Graduate Projects Meeting
May 3, 2024

Project Initiation Steps

1. Understand the Course Requirements and Procedures
2. Project Proposal Requirements
3. Exploring the available Projects
4. How to add the course

Course Requirements and Procedures

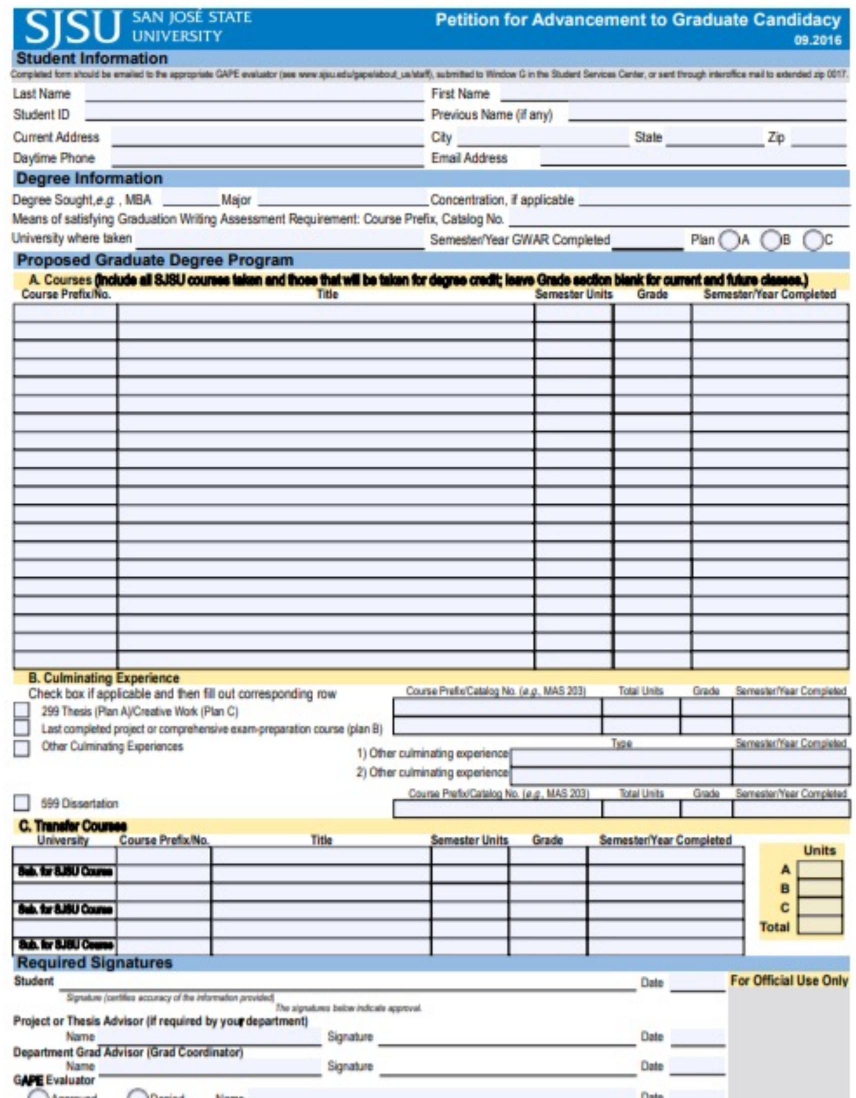
Prerequisites for ME 295 A and ME 299 Course

- Completed at lease nine-units in the program
- Classified status
- Not Conditionally classified
- Approved Candidacy form (or expected to be approved before submission of the project proposal)
- Not on probation

Project Proposal Requirements

1. Have an approved Candidacy Form

Form is available on the ME website



SJSU SAN JOSÉ STATE UNIVERSITY — Petition for Advancement to Graduate Candidacy 09.2016

Student Information

Last Name ____ First Name ____
Student ID ____ Previous Name (if any) ____
Current Address ____ City ____ State ____ Zip ____
Daytime Phone ____ Email Address ____

Degree Information

Degree Sought,e.g. , MBA ____ Major ____ Concentration, if applicable ____
Means of satisfying Graduation Writing Assessment Requirement: Course Prefix, Catalog No. ____
University where taken ____ Semester/Year GWAR Completed ____ Plan ◯A ◯B ◯C

Proposed Graduate Degree Program

A. Courses (Include all SJSU courses taken and those that will be taken for degree credit; leave Grade section blank for current and future classes.)

Course Prefix/No.	Title	Semester Units	Grade	Semester/Year Completed

B. Culminating Experience

Check box if applicable and then fill out corresponding row

- ☐ 299 Thesis (Plan A)/Creative Work (Plan C)
- ☐ Last completed project or comprehensive exam-preparation course (plan B)
- ☐ Other Culminating Experiences — 1) Other culminating experience; 2) Other culminating experience
- ☐ 599 Dissertation

C. Transfer Courses

University	Course Prefix/No.	Title	Semester Units	Grade	Semester/Year Completed
Sub. for SJSU Course					
Sub. for SJSU Course					
Sub. for SJSU Course					

Units: A, B, C, Total

Required Signatures

Student ____ Date ____ For Official Use Only
Project or Thesis Advisor (if required by your department) Name ____ Signature ____ Date ____
Department Grad Advisor (Grad Coordinator) Name ____ Signature ____ Date ____
GAPE Evaluator ◯Approved ◯Denied Name ____ Date ____

Project Proposal Requirements

Candidacy Form and Step-by-step Instructions for Filling out the Form

https://www.sjsu.edu/me/student-resources/forms/graduate.php

Requirements

2. A completed proposal should include:

A. The Project Cover Page

B. Approved committee evaluation

C. A copy of the approved Candidacy Form

D. A comprehensive and detailed proposal of the project

NOTE: Submit all the four items in the listed order and as one package

- **How to Write a Project Proposal?**

- **https://www.sjsu.edu/me/programs/ms-in-mechanical-engineering/project-and-thesis/project-proposal.php**

B. Committee Evaluation Form

MSME Project/Thesis Proposal Evaluation

San Jose State University   Department of Mechanical Engineering

Title:	___ Project ___ Thesis
Student Name:	SJSU ID:

Evaluators	Signature	Date
Committee Chair:		
Committee Member 1:		
Committee Member 2:		

Criterion	Committee Chair			Committee Member 1			Committee Member 2		
	Acceptable	Acceptable w/ [illegible]	Unacceptable	Acceptable	Acceptable w/ [illegible]	Unacceptable	Acceptable	Acceptable w/ [illegible]	Unacceptable
The **title** used effective wording to communicate the purpose and scope of the study accurately.									
The **significance and impact** of the endeavor were presented convincingly, and it was evident how the work benefits society or advances state-of-the-art in the topic of study.									
A sufficient **literature review** was conducted, and it revealed an understanding of relevance to the topic of study. A need that motivates the proposed project was identified.									
A clear engineering **objective statement** was stated, and it had appropriate technical rigor for graduate level study. Design or performance specifications (if applicable) were explicitly identified.									
A detailed description of the **methodology** and a realistic **implementation plan** were described, including required resources, contingency plans, and timeline.									
Tangible **deliverables** were stated explicitly, in a way that can be objectively measured.									
Wording, style, grammar, and spelling were used appropriately for graduate level technical **writing**.									
The proposal complied with all **format requirements** as stated in the ME 295/298 proposal guidelines.									
Overall, the proposal established high confidence that the endeavor will be completed successfully.									

3. Have the Proposal Ready

A proposal is considered complete when Signed by:

1. *Your committee Chair*
2. *The Graduate Advisor*
3. *The department Chair*

4. Post-Proposal Requirements

Meet regularly with the committee Chair and the committee members and have them sign the meeting-record form, shown on the next page

Committee Chair and Members Consultation Form

https://www.sjsu.edu/me/docs/graduate-thesis-project_committeechair_memberconsultation_records-eform.pdf

5. Oral Presentation

Make an Oral Presentation:
(Dead day of Classes)

NOTE: This is scheduled by the ME office

5. Oral Presentation

Before the Oral presentation:

Submit a final draft of the final report to your committee members

Deliverables

1. Midterm Report: Check with your committee chair

2. Oral Presentation

3. Final Report (draft): Before you make the Oral presentation

4. Advisory committee consultation form

4. Final Report: For due date, check with your Committee Chair

How to Arrange for the Oral Presentation?

Contact the ME office to schedule your oral presentation. The ME office will contact your advisory committee and schedule your presentation.

How to Add ME 295 A or ME 299

- You must have an **approved** proposal to get an add code.
- After the proposal is fully approved, ask your committee chair for an add code for the course
- No Pre-registration allowed

Important dates and Deadlines

This Semester:

- **May 3, 2024**
  - *Project Initiation Meeting*
- **May 3, 2024 through May 15, 2024**
  - *1. Search for Possible Projects*
  - *2. Contact ME Professors and select a Committee Chair*
  - *3. Form the advisory committee*
  - *4. Conduct a literature search on the project-topic and prepare a draft of the project proposal.*

Important dates and Deadlines

Next Semester

- **August 21, 2024, through September 10, 2024:**
  - *Finalize the draft of the project proposal*
  - *Have the proposal approved by the advisory committee*
  - *Be ready to submit the proposal to the department office*

- **September 10, 2024:** *Submit the approved proposal to the ME office, for approval by the Graduate Advisor and the department Chair*

- **September 17, 2024**: ***University Deadline for adding a course***

Note

When your proposal is approved by the ME office, you can obtain the add code from your committee chair.

Available Projects

Design, Development, Control, and AI

for

Assistive Robotic Systems

Mojtaba Sharifi

Assistant Professor, Department of Mechanical Engineering
Director, ARMS Lab & Mechatronics Lab

Research, Scholarship, and Creative Activity (RSCA) in 5 minutes

RSCA IN 5

SJSU SAN JOSÉ STATE UNIVERSITY

ARMS LAB
Assistive Robotics and Medical Systems Lab

Community Needs

US 2020 Census

- 55.7 million (16.8% of population) aged 65+
- By 2040, 21.6% of the US population will be 65+

CDC: “Disability Impacts All of Us”

- 61 million adults and children with disabilities
- 17.5% in San Francisco and 16.4% in Santa Clara

Community Challenges

- Performing daily living activities
- Commute to their destinations independently

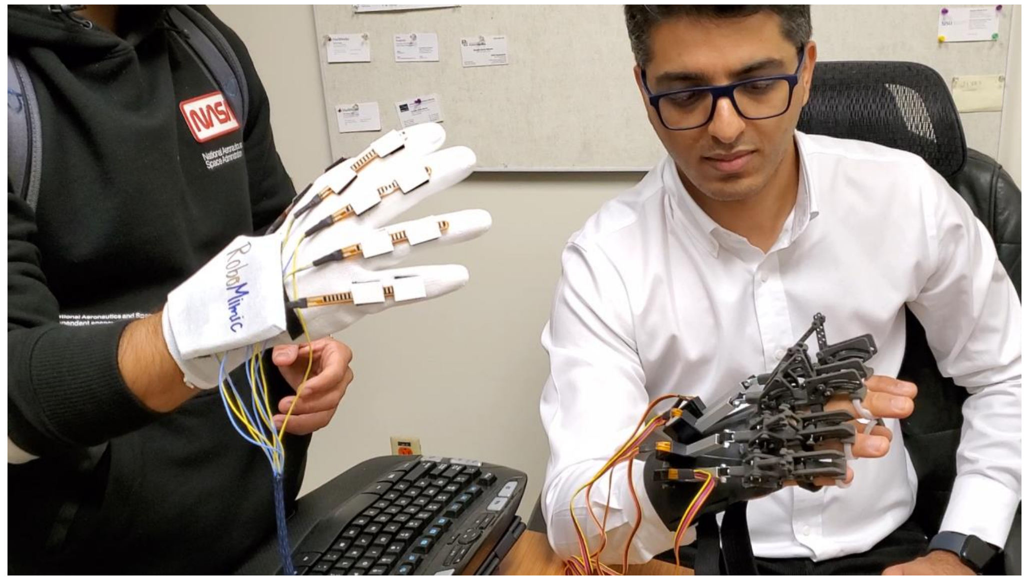
RSCA IN 5

ARMS LAB
Assistive Robotics and Medical Systems Lab

SJSU

ARMS Lab Products

Most Innovative Project at CoE Showcase 2024



- **Design, fabrication, and control of robotic systems**
  - Lightweight, high-torque, and cost-effective exoskeletons and walkers
  - Control and AI for exoskeletons and walkers

Most Engaging Project at CoE Showcase 2023

Lower limb exoskeletons

Upper limb exoskeletons

RSCA IN 5

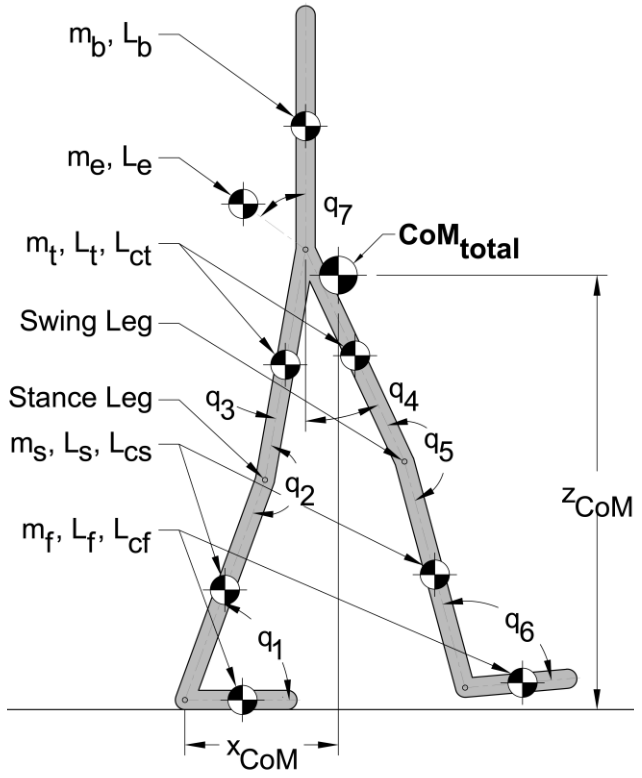
Research Project 1
Control and Autonomy

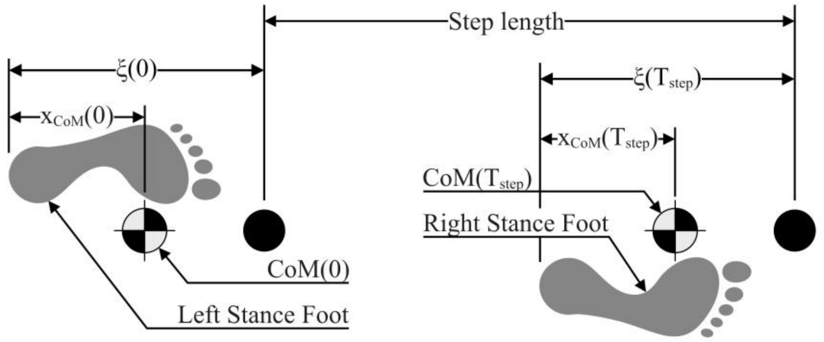
- **Intelligent control** of **lower-limb exoskeletons**
  - Personalized walking trajectories (autonomy)
  - Providing postural stability (safety)

- **High level: Online path planning and postural stability**
  - Adaptive central pattern generator (ACPG)
  - CoM adjustment using DCM and ZMP strategies
  - Reinforcement learning for adjusting controller gains

- **Low level: Position, torque and impedance control**
  - Impedance control with variable parameters
  - Joint position and motor torque control

- **NSF funding: Tuition waived**





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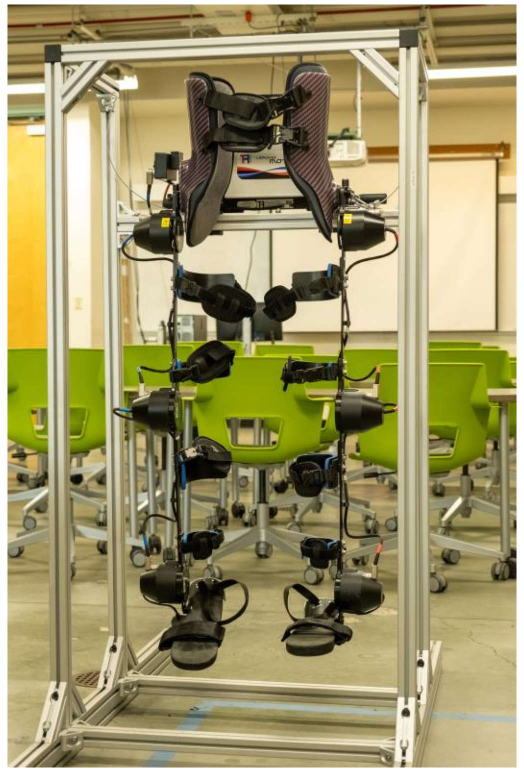
Research Project 2
Control and Autonomy

- **Need analysis for populations with disabilities**
  - Identify areas for modification and adapt the Exo-H3 for population with physical disabilities.
  - In-depth interviews with researchers, expert clinicians, caregivers, patients with physical disabilities.
  - Evaluate the appropriateness, acceptability, usability, and feasibility of the Exo-H3 for populations with physical disabilities: knee, hip, or ankle impairments

- **Programming and control of exoskeleton**
  - Programming Exo-H3 to deliver safe physical therapy
  - Creating a user-friendly interface to adjust controller gains and safety thresholds for end-users

- **Collaboration and funding**
  - Committee member from Department of Occupational Therapy
  - Option to receive external funding



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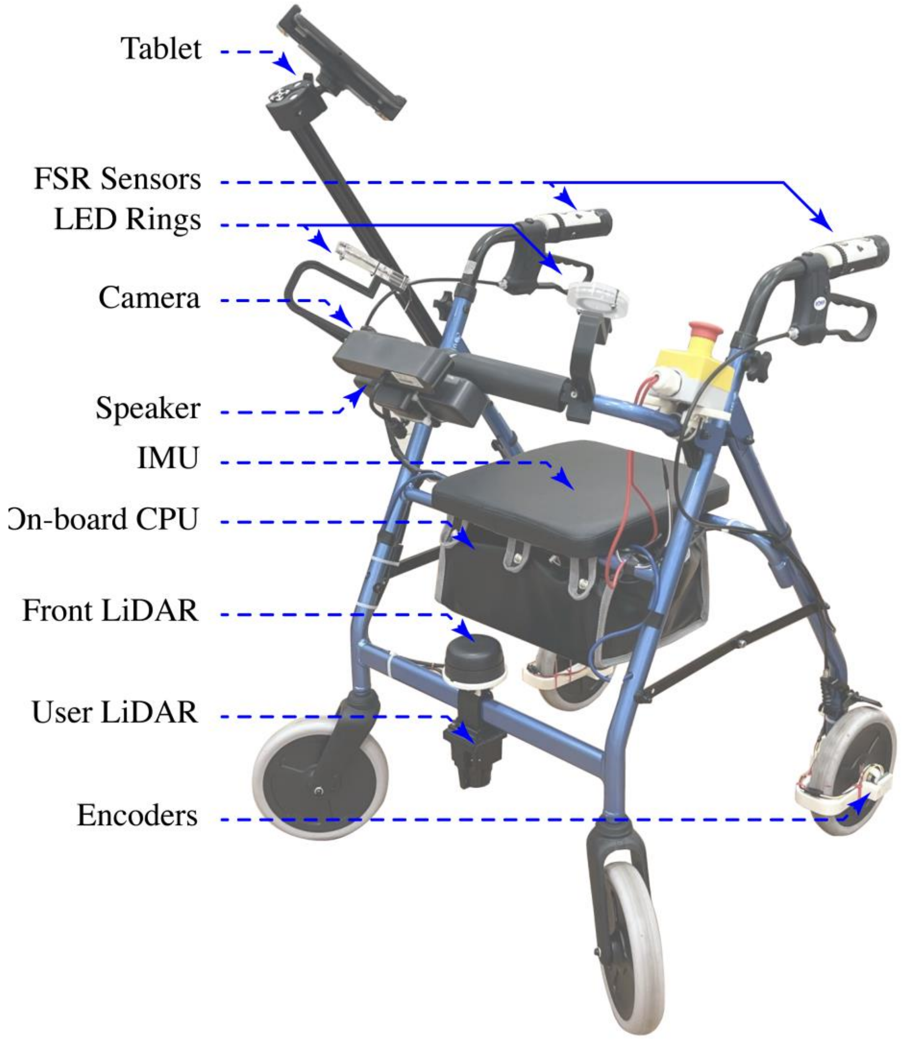
Research Projects 3

Design and Fabrication

- **Need analysis for populations with disabilities**
  - Identify areas for design modification and sensorizing a walker for different populations
  - People with dementia and visual impairments
  - Interviews with expert clinicians, caregivers, patients with various physical and mental disabilities

- **Modification of autonomous assistive walker (AAW)**
  - Equip the walker with force sensors, biofeedback sensors, light feedback and a tablet
  - Add automated brakes with linear actuators



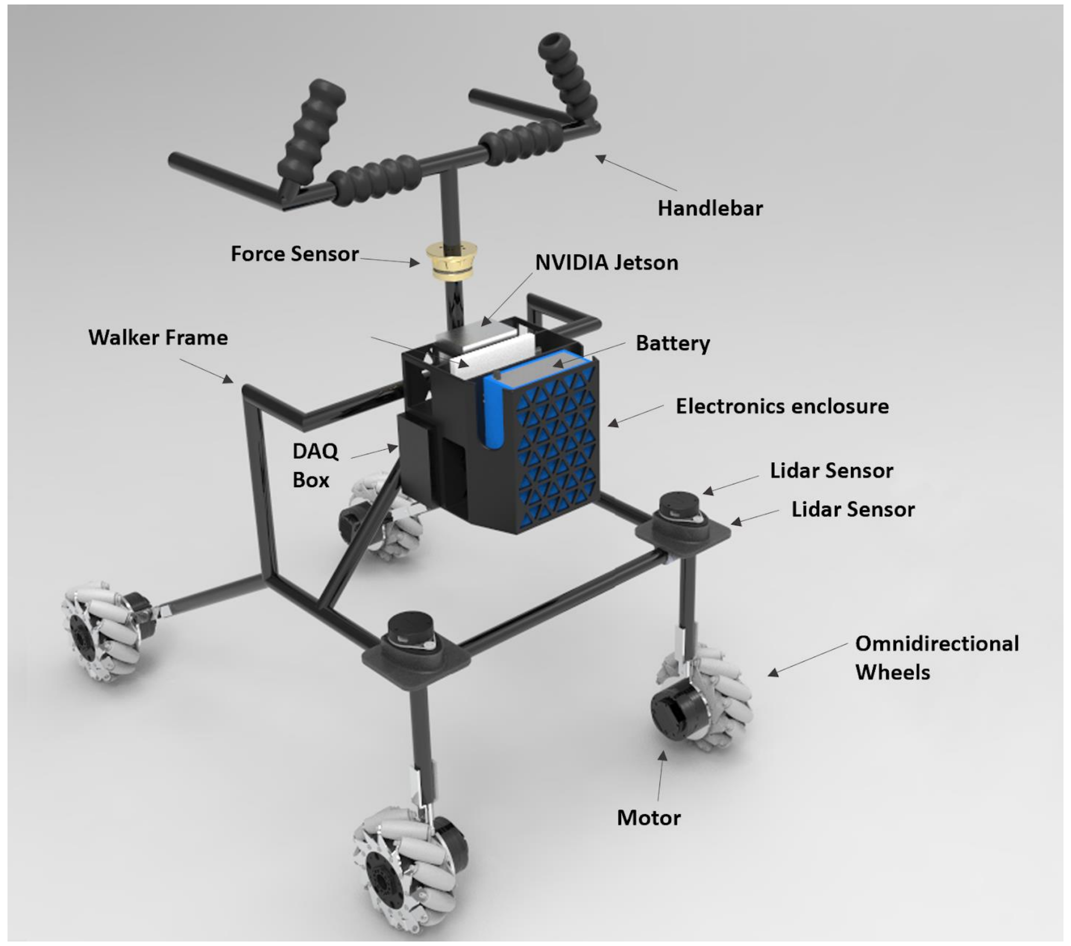
- **Collaboration and funding**
  - Committee member from Bristol Robotics Lab (UK)
  - Option to receive external funding

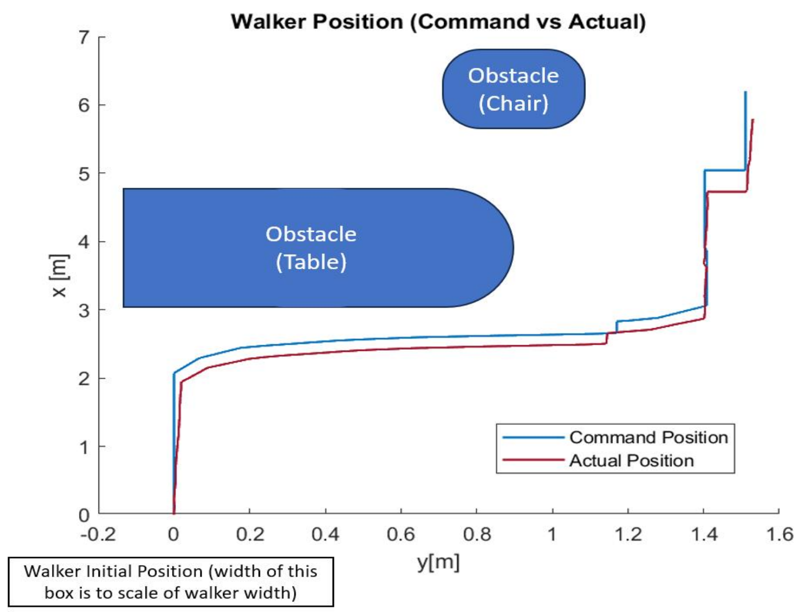
RSCA IN 5

Research Project 4
Control and Autonomy

- **Control of autonomous assistive walker (AAW)**
  - Online motion planning in ROS environment
  - 6-axis force/torque sensor for measuring human interaction and determine the user's desired direction and speed of movement
  - RP Lidar 2D scanning sensors and depth camera to observe static and dynamic obstacles
  - Walker’s position control for postural stability enhancement

- **Collaboration and funding**
  - Committee member from Bristol Robotics Lab (UK)
  - Option to receive external funding





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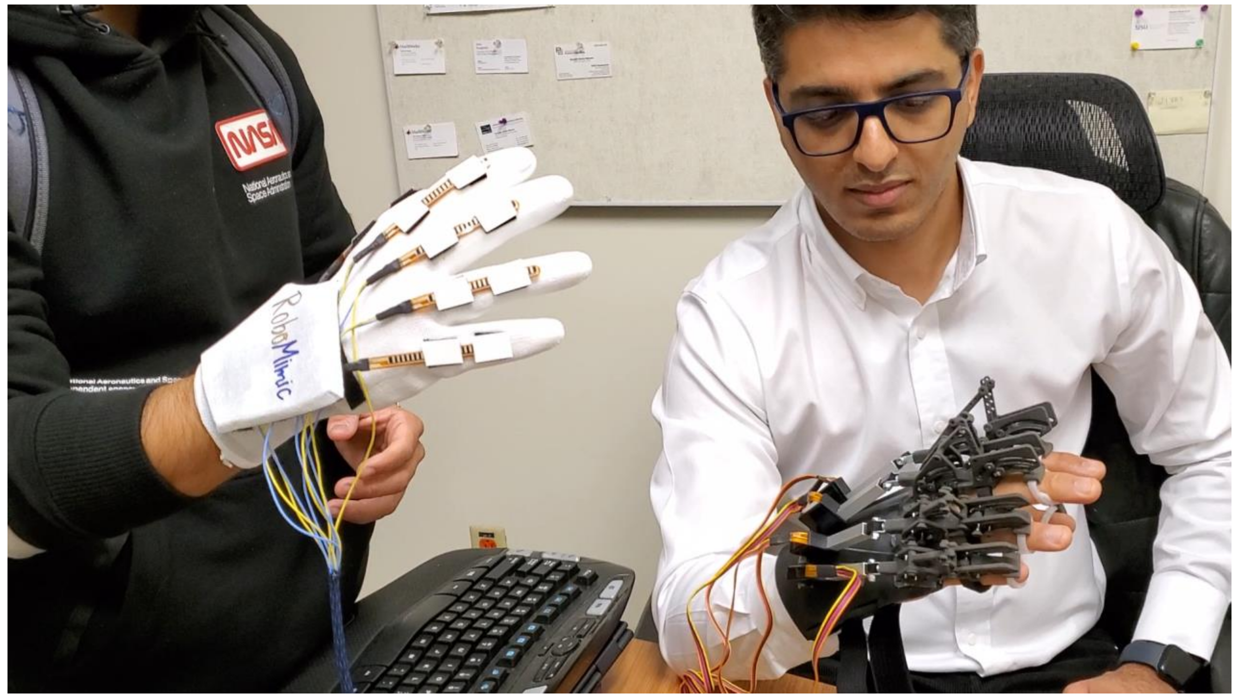
Research Projects 5
Design and Mechatronics

- **Re-design and modification of wearable robotic systems**
  - Design change to have more comfortable HRI
  - Add sensors, soft parts, and mechatronic system
  - Prepare the prototype for user studies



Hand exoskeleton

Lower limb exoskeleton

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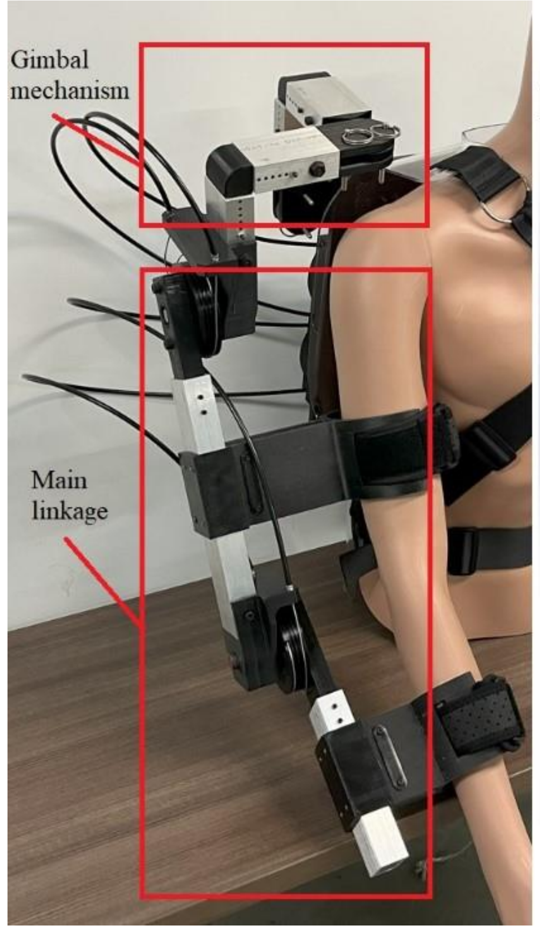
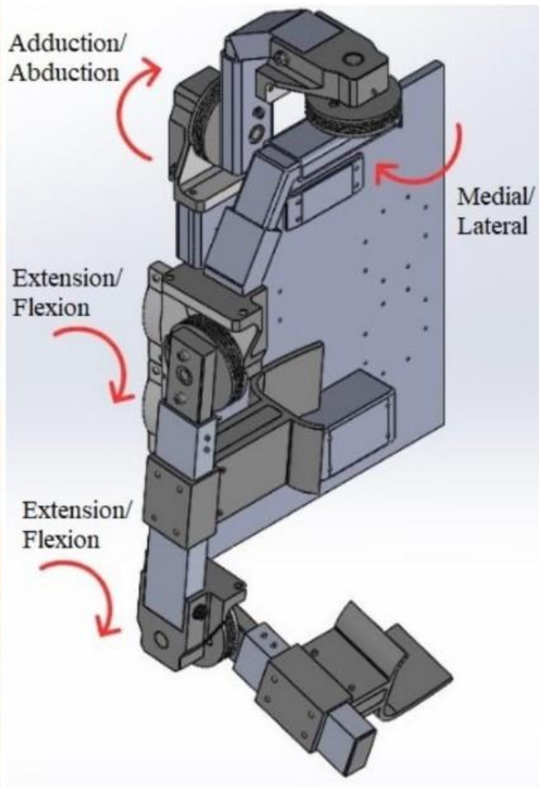
Research Project 6
Control and Autonomy

- **Need analysis for populations with disabilities**
  - Identify areas for modification and adapt our exoskeletons for population with physical disabilities.
  - In-depth interviews with researchers, expert clinicians, caregivers, patients with physical disabilities.
  - Evaluate the appropriateness, acceptability, usability, and feasibility of our exoskeleton for populations with physical disabilities: knee, hip, or ankle impairments

- **Programming and control of exoskeleton**
  - Programming exoskeleton to deliver safe physical therapy

- **Collaboration and funding**
  - Committee member from Department of Occupational Therapy
  - Option to receive external funding





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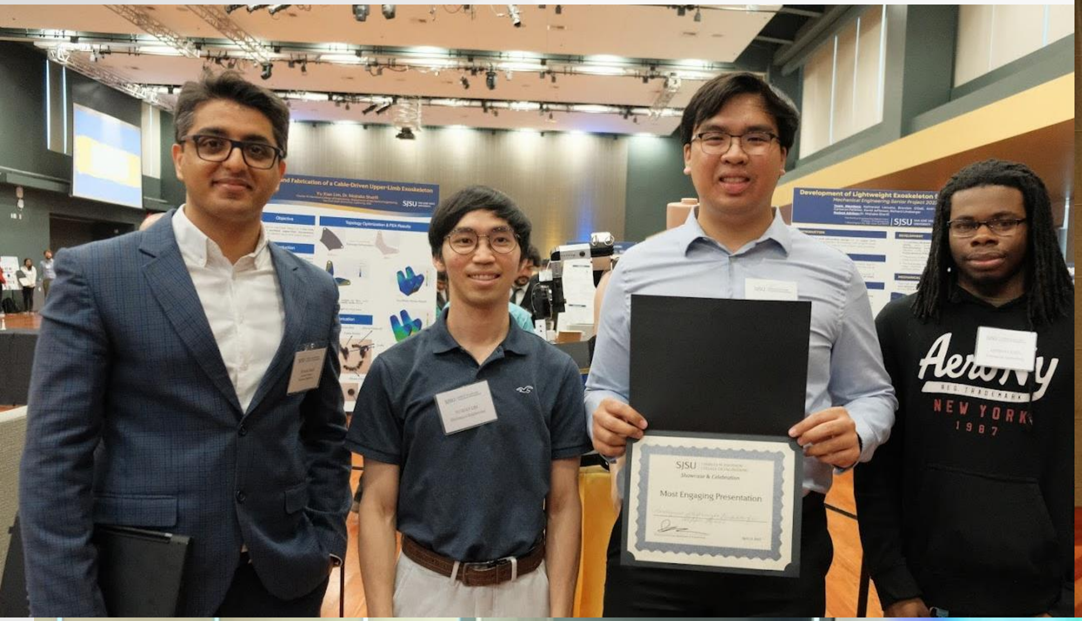

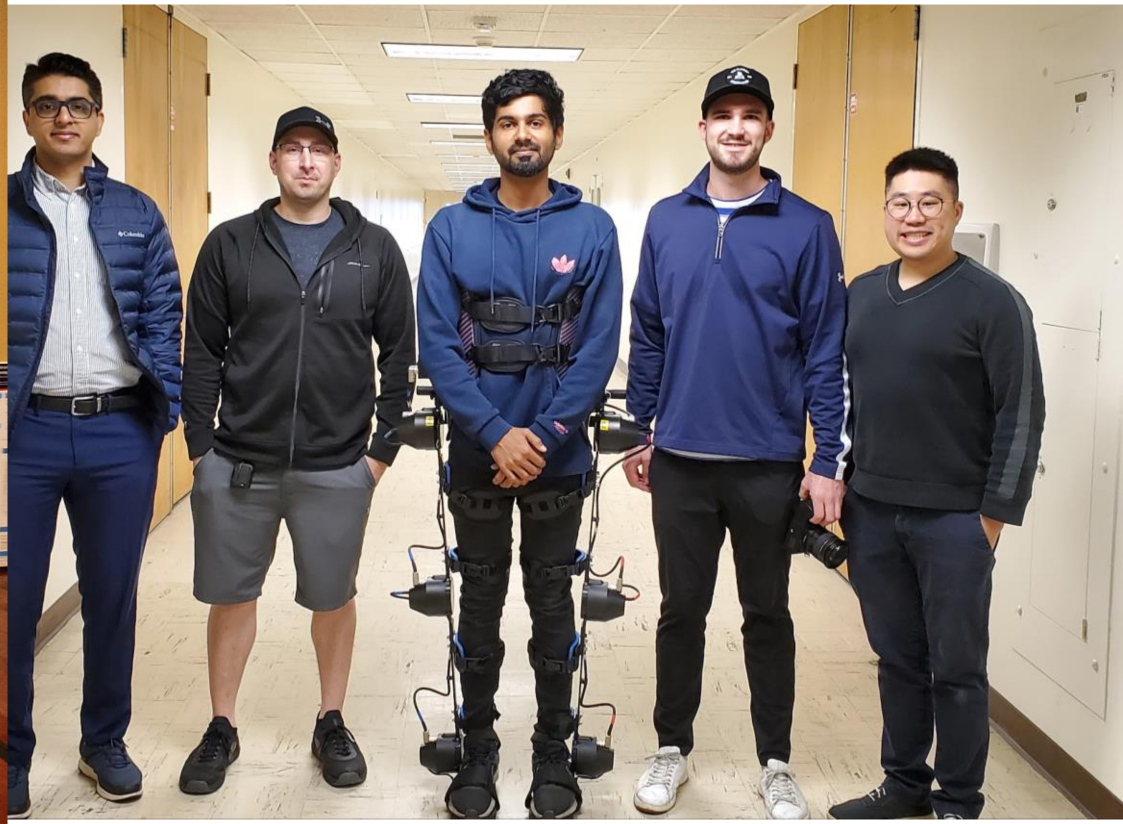

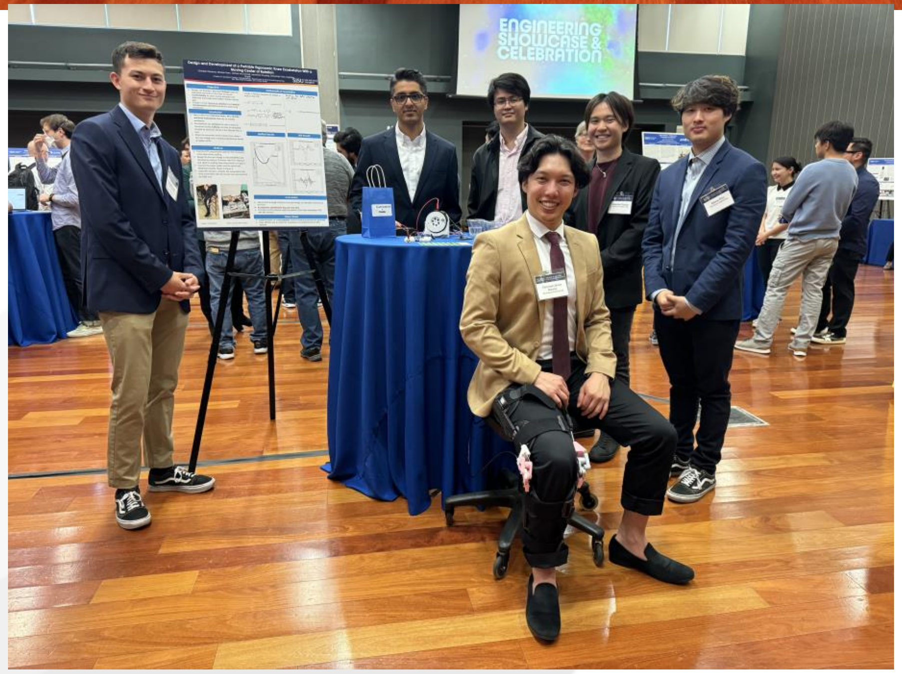

Email: mojtaba.sharifi@sjsu.edu, Phone: +1-408-898-8254, Website: https://sites.google.com/sjsu.edu/armslab

ARMS LAB
Assistive Robotics and Medical Systems Lab

Thank you

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ARMS Lab Website: https://sites.google.com/sjsu.edu/armslab

Google Scholar: https://scholar.google.com/citations?user=uoQP2HwAAAAJ&hl=en

ResearchGate: researchgate.net/profile/Mojtaba_Sharifi3

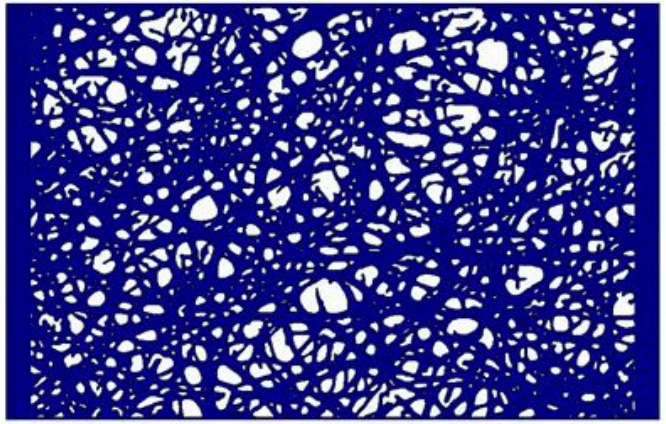
LinkedIn: linkedin.com/in/mojtaba-sharifi-9a0b66182

Student Research Opportunities in Microfluidics and Mechanics of Soft Materials

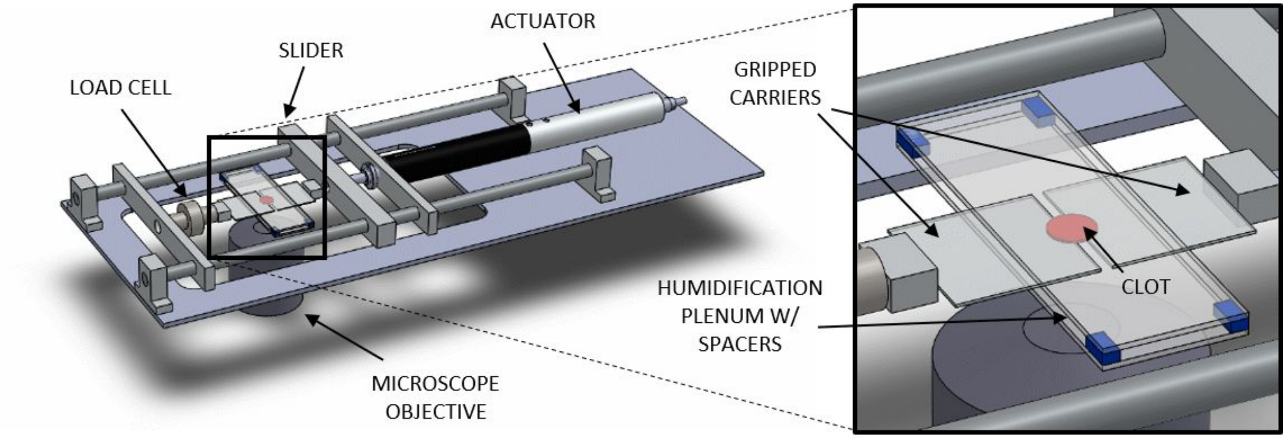
S. J. Lee
sang-joon.lee@sjsu.edu
San Jose State University
February 2, 2024

Modeling and simulation of blood clot mechanics

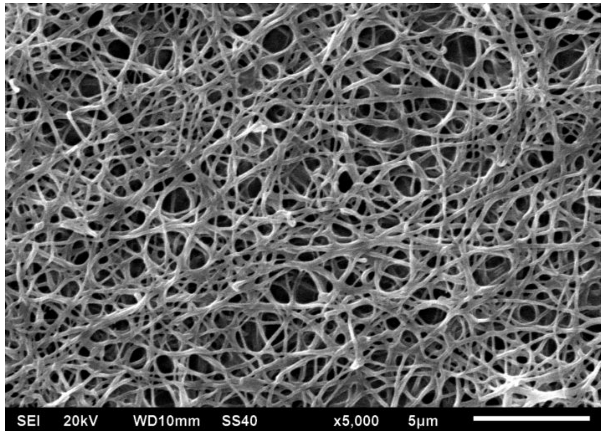
In collaboration with Dr. Ramasubramanian (Chemical Engineering), Dr. Dasbiswas (UC Merced) and Dr. Gopinath (UC Merced)



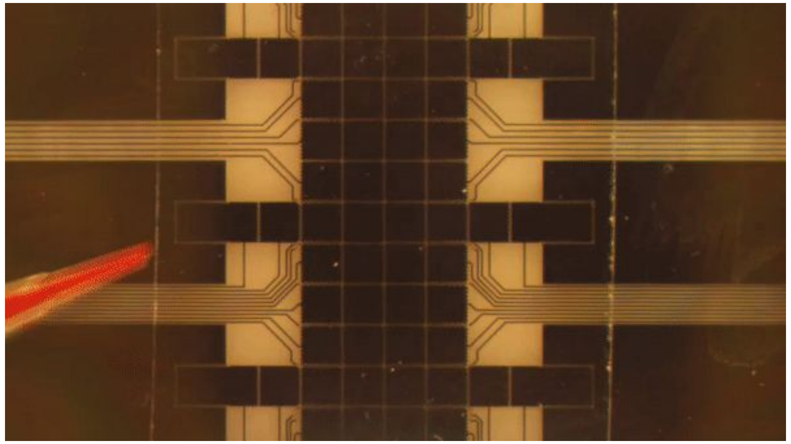
Finite element simulation of strain energy density* distribution through a fibrin network under tension



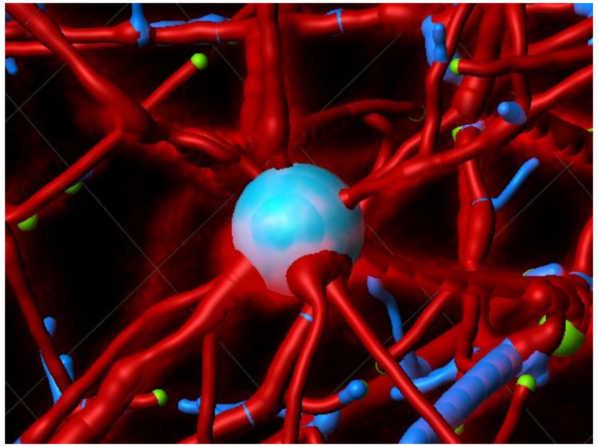
Design of apparatus for simultaneous extension and fluorescence microscopy.



Scanning electron microscope image of fibrin network



Stretching of a red blood cell suspension on a microfluidic chip by electrowetting



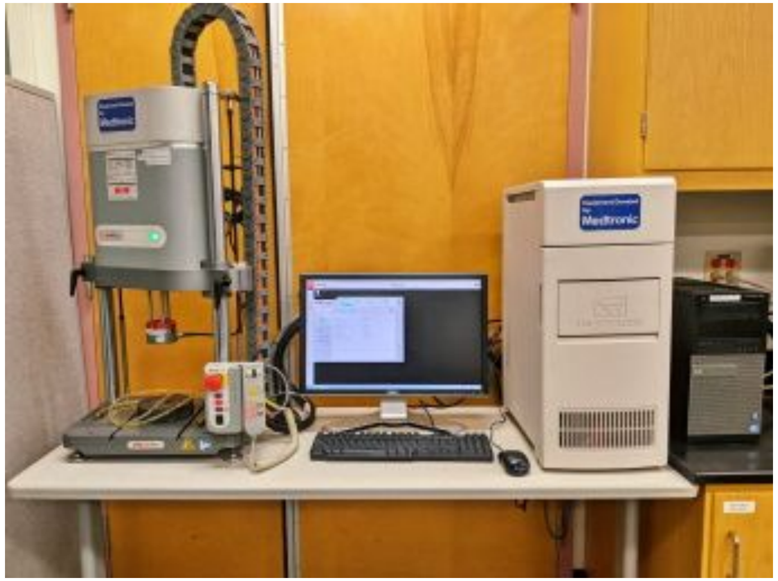
3-D feature recognition and topological reconstruction of network connectivity

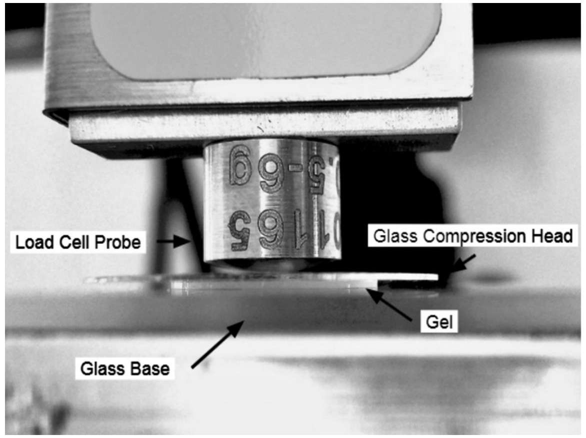
Early work sponsored by the American Heart Association, 2018-2020.

Related prior work: Lee 2020 https://doi.org/10.1007/s10237-019-01203-8, Pathare 2021 https://doi.org/10.1016/j.bpr.2021.100022, Zakharov 2023 https://doi.org/10.1101/2023.03.24.534185

Mechanics of battery polymer electrolytes

In collaboration with Dr. Dahyun Oh (Materials Engineering) and Dr. Min Hwan Lee (UC Merced)





Simultaneous measurement of force and micron-scale displacement

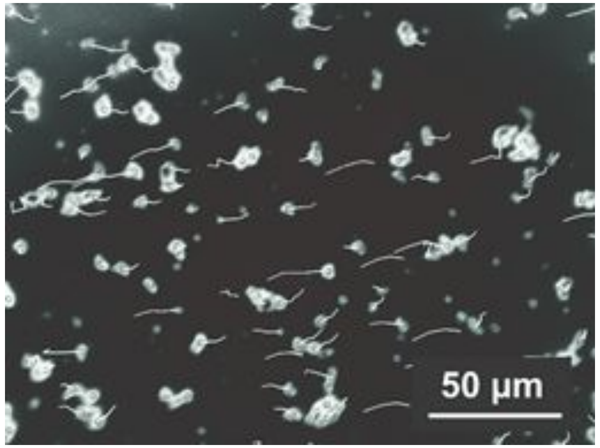
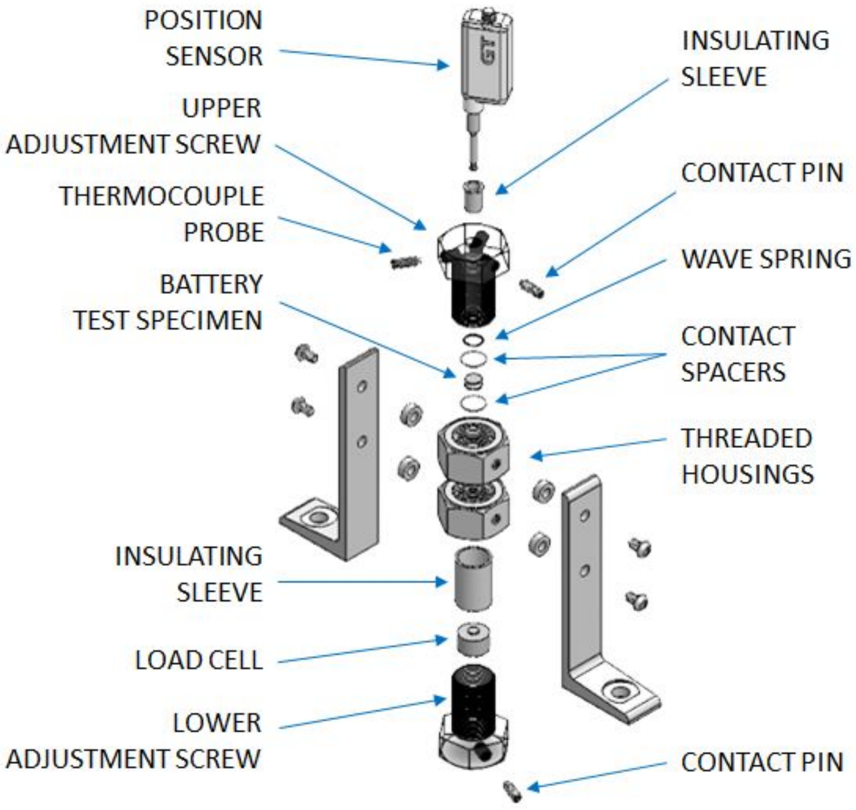


Image analysis and tracking of particle distribution in polymer matrix



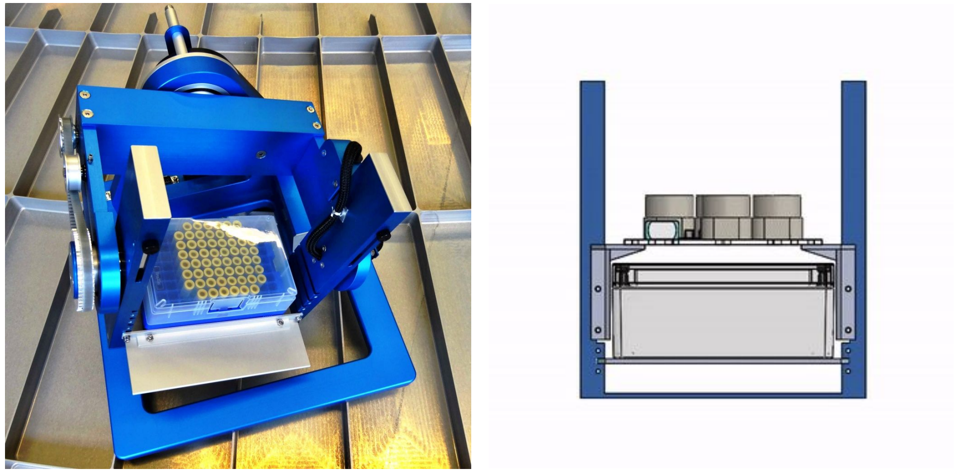
Multifunctional apparatus for simultaneous measurement of mechanical response and electrochemical performance

- This investigation quantifies ceramic particle redistribution within a thin polymer electrolyte, in response to deformation caused by compression.
- The compression mimics volumetric changes that occur during charge and discharge cycles in a lithium-ion battery.

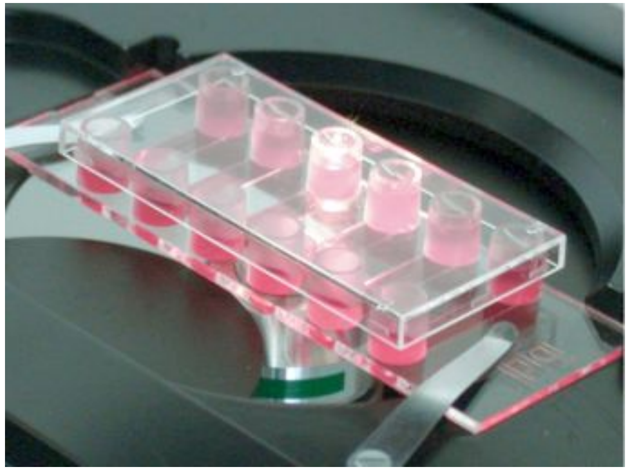
Sponsored by the National Science Foundation, 2022-2024.
Related prior work: Mulay 2022 https://doi.org/10.1115/IMECE2021-69196, Yoon 2023 https://doi.org/10.1021/acsaem.3c01357

Hemodynamics and thrombosis in microgravity

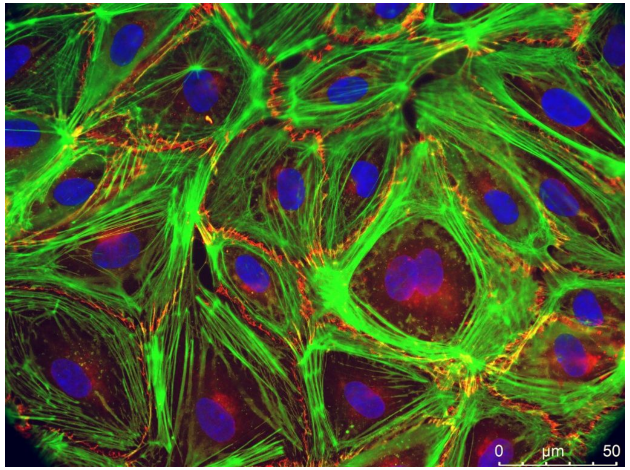
In collaboration with Dr. Anand Ramasubramanian (Chemical Engineering) and Dr. Wendy Lee (Computer Science)



Random positioning machine for simulated microgravity
Photo courtesy of Airbus Defence and Space Netherlands B.V. Used with permission, November 2020



6-microchannel chip on microscope
(photo from https://ibidi.com/)



Fluorescence microscope image
of endothelial cells

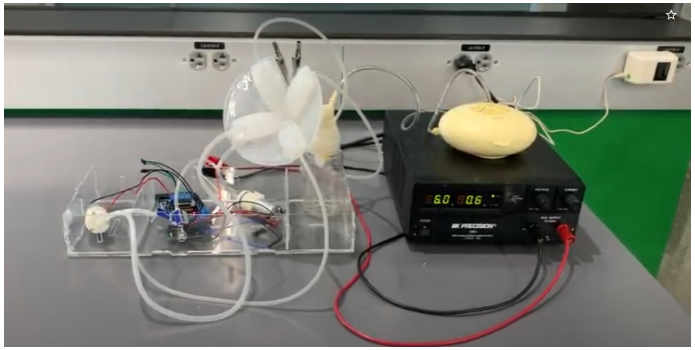
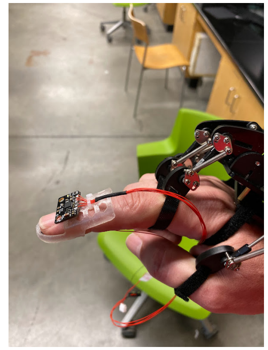
- This project is motivated by unexpected blood clotting in a jugular vein, as experienced by an astronaut on the International Space Station (ISS) during a mission [doi: 10.1001/jamanetworkopen.2019.15011].
- This NASA-sponsored project uses a random positioning machine (left) and perfused microchannels to study how the absence of constant gravitational direction affects endothelial cells and the formation of blood clots.
- An important engineering subsystem performs continuous perfusion system using micropumps and flow meters to mimic blood flow in the absence of normal gravity.

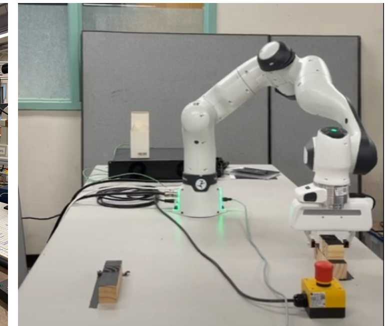
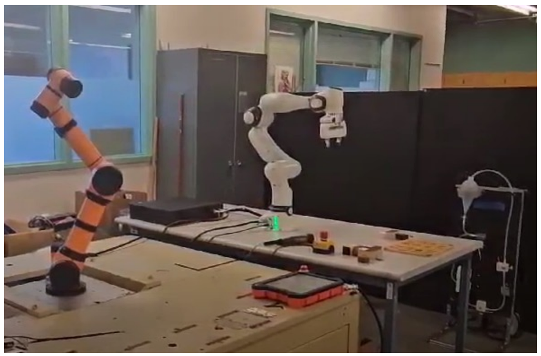
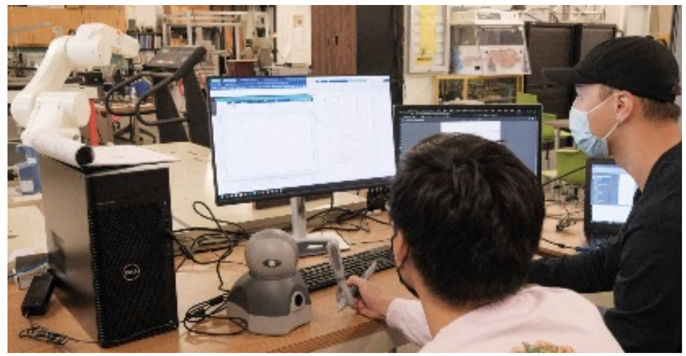
Sponsored by NASA Space Biology, 2021-2024. First manuscript in preparation.

Other notes

- ❏ I typically advise theses only (ME 299) rather than projects (ME 295). Most theses are multidisciplinary and co-advised with at least one committee member who has expertise **beyond mechanical engineering** (e.g., biology, electrochemistry, physics, or otherwise).
- ❏ Student **publications** (e.g., conference papers and/or journal articles) are highly encouraged and supported. All papers in the last several years have been published with student authors, often with a thesis student as the first author.
- ❏ Much of the research is in a **collaborative team environment**. There are typically 3 to 5 thesis students active in any given semester (not exclusively from mechanical engineering). We typically hold weekly lab group meetings in addition to individual thesis advising.
- ❏ ME 168 Microfluidics Fabrication and Design is a recommended hands-on lab class that is highly synergistic with research training.
- ❏ Paid lab assistantships are rare for first-semester students, but limited opportunities may come open to exceptionally qualified and/or more experienced lab members.

Biomechanics and Robotics Lab

Lin Jiang
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Mechanical Engineering
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Biomechanics and Robotics

Medical Device

- Neonatal ICU use Non-invasive assessment systems
- Portable Infant Oral Trainer
- Autonomous Medical Simulator
- Medical Devices for Maternal and Child Health

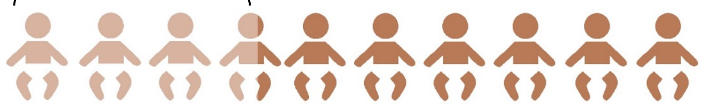
Human-Robot Interaction, Human-Robot Collaboration

- Digital Twin platform for HRI
- Automation and Intelligence Control (AI in robot control)
- Multi-robot communication and collaboration
- Human perception in HRI
- Robot Assisted HRI tasks
  ex. Upper Limb Rehabilitation, Occupational Therapy

Maternal and Child Health

Effective breast milk delivery provides health for both Infants and Mothers

38 % exclusive breastfeed



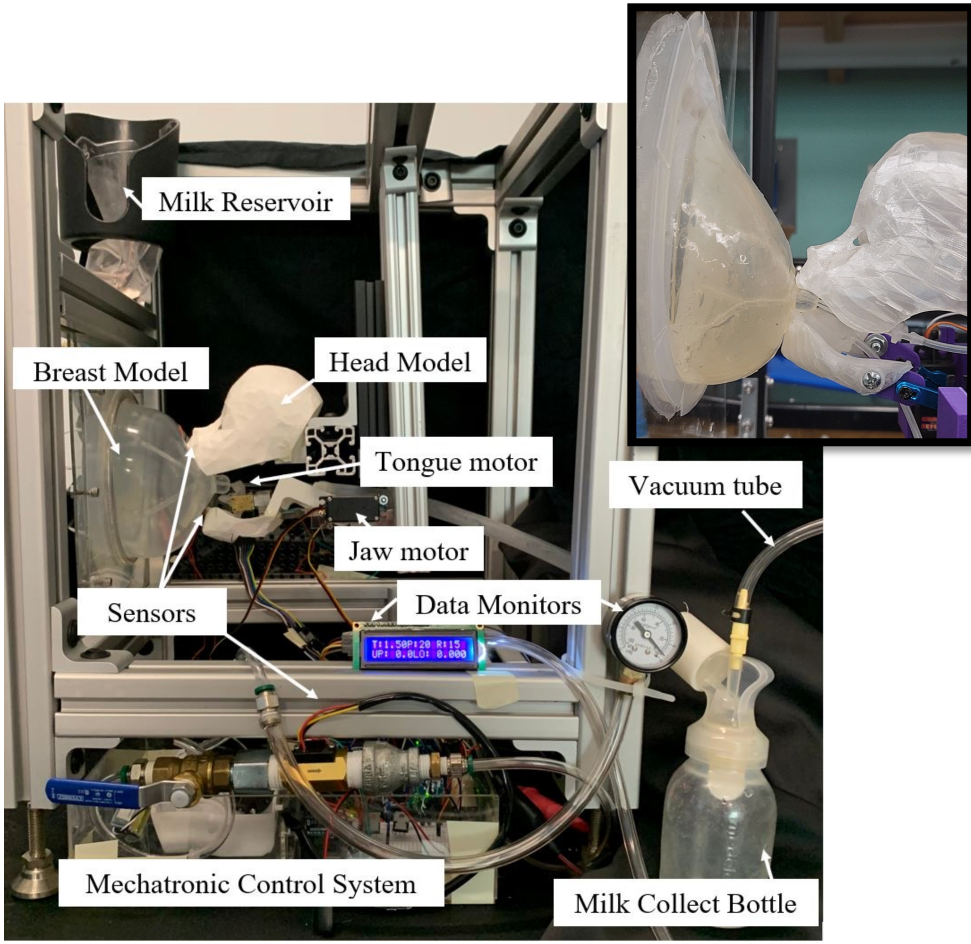
Maternal Factor

- Flat or Inverted Nipples
- Separated from infant
- Duct blockage
- Breast engorgement
- Mastitis/inflammation
- Breast surgery
- High fat breast milk
- Too slow/fast milk flow

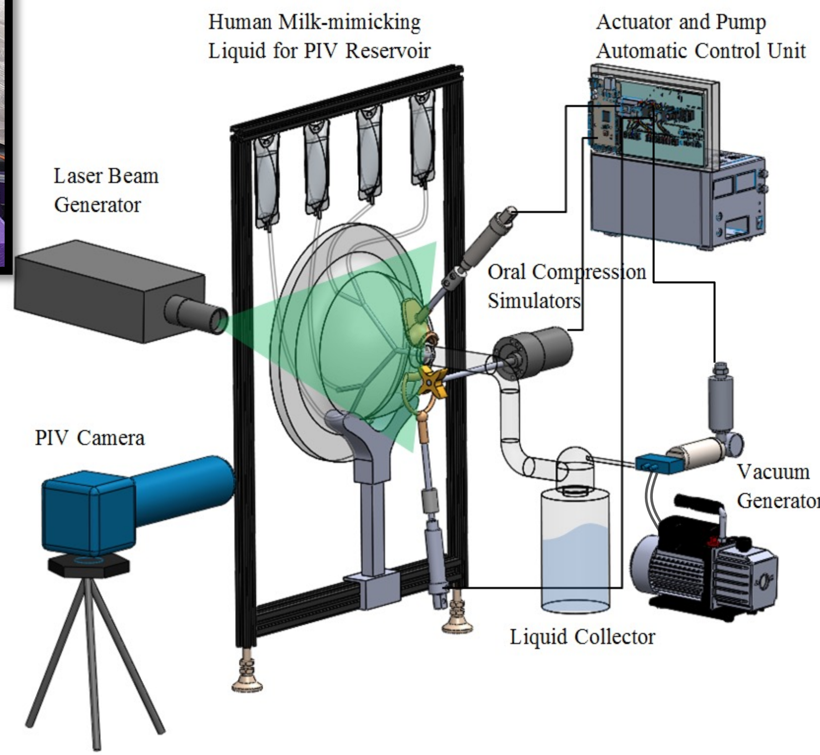
Infant Factor

- Premature Infants
- Tongue-Tie
- Cleft Lip
- Down Syndrome
- Neurological Problems
- Retracted jaw or tongue
- Excessive tongue-tip elevation
- Tongue protrusion/thrusting
- Excessive jaw excursion

Observe and Measure the Bio-fluid Mechanics in Synthetic Organs

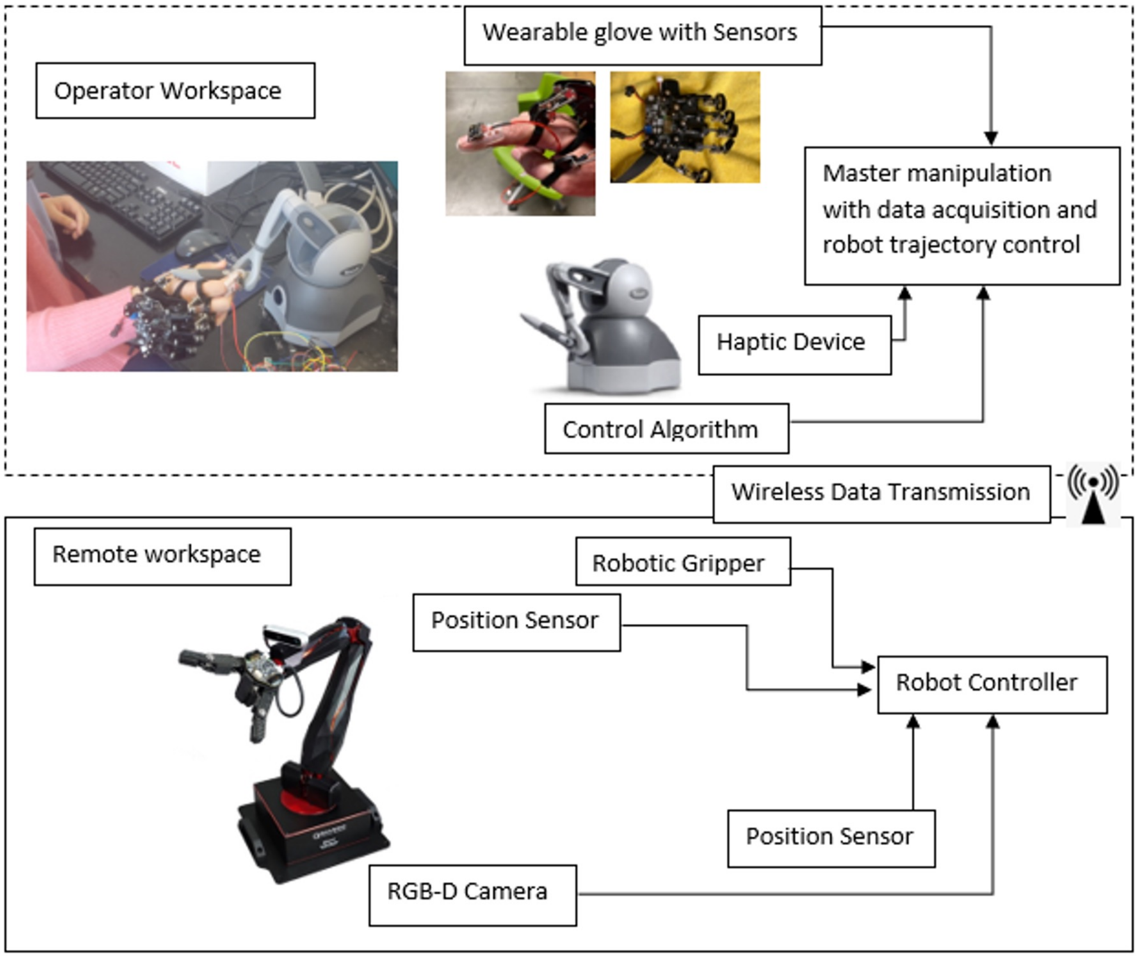


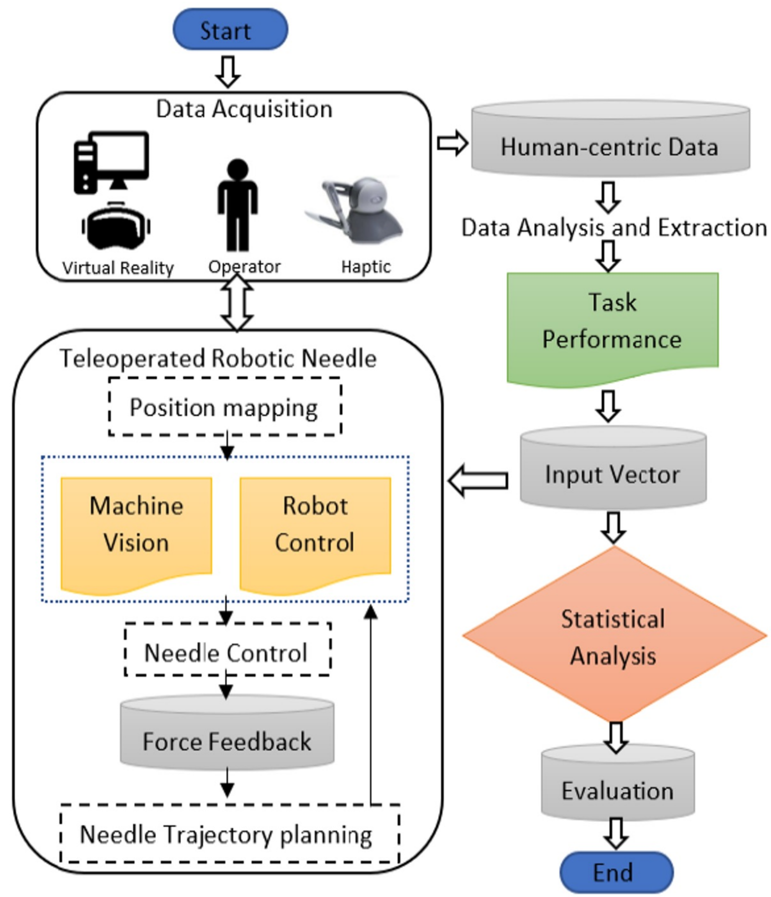
Bio-inspired Synthetic Simulator
Design and Development



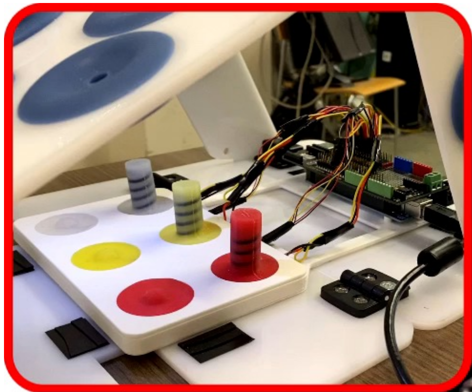
Micro-PIV experiments
in Flexible and Bifurcated Channels

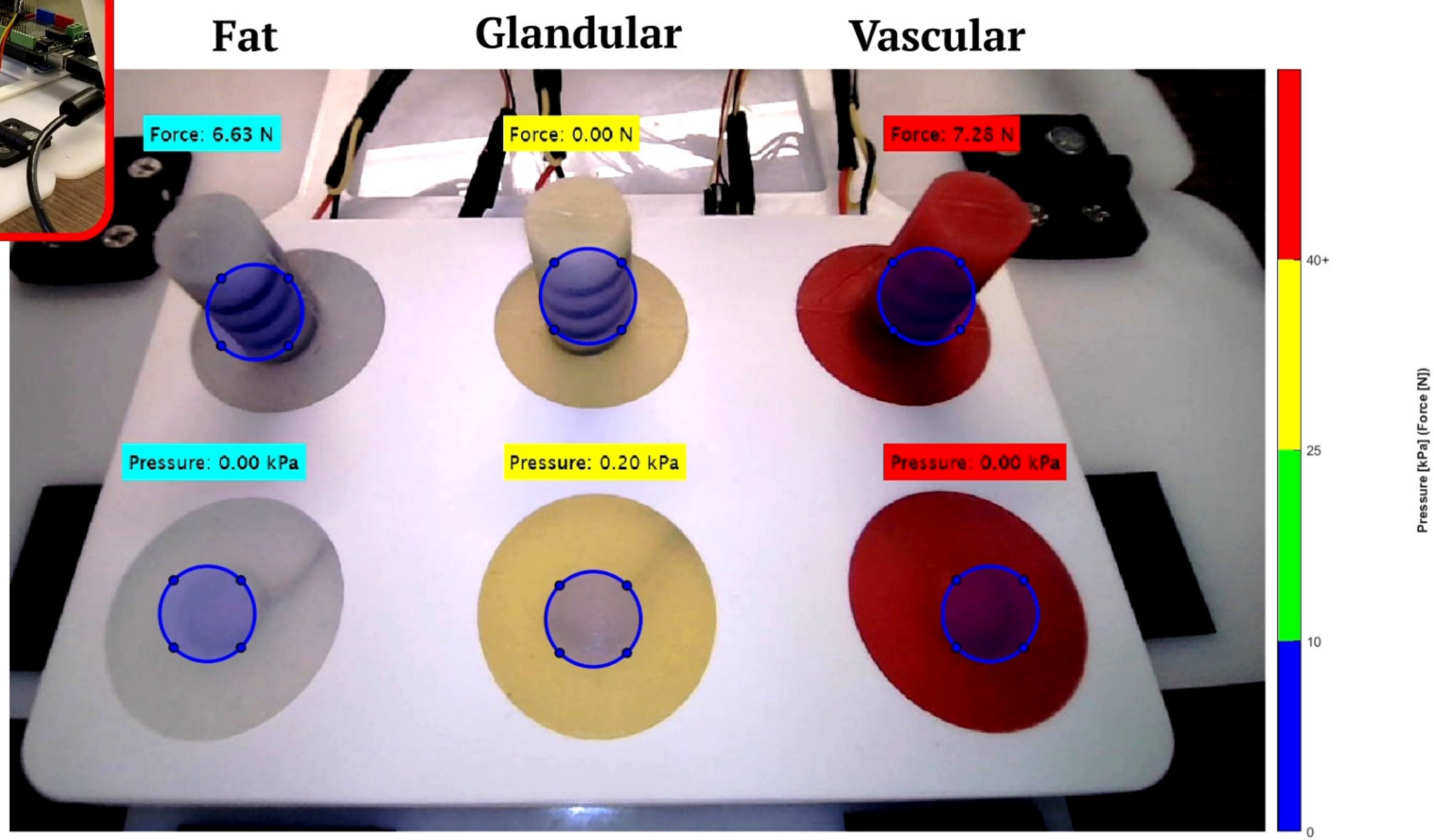
Bilateral Robot Teleoperation



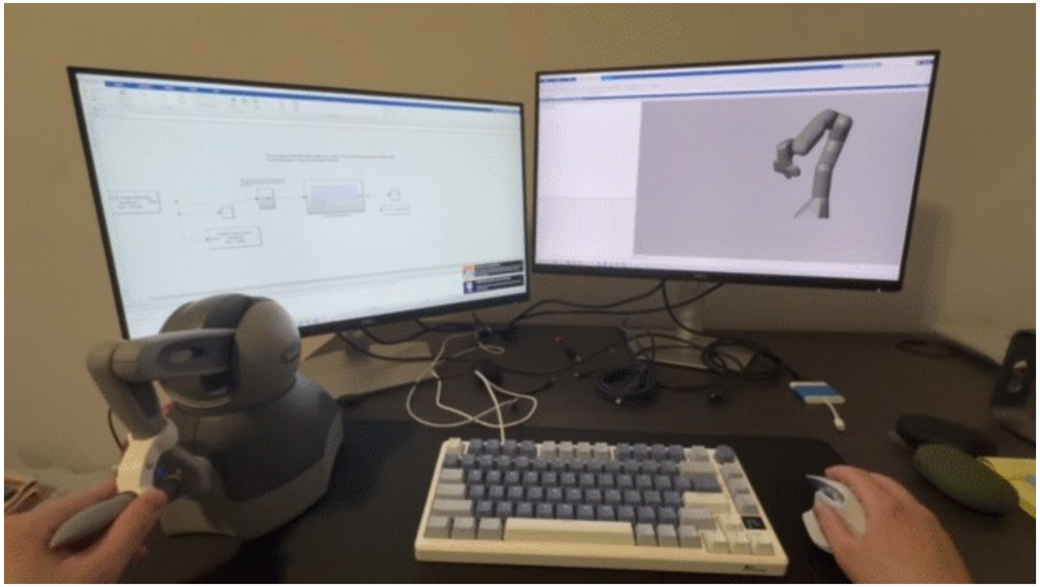


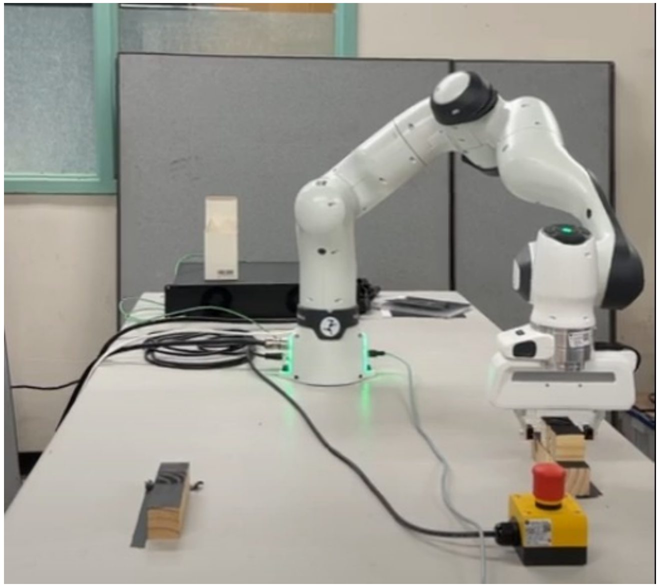
Haptic Feedback



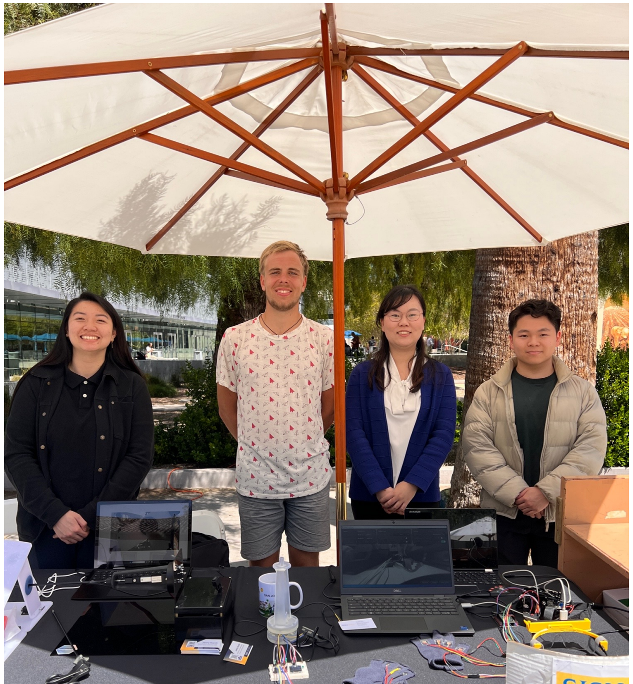


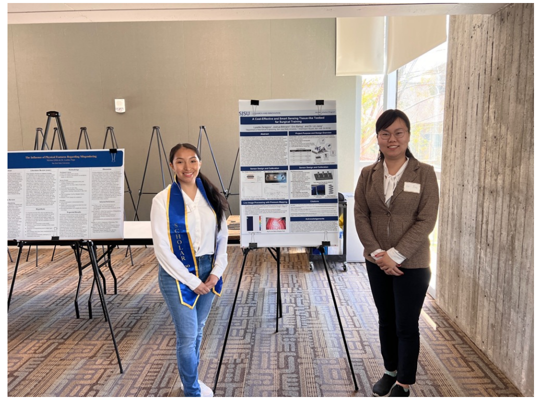
Robot Assist Rehabilitation

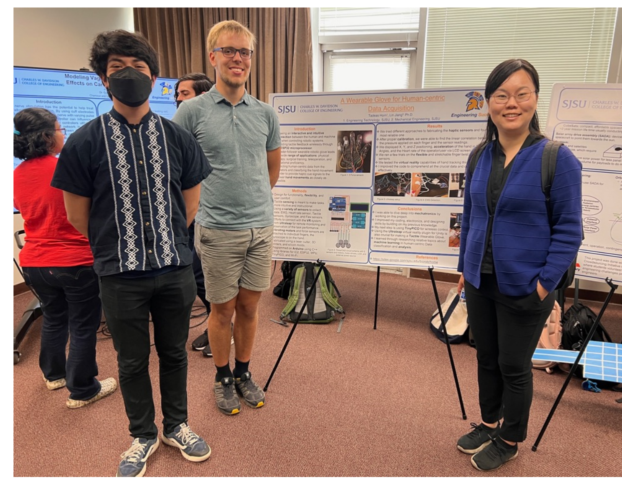


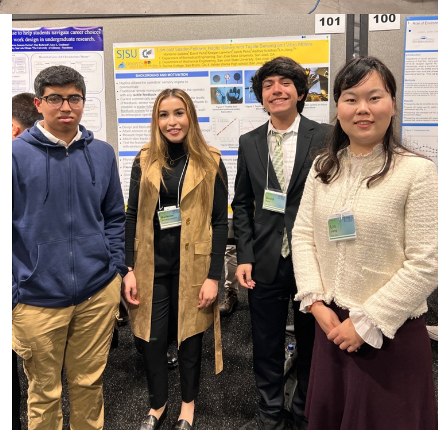


lin.jiang@sjsu.edu









Thank you!

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ME295A/B – Available MS Projects

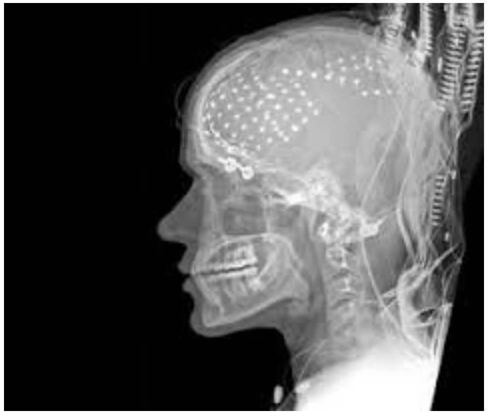
Winncy Du

Remote Control of an Industry Robot for Robotic Education

- Use a 6-axis of Denso Robot
- Develop or use MATLAB or other simulation software to remotely control the robot
- Develop & implement two or three experiments, e.g.,
  - Forward Kinematics
  - Inverse Kinematics
  - Pick-and-place Movement
  - Trajectory Design
- Demonstrate the experiments

Migraine and Sensory Overload Study

- Migraine affects more than 1 billion people worldwide
- Study mechanism of Migraine
- Using EEG sensors or other sensors to identify migraines
- Establish the relationship between a modulated frequency of 100–120 Hz with Migraine level



Mechanical Engineering

Experiment setup
- Using available EEG sensors

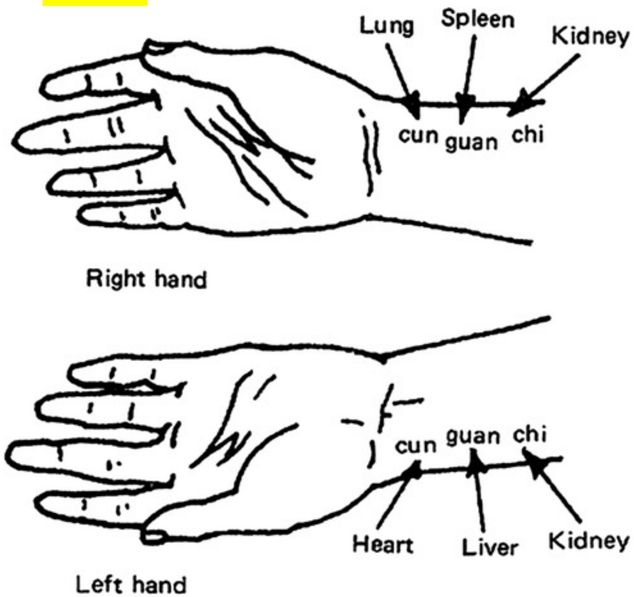
Electrical & Computer

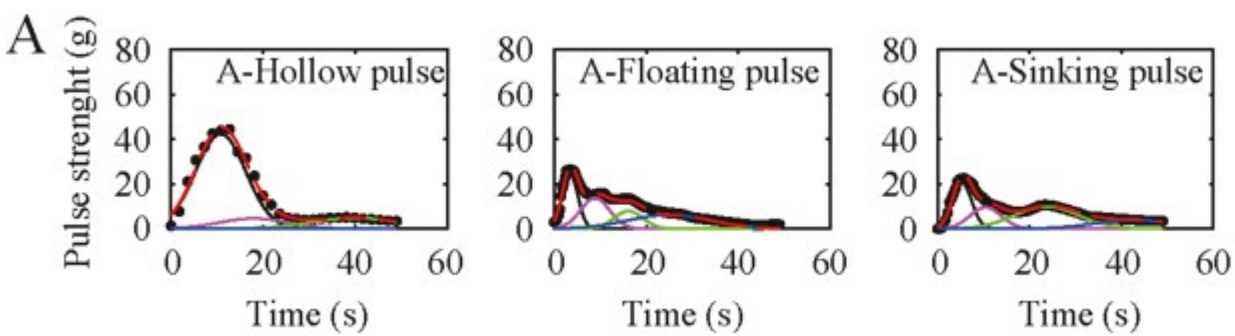
- Testing data acquisition
- Data analysis & findings

Neuroscience

- Neuron activities

Development of Traditional Chines Medicine Pulse Diagnosis System (Wearable Device)





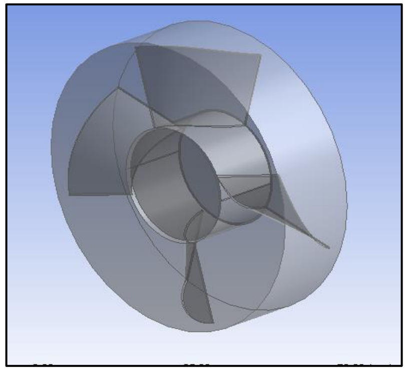
Fluid Retention Associated with Cardiovascular Mortality

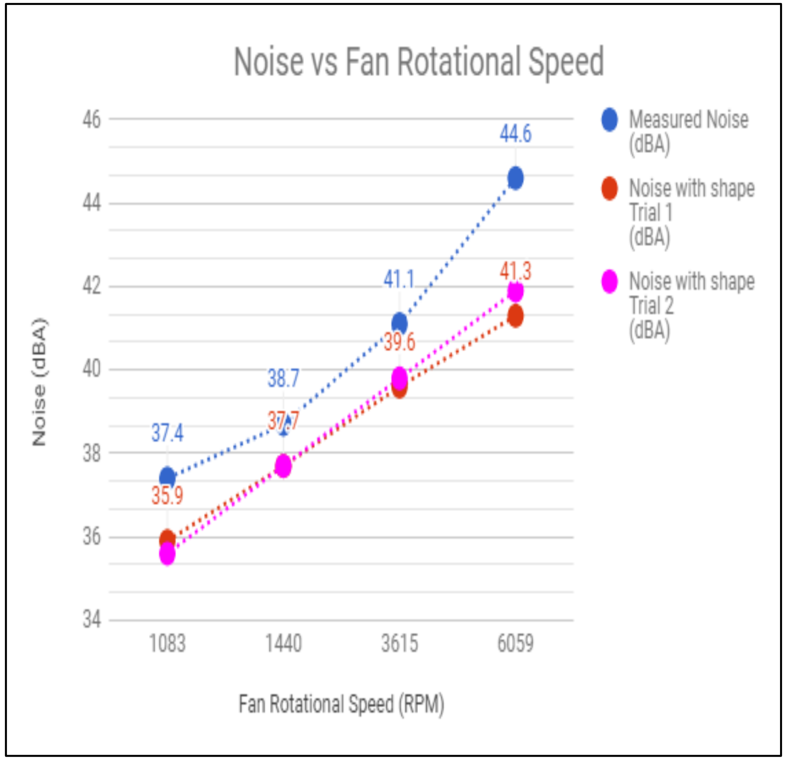
- Establish the relationship between fluid retention Associated with Cardiovascular
- Identify a typical problem/bacteria
- Design and build a fast, effective, and accurate food safety monitor (mechanical system, sensors, data analysis/processing, interface & integration, final testing)

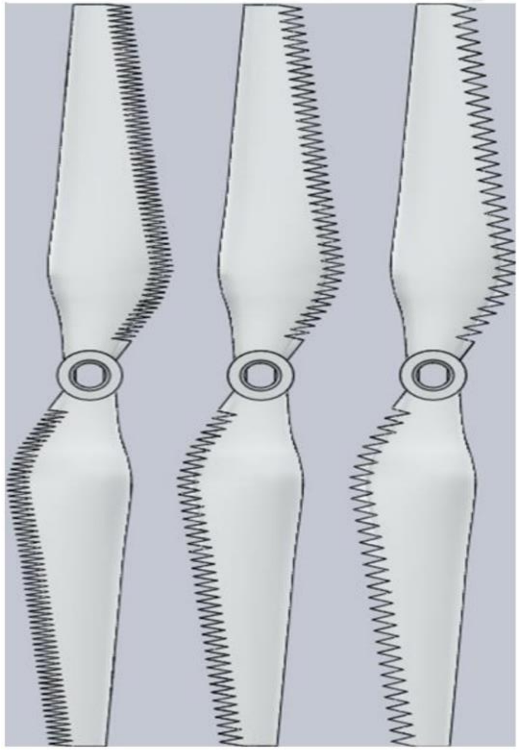
Noise Reduction Of Drones

- Experimental Studies

  > Noise Reduction Using Serration Method



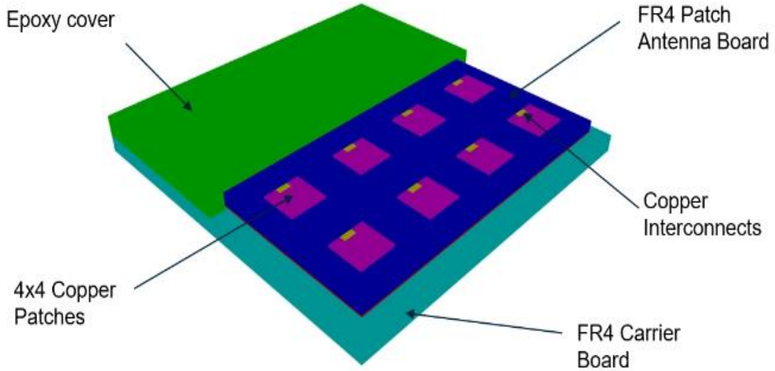


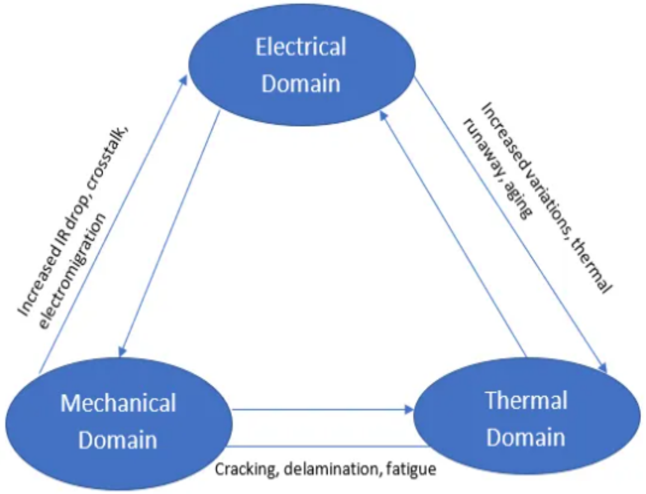


Electronics Packaging

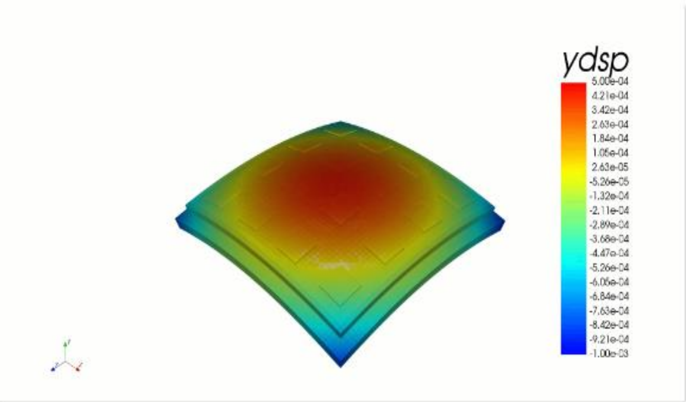
Domains and Issues

- Organic substrates: Tg, dielectric loss, planarity & warpage at processing temperature, moisture absorption, …
- Underfill for FC pkg: adhesion, moisture absorption, higher operating temperature (automotive applications)
- Chip, packaging & substrate co-design: digital & analog mixed signal, transient thermal analysis, thermo-mechanical analysis, electrical power disturb, signal integrity, EMI, commercial EDA supplier support
- Impact of Cu / low-k on packaging: wire bond, FC and underfill on Cu & low-k wafers (adhesion, materi strength, … etc.)
- Pb-, Sb- & Br-free packaging materials

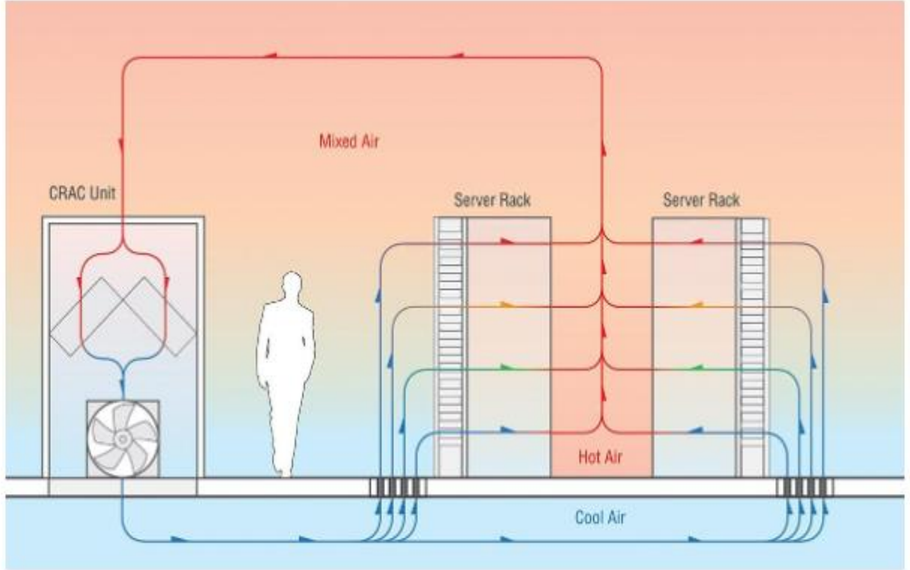




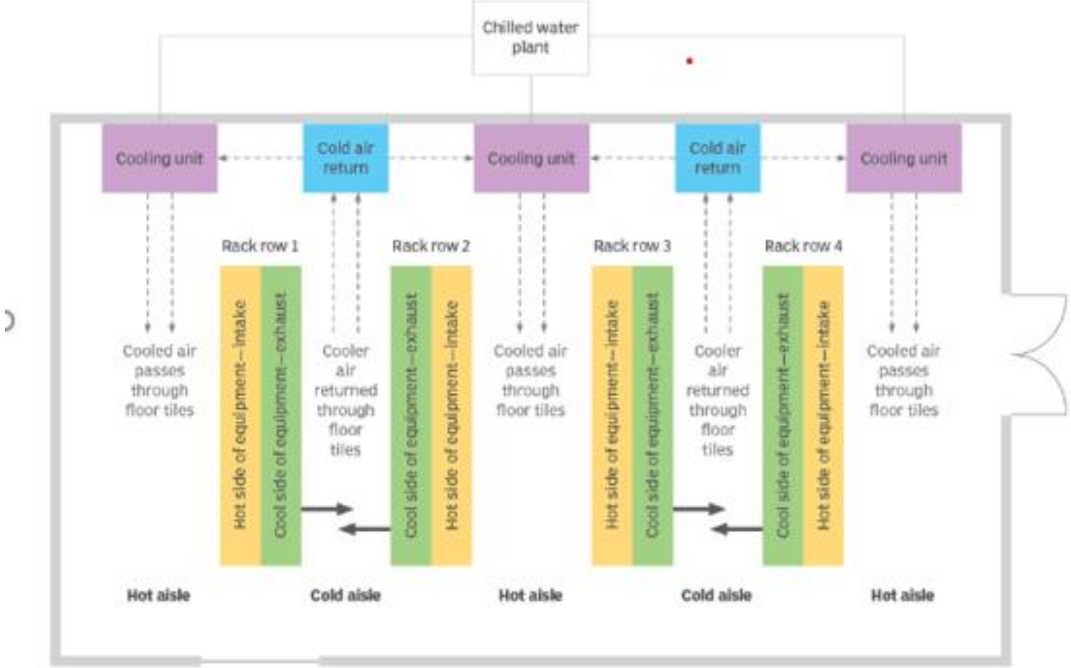
Electronics package design is a multiphysics problem with competing requirements from different parts. Chip package co-design is also essential for high-density devices in order to reach appropriate compromises while increasing the efficiency.



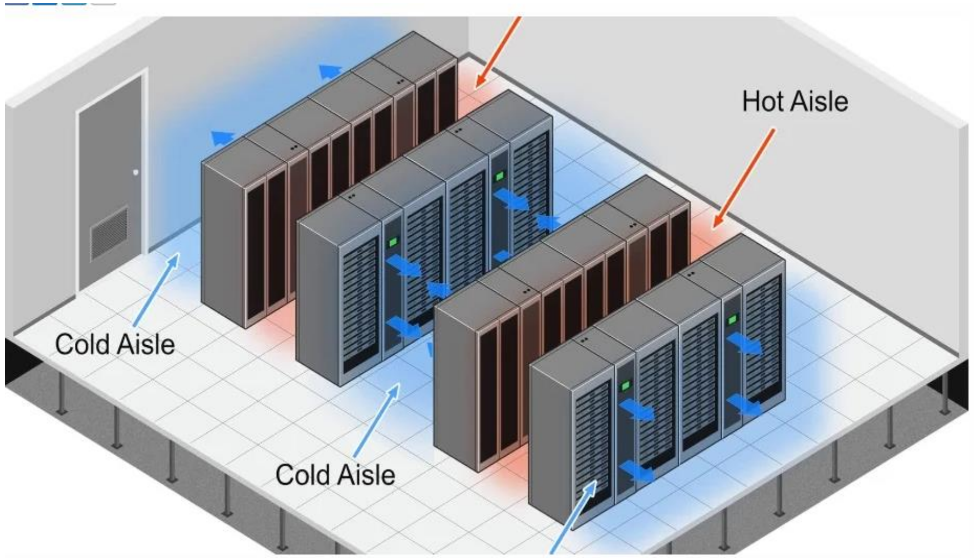
Data Center Cooling

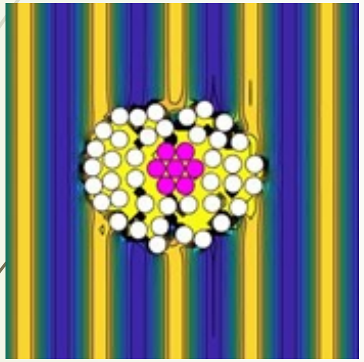


Data Centers

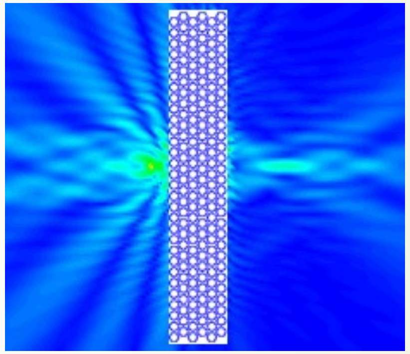


The key to the hot/cold aisle arrangement is the prevention of air mixing. If hot air reaches the cold aisle, the increase in cold aisle temperatures will result in not only warmer servers but additional energy use to maintain appropriate cold aisle temperatures.[3]





Research Interests and Proposed TopicS



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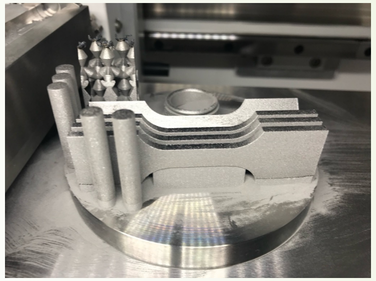
San Jose State University

May 3 2024

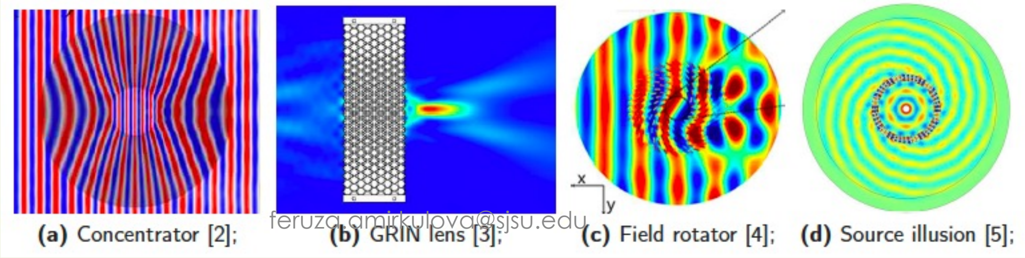
Inverse Design, Manufacturing, and Testing of Acoustic and Elastic Metamaterials

- Design of broadband Acoustic and Elastic Metamaterials using generative neural network, global optimization, and reinforcement learning
- Manufacturing of Metamaterials using selective laser melting (SLM) metal additive manufacturing system
- Testing of Metamaterials and metaclusters using sound & vibration analyzer platform from Brüel & Kjær
- Through the projects, the students are expected to gain practical experience in metamaterial design, manufacturing, and testing and be familiar with:
  - Julia and MATLAB programming, including various Toolboxes;
  - TensorFlow and PyTorch Python libraries, high performance computing on COE HPC cluster and Multi-GPUs ;
  - Developing deep reinforcement learning, deep learning and generative network models
  - Numerical simulation tool such as COMSOL Multiphysics;
  - Sound pressure level measurements and vibration testing using state-of-the-art sound & vibration analyzer platform from Brüel & Kjær, LDS control system, and BK connect software;
  - Selective laser melting metal additive manufacturing system (NSF-MRI award) , and 3D printing.



Our first build using EOS SML system

Forward and inverse design of pentamode metamaterials (optimization, DL, RL, COMSOL simulations) and Transformation acoustics devices



The examples of transformation acoustics devices.

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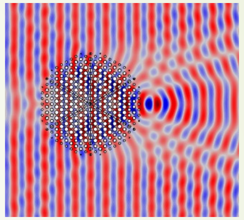
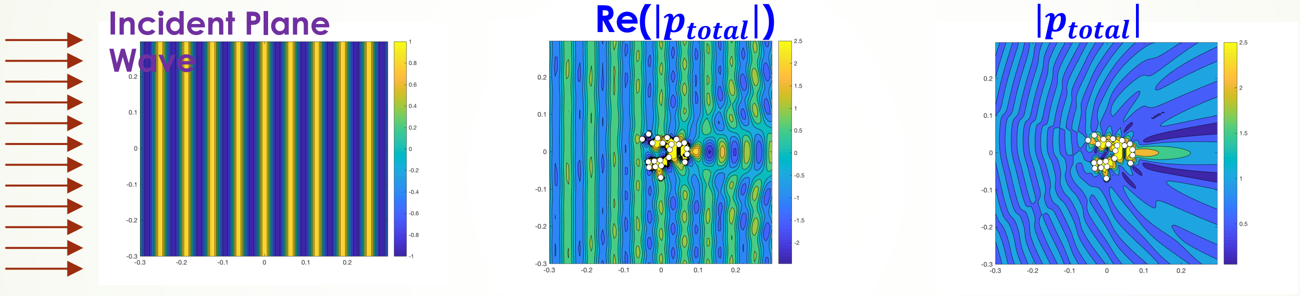
Design of some other devices



- Acoustic lens design: Maximizing sound pressure amplitude at focal point

  $ka = 0.75, a = 0.0075m,$ $\boldsymbol{x}_f = (R_2 + 5 * a),$ $M = 22,$ Final optimized configuration



Amirkulova et al. (*JASA*, 143(3), 2018)

- 3D Volume Sound Diffusers: Maximizing the diffusivity coefficient
- Positioning of offshore floating structures: Minimizing the scattered wave energy and wave drift force
- Optimized 2D and 3D multilayered metamaterials and phononic crystal structures can be realized by defining the gradients WRT to thickness

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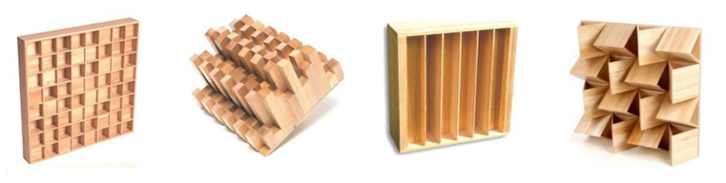
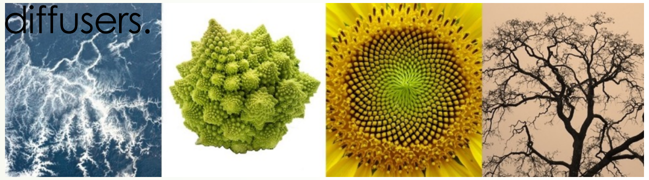
Sound Diffusers

Diffusers are a type of acoustic treatment installed in acoustically sensitive environments such as performing arts spaces, concert halls, and classrooms.

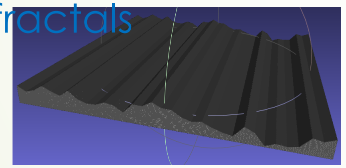


Examples of different types of geometric diffusers.



Examples of fractals in nature

RMD stochastic fractals



Fractal surfaces are virtually generated with a different roughness parameter

MOTIVATION:

Design of geometric sound diffusers

Frequency-invariant scattering is needed in these spaces because the human ear is sensitive across a broad frequency range (20 to 20KHz). Diffusers with fractal geometries can theoretically provide such scattering because they exhibit self-similarity at different dimensional scales.

Design of volume sound diffusers

Unlike the traditional surface diffusers, placing the scatterers in the volume of the room may provide greater efficiency by allowing the scattering into the whole space in all possible directions

Students will Perform numerical simulations, manufacture the diffusers, and measure sound pressure level using state-of-the-art sound & vibration analyzer platform from Brüel & Kjær.

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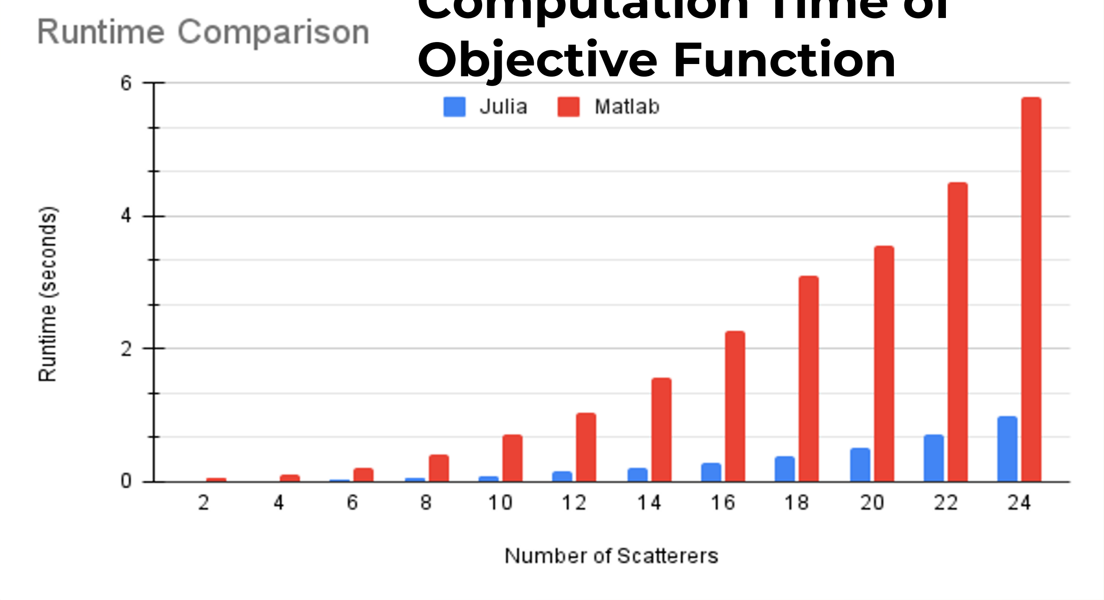
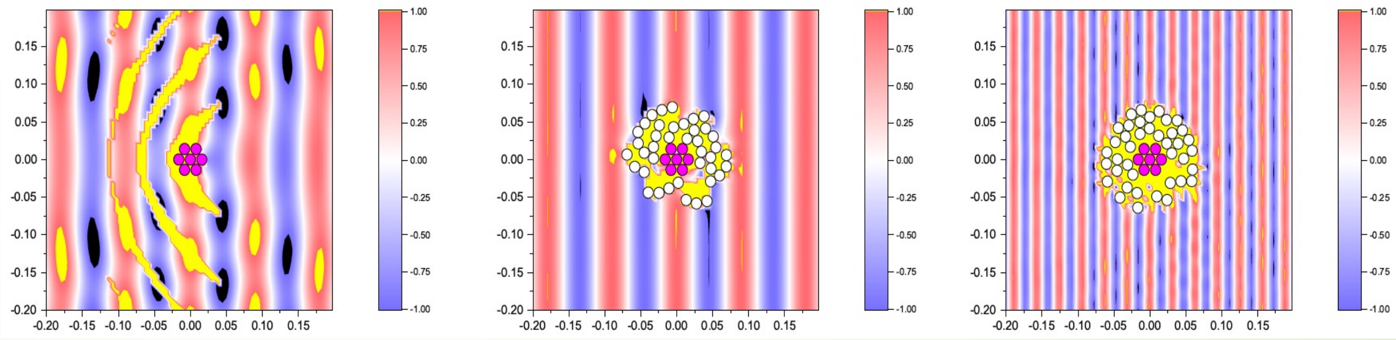
Design of Metamaterials Using Gradient Based Optimization

- Julia programming

Computation Time of Objective Function



Cloaking [1] with $M = 47 cylinders$: minimizes TSCS, σ, at single wavenumber $ka = 0.525; 1.5$.



(a) No cloak: $\sigma = 0.12595$ (b) $ka = 0.525, \sigma_r = 1.4106e-04$ (c) $ka = 1.5, \sigma_r = 0.0126$

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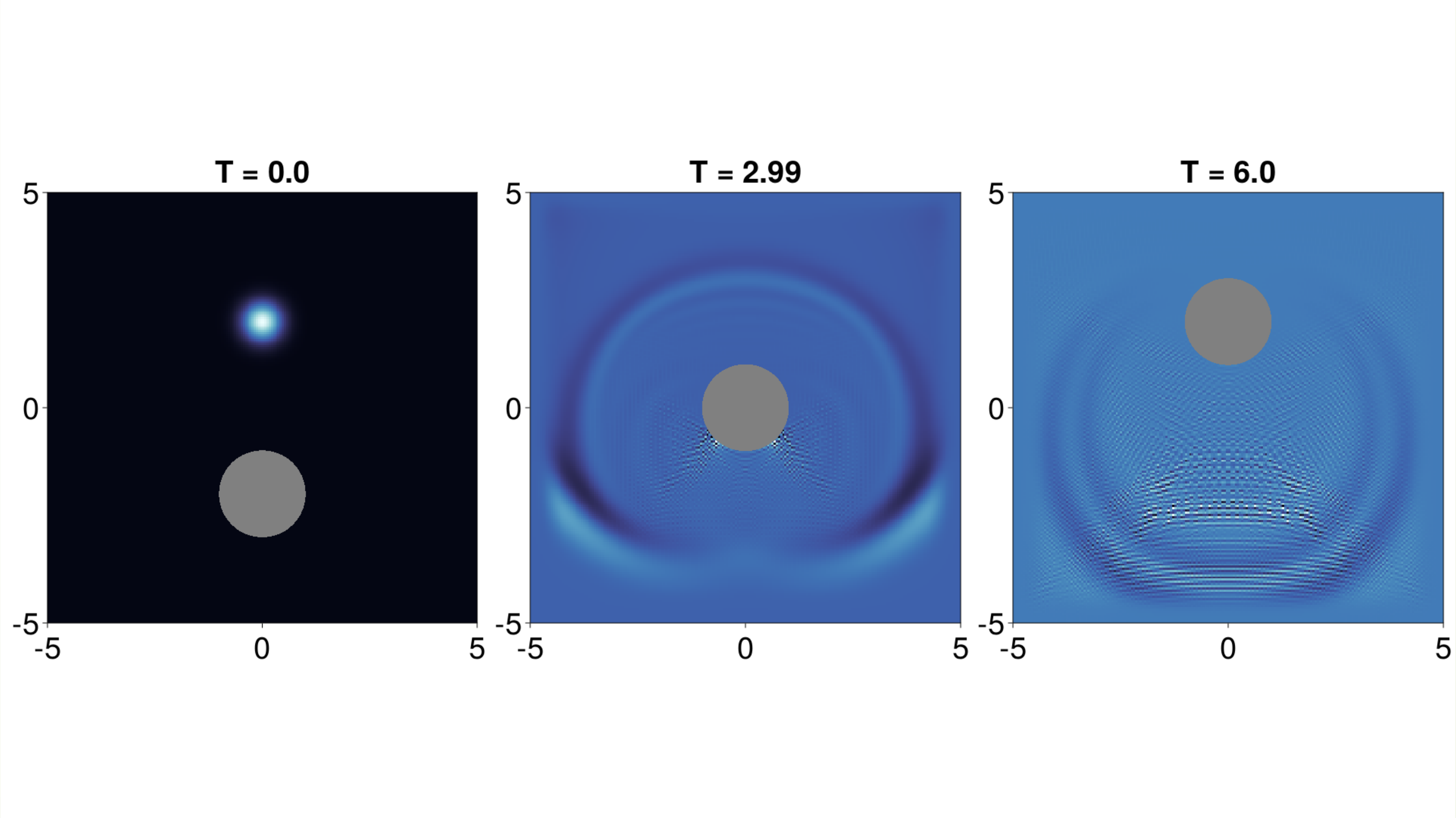
Design of Metamaterials Using Model Predictive Control and Reinforcement learning

- **Four-dimensional acoustics using time-varying metamaterials**
- **Julia programming**



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Proposed Topics by F. Amirkulova

Design of Metamaterials, Meta-devices and Hearing Aids using Optimization, Deep Learning and Reinforcement Learning and Performing Sound Measurements:

- **Inverse Design of Acoustic Metamaterials using Generative Neural Networks (WGAN and VAE)**
- **Design of Metamaterials Using Deep Learning (DL) and Model-free Deep Reinforcement learning (RL)**
  - Inverse design of Volume Sound Diffusers using neural networks (DL,RL)
  - Inverse design of 3D multilayered metamaterials using Deep Learning (DL)
  - Inverse design of 2D multilayered metamaterials using Deep Learning (DL)
  - Inverse design of 2D and 3D multilayered metamaterials via gradient based optimization and sound measurements
  - Design of pentamode metamaterials and Transformation Acoustics devices (optimization, DL, COMSOL simulations)
- **Design of Metamaterials Using Model Predictive Control (Julia programming)**
- **Design of Metamaterials Gradient Based Optimization Algorithms (Julia programming)**
- **Investigation of human directional hearing in a semi-anechoic environment**
- **AI assisted accessibility projects and hearing aids**
  - Develop novel innovative techniques for design of hearing aids using optimization, and artificial intelligence algorithms, including deep learning, reinforcement learning, and generative modeling

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EXTRA

Our Recent Publications

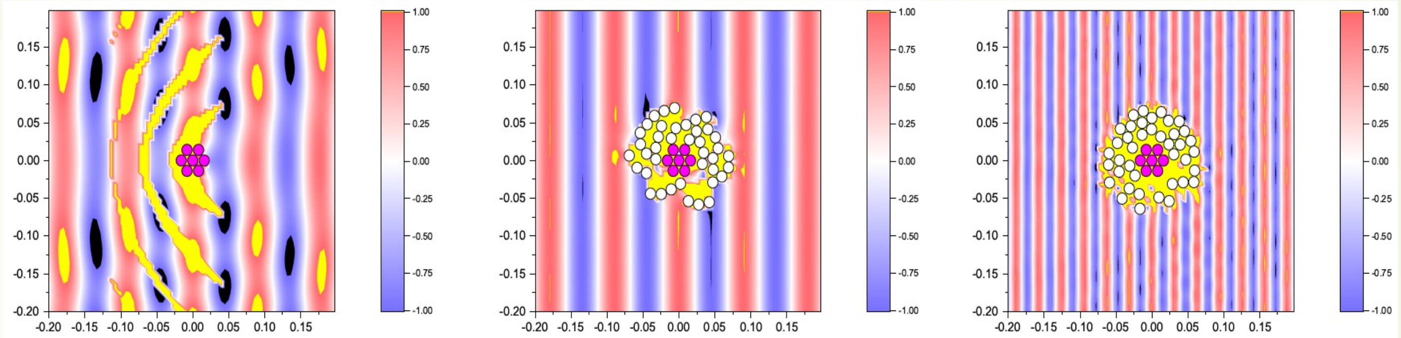
Metamaterials Through Multi-scattering and Gradient-based Optimization

- **Acoustic cloak**

Acoustic cloak renders an object invisible to incident waves

Optimize TSCS

Cloaking [1] with $M = 47 cylinders$: minimizes TSCS, σ, at single wavenumber $ka = 0.525; 1.5$.



(a) No cloak: $\sigma = 0.12595$ (b) $ka = 0.525, \sigma_r = 1.4106e-04$ (c) $ka = 1.5, \sigma_r = 0.0126$

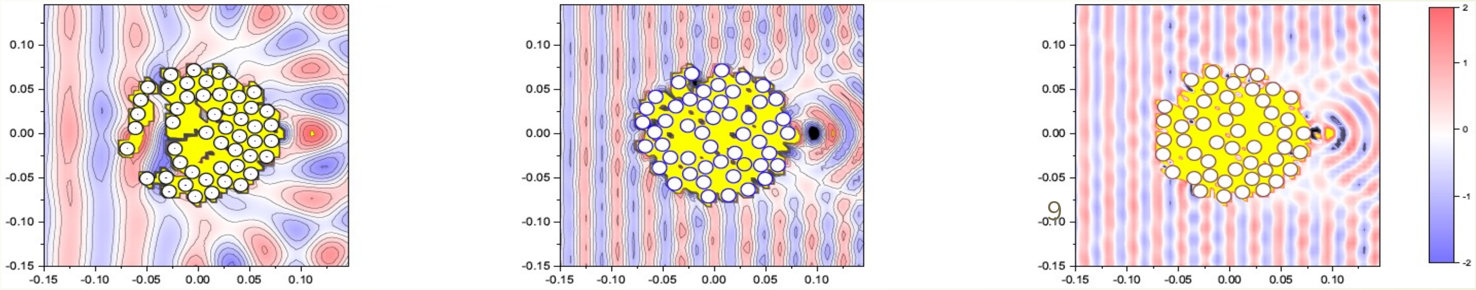
Amirkulova & Norris. The Gradient of Total Multiple Scattering Cross-Section and Its Application to Acoustic
Cloaking. *JTCA* 2020: 1950016. doi: 10.1142/s2591728519500166

- **Sound Localization**

Acoustic lens focuses the incident plane wave on the other side of lens

Optimize pressure at focal point $|p_f|$

Sound Localization [2] with $M = 50\ cylinders$: maximizes $|p_f|$, at wavenumbers $ka = 0.75; 1.5\ and\ 2$.



a $ka = 0.75$ **b** $ka = 1.5$ **c** $ka = 2$

Amirkulova, Gerges, & Norris. Sound Localization Through Multi-scattering and Gradient-based Optimization (Mathematics, 2021)

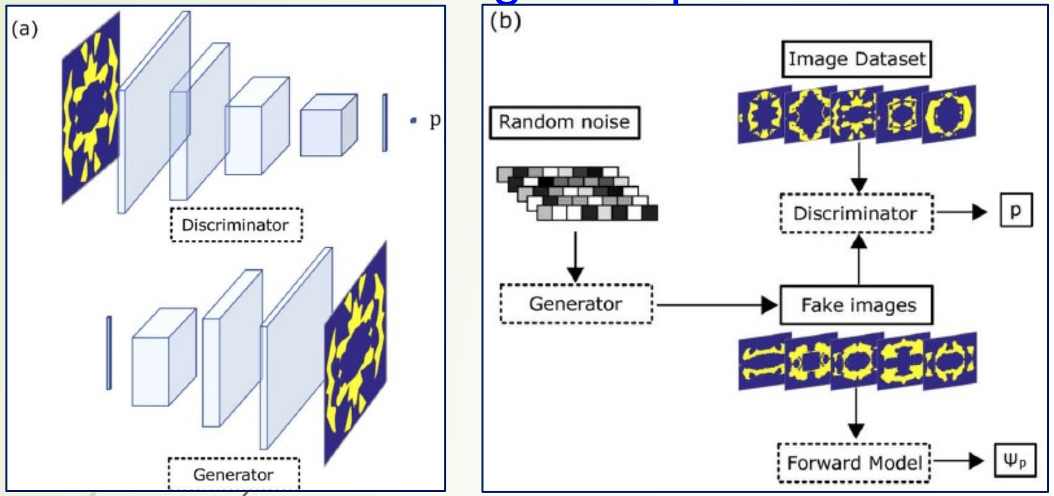
- **Sound Diffusers**

Optimize diffusion coefficient d_ψ

N. Shah & F. Amirkulova. 1aAA2: Broadband Optimization of Volumetric Sound Metadiffusers.
AiF, ASA Spring Virtual Meeting, June 8, 2021

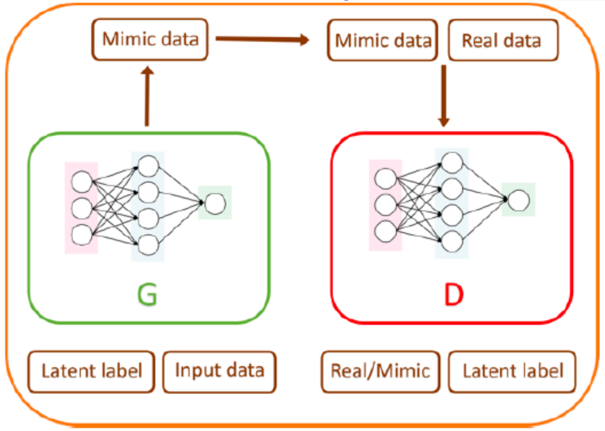
Applications of Generative Adversarial Networks (GAN)

GAN for design of optical cloak



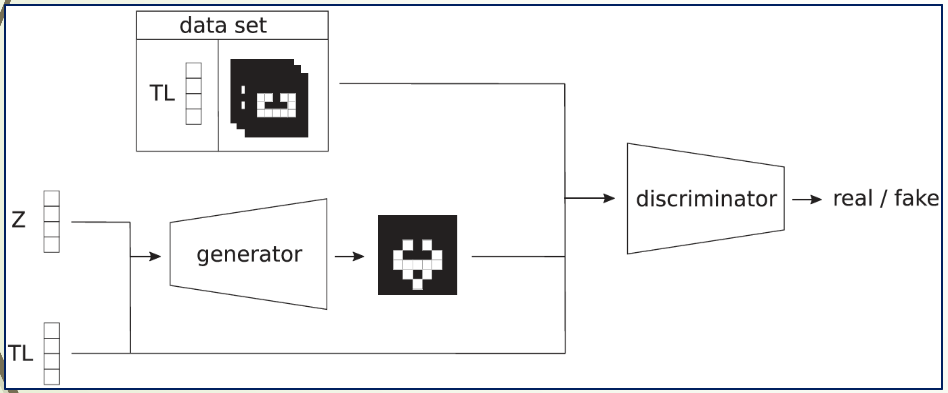
Blanchard-Dionne & Martin, OSA Continuum 2020.

Conditional WGAN for protein solubility prediction

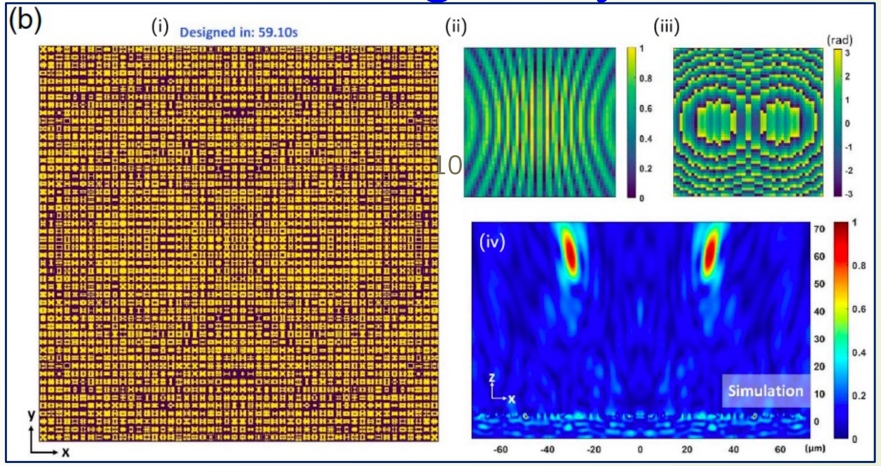


Han et al. InfoMat 2020

Conditional GAN for design of acoustic metamaterial



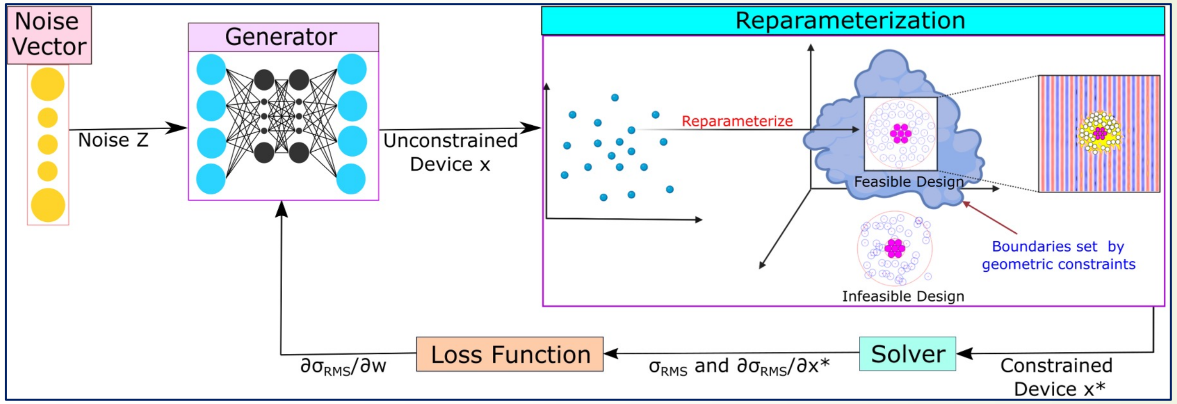
Double-focus flat lens designed by conditional WGAN



An et al., Advanced Optic. Mater. 2021

Our Recent Publications

2D-GLOnets Model Based Generative Modeling and Gradients



Noise Vector

- Gaussian Noise

Generator

- Fully Connected layers
- LeakyRelu
- Tanh for output layers

Solver

- In-house built multiple scattering solver that computes objective function and gradients g
- Implemented on PyTorch Python libraries calling MATLAB engine from Python

Loss Function

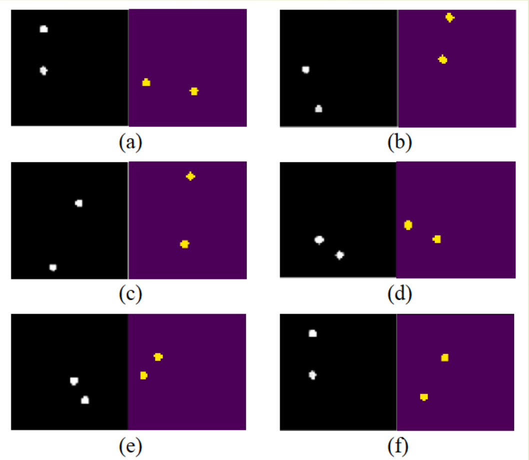
- Search and refine the optimized design space

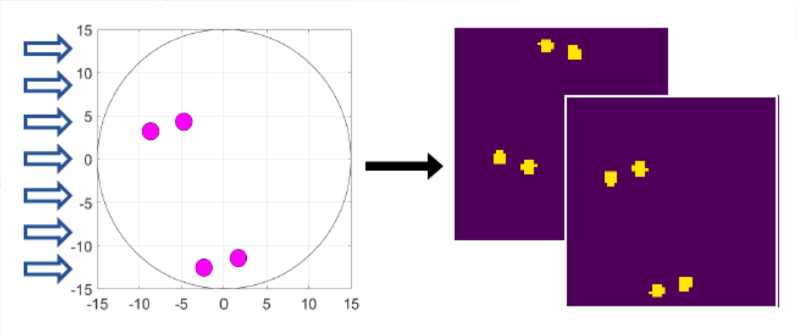
Algorithm 1: Training Process of 2D-GLOnets

Parameters: α, learning rate. ϕ, generator parameters. Adam, Adaptive Moment Estimation (ADAM)
initialization
while *i < total iterations* **do**
  sample $\{z^k\}_{k=1}^{K} \sim \mathcal{U}(0, 0.2)$
  generate $\{x^k = G_\phi(z^k)\}_{k=1}^{K}$
  reparameterize $\{x^* = \epsilon(x^k)\}_{k=1}^{K}$
  compute $\{q_j^k\}_{k=1}^{K}, \{\sigma_{RMS}^k\}_{k=1}^{K}$
  update $\phi \leftarrow \phi + \alpha \cdot$ Adam $L(x, g_\epsilon, \sigma_{RMS})$
end

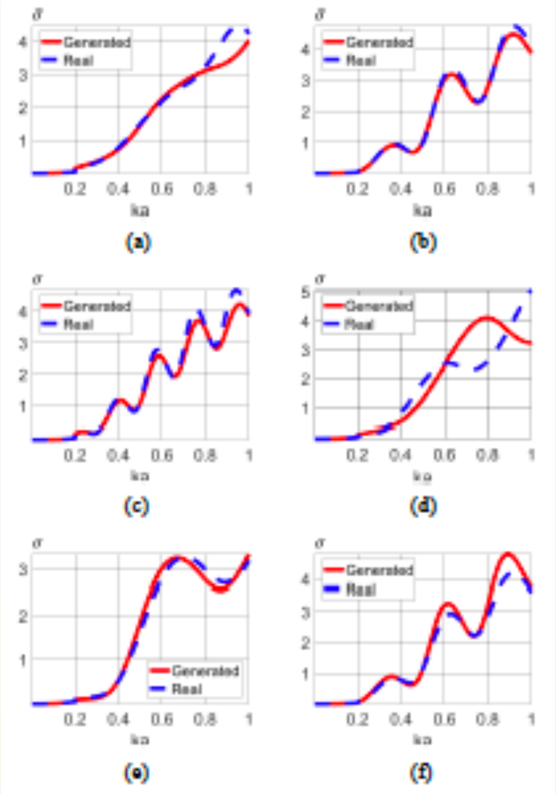
Zhuo* L., & Amirkulova, F. (2021). Design of Acoustic Cloak Using Generative Modeling and Gradient-Based Optimization. InterNoise21, Washington, D.C., USA, 263(3), 3511–3522, **2021** https://doi.org/10.3397/in-2021-2431

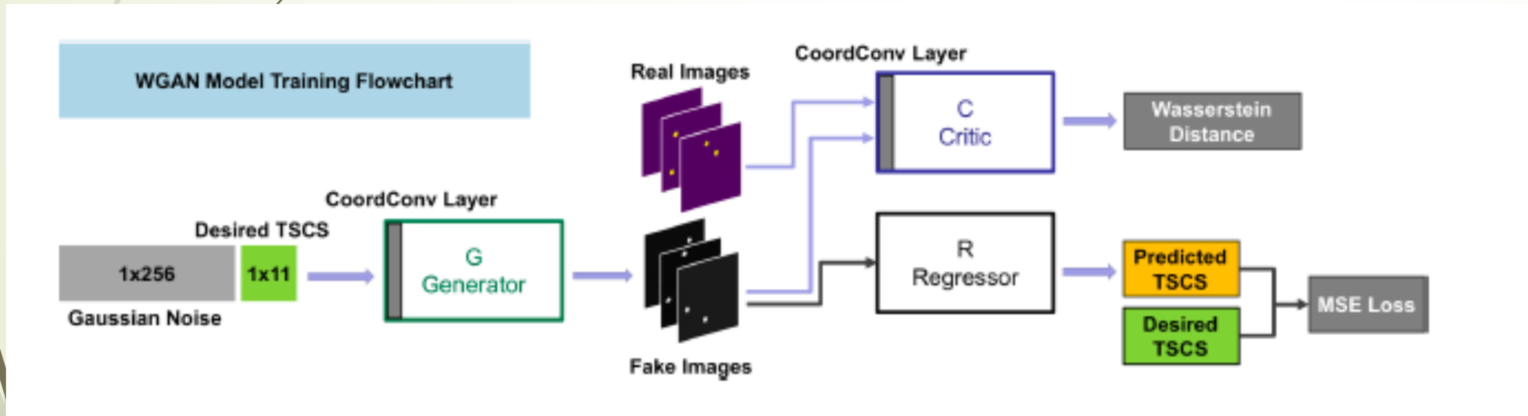
Our Recent Publications
Conditional WGAN model





TSCS





Lai* P., **Amirkulova F.**, Gerstoft P. Conditional Wasserstein Generative Adversarial Networks Applied to Acoustic Metamaterial Design. *J. Acoust. Soc. Am*, accepted 2021

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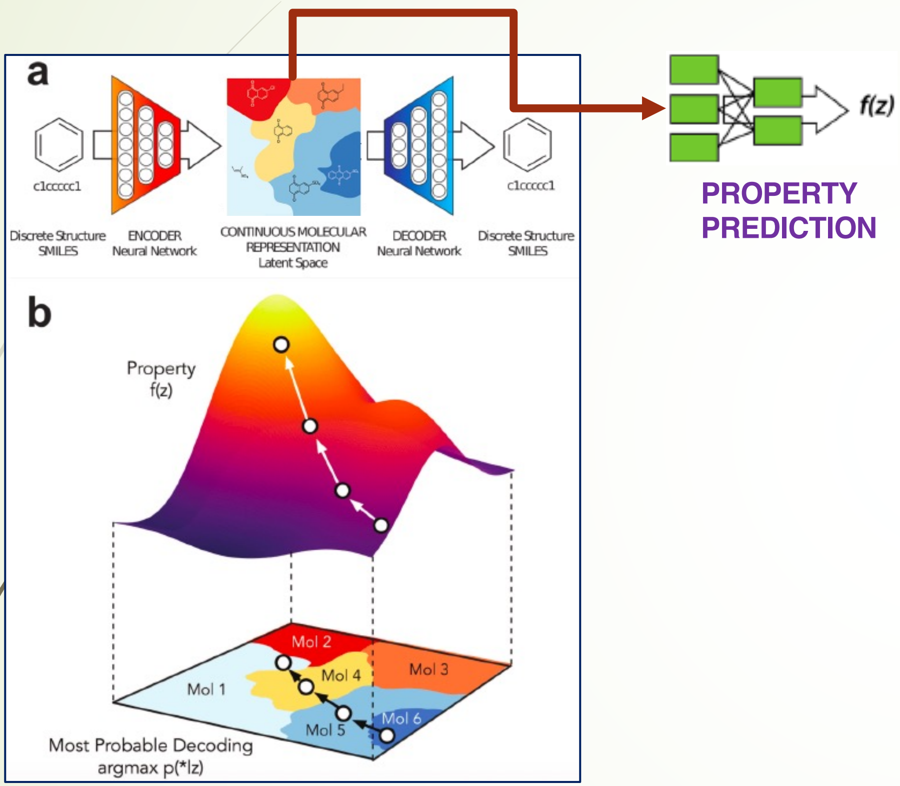
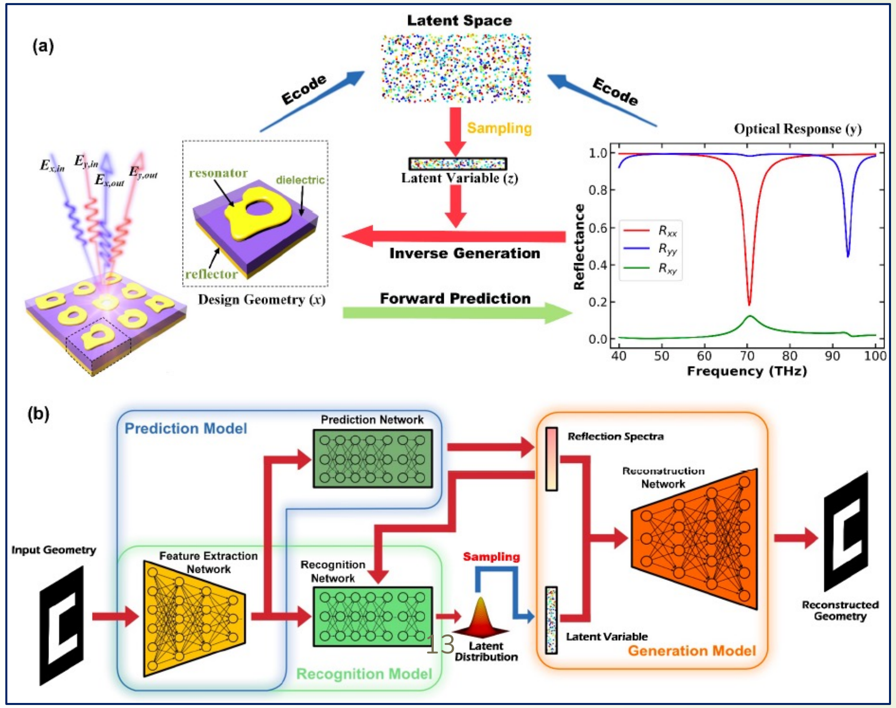
Applications of Variational Autoencoders (VAE)

Application of a VAE to chemical design:



Gómez-Bombarelli et al. ACS Cent. Sci. 2018

Application of VAE and semi-supervised learning to optical metamaterial design:

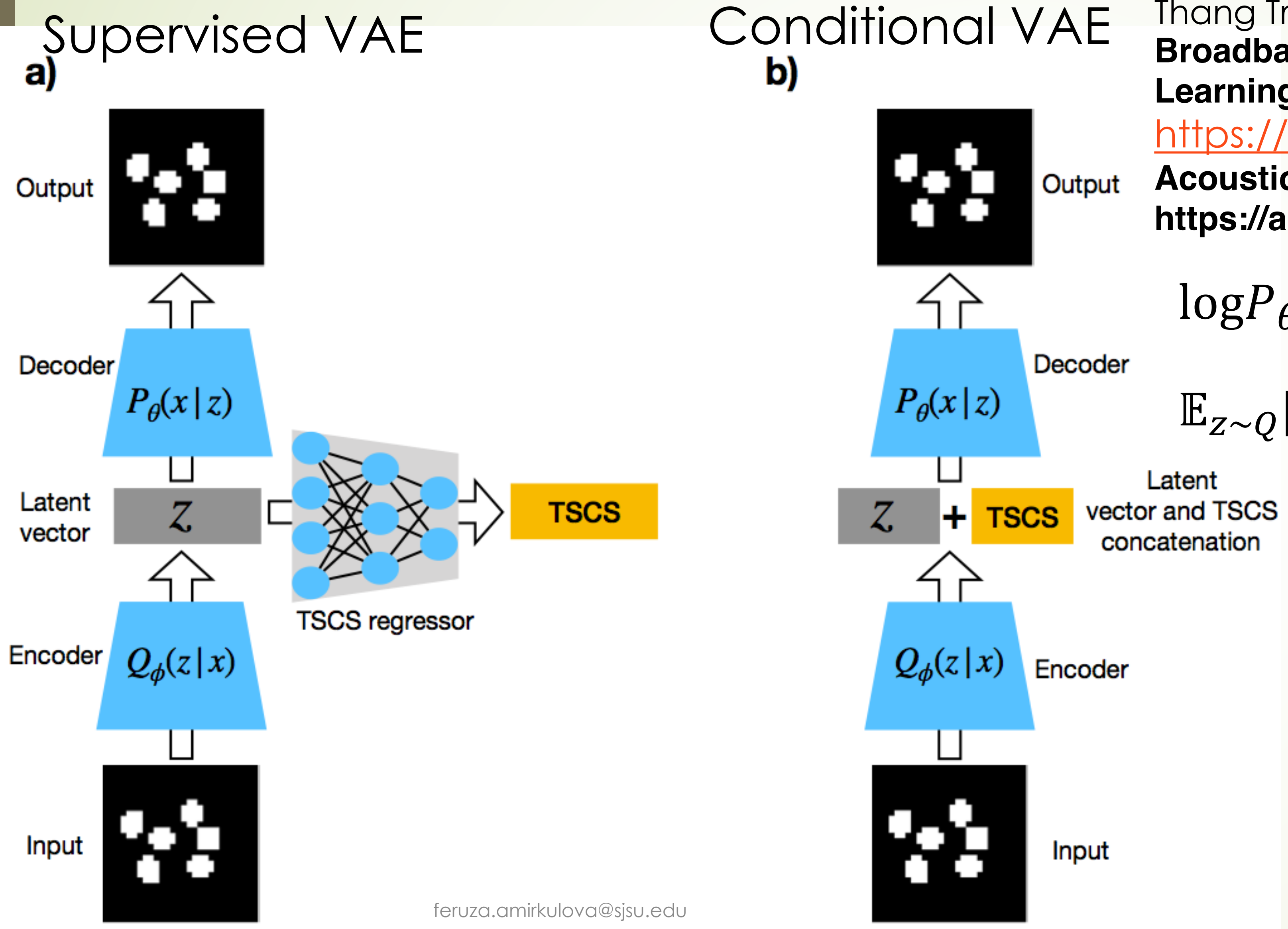


Ma et al. Adv. Mater. 2019

Application of CNN and VAE to acoustic metamaterial design:

T. Tran et al. 3aSA6: Total multiple scattering cross section evaluation using convolutional neural networks for forward and inverse designs of acoustic metamaterials. ***AiF, ASA Spring Virtual Meeting, June 10 2021***

Our Recent Publications



Thang Tran, Feruza Amirkulova and Ehsan Khatami

Broadband Acoustic Metamaterial Design via Machine Learning (accepted 2022, JTCA)

https://doi.org/10.1142/S2591728522400059

Acoustic Cloak Design via Machine Learning, 2021

https://arxiv.org/abs/2111.01230

$$\log P_\theta(x) - D_{KL}(Q_\phi(z|x)|P_\theta(z|x)) =$$

$$\mathbb{E}_{z\sim Q}[\log P_\theta(x|z)] - D_{KL}(Q_\phi(z|x)|P_\theta(z))$$

$$\mathcal{L}_{SVAE} = \mathcal{L}_R + \mathcal{L}_{KL} + \mathcal{L}_{TSCS}$$

$$\mathcal{L}_{CVAE} = \mathcal{L}_R + \mathcal{L}_{KL}$$

feruza.amirkulova@sjsu.edu

Our Recent Publications

Shah* T., Zhuo* L., Lai* P., De La Rosa-Moreno*^‡ A., **Amirkulova F.**, Gerstoft P. Reinforcement learning applied to metamaterial design. *J. Acoust. Soc. Am.*, 150(1), July **2021**

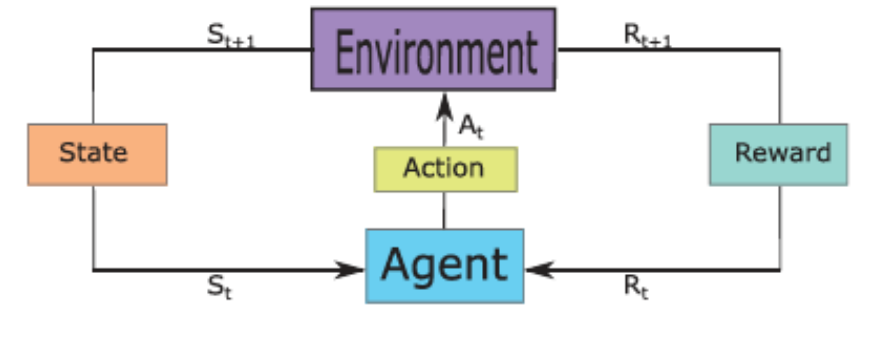
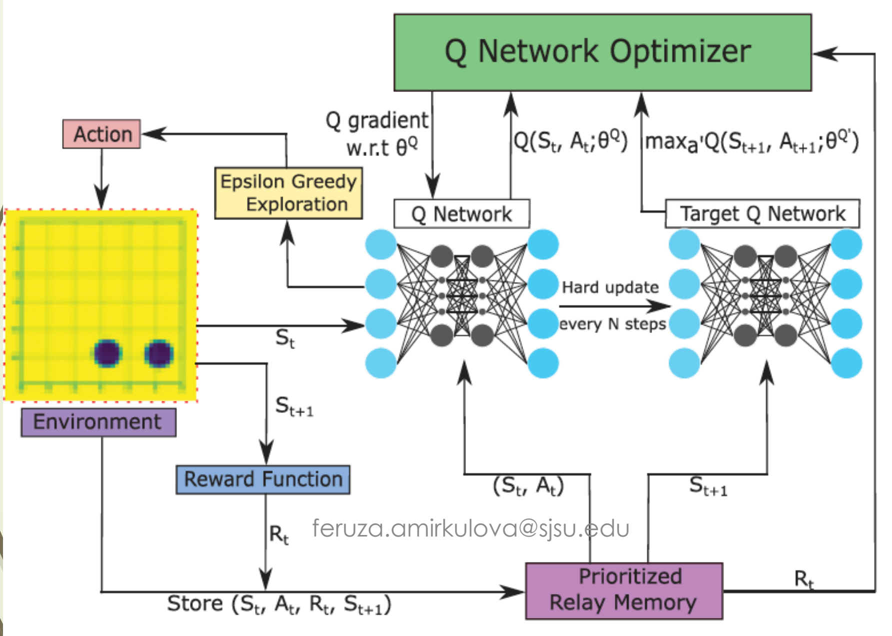
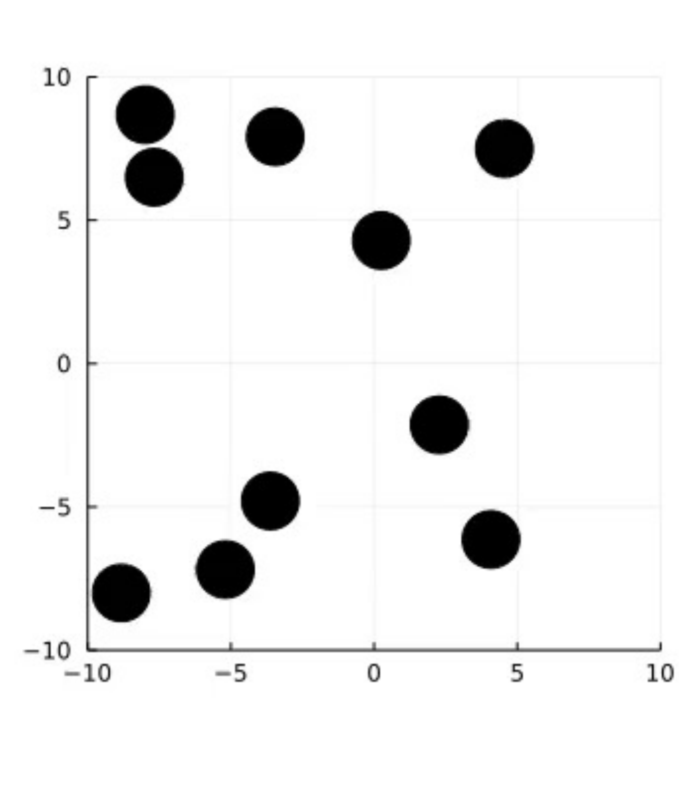
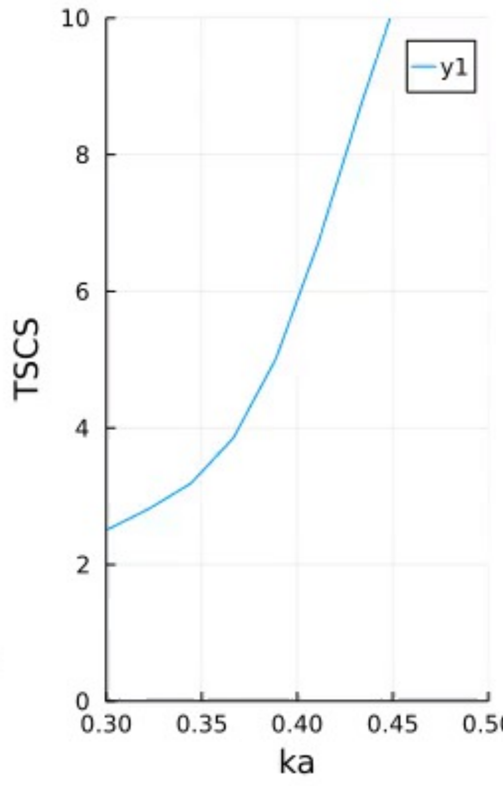


FIG. 1. (Color online) Agent interacting with environment in a MDP.





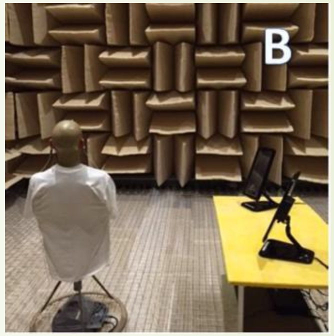


feruza.amirkulova@sjsu.edu

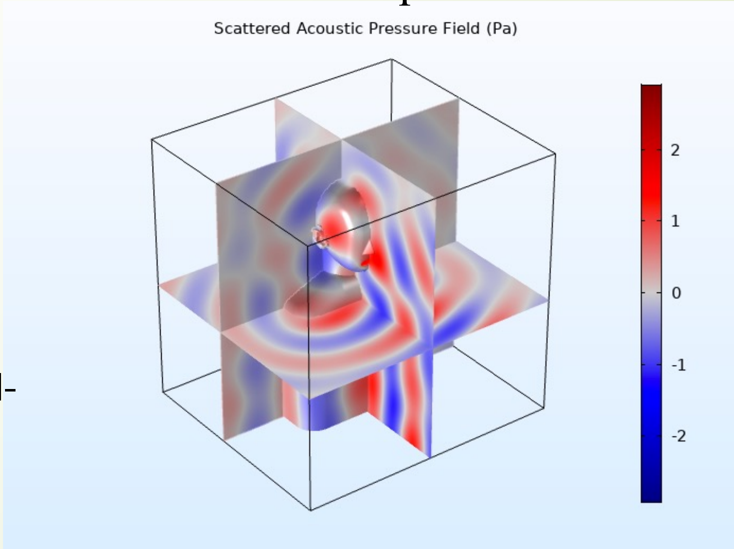
Investigation of human directional hearing in a semi-anechoic environment

Conduct a research on developing devices and methodology that are meant for improving hearing, including hearing aids and providing sound settings that lead to improved sound quality and greater listening comfort.

- AI assisted accessibility projects on hearing aids.
- Modeling head and torso interference and extrapolation to listening environments:
  - Construct a model to simulate an acoustic field impinging on a simulated average head and torso. This model presents a generic Head and Torso Simulator and showcases some of the post-processing methods of the effects of effects of the head and torso on the pressure level gain at the ear. The simulation will be built to incorporate ear-level microphone measurements as will take place in the physical model.
  - Analyze the Acoustics of a Head and Torso Simulator on COMSOL.
  - Measure the Performance of Acoustic Devices for the Human Ear performing simulations and experimental testing in Anechoic chamber.
- Develop novel innovative techniques for design of hearing aids using optimization, and artificial intelligence algorithms, including deep learning, reinforcement learning, and generative modeling



A mannequin test



References:

1. Gary Dagastine. On the Cutting Edge of Hearing Aid Research. COMSOL News 2017. https://spectrum.ieee.org/consumer-electronics/audiovideo/on-the-cutting-edge-of-hearing-aid-research
2. https://www.comsol.com/blogs/analyzing-the-acoustics-of-a-head-and-torso-simulator/

AVAILABLE PROJECTS FOR FALL2024

Dr. Yunjian (Jojo) Qiu

Assistant Professor

Mechanical Engineering

AREAS OF RESEARCH

- Primary Research Interests
    - Design Theory and Methodology
    - AI/LLM in Design
    - Design Automation
    - Engineering Education
- Recent Projects
    - AI/LLM in Design (ongoing project)
    - Human-AI System Interaction (ongoing project)

AVAILABLE PROJECT 1: AI/LLM APPLICATIONS IN DESIGN

- Must have programming experience and at least basic knowledge of ML

ASME Journal of Mechanical Design
Online journal at:
https://asmedigitalcollection.asme.org/mechanicaldesign

Document Understanding-Based Design Support: Application of Language Model for Design Knowledge Extraction

Yunjian Qiu
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Yan Jin[1]
Department of Aerospace and Mechanical Engineering,
University of Southern California,
Los Angeles, CA 90089
e-mail: yjin@usc.edu

Design knowledge in the vast amount of design reports and documents can be an excellent resource for designers in their practice. However, capturing such domain-specific information embedded in long-length unstructured texts is always time-consuming and sometimes tricky. Therefore, it is highly desirable for a computer system to automatically extract the main knowledge points and their corresponding inner structures from given documents. In this study of document understanding for design support (DocUDS), a design-perspective knowledge extraction approach is proposed that uses phrase-level domain-specific labeled datasets to finetune a Bidirectional Encoder Representation from Transformers (BERT) model so that it can extract design knowledge from documents. The BERT model finetuning attempts to blend in the domain-specific knowledge of well-recognized domain concepts and is based on the datasets generated from design reports. The model is utilized to map the captured sentences to the main design entities <requirement>, <function>, and <solution>. In addition, this approach uncovers inner relationships among the sentences and constructs overall structures of documents to enhance understanding. The definitions of design perspectives, inter-perspective relations, and intra-perspective relations are introduced, which together capture the main design knowledge points and their relations and constitute an understanding of the design domain knowledge of a text. The case study results have demonstrated the proposed approach's effectiveness in understanding and extracting relevant design knowledge points. [DOI: 10.1115/1.4063161]

Keywords: design-perspective knowledge extraction, document understanding, phrase-level dataset, language model, text classification, sentence-design entity mapping, artificial intelligence, conceptual design, design automation, machine learning

1 Introduction

As the amount of textual material grows daily, there is a great need to reduce unstructured text data to shorter, more focused information while maintaining significant meanings. For example, text summarization using automatic text processing techniques has been developed recently in domains such as medical biology, healthcare, and engineering [1]. This summary-generating process can efficiently capture the primary information of the text and significantly reduce the problem of overwhelming data [2]. Researchers have used sentence features like term frequency to summarize information underlying the text [3]. The contextual embedding method has also been applied to capture texts' main content [4]. The recent progress of language model research has made it possible to finetune a language model with domain-specific datasets to carry out domain-specific tasks, such as generating a summary for a given design report [5].

In addition to general text summarization, researchers in the engineering design domain have focused on design knowledge retrieval and extraction to distill the critical information from long-length texts. Different knowledge retrieval methods have been proposed to quickly retrieve critical information from engineering documents. Traditional keyword-based methods [6] and ontology-based retrieval methods [7,8] have been used to capture the concepts and their relationships. However, this literal matching and "flat" search tend to lose the semantic information within the text. As the development of natural language processing (NLP) techniques accelerates, researchers have started exploring semantic-level knowledge extraction in engineering design using NLP methods. Most existing methods focus on word-level applications by extracting essential entities and their associations [9–12]. Knowledge reuse and exploration remain in the attribute-level application [13]. As a result, knowledge extraction may lead to insufficient information capture and a discontinuity in knowledge representation.

Through the engineering design process, applying domain knowledge is critical to successful design activities such as design ideation, analysis, and evaluation. Designers often record their ideas and solutions in various design documents. It will be of great value if the information underlying these document texts

[1]Corresponding author.

Manuscript received March 20, 2023; final manuscript received August 2, 2023; published online September 12, 2023. Assoc. Editor: Conrad S. Tucker.

AVAILABLE PROJECT 2: DESIGNER-AI INTERACTION ON LLM INTERFACE

- Ideal for students interested in cognitive study and human-AI interaction
- Experimental

Intelligent Systems with Applications 21 (2024) 200308

Contents lists available at ScienceDirect

Intelligent Systems with Applications

journal homepage: www.journals.elsevier.com/intelligent-systems-with-applications

ELSEVIER

Check for updates

ChatGPT and finetuned BERT: A comparative study for developing intelligent design support systems

Yunjian Qiu, Yan Jin *

Department of Aerospace & Mechanical Engineering, University of Southern California, Los Angeles, CA 90089, United States

ARTICLE INFO

Keywords:
Language model
Knowledge transferring
Knowledge elicitation
Text classification
Text generation

ABSTRACT

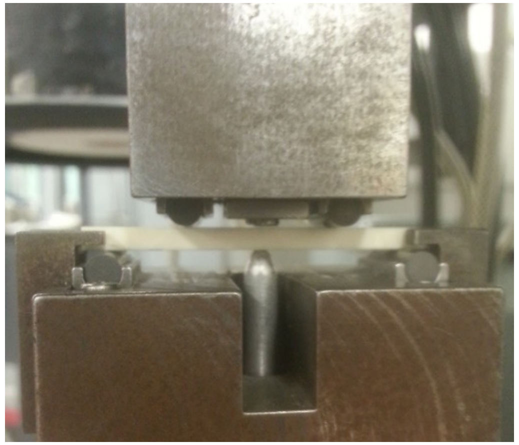
Large Language Models (LLMs), like ChatGPT, have sparked considerable interest among researchers across diverse disciplines owing to their remarkable text processing and generation capabilities. While ChatGPT is typically employed for tasks involving general knowledge, researchers increasingly explore the potential of this LLM-based tool in specific domains to enhance productivity. This study aims to compare the performance of a finetuned BERT model with that of ChatGPT on a domain-specific dataset in the context of developing an intelligent design support system. Through experiments conducted on classification and generation tasks, the knowledge transfer and elicitation abilities of ChatGPT are examined and contrasted with those of the finetuned BERT model. The findings indicate that ChatGPT exhibits comparable performance to the finetuned BERT model in sentence-level classification tasks but struggles with short sequences. However, ChatGPT's classification performance significantly improves when a few-shot setting is applied. Moreover, it can filter out unrelated data and enhance dataset quality by assimilating the underlying domain knowledge. Regarding content generation, ChatGPT with a zero-shot setting produces informative and readable output for domain-specific questions, albeit with an excessive amount of unrelated information, which can burden readers. In conclusion, ChatGPT demonstrates a promising potential for application in facilitating data labeling, knowledge transfer, and knowledge elicitation tasks. With minimal guidance, ChatGPT can substantially enhance the efficiency of domain experts in accomplishing their objectives. The findings suggest a nuanced integration of artificial intelligence (AI) with human expertise, bridging the gap from mere classification models to sophisticated human-analogous text generation systems. This signals a future in AI-augmented engineering design where the robust capabilities of AI technologies integrate with human creativity and innovation, creating a dynamic interactions to redefine how we tackle design challenges.

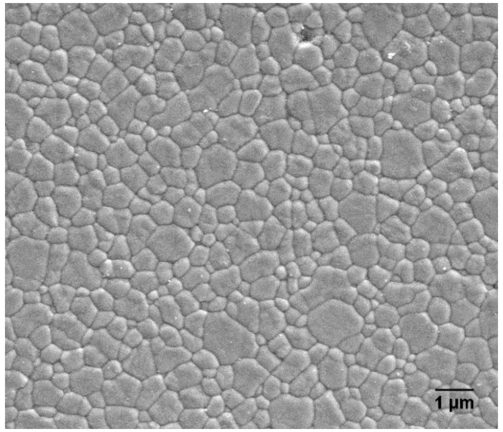
CONTACT INFORMATION

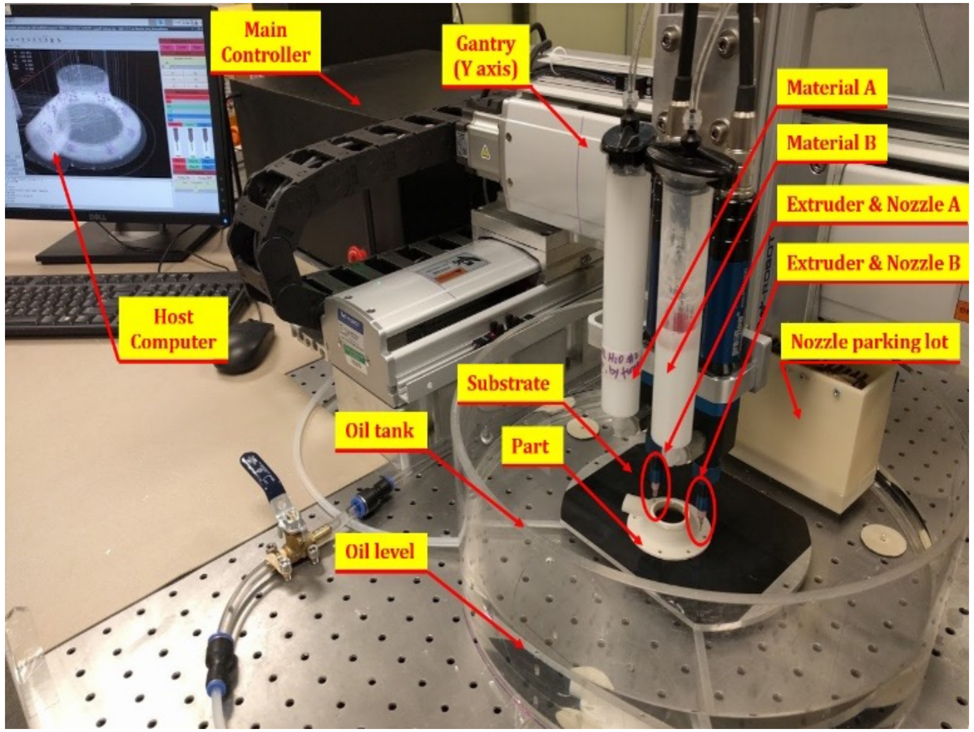
- yunjianq@usc.edu

Additive Manufacturing & Material Characterization

- **Experimental** project
- Novel AM process
- Supported by Lam Research Corporation

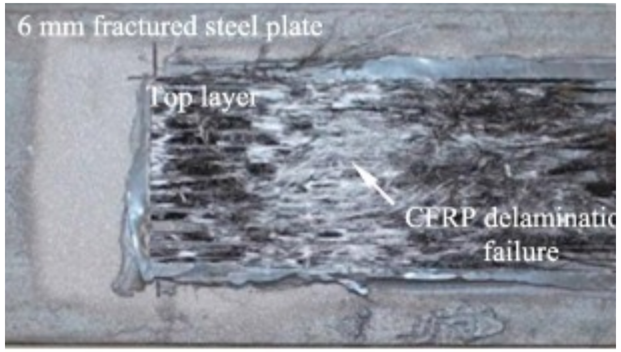


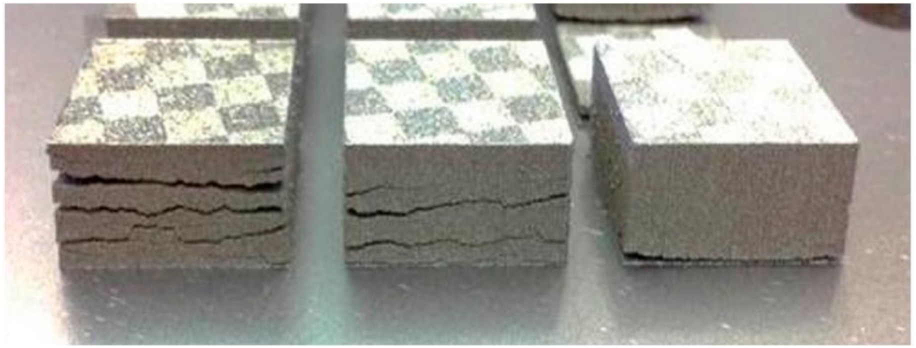


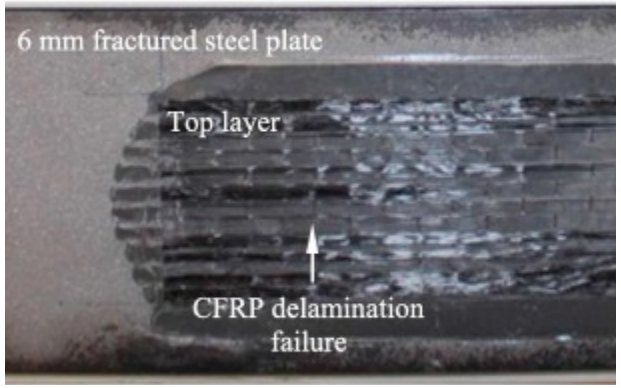


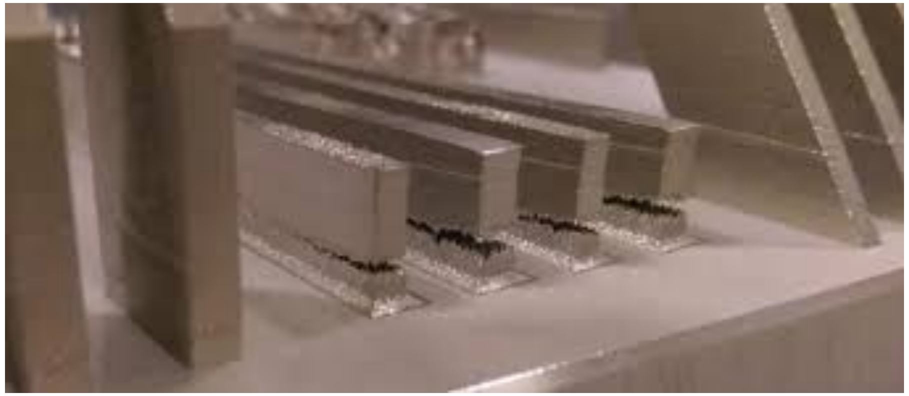
Improving AM with ML

- **Experimental and theoretical**
- Applying machine learning algorithms to improve the quality of additively manufactured parts



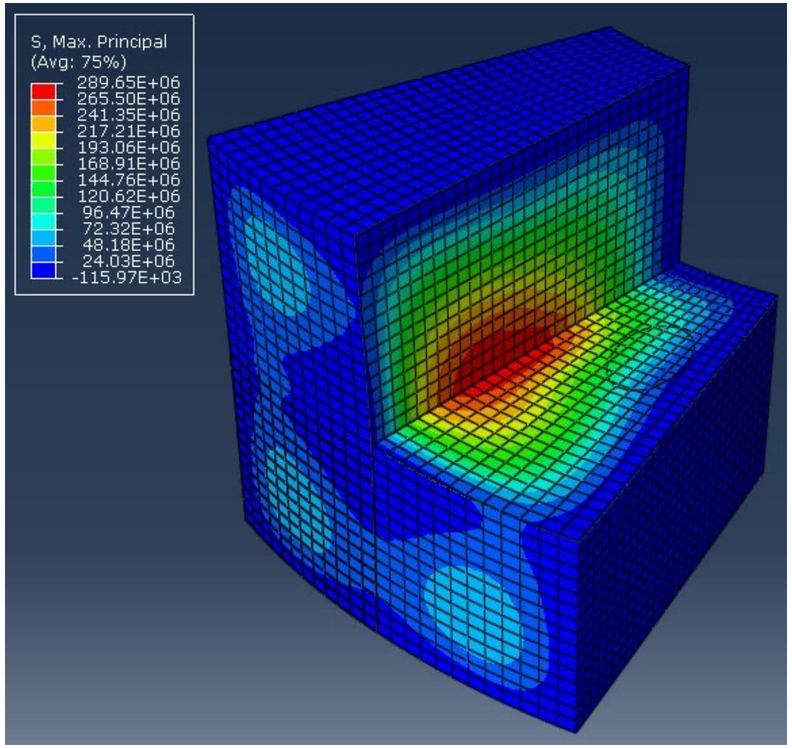


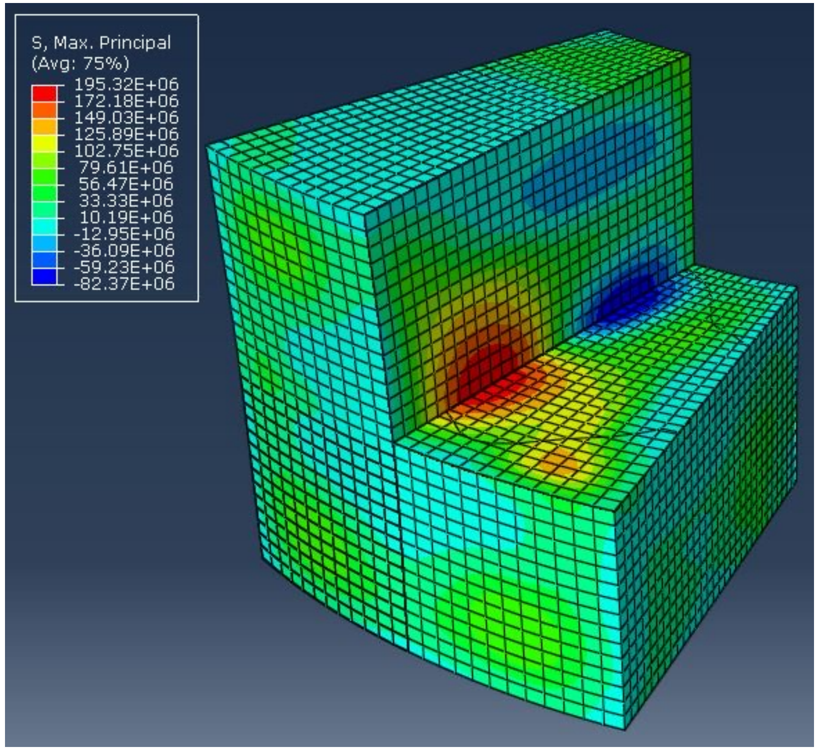




Design of Functionally Graded Materials for 3D Printing

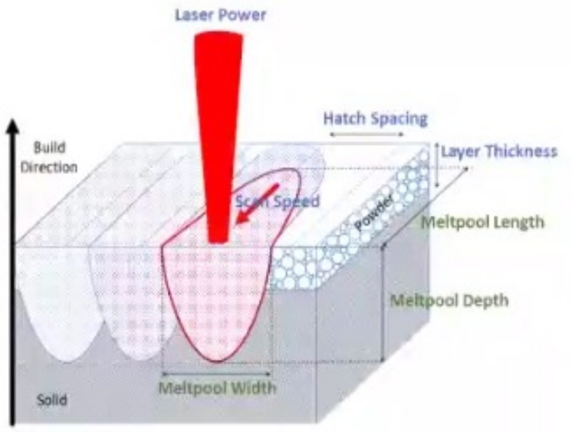
- **Numerical** project with ANSYS & MATLAB
- Material distribution can be optimized

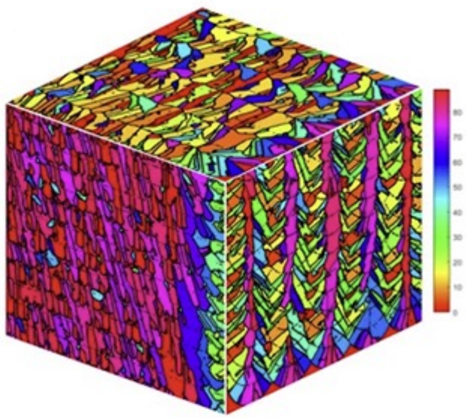


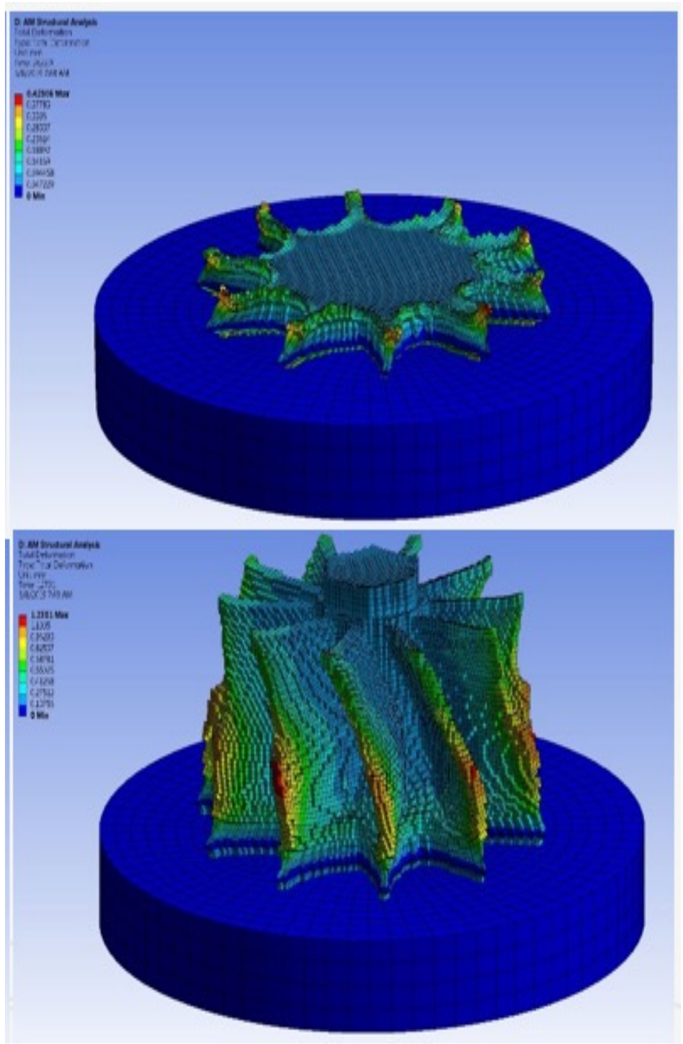


Simulation of Superalloy 3D Printing

- **Numerical** project with ANSYS
- Thermal residual stress
- Optimization

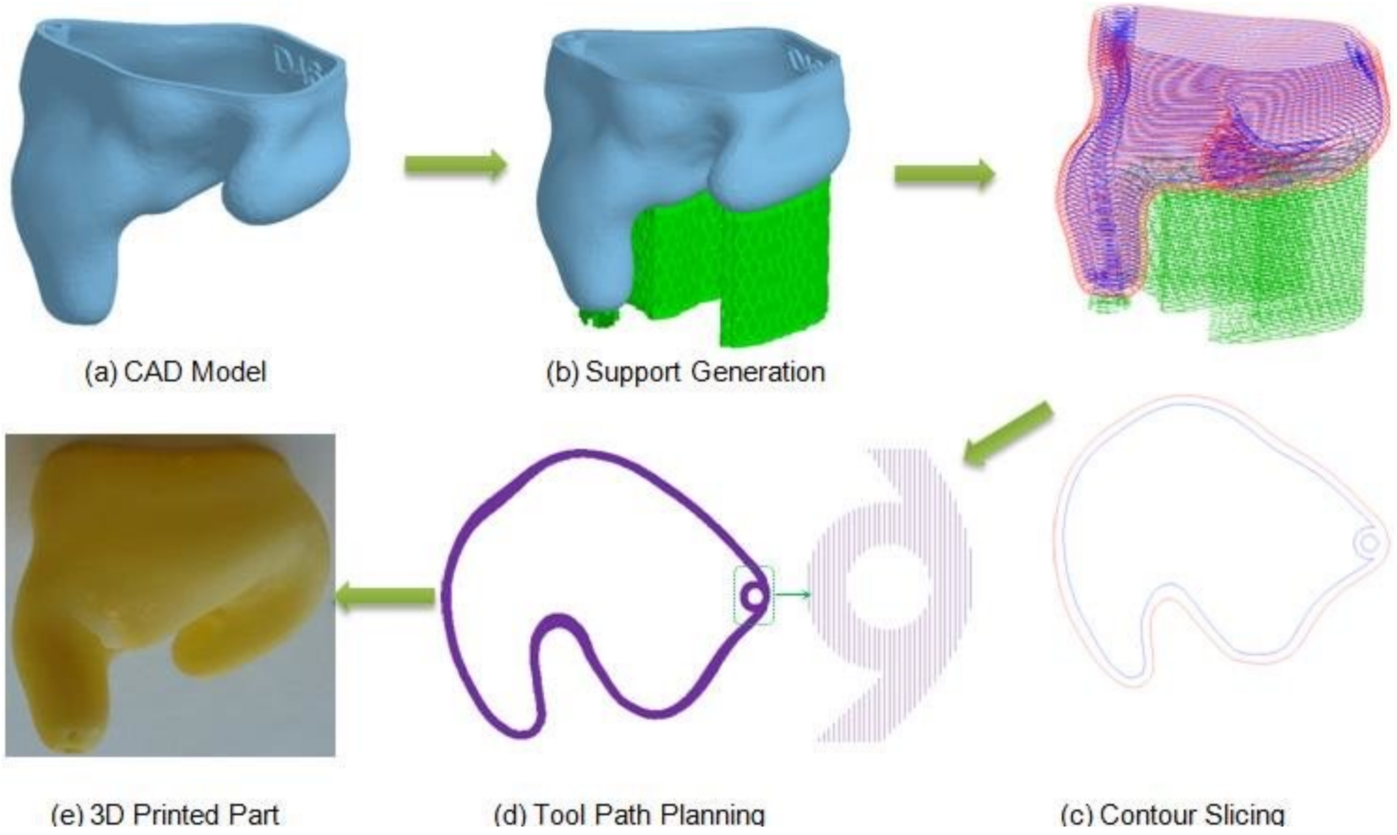






Tool-path Planning for 3D Printing

- **Experimental and theoretical** project
- Improving the productivity and/or accuracy of AM system



Other Projects

If you have an idea, we can talk about it!

Amir Armani

amir.armani@sjsu.edu

Project Opportunities

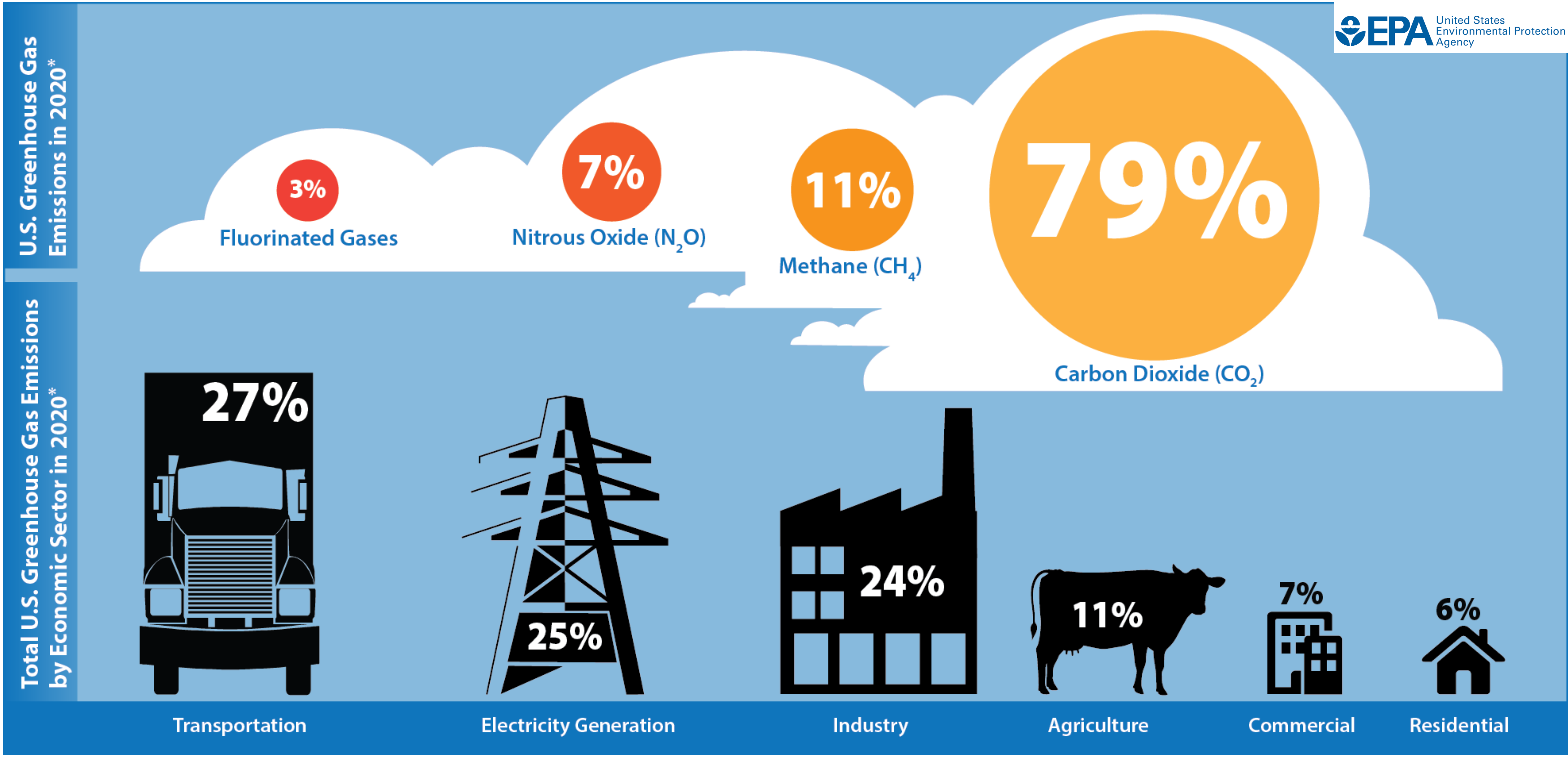
Farzan Kazemifar

Department of Mechanical Engineering

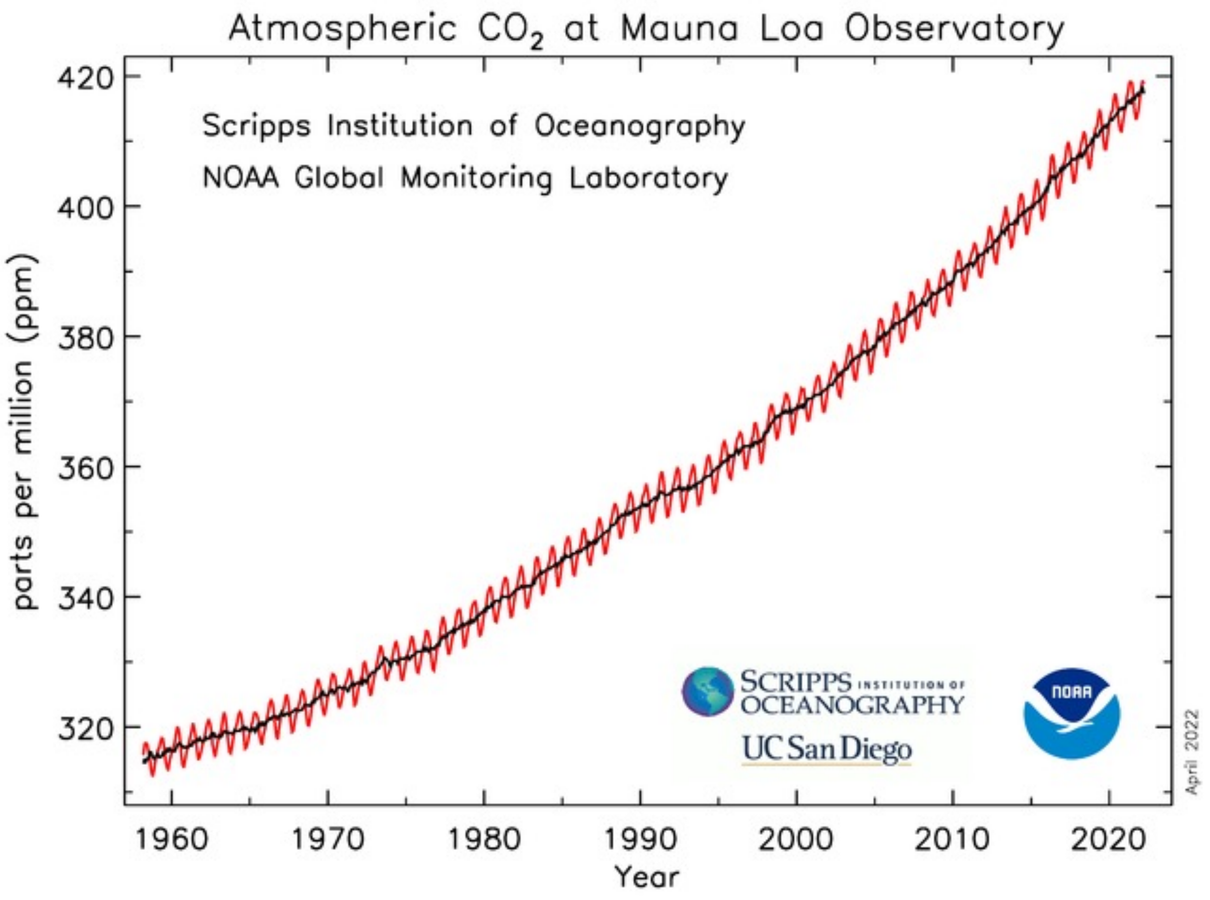
San José State University

Project Initiation Meeting – May 2024

US annual greenhouse gas emissions: ~5.2 $GtCO_2e$

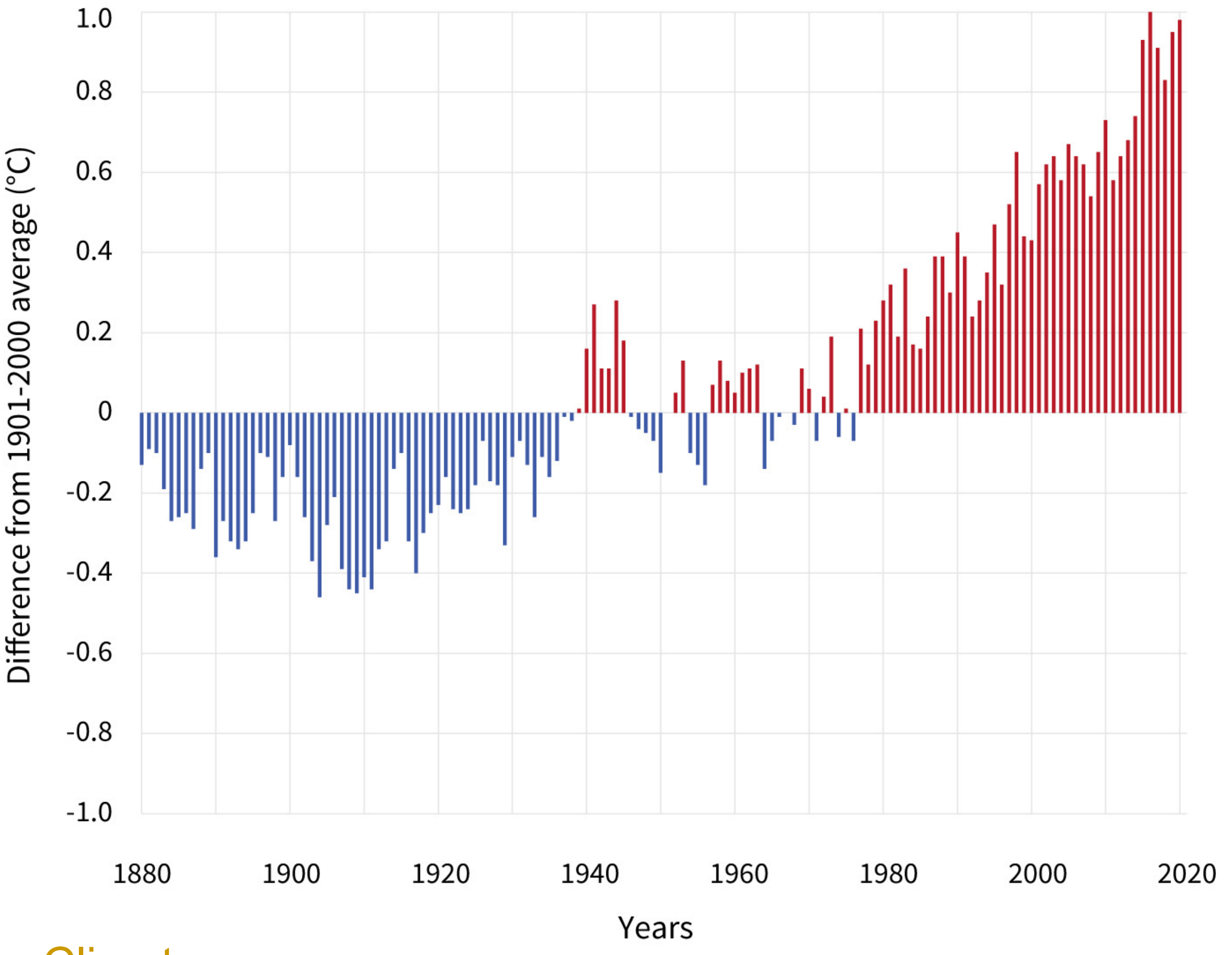


Atmospheric CO_2 Concentration & Global Temperature Trends



NOAA.gov

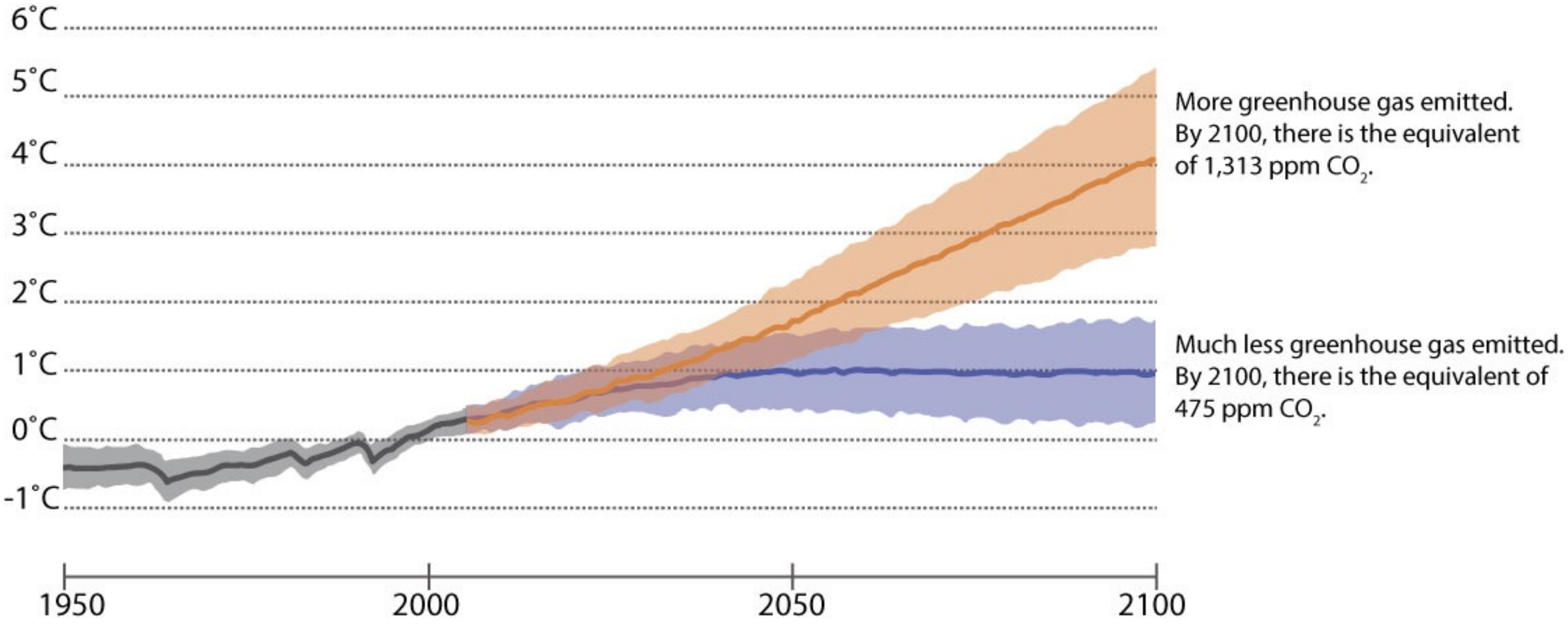
GLOBAL AVERAGE SURFACE TEMPERATURE



Climate.gov

Global Warming Projections

- Global average surface temperature change relative to year 2000.



L.S. Gardiner/UCAR with IPCC (2013) data

This year's projects are focused on decarbonization solutions in industrial and commercial building sectors.

Heat Pumps for Industrial Process Heat

- A major source of CO_2 emissions in the manufacturing sector is process heat
- Heat pumps can help reduce the CO2 emissions from process heat, however they are limited in their heat rate and temperature lift.
- In the US adoption of industrial heat pumps has been limited, in part due to high cost of electricity to natural gas.
- Successful implementation of industrial heat pumps requires careful integration with existing processes to recover waste heat.
- This project will be based on an existing manufacturing facility.
- Relevant Skills/Coursework: Heat transfer and thermodynamics

Optimum Sizing of Domestic Hot Water System

- Domestic hot water accounts for significant energy use in multifamily buildings
- Heat pumps can be used to reduce the associated CO_2 emissions
- Performance of heat pumps is limited in terms of heat rate and temperature lift
- The limitations can be addressed by combining storage and solar heat
- In this project, optimized solution in terms of system size and capacity for typical multifamily buildings will be developed.
- Relevant Skills/Coursework: Thermodynamics, Heat Transfer, MATLAB, Optimization

Control of Solar PV and Battery Storage

- New Net Energy Metering rules in California (NEM 3.0) will reduce the return on investment for standalone solar PV systems and have made electric batteries more viable.
- Realizing maximum financial benefit from a solar + battery system requires optimization based on system size, usage patterns, rate structure, etc.
- In this project, optimized solutions for existing commercial and industrial facilities will be developed.
- Relevant Skills/Coursework: MATLAB, Optimization

- Students who work on energy these projects will have the opportunity to join the SJSU Industrial Assessment Center.
  - Eligible for **tuition waiver** for 2 semesters when enrolled in ME 295A/B
  - Paid position
  - Travel to manufacturing facilities in California
  - Sponsored by the US Department of Energy
  - Check out the website for more info: sjsu-iac.org

Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

MSME Research Projects
ME295A for Fall 2024

Crystal Han
crystal.m.han@sjsu.edu

Development of custom instructional laboratory units for undergraduate thermal engineering lab

Commercial air conditioning lab unit

Commercial centrifugal pump unit ($36,000)

Background

Commercial instructional lab modules are costly and allows only limited controls. A low-cost, customizable laboratory units are in need to increase capacity of the SJSU undergraduate thermal engineering lab.

Current lab modules:
https://www.sjsu.edu/people/nicole.okamoto/courses/me_115/index.html

Goals (may be pursued by several students)

1. Analyze learning outcomes and physical parameters involved with the current SJSU thermal lab modules and other university's.
2. Develop low-cost, custom laboratory units for each specific topic.
3. Create a laboratory protocol and sample results.
4. Identify and assess learning outcomes of the lab.

Funding for materials available (has to be expended by Jan 2025)

Research Projects for MSME Students

Dr. Ali Tohidi

Email: ali.tohidi@sjsu.edu

Laboratory Website: www.tfx-lab.com

Mechanical Engineering Department,
Charles W. Davidson College of Engineering

TfX SJSU SAN JOSÉ STATE UNIVERSITY WIRC Wildfire Interdisciplinary Research Center

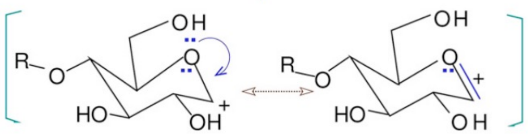
May 3, 2024

Modeling (Wild)fire Behavior and Impacts

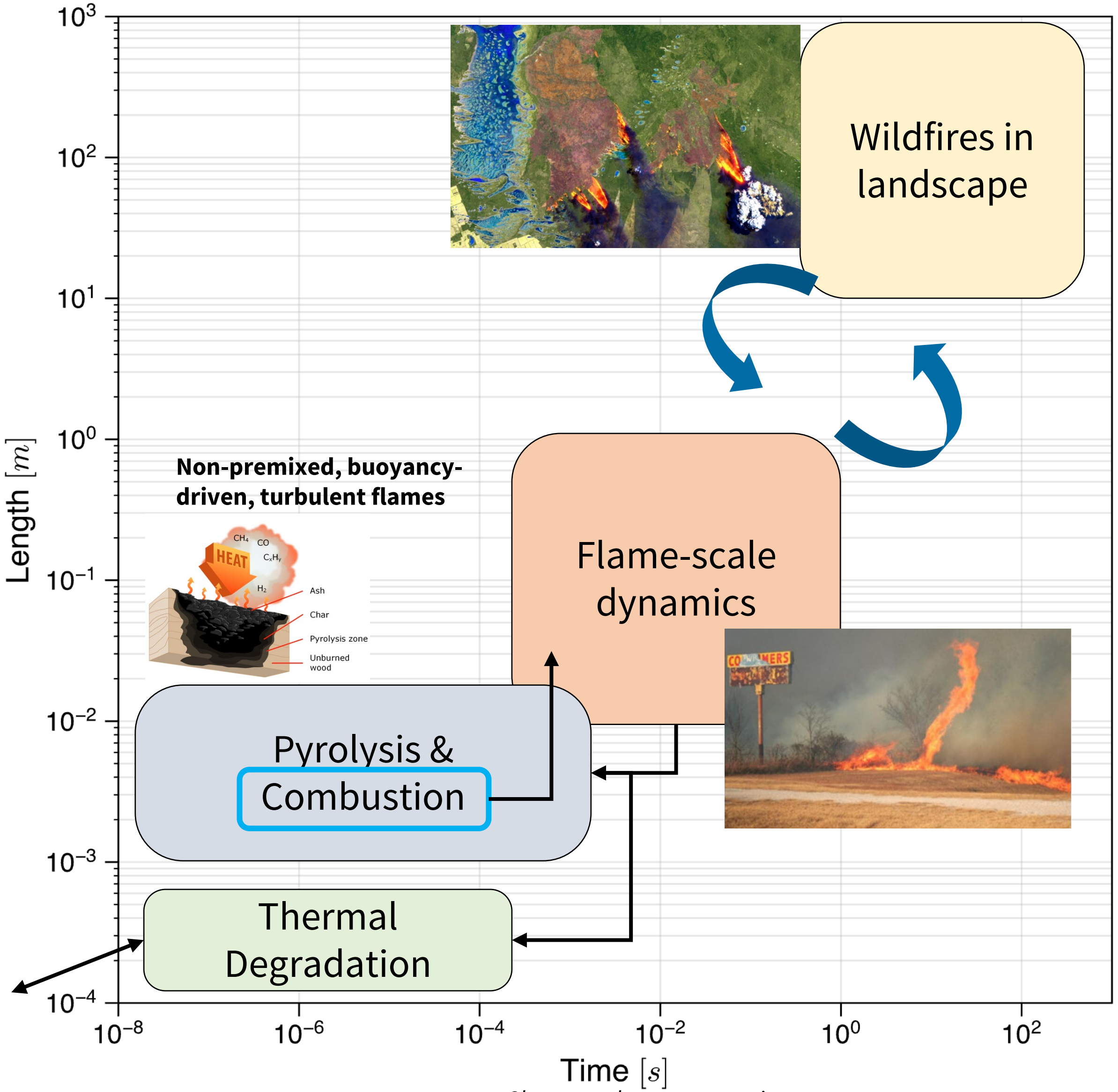
- Multi-scale and Multiphysics nature of (wild)fires
    - Boundary layer evolution in fire scenarios
    - Dominant modes of heat transfer
    - Fuel types and specific reactions
    - …

Single tree burn. Image source: [American Red Cross Eastern North Carolina Region]

An example of Pyrocumulonimbus (fire-breathing weather storms); Creek fire CA, 2020.



Depolymerization process[1]

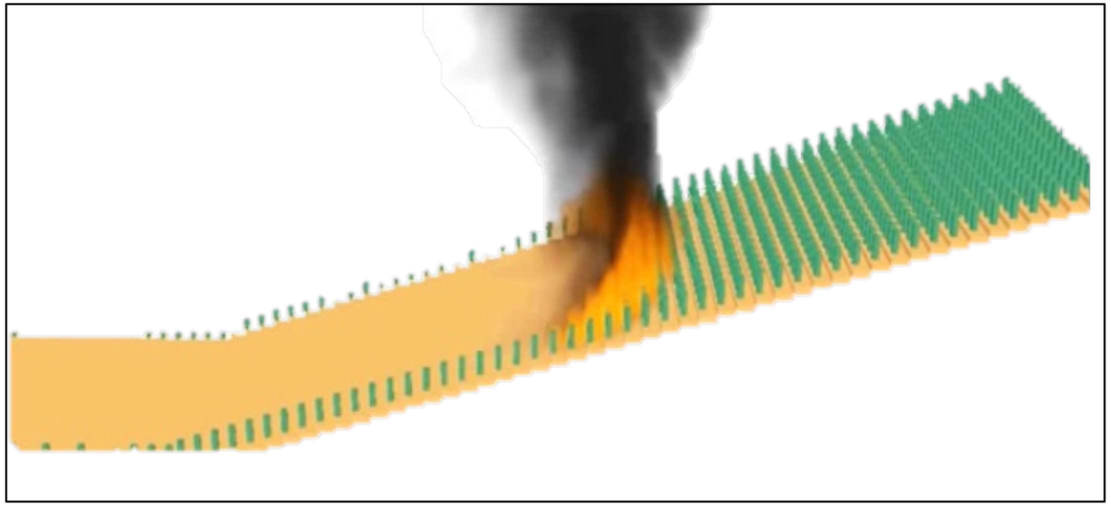


Shown scales are approximate.

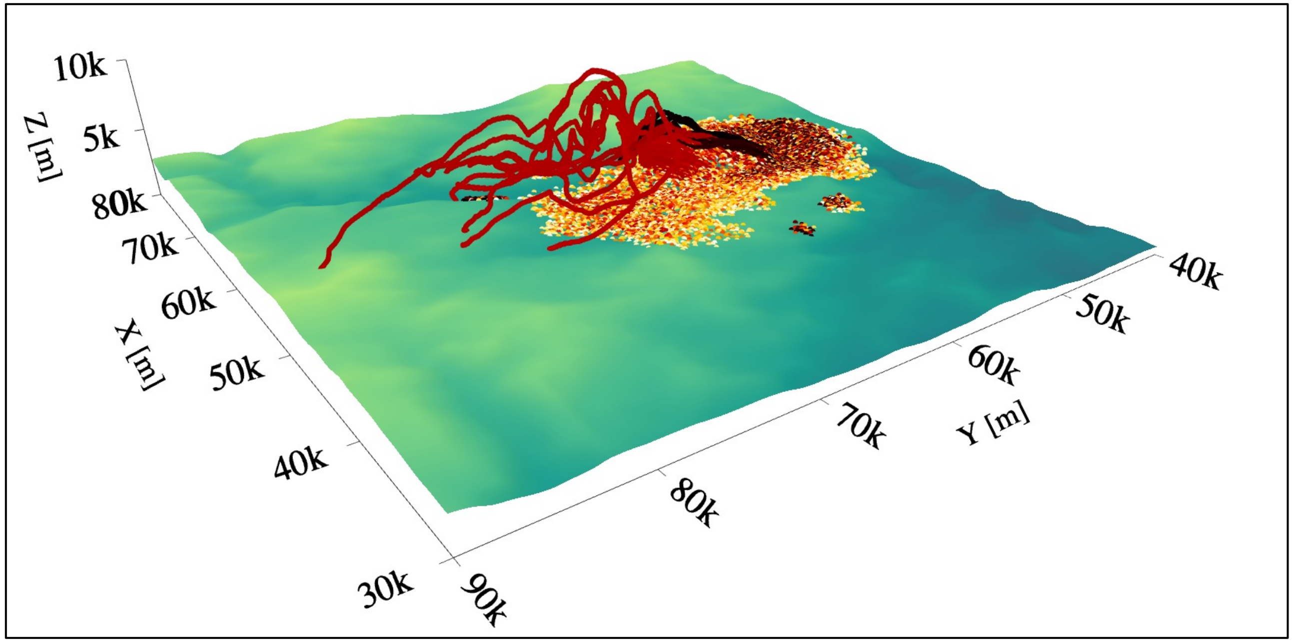
[1] A. L. Sullivan, R. Ball, *Atmospheric Environment*. **47**, 133–141 (2012).

Project 1: Understanding the Effects of Turbulent Flow on Particle Transport in Large Spatiotemporal Scales

High-fidelity CFD & Combustion models



Particle Transport Model



<u>**Project Goals**</u>

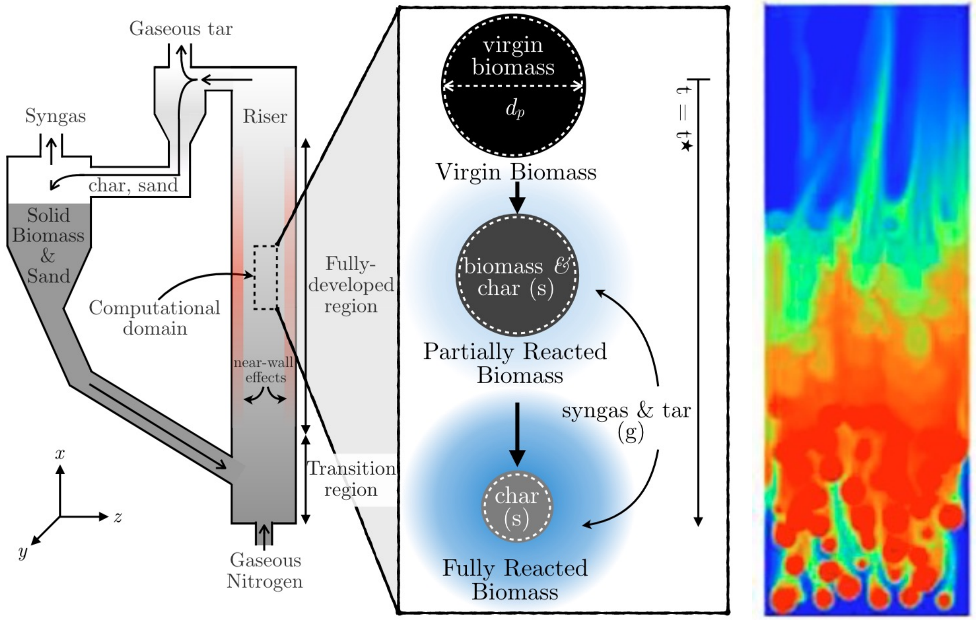
- Simulate fire spread in canopy and urban areas
- Couple the in-house particle transport model with the simulation outputs
- Conduct data-driven parameterization of the results
- Derive insights from the simulations

<u>**Learning Outcomes**</u>

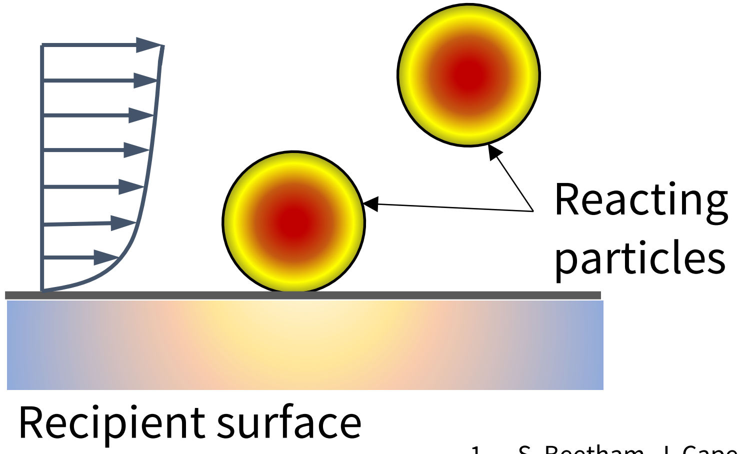
- Become an expert in Fire Modeling
- Learn about high-performance scientific computing
- Learn data-driven statistical analysis

Project 2: Effects of Biomass Size & Shape on its Thermal Degradation

Source of the image: https://www.santacruzsentinel.com/2021/08/19/more-evacuations-some-weather-help-as-californias-five-major-wildfires-continue-to-roar/



(Left) biomass pyrolysis reactor excerpted from [1], and (right) CDF simulation of biomass particle temperature from [2].



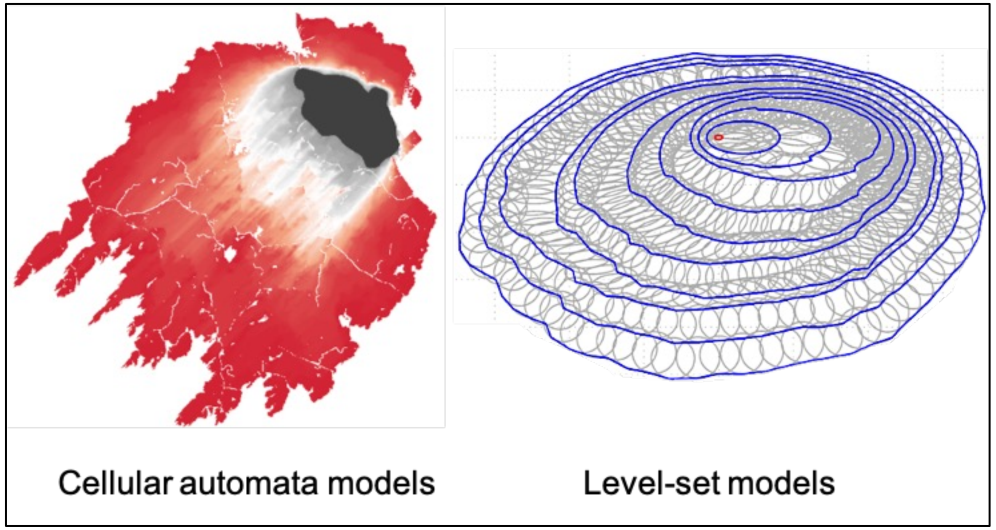
Learning Opportunities

- Heat transfer
- Computational Fluid Mechanics (CFD)
  - Ansys
  - OpenFOAM
  - COMSOL
  - …

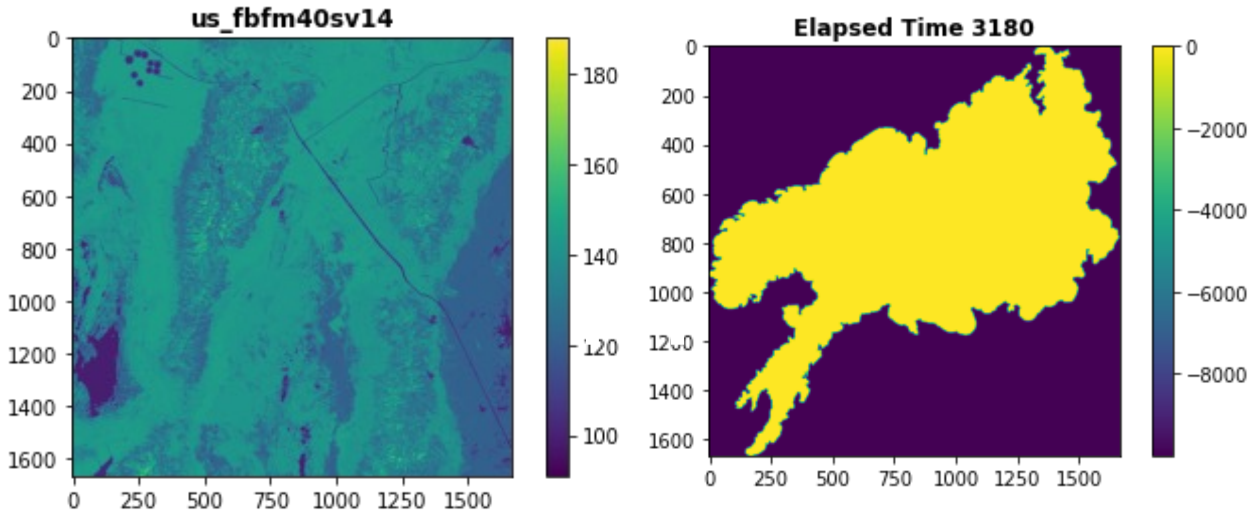
1. S. Beetham, J. Capecelatro, *Renewable Energy*. **140**, 751–760 (2019).
2. L.-T. Zhu, Y.-X. Liu, Z.-H. Luo, *Chemical Engineering Journal*. **374**, 531–544 (2019).

Project 3: Application of Deep Learning in Wildfire Modeling

Empirical Rate of Spread models



$$I_R = f(T, \overline{U}_\infty, t, \beta, \psi, P_{\infty,z}, \nu_\alpha S_\alpha, \ldots)$$

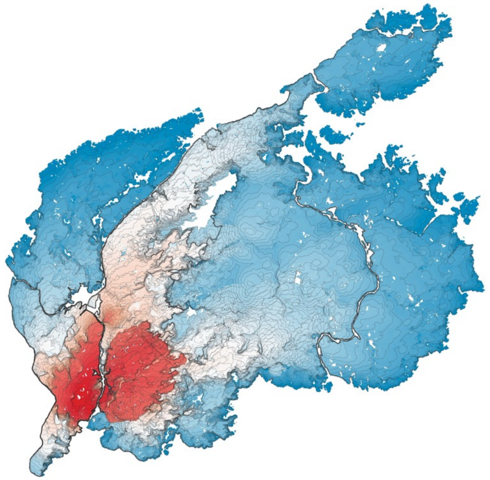


<u>**Project Goals**</u>

- Implement novel deep learning architecture to develop a data-driven operational wildfire model

<u>**Learning Opportunities**</u>

- Hands-on experience in developing deep learning models
- Experience in multi-scale modeling of wildfires
- Working experience with high-performance scientific computing (HPSC)



83,200 simulations are available

Available Projects for Fall 2024

Dr. Vimal Viswanathan
Associate Professor
Mechanical Engineering

Areas of Research

Primary Research Interests

Design theory and methodology
Design automation
AI/Machine learning in design
Product design
Engineering Education

Recent projects

Design automation (concluded)
AI/ML in design (ongoing project)
Design of rehabilitation devices (ongoing project)
4D printing (ongoing projects)
Improving the efficiency of 3D printing processes (recently published)
The Spartan Hyperloop (multiple ongoing projects)

Available Project 1: Developing new composite materials for 4D printing

- Ideal for: students interested in materials and 3D printing
- Experimental
- Thesis option preferred

Collaborators:

Dr. Yanika Schneider (CME)

Dr. Sohail Zaidi (ME)

materials

Article

Material and Design in 4D Printing: Building the Future with Shape Memory Polymers

David Pokras [1], Yanika Schneider [2], Sohail Zaidi [1,3], and Vimal K. Viswanathan [1,*]

[1] Mechanical Engineering, San Jose State University, San Jose, CA, USA; dpokras98@gmail.com (D.P.); vimal.viswanathan@sjsu.edu (V.V.)
[2] Chemical and Materials Engineering, San Jose State University, San Jose, CA, USA; yanika.schneider@sjsu.edu (Y.S.)
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Abstract: This paper evaluates the design and fabrication of a thermoplastic polyurethane (TPU) based shape memory polymer (SMP) using fused deposition modeling (FDM). The commercially available SMP TPU was used to create parts capable of changing their shape following the application of an external heat stimulus. The interlocking lattice structures were evaluated by combining SMP with another thermoplastic that has poor adhesion with TPU. The characterization of thermal and viscoelastic properties of the SMP TPU revealed a lower glass transition temperature than provided by the manufacturer, a proportional change in shape fixity and shape recovery with respect to heating and cooling rates, as well as a decreasing softening temperature with increasing shape memory history due to changes in the polymer microstructure. Further, the study characterized a multi-material interlocking lattice structure between a shape memory polymer and a common 3D printing material. Tensile testing of multi-material ASTM D638-14 type IV specimens with interlaced topologically optimized lattices also revealed an average ultimate interface tensile strength of approximately 41% and a maximum ultimate strength of 62% of the SMP TPU's 16 MPa ultimate tensile strength. These characterizations can make 4D printing technology more accessible to common users and make it available for new markets.

Keywords: 3D Printing; 4D Printing; shape memory polymers; self-assembly; interlocking structures; multi-material

Available project 2:

Must have programming experience and at least basic knowledge of ML

Collaborator:
Dr. Mahima Agumbe Suresh (COMPE)

algorithms

MDPI

Article

Enhancing Product Design through AI-Driven Sentiment Analysis of Amazon Reviews Using BERT

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Abstract: Understanding customer emotions and preferences is paramount for success in the dynamic product design landscape. This paper presents a study to develop a prediction pipeline to detect the aspect and perform sentiment analysis on review data. The pre-trained Bidirectional Encoder Representation from Transformers (BERT) model and the Text-to-Text Transfer Transformer (T5) are deployed to predict customer emotions. These models were trained on synthetically generated and manually labeled datasets to detect the specific features from review data, then sentiment analysis was performed to classify the data into positive, negative, and neutral reviews concerning their aspects. This research focused on eco-friendly products to analyze the customer emotions in this category. The BERT and T5 models were finely tuned for the aspect detection job and achieved 92% and 91% accuracy, respectively. The best-performing model will be selected, calculating the evaluation metrics precision, recall, F1-score, and computational efficiency. In these calculations, the BERT model outperforms T5 and is chosen as a classifier for the prediction pipeline to predict the aspect. By detecting aspects and sentiments of input data using the pre-trained BERT model, our study demonstrates its capability to comprehend and analyze customer reviews effectively. These findings can empower product designers and research developers with data-driven insights to shape exceptional products that resonate with customer expectations.

Keywords: BERT; T5; natural language processing; content analysis; customer requirements

check for updates

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