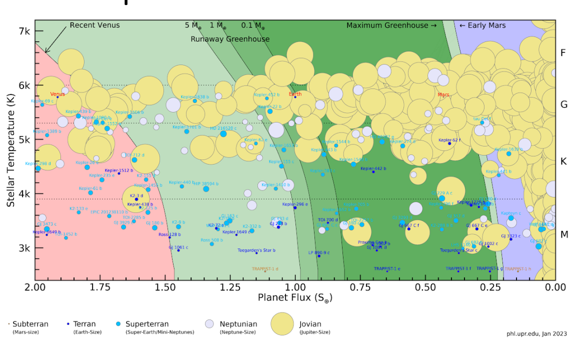
Research Capabilities of the PHL @ UPR Arecibo

1. A catalog of potentially habitable exoplanets that could be used to compare and select targets of interest for modeling and observations.

2. Analytical models of planetary temperatures that could be used to complement and validate results from General Circulation Models (GCMs).

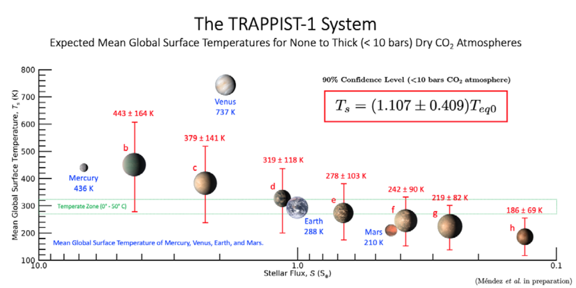
3. Quantitative habitability models adapted from biology that could be used to formally assess the habitat suitability of planetary environments.

Exoplanets in the Habitable Zone



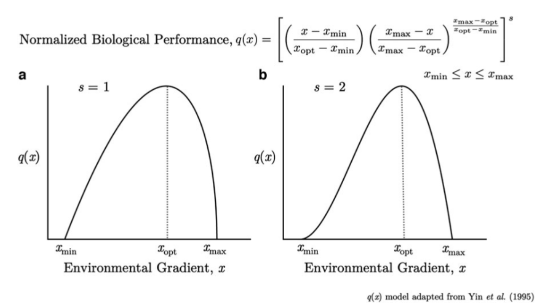
phl.upr.edu/hec

Surface Temperature of Exoplanets



Méndez & Rivera-Valentín (2017)

Thermal Habitat Suitability



Méndez *et al.* (2021)

Exoplanets: Finding Worlds Beyond Our Own

Measuring the line-of-sight distribution of potential exoplanet host microlenses with K2 Campaign 9 data

Matthew Penny

Louisiana State University
Department of Physic & Astronomy
Center for Computation & Technology
penny1@lsu.edu; 225-578-7711

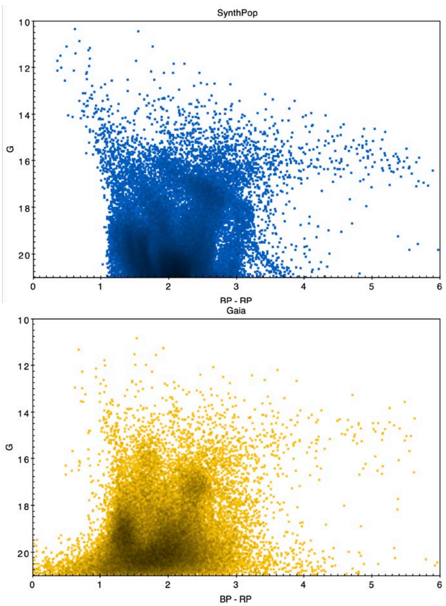
Dr. Penny is an observational astronomer with experience designing and conducting large-scale time-domain surveys for exoplanets using the gravitational microlensing and transit techniques. He is the PI of the MISHAPS survey searching for transiting hot Jupiter exoplanets in the Galactic bulge using the Blanco 4-m telescope and DECam imager. He has led efforts to simulate the performance of the Nancy Grace Roman Space Telescope's Galactic Bulge Time Domain Survey to search for cold exoplanets using microlensing. He played a major role in the K2 Campaign 9 microlensing survey, and ground-based observing campaigns to support it using CFHT and other telescopes. He has expertise in gravitational microlensing and exoplanet transit techniques generally, time series photometry in crowded fields, and Galactic population synthesis modeling.

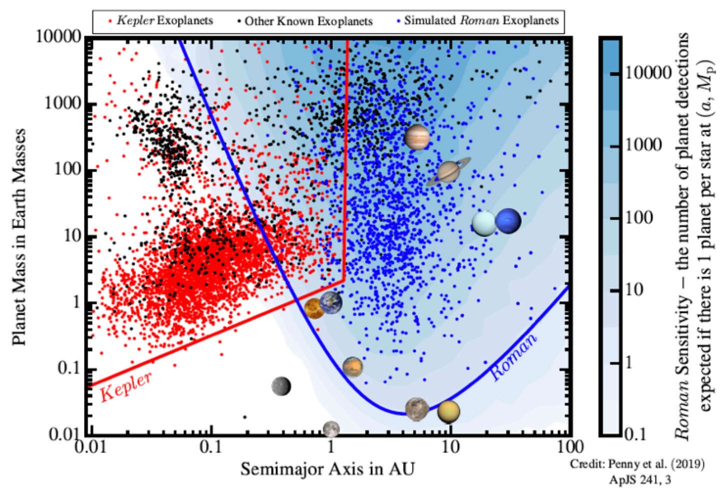
SynthPop + gulls + K2 Campaign 9

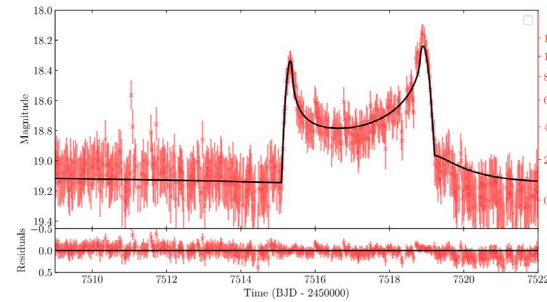
SynthPop: Galactic stellar population synthesis

gulls: Microlensing simulations

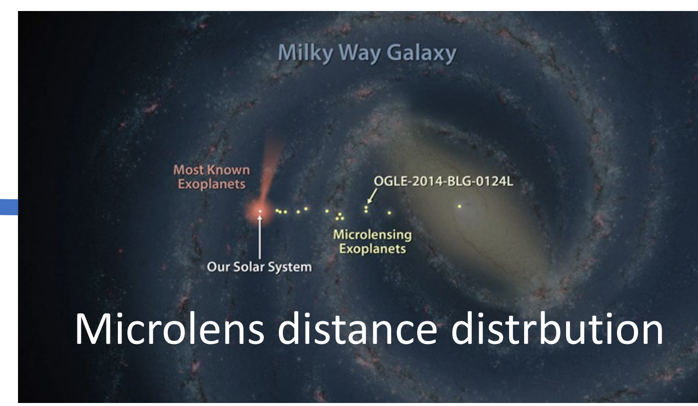
K2 Campaign 9: Microlensing parallax campaign data







Improved Galaxy models for Roman Microlensing survey



Dr. Matthew Penny

LSU
Department of Physics & Astronomy