Texas Tech University
Department of Mechanical Engineering
Research Laboratories

November 2024

Turbulence and Big-Data (TURB) Lab

Department of Mechanical Engineering, Texas Tech University

www.turblab.com

Principal Investigator

Dr. Dhawal Buaria
is an Assistant Professor in the Mechanical Engineering department at Texas Tech. He obtained his Ph.D. in Aerospace Engineering from Georgia Tech. His research focuses on advancing the understanding and modeling of fluid turbulence as relevant for engineering and geophysical applications.

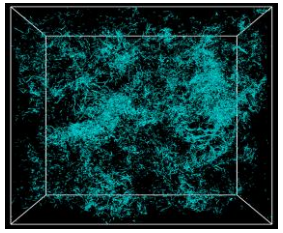
EMAIL:
dhawal.buaria@ttu.edu

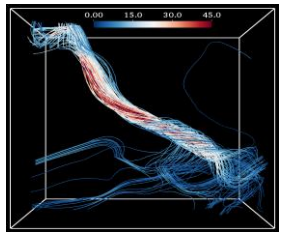
WEBSITE:
www.turblab.com

The TURB Lab investigates fluid turbulence and associated mixing and transport phenomena by integrating rigorous theoretical frameworks with cutting-edge computations and big-data techniques.

Direct numerical simulations (DNS)

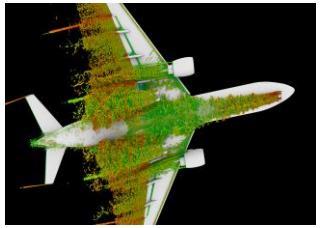
Solve governing fluid equations on a supercomputer by resolving all physics





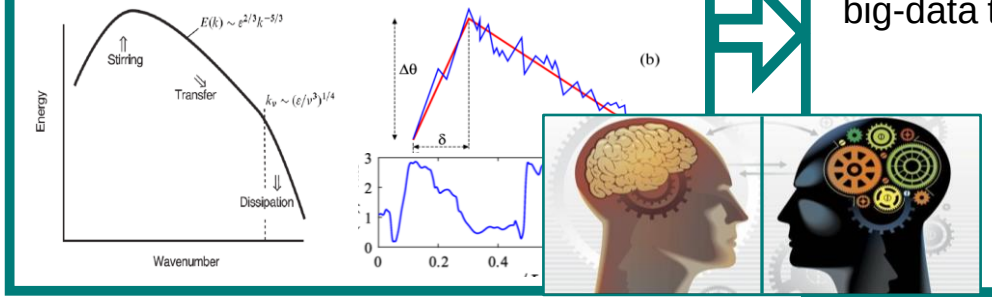
Modeled simulations (LES/RANS)

Part-resolved simulations with ML models for practical applications



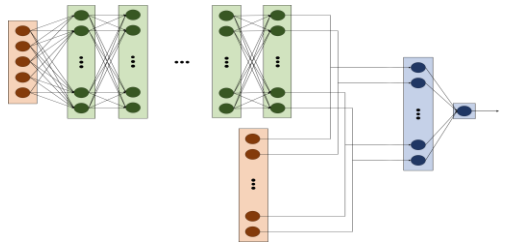
Turbulence Theory

Advance physical understanding



Machine-learning based modeling

Develop high-fidelity models using big-data techniques



WHAT WE STUDY

- Fluid dynamics
- Turbulence physics
- Mixing and Transport
- Data-driven modeling for CFD

OUR TOOLS

- High Performance Parallel Computing
- Computational and numerical methods
- Machine learning
- Statistical techniques

Aero-Turbulence Lab

Dr. Chang Hsin Chen, Assistant Professor

Chang Hsin Chen

Ph.D.

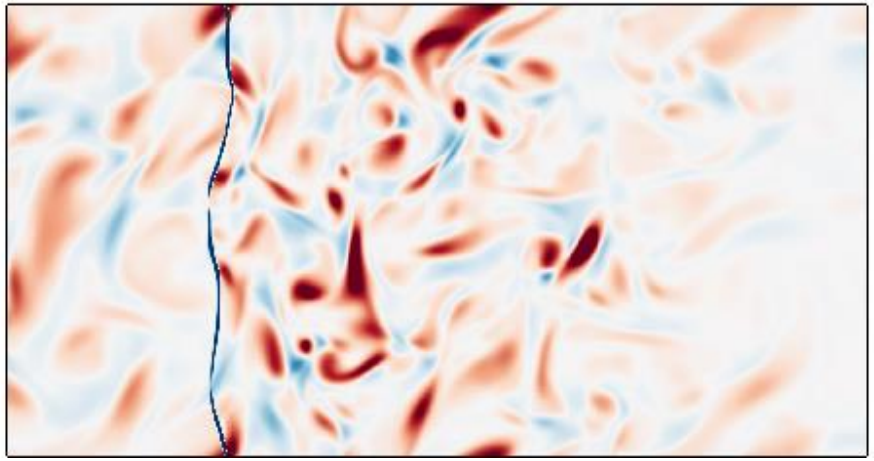
Aerospace Engineering

Texas A&M University

Research:

- Shock waves
- Turbulence
- High-performance computing

Research Highlight



Shock-turbulence interactions

- Two-way coupling between shocks & turbulence
- Critical to
  - aerodynamic performance
  - propulsion capability
  - astrophysical phenomena

Join Us

- **Visit** www.aeroturb.com
- Domestic & international persons are welcome
- Work with brilliant scientists
- Use top worldwide supercomputers
- Present work in conferences

Vehicle and Instrument Laboratory for Avionics Integration (VILAI)

Dr. Thanakorn Khamvilai, Assistant Professor

Who is Dr. Khamvilai? Dr. Khamvilai joins TTU in Fall 2024 with prior PhD in Aerospace Engineering from Georgia Tech. Dr. Khamvilai is highly interested in research related to Guidance, Navigation, and Control of Aerospace Vehicles. Dr. Khamvilai also holds private pilot and remote pilot certificates.

Contact Info:
thanakorn.khamvilai@ttu.edu
https://tkhamvilai.github.io

The VILAI research group conduct theoretical, computational, and experimental research for aerospace and aviation innovations.

Our Expertise

Flight Theory
- Dynamics & Modeling
- Guidance
- Navigation
- Control

Implementation
- Software
- Hardware
- Vehicles
- Flight / Field Operations

Applications
- Fault-Tolerant System
- Detect-and-Avoid
- Landing on Moving Platform
- Acoustic Control
- Aviation and Avionics

Highlighted Research

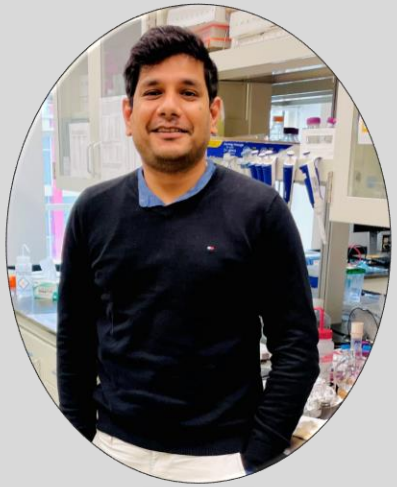
Multi-Outer Loop Dynamic Inversion Control: An Application to a VTOL Free-Wing Aircraft

- Design and flight tests flight control software and hardware for VTOL aircraft
- Use adaptive control to minimize relative oscillation between free-swing fuselage and wing in hover and forward flights.
- Published in *IEEE CONTROL SYSTEMS LETTERS*

The Srivastava Lab: Bioinspired Nanotechnology to Improve Healthcare

Dr. Indrajit Srivastava, Assistant Professor

the Srivastava LAB



Who is Dr. Srivastava? Dr. Srivastava has been a faculty at Texas Tech for 1 year with a prior PhD in bioengineering and post-doctoral training in cancer nanotechnology and image-guided surgery from the University of Illinois at Urbana-Champaign. Dr. Srivastava is interested in bringing his laboratory research to clinics and currently has several ongoing collaborations with clinicians.

Contact info:
indrajit.srivastava@ttu.edu

Lab website:

SCAN ME!

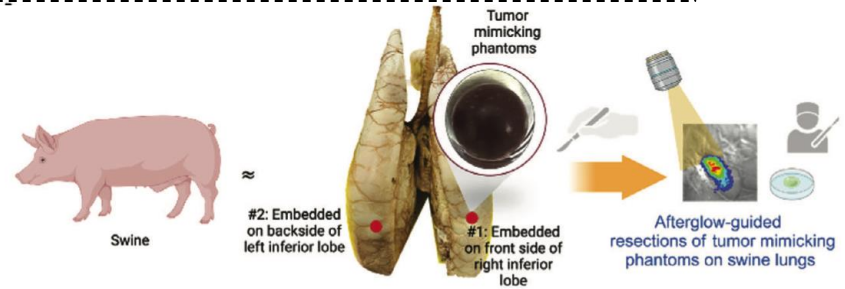
At **The Srivastava Lab**, we develop advanced biomaterials and nanosensors inspired by nature and leveraging nanoengineering design principles. Our ultimate goal is to use them for surgical interventions and disease diagnostics to improve human health.

At **The Srivastava Lab,** we strongly believe that someone's passion for science is a more important metric than someone having scientific experience.

Highlighted Research from Texas Tech University

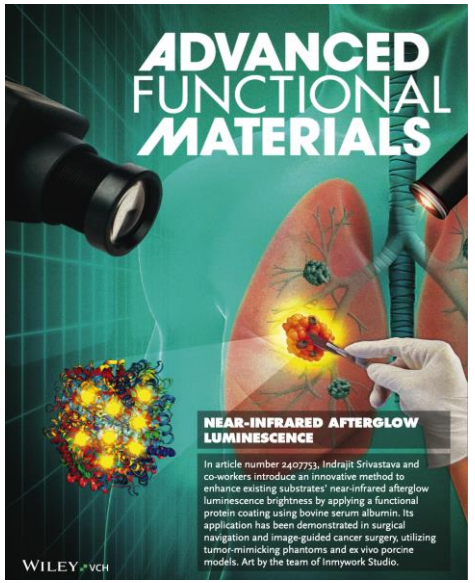
Research

Assistant Professor Aims to Improve Cancer Surgery with Afterglow Imaging



Bendele, N., Kitamura, K., Vasquez, I., Harun, A., **Carroll, M.,** Srivastava, I. *Adv. Funct. Mat.* 2024. (Impact Factor: 19)

Undergrad mentees at Texas Tech University are **highlighted**



Our Expertise.

- Novel nanoparticle design for bioimaging, drug delivery, and diagnostic applications.
- Developing novel point-of-care devices and platforms conducive to deployment at hospitals
- Developing novel technologies for aiding image-guided surgical interventions

Our Capabilities.

- Nanoparticle Synthesis and Purification
- Nanoparticles Physicochemical and and Optical Characterization
- *In vitro* Biocompatibility and Endocytosis Validations of Nanoparticles
- *Ex vivo* Optical Tissue Permeation and Surgical Evaluations of Nanoparticles
- *In vivo* Murine Models to Investigate Nanoparticle Performance

Follow us on Social Media.

SCAN ME!

SCAN ME!

Cardiovascular Biomechanics Laboratory (CBL)

Dr. Minliang Liu, Assistant Professor

Dr. Minliang Liu
Assistant Professor
Education:
Ph.D., Georgia Institute of Technology
B.Eng., Zhejiang University

Contact Info:
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Lab website:
https://www.myweb.ttu.edu/minlliu/

The CBL Lab develops noninvasive personalized computational tool to aid in the clinical prognosis and treatment of cardiovascular diseases.

Research Highlight: Personalized Digital Twin of Aortic Dissection

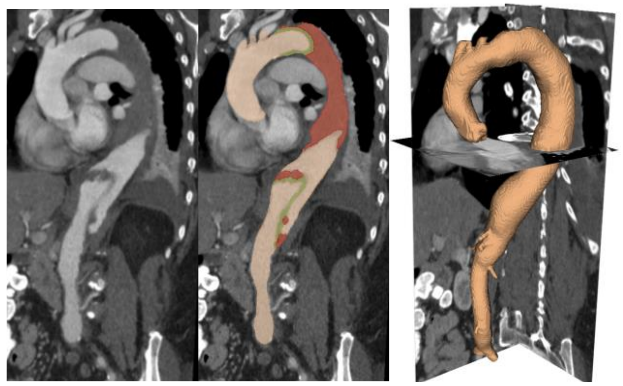
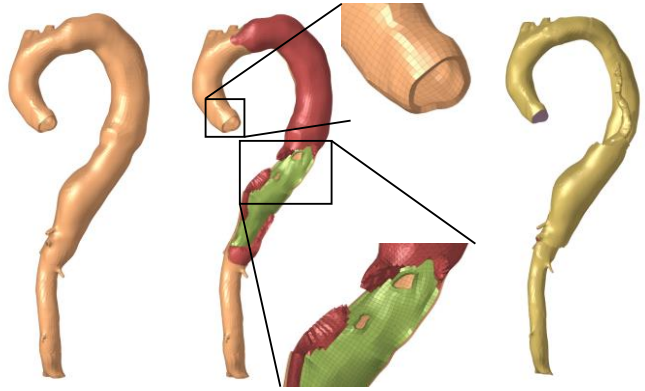
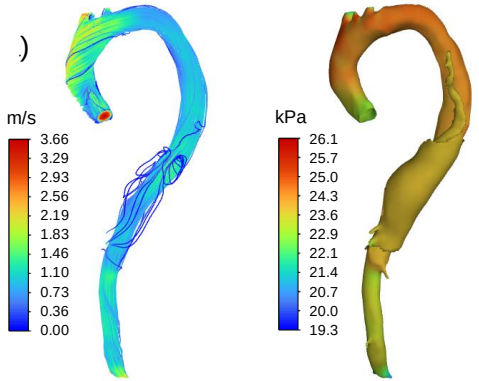


Image Segmentation

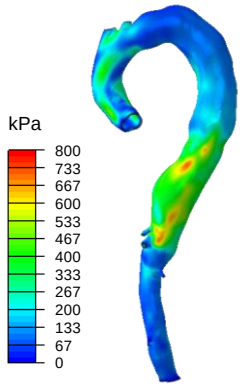


Mesh Generation

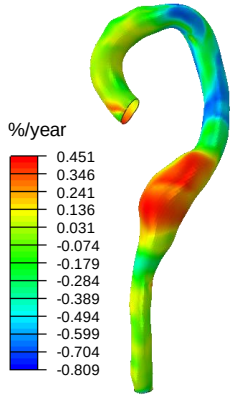


Velocity (Pathline)

Pressure



Stress (baseline)



Growth Rate (8 months)

Sponsors: NIH National Heart, Lung, and Blood Institute; American Heart Association.; NSF

Methods

- Cardiovascular Mechanics
- Physics-Informed Machine Learning
- Data-Driven Modeling
- Statistical Shape Analysis
- Inverse Methods
- Constitutive Modeling
- Tissue Mechanical Testing

Applications

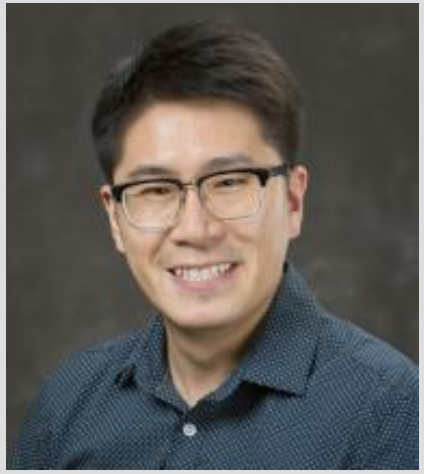
- Personalized Surgical Planning
- Medical Device Selection
- Disease Prognosis
- Risk Assessment

Collaborators

Emory University; Yale; University of Miami; Texas A&M

Computational Robotics and Mechatronics (CRM) Lab

Dr. Xiaolong Liu, Assistant Professor



Who is Dr. Liu? Dr. Liu has around 10 years of experience developing medical robotics and computer-assisted systems for surgeries ranging from gastrointestinal to cardiovascular and neurovascular, with training in both industry and academia. Dr. Liu is driven by a strong interest in research and commercialization that can make a meaningful impact on society.

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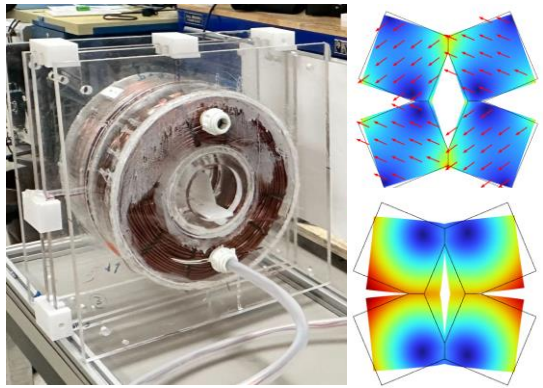
http://www.myweb.ttu.edu/xiaolonl/

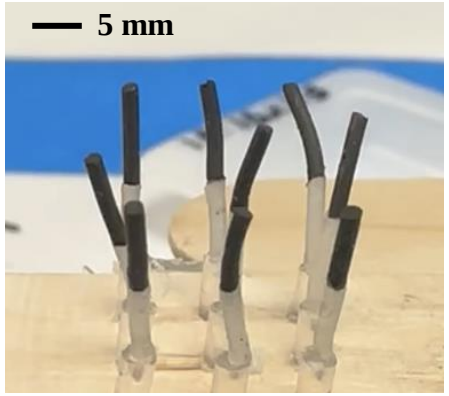
The CRM lab focuses on creating advanced medical robotic systems and mechatronic devices for minimally invasive surgeries (MIS) and interventions. Our work emphasizes precision control, dexterous manipulation, increased autonomy, and scalable designs across multiple sizes.

Highlighted Research



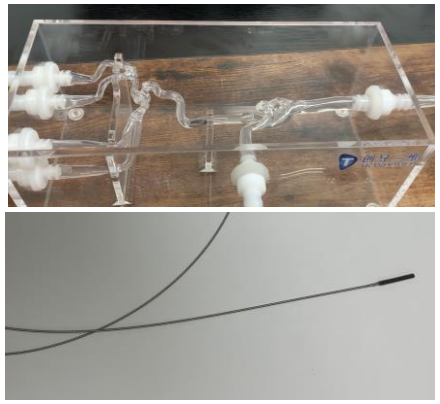
Magnetic Soft Metastructures

Designing functional actuators with prescribed behaviors using magnetic soft materials embedded in metastructures. These actuators are reconfigurable and adaptable for diverse applications.



Small-Scale Soft Robots

Designing small-scale (from cm to um) soft robots inspired by biological systems, focusing on adaptable motion, precise manipulation, and environmental responsiveness for use in healthcare and industrial applications.



Autonomous Robots for MIS

Developing autonomous soft robotic systems for minimally invasive surgeries (MIS), such as neurovascular and cardiovascular procedures, aims to enhance precision, safety, and effectiveness.

Our Expertise

- Robotic System Design
- Mechatronics Design
- Robotic Autonomy
- Surgical Innovation
- Design Optimization
- Medical Devices
- Device Manufacturing

Our Capabilities

- Multiphysics Modeling
- Multi-Scale Manufacturing
- Machine Learning
- Experimental Testing

Lab Website

Ahmad Materials and Energy Research Group (AMERG)

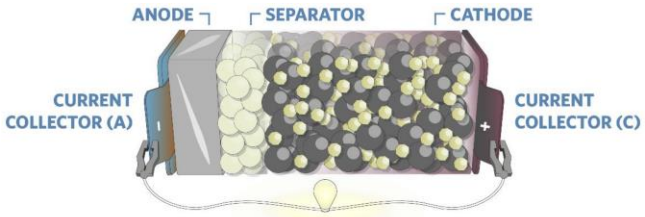
Dr. Zeeshan Ahmad, Assistant Professor

Dr. Ahmad is an Assistant Professor of Mechanical Engineering at Texas Tech University. He obtained his PhD from Carnegie Mellon University working on solid-state batteries. He directs AMERG consisting of 3 PhD, 1 Master's and 3 undergraduate students.

Contact Info:
zeeahmad@ttu.edu
https://ahzeeshan.github.io/

We develop functional materials and interfaces for next-generation technologies – lithium-ion batteries, solar photovoltaics and semiconductor processing. We use atomistic and continuum simulations as well as device-scale experiments.

Research Areas

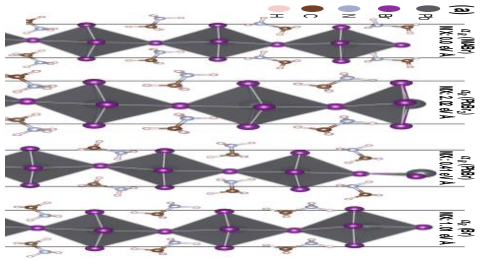


Solid-state batteries

Our research enhances the energy density and reduce the charging time electric vehicle batteries by controlling defects in solid ion conductors

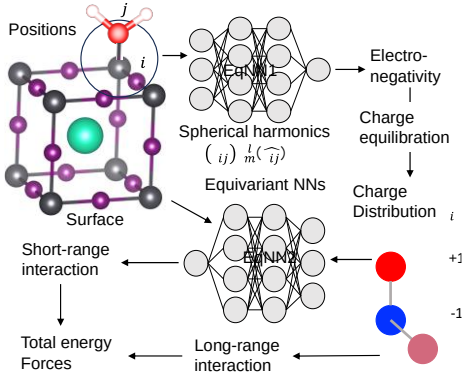
Leveraging artificial intelligence for materials science

We develop machine learning interatomic potentials for simulating materials at large length and time scales, e.g., during semiconductor manufacturing



Perovskite semiconductors

We investigate the origin of high efficiencies and design perovskite semiconductors for solar cells and optoelectronics



AMERG is one of the 20 groups worldwide that were awarded the Samsung Global Research Collaboration grant in 2023

Applications

- Batteries
- Solar cells
- Semiconductors
- Material processing

Research Methods

- Atomistic simulations
- Machine learning
- Continuum modeling
- Electrochemistry
- Device experiments
- Material characterization

Publications

Our work has been published in leading journals such as ACS Applied Materials & Interfaces, Nature materials and ACS Energy Letters

Smart Human-Centric Automation Resilience Lab

Dr. Tanushree Roy, Assistant Professor

SHARE lab focuses on building safer smart cities by ensuring reliable operations of connected autonomous vehicles and energy systems using control theoretic techniques, mathematical modeling, machine learning, and experimental validations.

Contact info:
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Website
Google Scholar

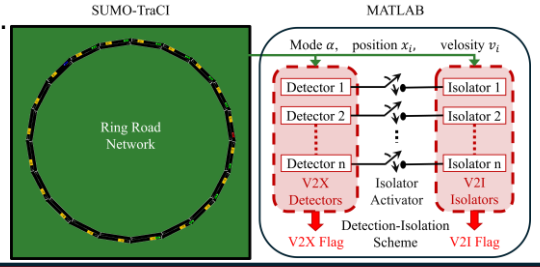
Focal Themes:
System-level Cybersecurity
Diagnostics
Sensor fusion
System resilience & control
Cyber-physical-social systems
Anomaly characterization

Tools Used:
Robust residual generators
Barrier functions
Distributed learning
Operator theory
Stochastic modeling
Kernel density estimations

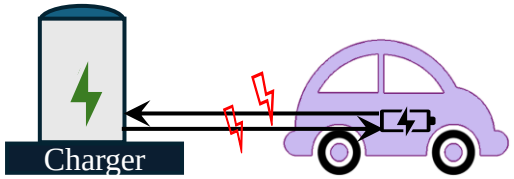
Lab Facilities:
Static Driving simulator
Arbin Battery cycler
dSPACE SCALEXIO
Simulation of Urban Mobility (SUMO) software, RC cars
High performance computing

SHARE Lab Research Highlights

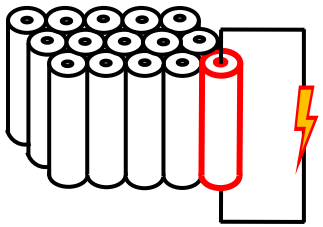
Detection and isolation of infrastructure-level attacks on vehicle platoon in changing driving environment, validated in SUMO
Published in IEEE Transactions in Intelligent Transportation Systems, under review L-CSS Letters.

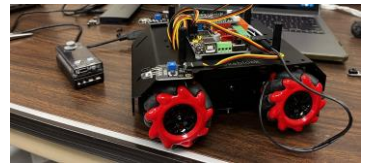


Koopman operator-based identification of sensor and actuation attacks on battery charging, validated on PyBamm
Published in ACC, under review in Applied Energy



Extremely fast & sensitive internal short circuit detection scheme for battery pack using model-free learning
Under review at ACC





Design Optimization and Control Lab

Dr. Donald Docimo, Assistant Professor

Our lab focuses on researching heterogeneous energy systems and sustainability.

Contact Email:
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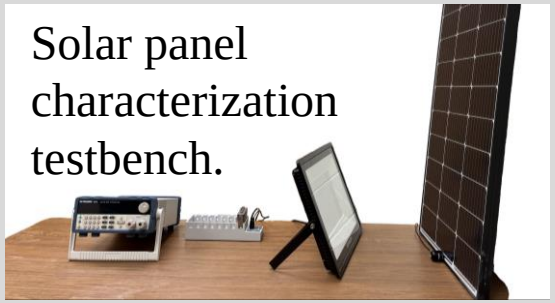
Website:
https://www.docimocontrols.com/

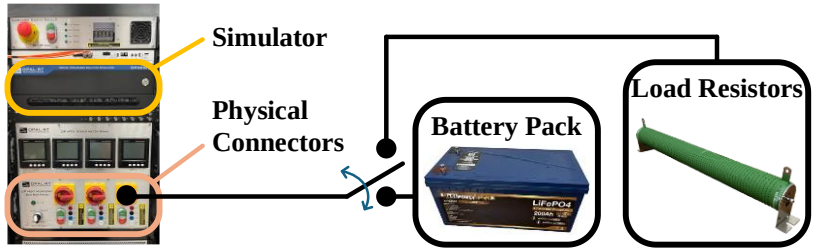
Experimentation for validation of key results and discoveries.

Cycler for electrical and thermal testing of battery cells/packs.

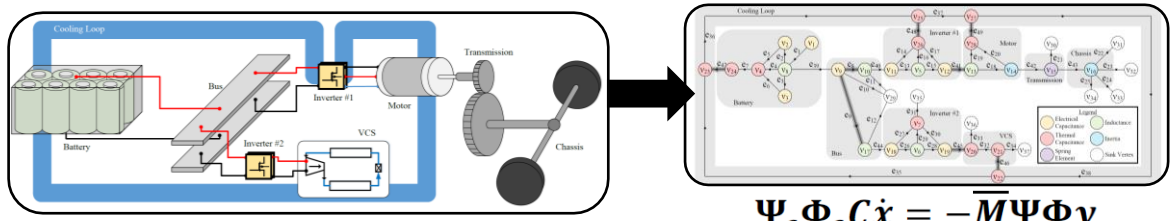
Solar panel characterization testbench.



Power hardware-in-the-loop for controller validation.

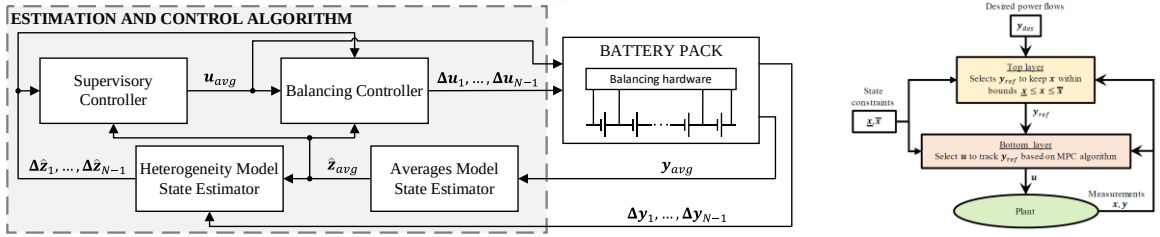


Modeling of coupled electrical and thermal dynamics.

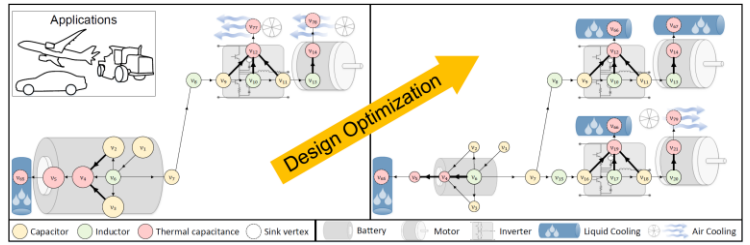


$$\Psi_c \Phi_c C \dot{x} = -\overline{M} \Psi \Phi y$$

Real-time estimation and predictive control.



Design and control co-design of electric vehicles, microgrids, and data centers.



Biomedical Acoustics Research (BMAR) Lab

Dr. Jingfei Liu, Assistant Professor

Mission: The BMAR Lab addresses the current challenges in human healthcare by harnessing the power of acoustics (sound & vibration) to develop new diagnostic and therapeutic methods and devices.

Dr. Liu has a multidisciplinary background in Mechanical Engineering, Electrical and Computer Engineering, and Biomedical Engineering. The current research is focused on biomedical ultrasound imaging, focused ultrasound therapy, medical instrumentation, biomechanics, and nondestructive testing/evaluation.

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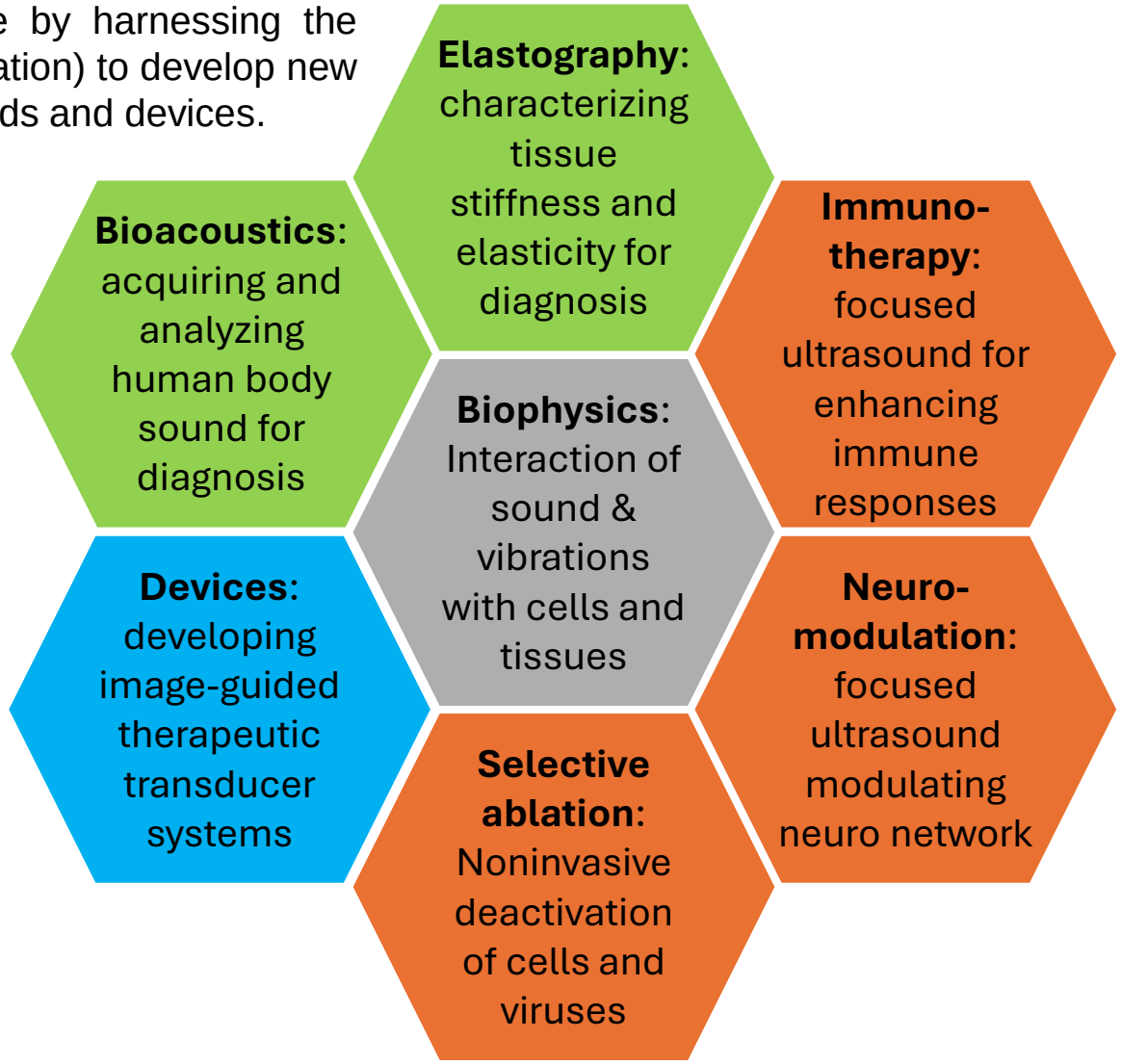
jingfei.liu@ttu.edu
https://www.depts.ttu.edu/me/research/barlab/



Lab Expertise

- Noninvasive real-time *in vivo* **tissue elasticity measurement & imaging**:
  - Bulk tissue: *muscle, tendon*
  - Interfacial tissue: *skin, oral tissue*
  - Layered tissue: *blood vessels, heart, diaphragm, etc.*
- Measurement and analysis of **biological sounds & vibrations**:
  - Cardiovascular system: *heart, major blood vessels*
  - Skeletomuscular system: *joints, muscle*
  - Digestive system: *abdominal organs*
- Ultrasound **transducer/sensor design** for imaging and therapy
- Ultrasound **nondestructive testing and evaluation** of material properties and defects

Distributed Parameter Systems & Control Laboratory

Dr. Shu-Xia Tang, Assistant Professor, shuxia.tang@ttu.edu

TEXAS TECH UNIVERSITY
Edward E. Whitacre Jr. College of Engineering

Lab Director

Dr. Shu-Xia Tang

Battery Testing Team

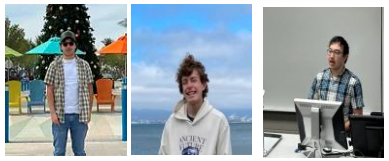
Ph.D. Students: Patryck Ferreira, Sara Sepasiahooyi

Undergraduates: Sambrid Raj Shrestha, Ethan Anderson

Multi-Agent System Control Team

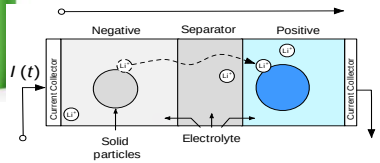
Undergraduate: Edward Cruz-Noble, Nathan Bartley,

Edward Noble, etc.



Battery Systems

Sensitivity analysis
State-of-charge and state-of-health estimation
Temperature management

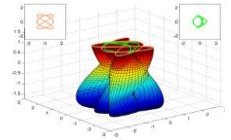


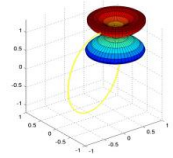
PDE-Modeled Dynamic Systems and Control

System Modeling
State Estimation & Control
Optimization

Multi-Agent Systems

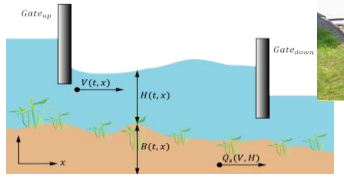
Cooperative estimation and control
Synchronization and consensus
Delay compensation





Water Management Systems

Null controllability
Stabilization for navigable waterways

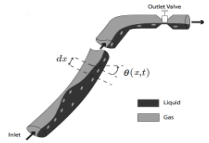


Traffic Management Systems

Real-time routing policy making
Automated platoon control

Oil Drilling Systems

Vibration suppression in oil drilling
Slugging control in oil production



We actively seek for collaborations!

Medicine Mechanics and Manufacturing Design (M3D) Lab

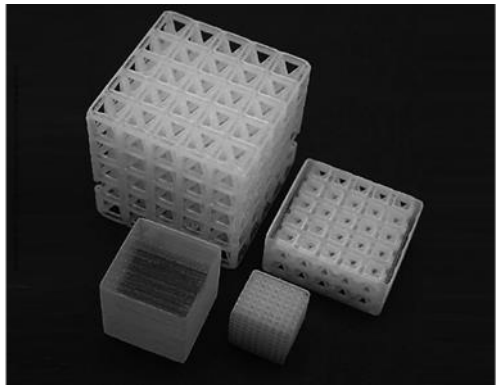
Dr. Paul Egan, Assistant Professor

Who is Dr. Egan? Dr. Egan has been faculty at TTU for 6+ years with prior PhD and post-doctoral training in product design, additive manufacturing, cognition, entrepreneurship, and medicine. Dr. Egan is highly interested in research and commercialization with high impact for society.

Contact Info:
paul.egan@ttu.edu
m3d-lab.com
linkedin.com/in/paul-egan-phd/

The M3D Lab uses interdisciplinary 3D printing, computation, experiments, and engineering approaches to drive design science research for medical innovations.

Highlighted Research



Mechanical metamaterials

- Design and mechanically test architected structures for medical applications
- Use multi-objective optimization to tune tissue scaffolds for higher mechanical efficiency and tissue growth rates
- Published in *Computers in Biology and Medicine* & *J. Mechanical Design*

Printed food personalization

- Design customized foods with user studies for improved nutrition and sensory appeal
- Mechanically characterize food inks using texture analysis and rheology to optimize printability using machine learning
- Published in *3D Printing and Additive Manufacturing* and *J. of Food Engineering*

Funding Sources: The M3D lab research is sponsored by NSF, USDA, ASEE, DOD, DOE, The Lemelson Foundation, and external companies focused on medical innovation.

Our Expertise

- Product Design
- Medical Innovation
- 3D Printing
- Biomechanics
- Design Cognition
- Design Automation
- Sustainability

Our Capabilities

- Polymer/Bio Printing
- Finite Element Models
- User Interfaces
- Machine Learning
- Mechanical Testing
- Life-cycle Analysis

Biomechanics, Mechanobiology, and Biomaterials Laboratory

Dr. Zhongkui Hong, Associate Professor

Dr. Zhongkui Hong is an Associate Professor in the Department of mechanical engineering at the Texas Tech University. His research focuses on Biomechanics in cardiovascular diseases, and Mechanics in biomaterial design and tissue engineering. Dr. Hong's research has been funded by the American Heart Association, National Institutes of Health, National Science Foundation, and South Dakota Board of Regents.

Contact Info:
Email: Zhongkui.hong@ttu.edu
Phone: 806.834.5395
Fax: 806.742.3540
Office: ME South 201D

Research Interests

1. Biomechanics in Cardiovascular Disease

This research aims to enhance understanding of atherosclerosis and provide insights into vascular biomechanics, potentially guiding new cardiovascular disease therapies.

2. Biomaterials, Tissue Engineering, and Drug Delivery

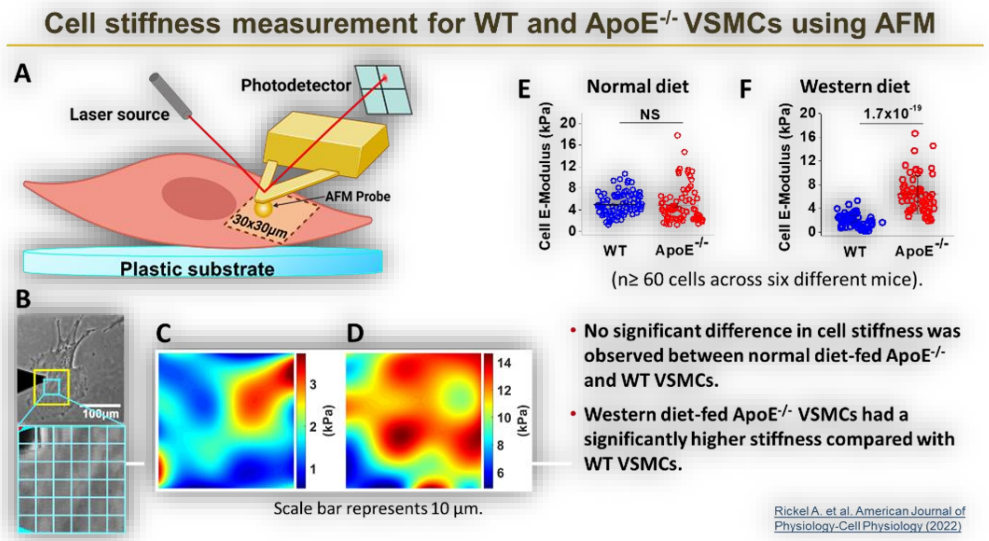
This research focuses on developing materials that support cell growth and tissue regeneration, aiming to repair or replace damaged tissues. This involves designing scaffolds, studying cell-material interactions, and incorporating biological signals to enhance healing and functionality.

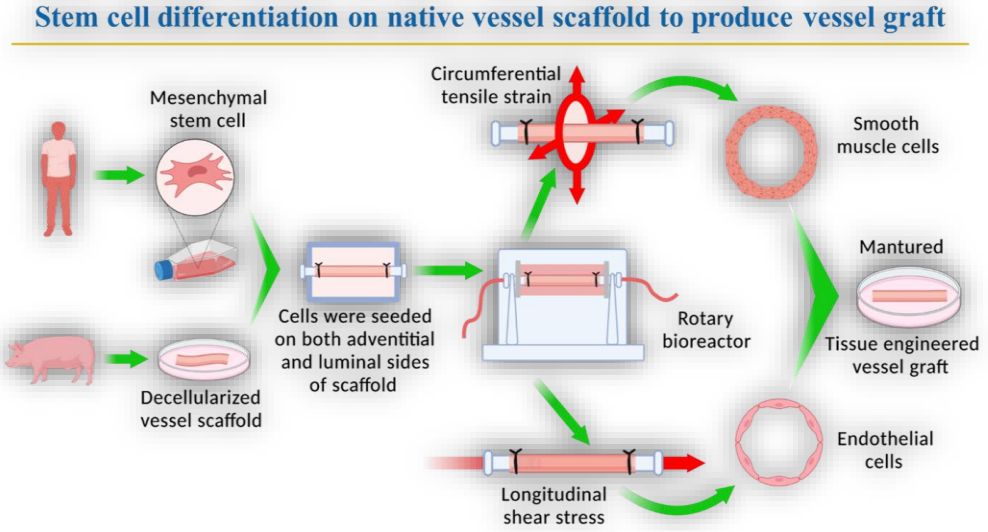
3. Cell Dynamics, Cell Migration, and Their Clinical Relevance

This research topic seeks to reveal the mechanism underlying cell dynamics and migration, and their relevance in cardiovascular disease and cancer metastasis.

Lab Expertise

- **Atomic Force Microscopy (AFM)**
- **2D and 3D Cell Culture systems**
- **Fluorescent Imaging Systems**
- **Prefusion Bioreactor**
- **Myography**
- **Western Blot**
- **Electrospinning**





Flow Control and Aerodynamics Lab

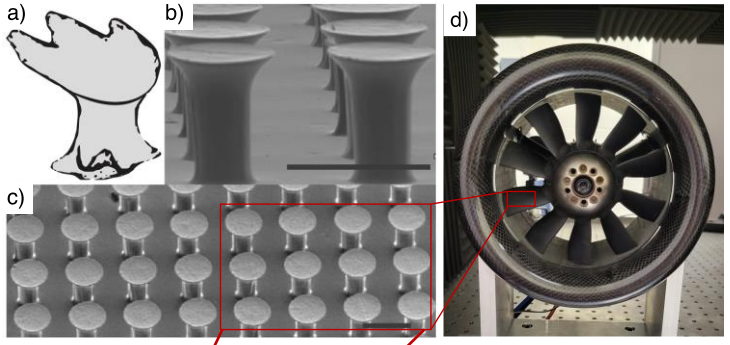
Dr. Victor Maldonado, Associate Professor

Dr. Maldonado has been a faculty member at TTU since 2019. He received the NSF CAREER Award and was a summer research faculty fellow at NASA, ONR, and the AFRL in research related to unsteady aerodynamics and flow control of aerospace and naval systems.

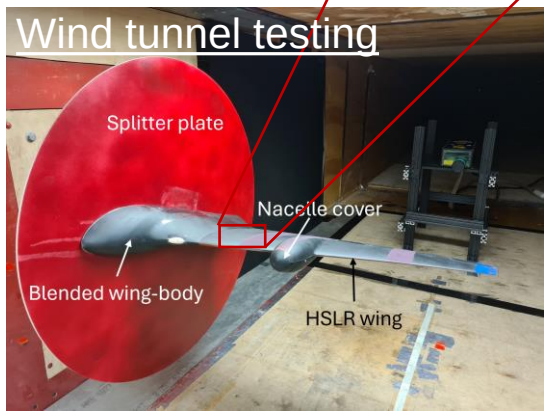
Contact Info:
victor.maldonado@ttu.edu
https://www.depts.ttu.edu/me/faculty/victor_maldonado/index.php

The Flow Control and Aerodynamics Lab performs experiments with simulations of complex and unsteady flows in fixed-wings, rotor blades, and ducted fans in order to design aircraft systems with flow control technology to achieve superior aerodynamic performance.

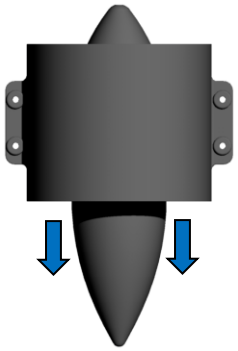
Passive sharkskin-inspired coating

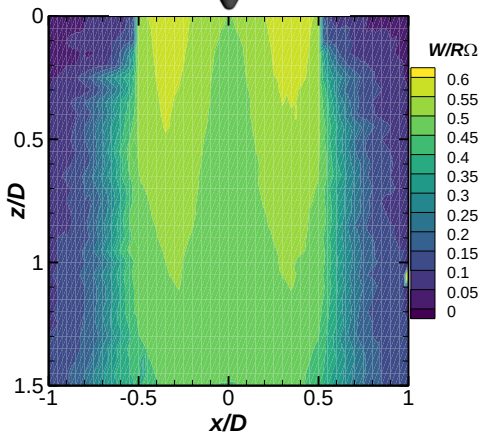


Wind tunnel testing



Ducted fan jet flow





Our Disciplines

- Aerodynamics
- Fluid Mechanics
- Flow Control
- Aeroelasticity
- Aircraft Design

Our Capabilities

- Wind Tunnel Testing
- Particle Image Velocimetry
- Laser Doppler Velocimetry
- Rotor Tower Testing
- CFD and Simulations

Publications: Our research is published in *Aerospace Science and Technology*, *Physics of Fluids*, and *Aerospace*
Funding Sources: The Lab is sponsored by NSF, NASA, and the DOD

Energetic Materials Combustion Research Laboratory

Dr. Michelle L. Pantoya, J. W. Wright Regents Endowed Chair Professor

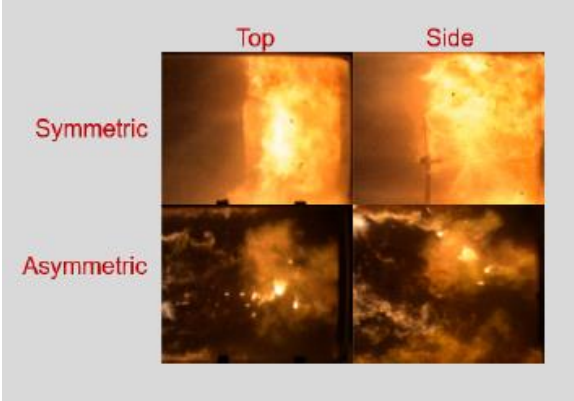
Dr. Michelle L. Pantoya
JW Wright Regents Endowed Chair; Professor at Mech. Eng., TTU

Contact Info:
Michelle.Pantoya@ttu.edu

https://www.depts.ttu.edu/me/research/combustionlab/index.php

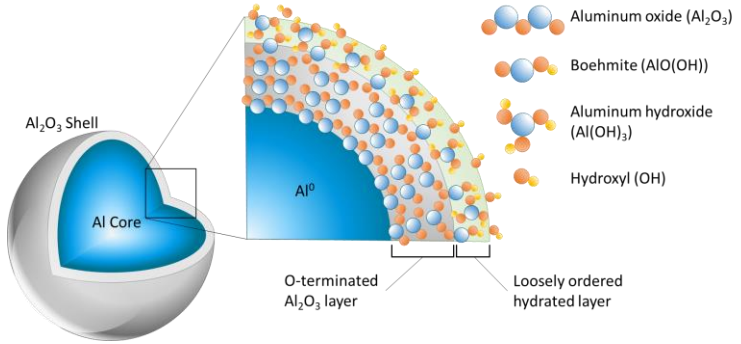
Our group studies solid fuel combustion and energy conversion processes resulting from reacting energetic materials with applications in national security and defense. We develop diagnostic systems for experimental studies and advance analytical models for metal oxidation mechanisms and energy conversion processes.

Highlighted Research



Reactive Material Ballistics

- Investigate the dynamic response of intermetallic and thermite projectiles upon high velocity impact ignition and reaction
- Utilize advanced diagnostic systems and analytical methods to resolve energy partitioning into the gas and condensed phases



Metal Fuels for Power Generation

- Synthesize metal fuels by altering the passivation shell chemistry
- Characterizes the reactivity of the newly synthesized fuel particles including ignition sensitivity, energy generation, and completeness of combustion
- Design synthesis strategies to increase power generation capabilities

Our Expertise

- Solid metal particle combustion
- Equilibrium thermodynamics and reaction kinetics
- Characterizing reactions in extreme environments

Our Capabilities

- Ballistic impact testing
- Propellant strand burner testing (high pressure burn rates)
- High-speed imaging, thermography, and imaging emission spectroscopy
- Vented chamber & detonation calorimetry
- Materials characterization

Modeling of Mineral Surfaces Processes

combustion lab
inspiring, engaging, and securing the future.

TEXAS TECH UNIVERSITY

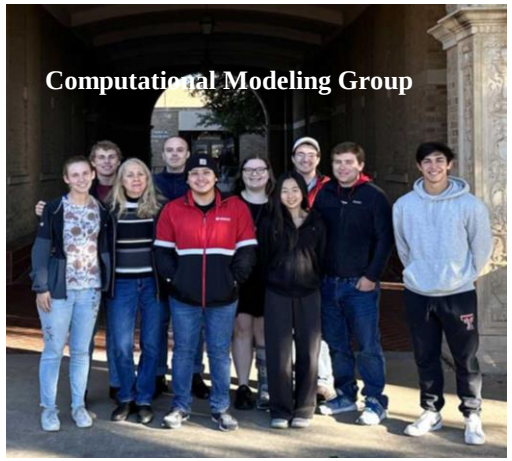
Dr. Adelia Aquino
Associate Professor of Practice
https://www.depts.ttu.edu/me/faculty/adelia_aquino/index.php

Research Program:

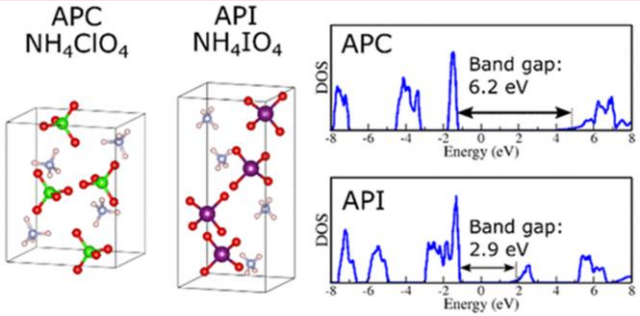
Computer simulations based on quantum chemical methods applied to

- Energetic material
- Renewable energy
- Material science
- Environmental and related fields

$\hat{H}\psi = E\psi$

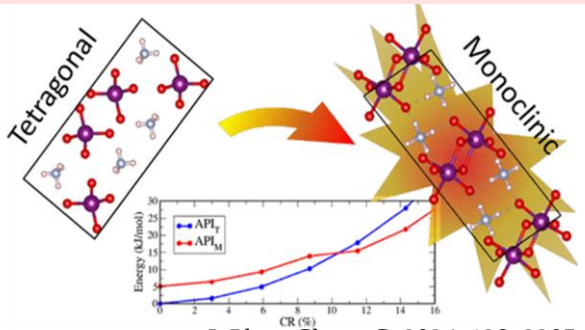


Band gap energy of ammonium perchlorate and ammonium periodate



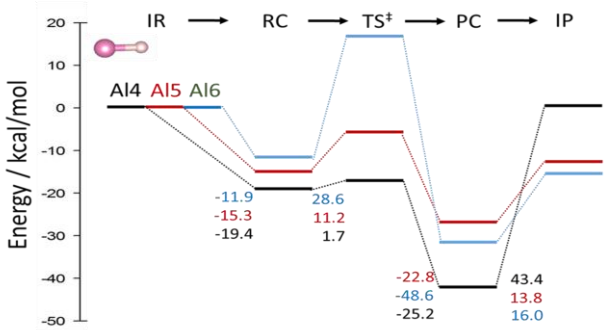
J. Phys. Chem. C, 2022, 126, 21723

Transition phase of ammonium periodate



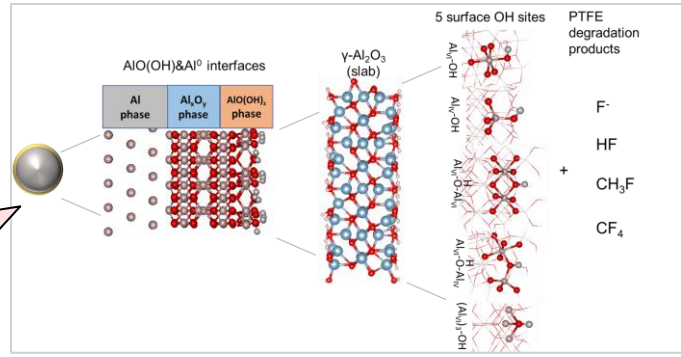
J. Phys. Chem. C, 2024, 128, 2205

Relative reaction energies of $Al(OH)_x$ complexes reacting with HF

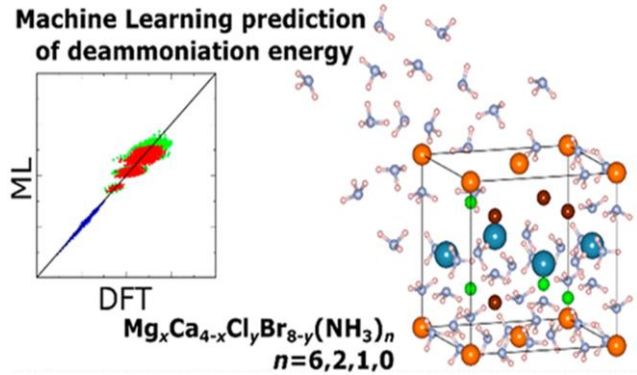


J. Phys. Chem., 2021,154, 104310

Schematic view on interfaces between $Al/Al_2O_3/(Al(OH)_2$ phases



Machine Learning prediction of deammoniation energy

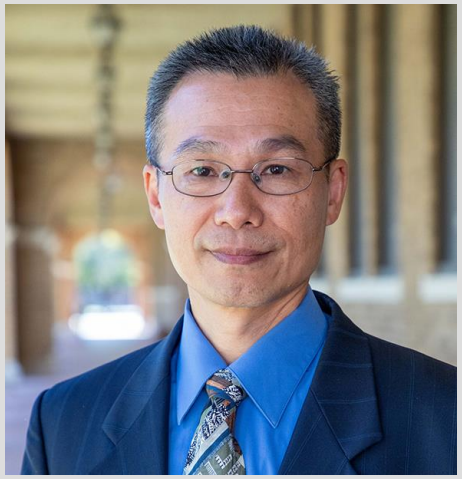


J. Phys. Chem. C, 2022, 126, 12184

Funding Sources: The Computational Modeling Group is sponsored by ARO,ONR, and DOE.

Propulsion and Reacting Flow Research Laboratory

Dr. Song-Charng Kong, Professor



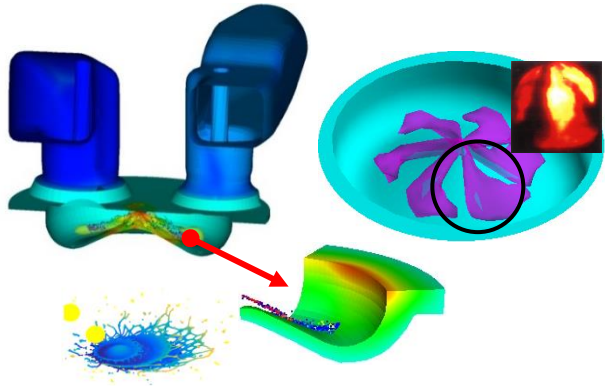
Dr. Song-Charng Kong
Don Kay Clay Endowed Chair;
Professor at Mech. Eng., TTU
Previous Program Director at NSF (2015–2018)

Contact Info:
sokong@ttu.edu

https://www.depts.ttu.edu/me/research/reactingflowlab/index.php

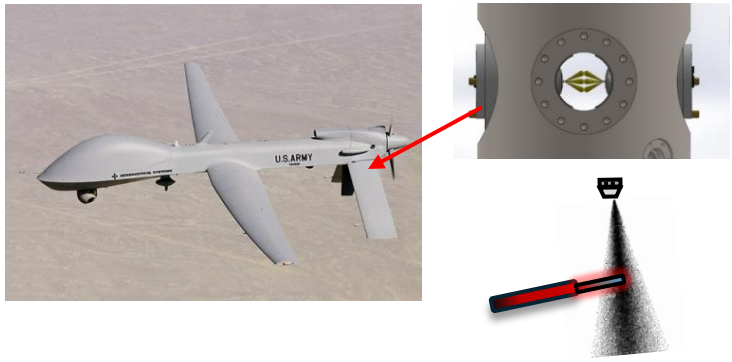
Our group studies multiphase, chemically reacting flows with applications in engine spray combustion and biomass thermochemical conversion. We develop high-fidelity computational models for designing novel propulsion and energy systems.

Highlighted Research



Engine Combustion

- Investigates complex fluid dynamics and combustion chemistry in engines.
- Develops high-fidelity computational models for engine design and optimization.
- Optimizes engine performance using alternative fuels and biofuels.



Military UAS Propulsion

- Explores future propulsion systems for military unmanned aerial systems (UAS).
- Characterizes performance of ignition-assistant devices for high-altitude operation.
- Optimizes opposed-jet configuration for increased power density.

Our Expertise

- Fuel spray and droplet dynamics
- Gas phase combustion
- Spray-wall interactions
- Optimization algorithm
- Biomass fast pyrolysis
- Thermal spray analysis

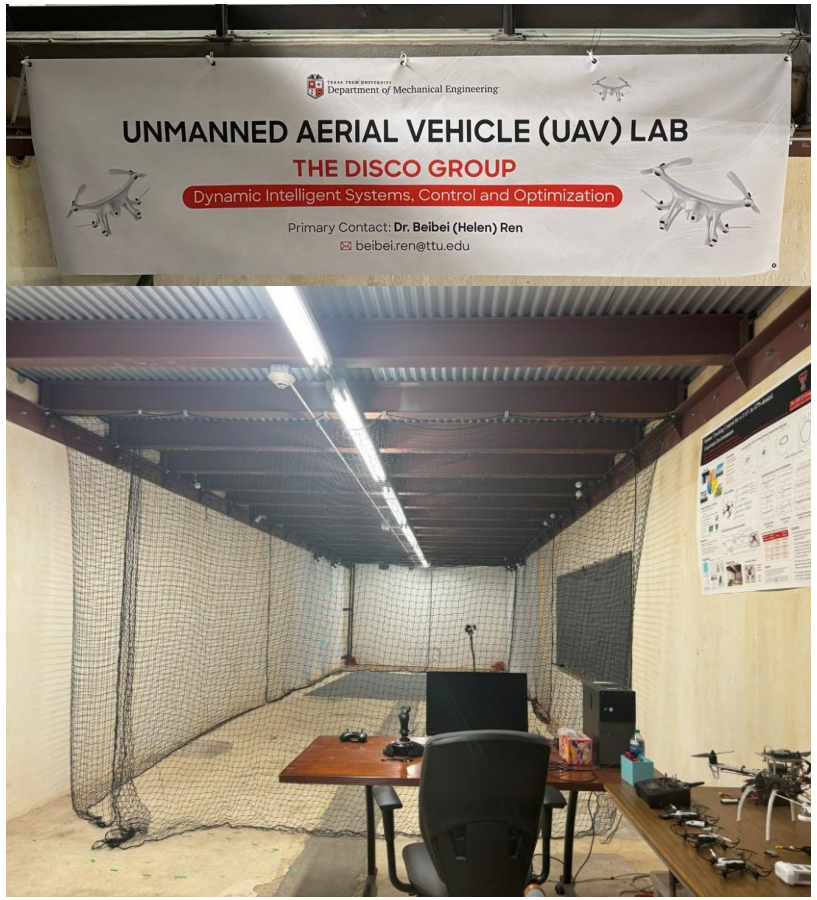
Our Capabilities

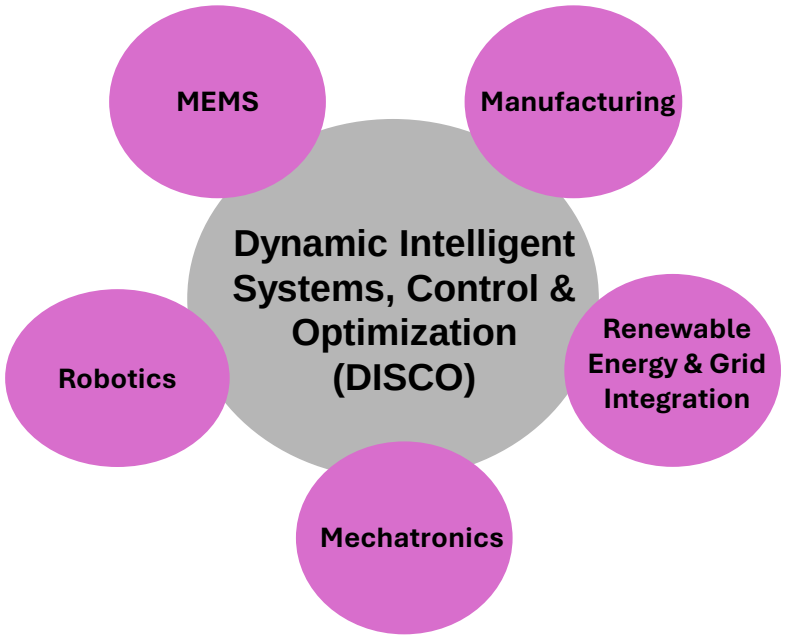
- High-fidelity CFD modeling
- Integrated simulation of solid conduction and droplet impact
- Engine combustion optimization
- Novel UAS propulsion system analysis

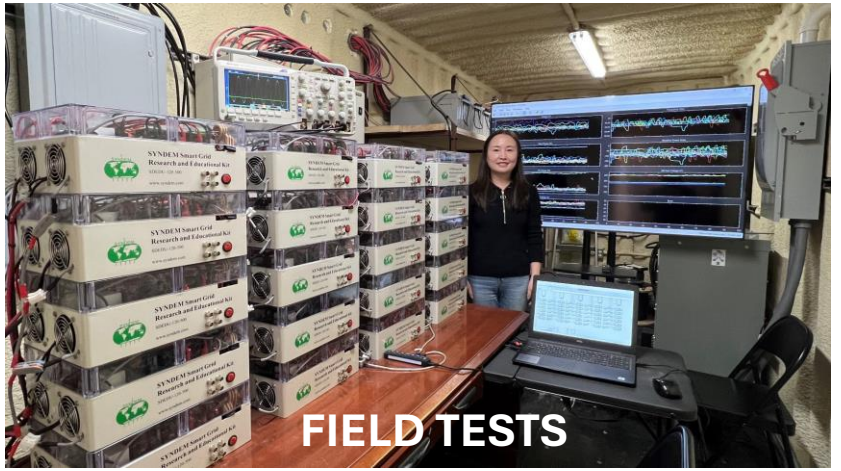
The DISCO Group

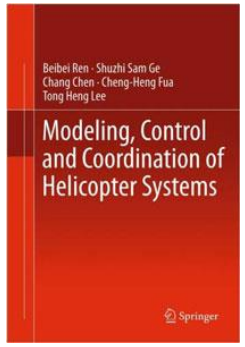
Dynamic Intelligent Systems, Control and Optimization

Dr. Beibei Ren (beibei.ren@ttu.edu)
McVay Endowed Professor in Engineering
Web: www.myweb.ttu.edu/bren/









Sponsors

NSF

U.S. DEPARTMENT OF ENERGY

SYNDEM

GLEAMM
GLOBAL LABORATORY FOR ENERGY ASSET MANAGEMENT AND MANUFACTURING

Texas Instruments

WINDAR PHOTONICS

Christopher Lab: Microfluidics, Rheology, & Soft Matter

Dr. Gordon Christopher, Professor

Dr. Christopher is the associate chair of research and a professor at Texas Tech. He received a PhD in mechanical and a MS in chemical engineering from Carnegie Mellon and was a NRC postdoc at the National Institute of Standards and Technology. Since beginning at Texas Tech in 2011, he has been named a Whitacre Research Fellow and won the TA Distinguished Young Rheologist award.

Contact Info:
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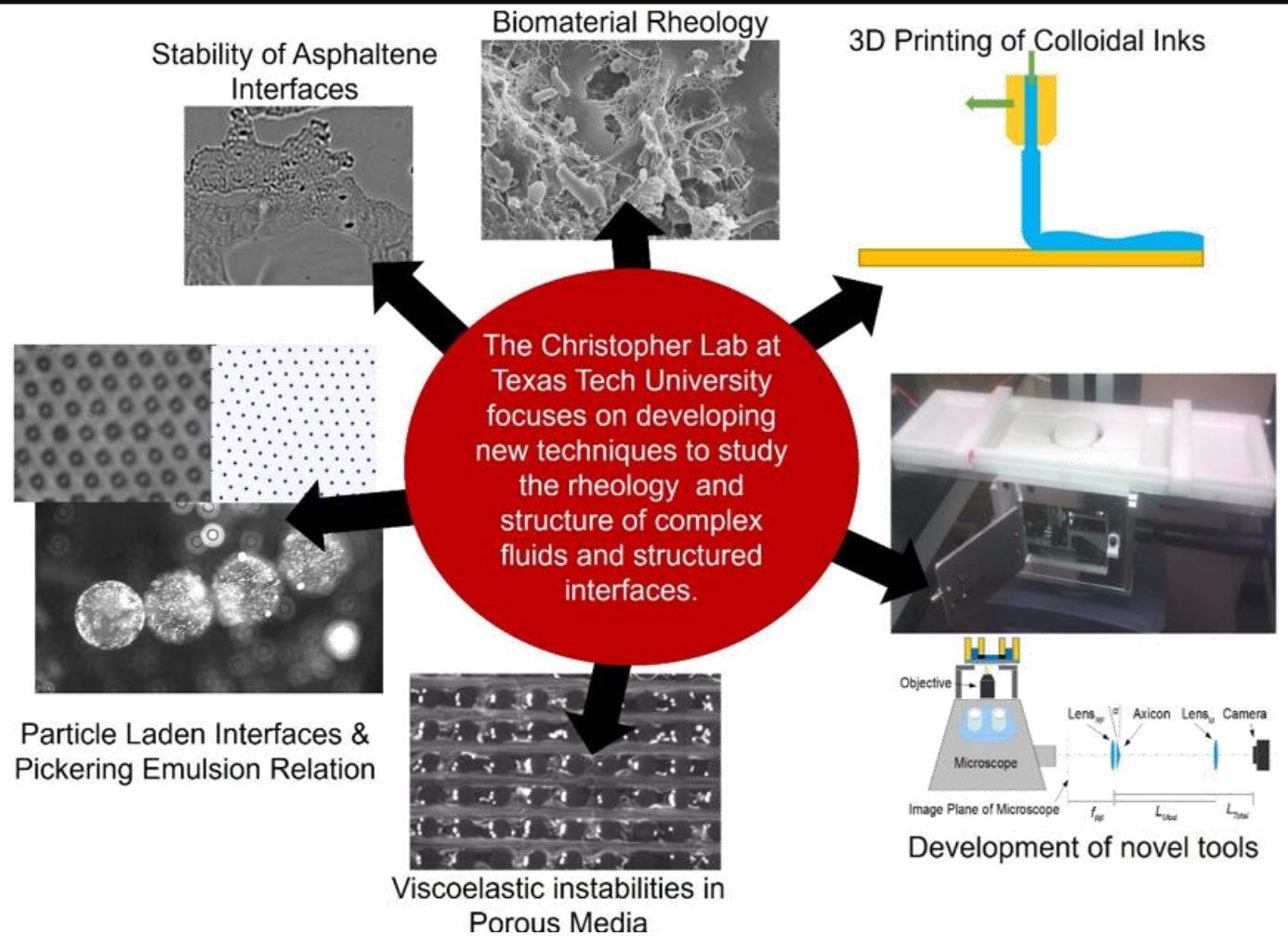
https://www.depts.ttu.edu/me/research/Christopherlab/index.php



Funding Sources
NSF · DOE · ACS PRF · NIH National Institutes of Health *Turning Discovery Into Health* · USDA · PanTEX

Our Expertise

- Pickering Emulsions
- Interfacial Materials
- 3D Printing ink characterization
- Biofilm mechanics and treatment
- Flow of viscoelastic materials

Our Capabilities

- Tensiometery
- Bulk, micro, and interfacial rheology
- Molecular Simulation
- Cell culturing
- Colloidal Printing
- Microfluidics

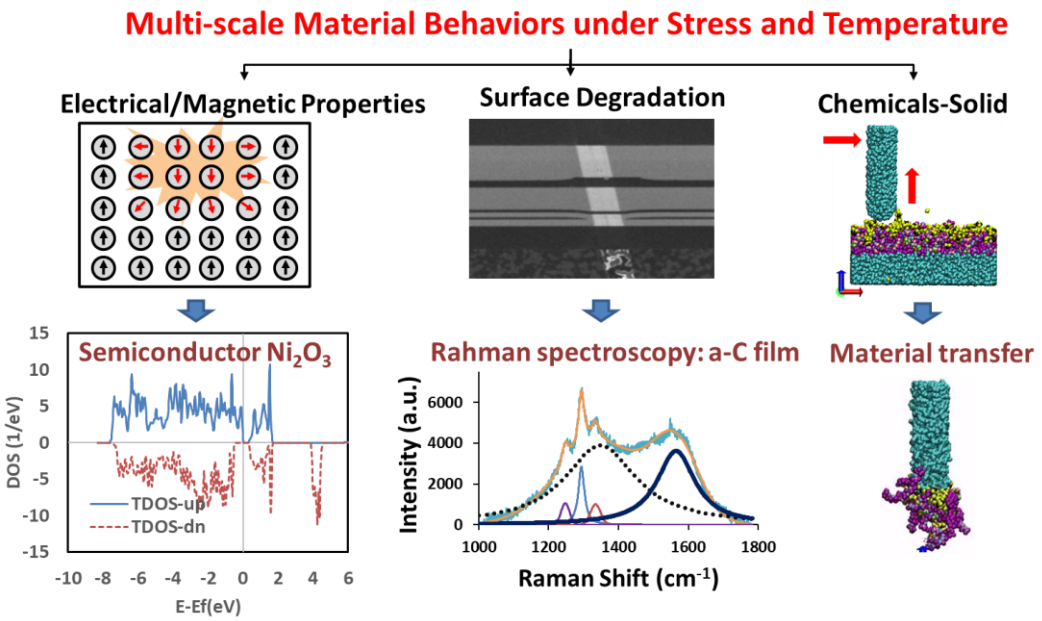
Materials and Interface Mechanics Laboratory

Dr. Changdong Yeo, Professor of Mechanical Engineering

Who is Dr. Yeo? Dr. Yeo is a professor of Mechanical Engineering. His research focuses on the niche area of multi-physics modeling of interface science, novel design of functional materials and metal oxides, advanced manufacturing of graphene derivatives and ionic liquids, and integration of mechanics and electromagnetics.

Contact Info:
changdong.yeo@ttu.edu
http://www.myweb.ttu.edu/cyeo

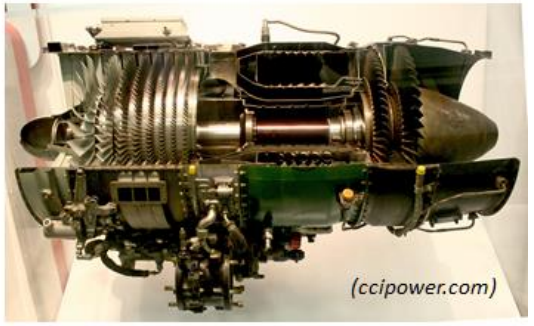
The Materials and Interface Mechanics Laboratory (MIML) at Texas Tech University is carrying out a cutting-edge research on thermomechanical/chemical behaviors of advanced materials in relation to electrical/magnetic properties, surface degradation, and material transfer.




(hitechreview.com)

(C. Hale 2008)


(wikimedia.org)


(ccipower.com)

MMIL is performing both fundamental and application research through:

- Experiments and Material Characterization: A custom-built tribometer, synthesis of nanocomposite and graphene products, SEM-EDS/XPS/TEM/XRD/Rahman Spectroscopy
- Computation: FEA, First-Principle-Calculation, Monte Carlo Calculation

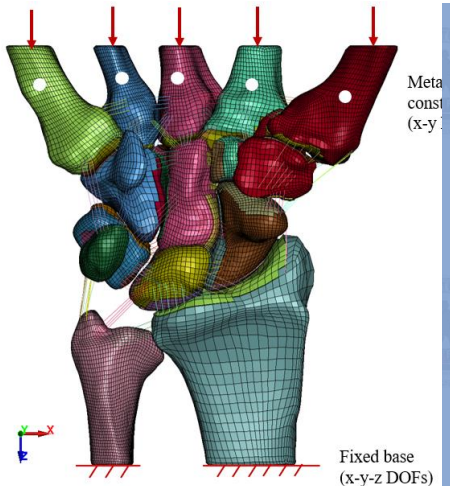
Funding Sources: National Science Foundation (NSF), DOE-Sandia National Laboratories, Seagate Technology LLC, Air Force, and Texas Tech University

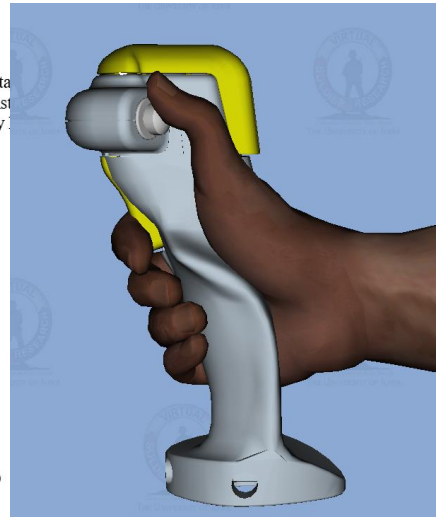
Human-Centric Design Research Lab

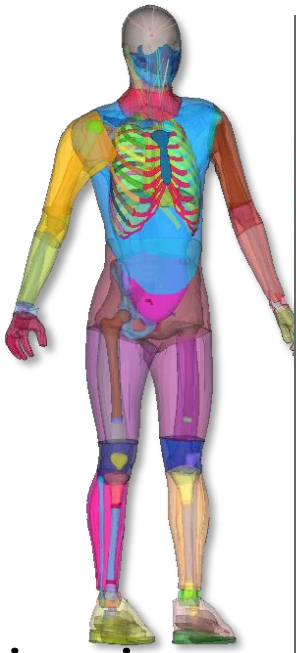
Dr. James Yang
Professor
SAE and ASME Fellow
Contact:
james.yang@ttu.edu
www.myweb.ttu.edu/jiyang

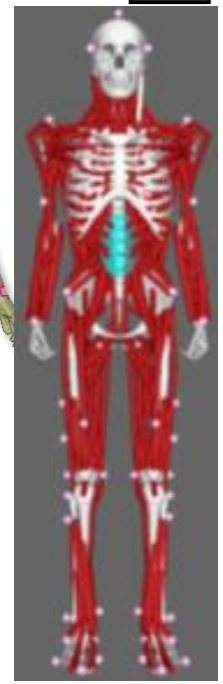
Research focuses on developing digital human models, novel robots, and innovative simulation methods for engineering design, biomechanics, rehabilitation, injury/fall prevention, healthcare, and autonomous vehicles.

• Digital Human Modeling and Simulation

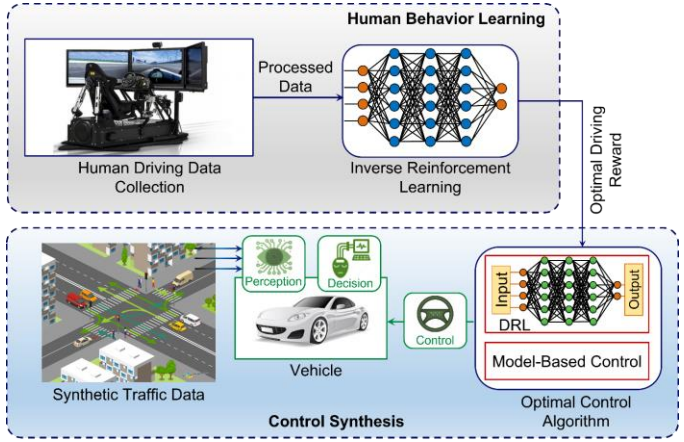




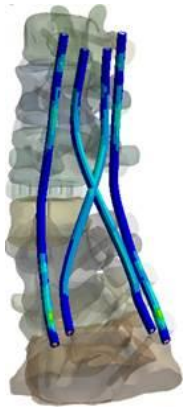


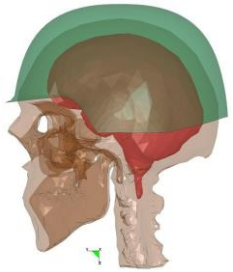


• Robotics and Vehicle Systems



• Healthcare Engineering





Sponsors

USARIEM Warfighter Health & Performance
NSF
Department of Defense
Department of Energy
National Institute for Occupational Safety and Health NIOSH
NPSF National Patient Safety Foundation
UTHealth The University of Texas Health Science Center at Houston School of Public Health Southwest Center for Occupational & Environmental Health
CATERPILLAR
HONDA Honda R&D Americas, Inc.

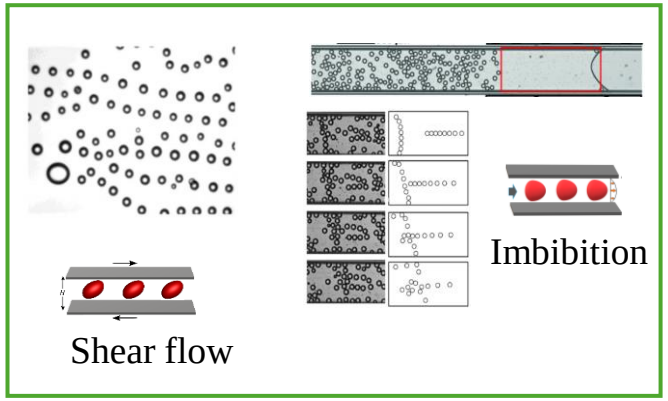
Complex Fluids and Soft Materials Lab

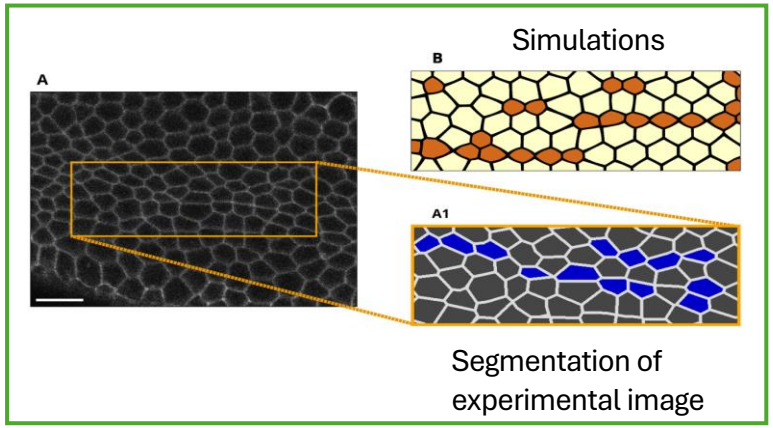
Dr. Jerzy Blawzdziewicz, Professor

Dr. Blawzdziewicz joined the ME Department at TTU in 2010. He is also an Adjunct Professor of Physics. Before coming to TTU, he was an Associate Professor at Yale University. His soft matter investigations span Mechanical Engineering, Chemical Engineering, Physics, and Biology.

Contact Info:
jerzy.blawzdziewicz@ttu.edu

Highlighted Research





Self-organization in soft matter

Our lab investigates self-organization of particles into a variety of structures in microfluidic channels and shear-driven flows. Such structures can be used to manufacture novel materials and to control particle flows in lab-on-chip devices. Published in *Soft Matter.*

Mechanically active biological matter

We study problems ranging from microscale locomotion to formation of embryonic architecture to self-organized motion in cilia arrays. Our research elucidates the role of mechanical feedback control and hydrodynamic self-organization in biological systems and is relevant for soft robotics. Published in *PNAS, PLOS Computational Biology, and Frontiers in Physics.*

Funding Sources: Our research has been sponsored by NSF, NASA, and NIH.

Our Expertise

- Microhydrodynamics of particulate matter
- Self-organization in flow-driven systems
- Mechanobiology of embryonic development
- Microscale locomotion
- Soft robotics

Our Capabilities

- Development of mesoscale theories of soft materials
- Numerical simulations of suspension and emulsion flows
- Numerical modeling of active biological matter

Computational Mechanics Lab

Director: Prof. Alexander Idesman (E-mail: alexander.idesman@ttu.edu)

Dr. Idesman is a Professor in the Department of Mechanical Engineering at Texas Tech University. His research interests include the development of high-order accurate numerical techniques for different PDEs (including wave and heat equations, elastodynamics at low frequency and impact loadings, Helmholtz, Poisson and elasticity equations), the application of numerical techniques to engineering problems. Dr Idesman has authored and co-authored 110 journal and conference papers. His research was supported by NSF, Army Research Office, Air Force Office of Scientific Research, and Sandia.

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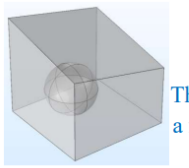
The Computational Mechanics Lab's research focuses on the development of numerical algorithms for the simulation of mechanical systems and their application to the analysis of different engineering problems. One of the main results obtained is related to the development of a new numerical approach to the solution of PDEs with optimal accuracy on irregular domains and interfaces and unfitted Cartesian meshes. We call it the Optimal Local Truncation Error Method (OLTEM). OLTEM is based on the minimization of the order of the local truncation error for the discrete or semi-discrete equations and provides the maximum possible order of accuracy compared to other numerical techniques with a similar structure of discrete or semi-discrete equations. Currently, the new technique is applied to the solution of the time dependent and independent elasticity equations, the wave and heat equations, the Poisson equation, the Helmholtz equation. Homogeneous and heterogeneous materials are considered. The new approach significantly reduces the computation time at a given accuracy compared to other numerical techniques (e.g., it is 1000 and more times faster than finite elements and does not require complicated mesh generators for complex irregular domains due to unfitted meshes; e.g., see [1,2,3]).

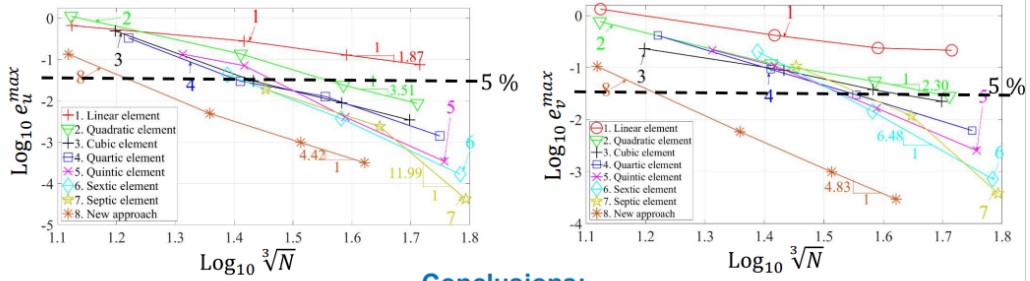
Some other results are related to the development of new finite elements with reduced dispersion that are used for elastodynamics, the time integration methods for elastodynamics problems, finite elements algorithms for the simulation of large thermoelastoplastic deformation and phase transformations as well as the modeling of numerous engineering problems.

3-D wave equation with zero loading and the Dirichlet boundary conditions (3-D trapezoidal prism with a spherical hole) [1]



Exact solution: $u(x,y,z,t) = \sin(5\pi x)\sin(5\pi y)\sin(5\pi z)\cos(\sqrt{35}\pi t)$, $f(x,y,z,t) = 0$
$v(x,y,z,t) = -\sqrt{35}\pi\sin(5\pi x)\sin(5\pi y)\sin(5\pi z)\cos(\sqrt{35}\pi t)$ $\quad t_i = 0 \le t \le t_f = 0.2$

The maximum relative errors in displacement e_u^{max} and in velocity e_v^{max} at time $t_f = 0.2$ as a function of the number of degrees of freedom N for the new approach, curve 8, and linear and high-order FEM, curves 1-7, at mesh refinement



Conclusions:

1. At the same numbers of degrees of freedom *N*, the new 3-D approach, curve 8, with the 27-point stencils (similar to those for the linear FEs) yields much more accurate results than those obtained by the high-order finite elements (up to the seventh order) with much wider stencils, curves 1-7 !!!

2. At the accuracy of 5%, the new approach for 3-D irregular domains reduces the number of degrees of freedom *N* by a factor of greater than 1000 compared to that for the linear FEs!!!

[1] Optimal local truncation error method for 3-D elasticity interface problems, Idesman, A., Mobin M., Bishop J., International Journal of Mechanical Sciences, 271 (2024), 109139.

[2] 11-th order of accuracy for numerical solution of 3-D Poisson equation with irregular interfaces on unfitted Cartesian meshes. Idesman, A. and Mobin M., Computer Methods in Applied Mechanics and Engineering, 2023, pp. 1-22.

[3] Optimal local truncation error method for solution of partial differential equations on irregular domains and interfaces using unfitted Cartesian meshes. Review. Idesman, A., Archives of Computational Methods in Engineering, 2023, 30, pp. 4517–4564.

Product Design & Development Laboratory

Dr. Stephen Ekwaro-Osire, Professor

Who is Dr. Stephen Ekwaro-Osire?
Dr. Ekwaro-Osire has been a faculty member at TTU for 26 years. Prior to that, he practiced in industry.

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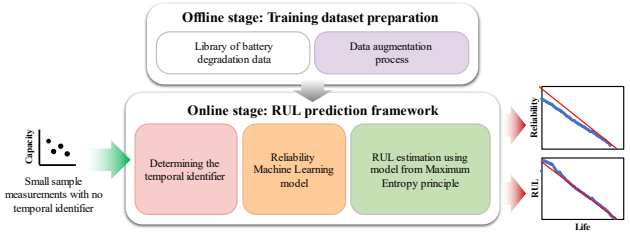
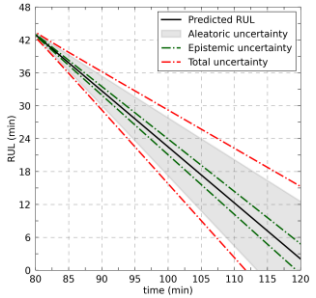
The Product Design & Development Laboratory develops techniques for managing uncertainty in products and systems from the conceptual stage to the end of life.

Highlighted Research



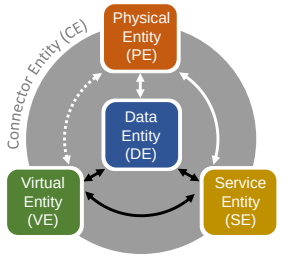
Limited experimental data

- Can the remaining useful life of a Li-ion battery be predicted using a data-driven approach and having limited data without temporal identifiers?
- Published in *Reliability Engineering & System Safety*



Uncertainty in failure modes

- Can uncertainties be quantified in predicting the remaining useful life of systems with multiple failure modes?
- Published in *ASCE-ASME Journal of Risk & Uncertainty in Engineering Systems, Part B: Mechanical Engineering*



Verification & validation using digital twin

- Does implementing V&V using digital twin improve access to data and reduce the effort of data exchange?
- Published in *ASCE-ASME Journal of Risk & Uncertainty in Engineering Systems, Part B: Mechanical Engineering*

Our Expertise

- Product design
- Uncertainty management
- Structural diagnosis & prognosis
- Orthopedic biomechanics

Our Capabilities

- Design methods
- Digital twin
- Experimental methods
- Probabilistic methods
- Deep learning
- Sensitivity analyses

Fazle Hussain's Research Lab

Fazle Hussain, Ph.D., NAE
President's Endowed Distinguished Chair in Engineering, Science, & Medicine, and Senior Adviser to the President, Texas Tech University
Professor, Departments of Mechanical Engineering, Physics, Chemical Engineering, Petroleum Engineering, Internal Medicine, and Cell Physiology & Molecular Biophysics
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Fluid Dynamics Research: Our group is dedicated to the study of fluid dynamics, with a particular focus on understanding the complexities of turbulence and vortex dynamics. We use state-of-the-art computational methods to uncover new insights and applications in this fascinating field. **Research areas:** Wall-bounded turbulence, Flows over roughness, Drag control, Shock and vortex structures interaction, Vortex reconnection, and noise generation mechanisms.

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Cancer Research: We perform fundamental research in cancer cells mechanics, mechanotranduction, fluid mechanics/ Bio-fluidics, effect of naturopathic therapy and role of novel nanotherapies in mitigation of cancer metastasis, cell signaling pathway alterations, and chemoresistance.

Microalgae Research: This is new inclusion of our research initiative where we are studying stress and nanoparticle mediated alteration of microalgae cellular pathways for enhanced production of nutraceuticals, proteins, and clean biofuel.

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