Graduate Projects Meeting
November 16, 2023

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

Completed form should be emailed to the appropriate GAPE evaluator (see www.sjsu.edu/gape/about_us/staff), submitted to Window G in the Student Services Center, or sent through interoffice mail to extended zip 0017.

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

	Course Prefix/Catalog No. (e.g. MAS 203)	Total Units	Grade	Semester/Year Completed
☐ 299 Thesis (Plan A)/Creative Work (Plan C)				
☐ Last completed project or comprehensive exam-preparation course (plan B)				

☐ Other Culminating Experiences

	Type	Semester/Year Completed
1) Other culminating experience		
2) Other culminating experience		

	Course Prefix/Catalog No. (e.g. MAS 203)	Total Units	Grade	Semester/Year Completed
☐ 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 ______
Signature (certifies accuracy of the information provided)

For Official Use Only

The signatures below indicate approval.

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

https://www.sjsu.edu/me/docs/forms_gape-candidacy.pdf

Step-by-step Instructions for Filling out the Form

https://www.sjsu.edu/me/docs/msme_currentstudents-candidacy_form_instructions_02_05_19.pdf

Requirements

2. A completed proposal should include:

A. The Project Cover Page

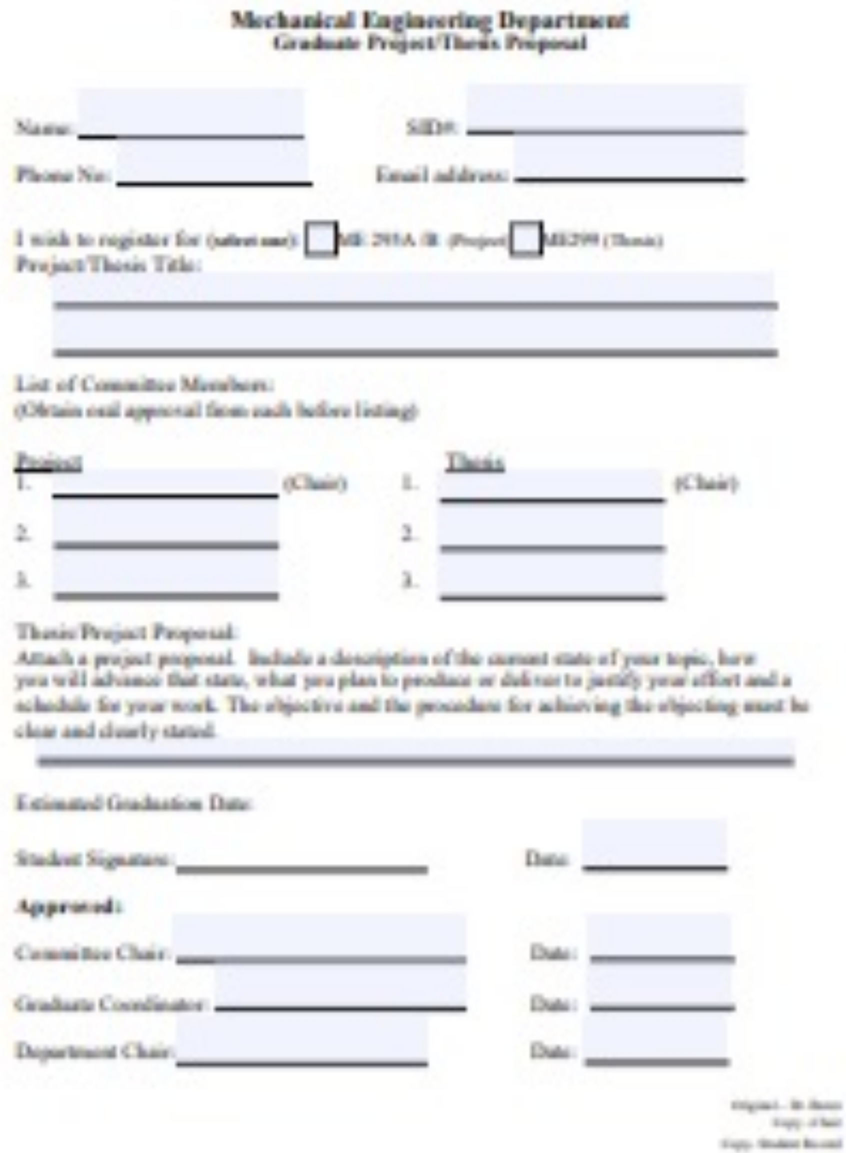
B. Approved committee evaluation

C. 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

A. Project Cover Page


Mechanical Engineering Department
Graduate Project/Thesis Proposal

Name: ______ SID#: ______

Phone No: ______ Email address: ______

I wish to register for (select one): ☐ ME 295A/B (Project) ☐ ME299 (Thesis)

Project/Thesis Title:

List of Committee Members:
(Obtain oral approval from each before listing)

Project		Thesis	
1. ______	(Chair)	1. ______	(Chair)
2. ______		2. ______	
3. ______		3. ______	

Thesis/Project Proposal:
Attach a project proposal. Include a description of the current state of your topic, how you will advance that state, what you plan to produce or deliver to justify your effort and a schedule for your work. The objective and the procedure for achieving the objecting must be clear and clearly stated.

Estimated Graduation Date:

Student Signature: ______ Date: ______

Approved:

Committee Chair: ______ Date: ______

Graduate Coordinator: ______ Date: ______

Department Chair: ______ Date: ______

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/ improvement	Unacceptable	Acceptable	Acceptable w/ improvement	Unacceptable	Acceptable	Acceptable w/ improvement	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 295/299 proposal guidelines.									
Overall, the proposal established high confidence that the endeavor will be completed successfully.									

Step-by-step Instructions for Submitting the Proposal

- **https://www.sjsu.edu/me/docs/forms_msme-DocuSign_MSME%20Project_Thesis%20Proposal_Procedures_090221Rev.pdf**

Submit your proposal to the ME office

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

Adviser meeting-record form

Mechanical Engineering Department
Graduate Student Thesis/ Project Committee Chair and Members
Consultation Records

Graduate students enrolled in Project/Thesis courses are expected to meet with their study committee chairs a minimum of four (4) periods during each semester, preferably, on a monthly basis and at least one meeting with each committee member. Please be sure to take this sheet to your meetings with your study Committee Chair and Members and request acknowledgement.

Date: ________ Time: _______ Committee Chair Signature: ________________________

Date: ________ Time: _______ Committee Chair Signature: ________________________

Date: ________ Time: _______ Committee Chair Signature: ________________________

Date: ________ Time: _______ Committee Chair Signature: ________________________

Date: ________ Time: _______ Committee Member Signature: ______________________

Date: ________ Time: _______ Committee Member Signature: ______________________

Date written draft report received by the Committee Chair: ___________ Date: ______

Students are expected to give this sheet to the Committee Chair on their presentation day.

Student Name: ___________________________________

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:

- **November 16, 2023**
  - *Project Initiation Meeting*
- **November 16, 2023, through December 7, 2023**
  - *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

- **January 24, 2024, through February 19, 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*

- **February 12, 2024:** *Submit the approved proposal to the ME office, for approval by the Graduate Advisor and the department Chair*

- **February 19, 2024**: ***University Deadline for adding a course***

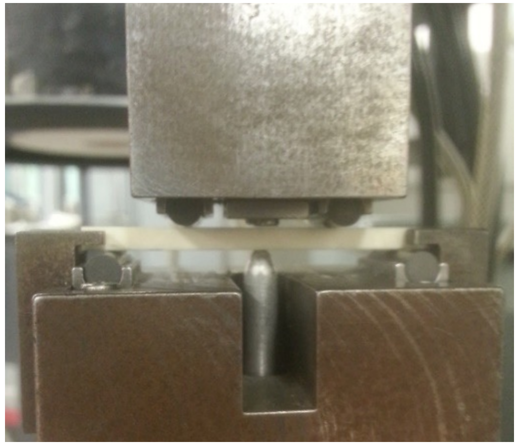
Note

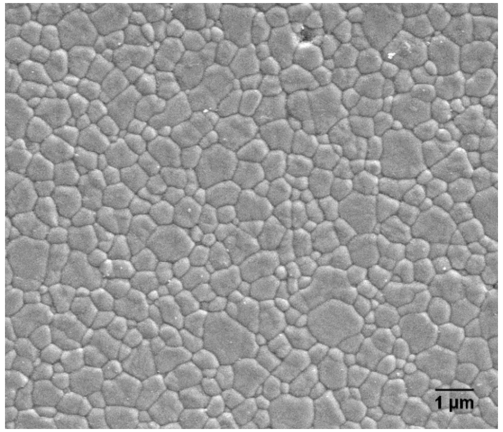
When your proposal is approved by the ME office, you can obtain the add code from your committee chair.

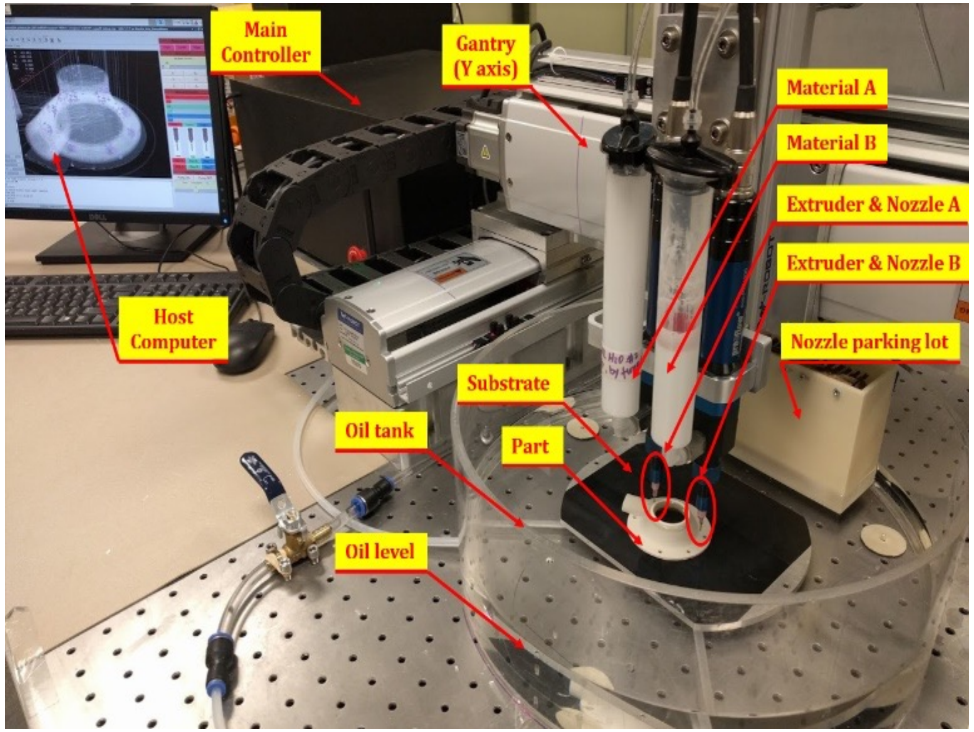
Available Projects

Additive Manufacturing & Material Characterization

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

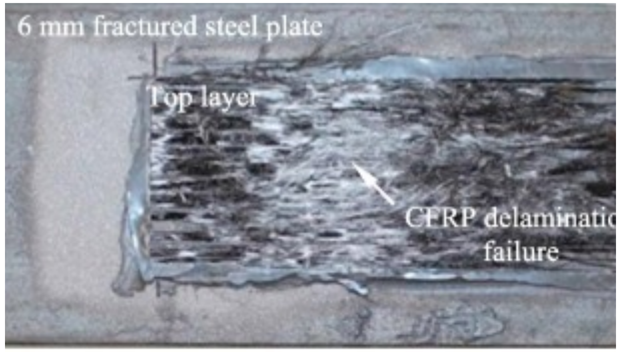


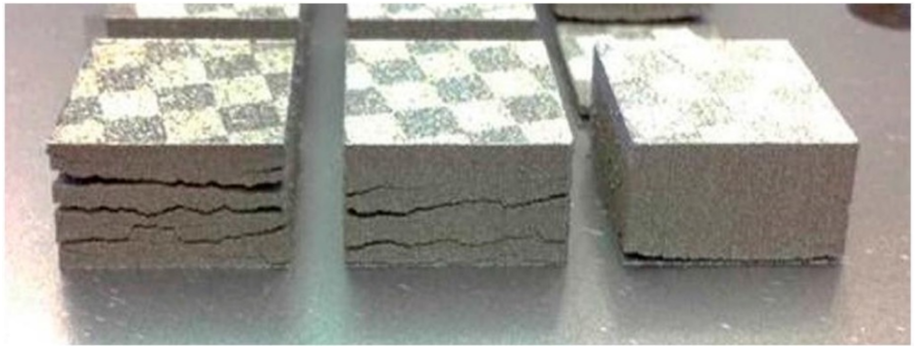


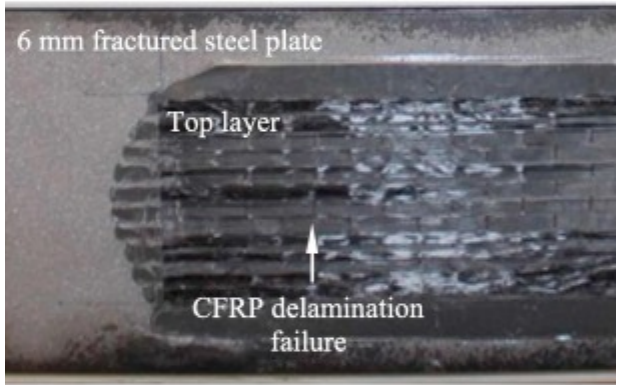


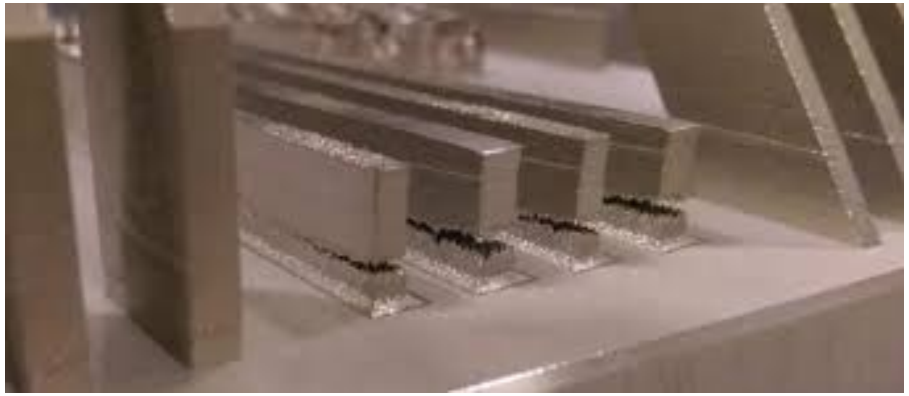
Improving AM with ML

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



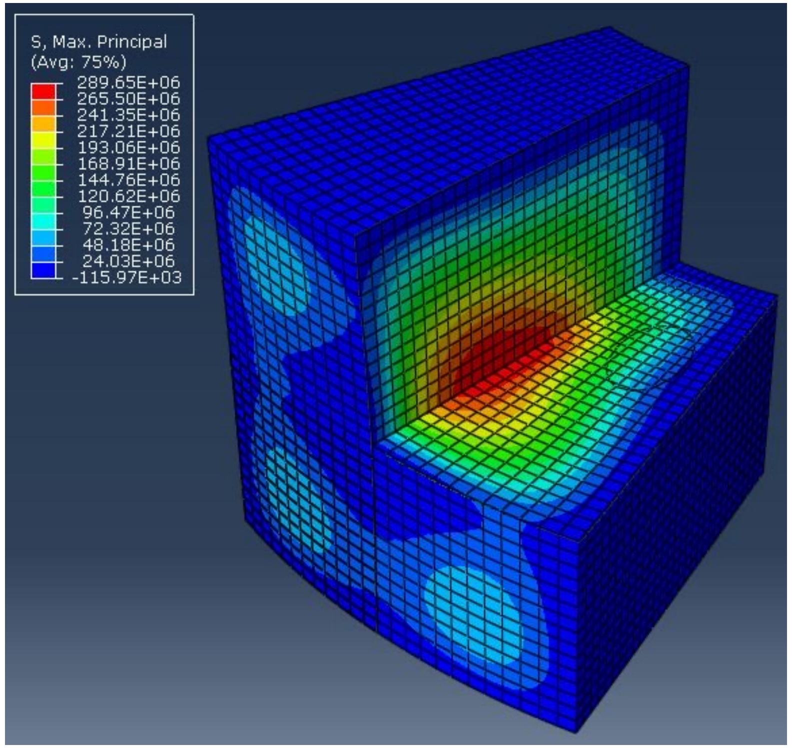


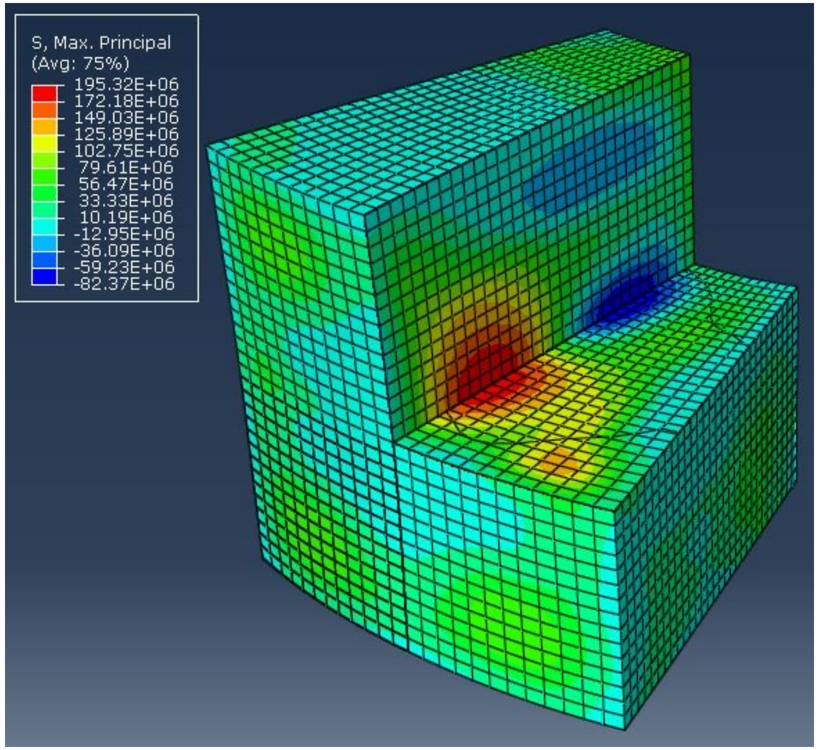




Design of Functionally Graded Materials for 3D Printing

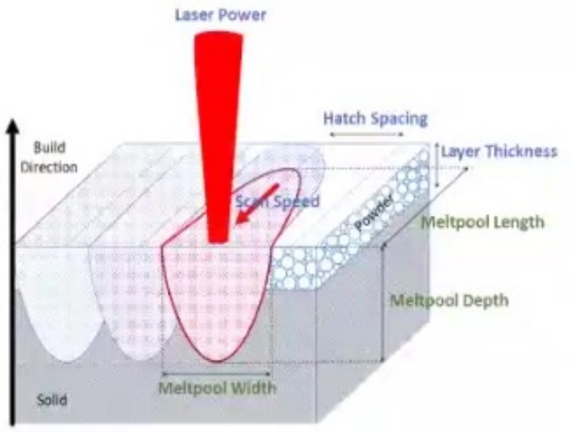
- **Numerical** project with ANSYS & MATLAB
- Material distribution can be optimized

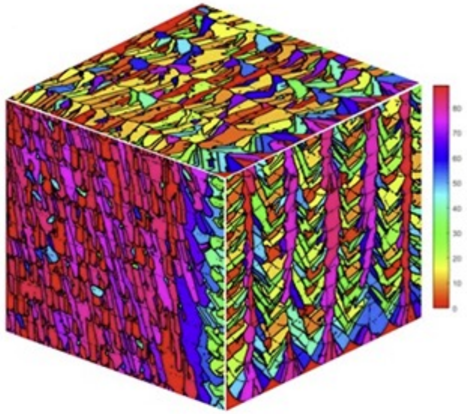


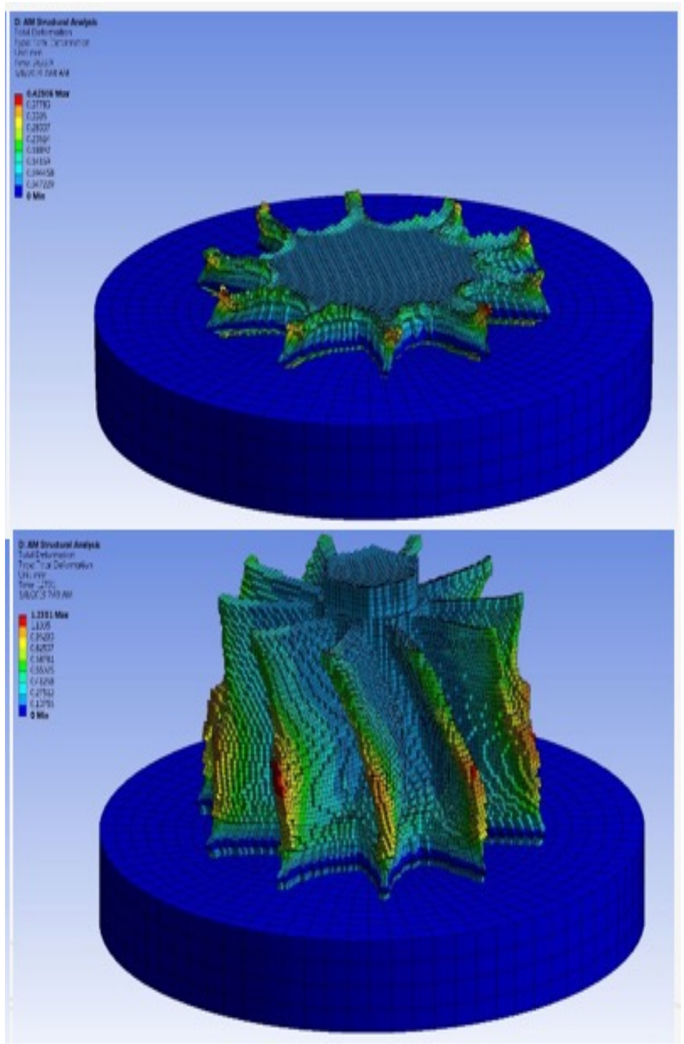


Simulation of Superalloy 3D Printing

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

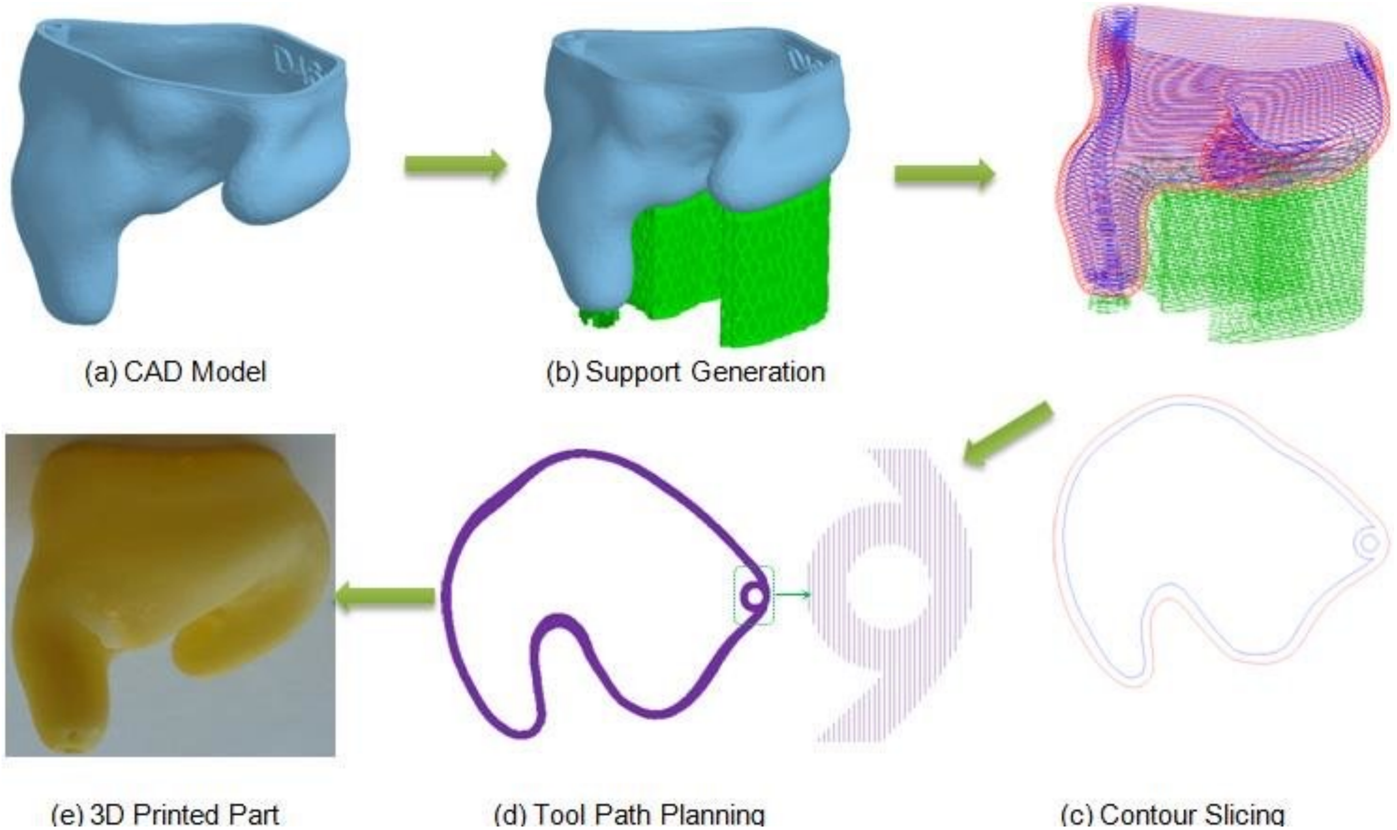






Tool-path Planning for 3D Printing

- **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

MSME Research Projects

Mechanical Engineering Department
ME295A
For **Spring or Fall 2024**

Professor Raymond K. Yee
raymond.yee@sjsu.edu

A Technology-Assisted Mobility Device/System for Aging Population (Fall 2024 MS project)

Objective: To develop an assistive mobility device/system which provides stability, support, balance, and mobility for elderly folks to maneuver around their home (e.g. one-floor apartment).

Project goal: To design a lightweight, simple, wearable/rideable optimal kinematic system
for seniors to support & preserve their personal mobility and stability in a home environment.

- Maintaining an acceptable level of life quality.
- Preventing falling from occurring

Desired knowledge: Kinematics & Design (ME154 or equivalent), Robotics (ME192), and Mechatronics & Control courses (such as ME106 and/or ME190 or ME192 or similar U/G courses.
Grad courses: ME280, ME281 and/or ME282 at SJSU is a plus).

https://ae01.alicdn.com/kf/Sb8d30d52d5784bb0a117e3c67c5e86e6a/Walking-Aid-Walking-Rehabilitation-Helps-Elderly-Training-Equipment-Stroke-Hemiplegia-Exoskeleton-Lower-Limb-Walking-Leg-Lifting.jpg_50x50.jpg_.webp

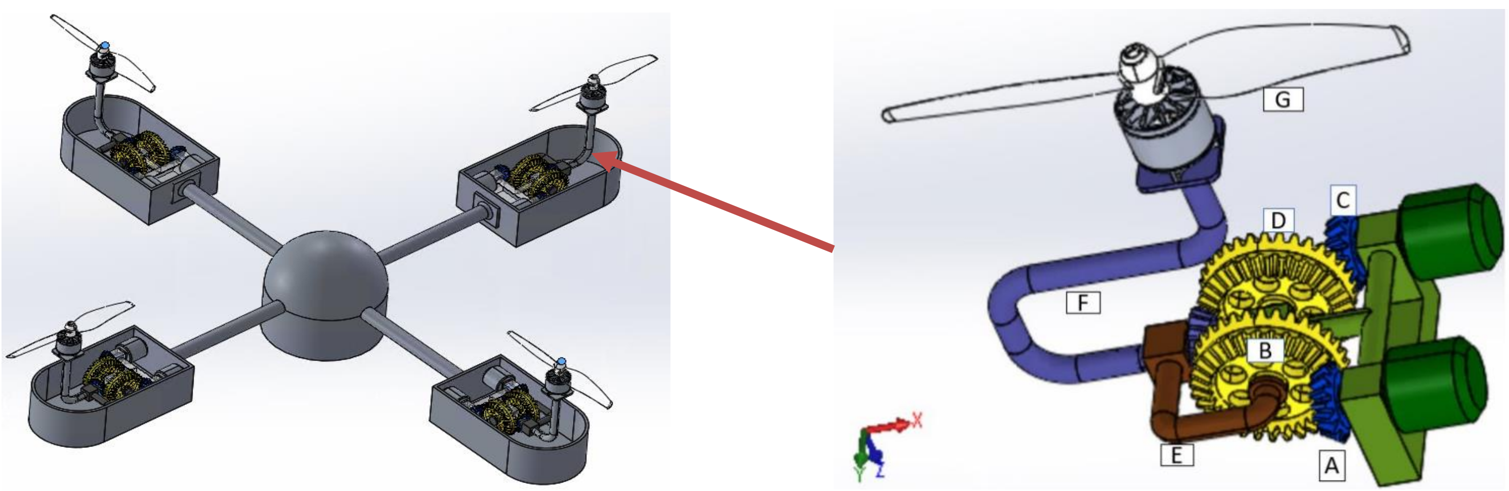
https://ae01.alicdn.com/kf/Sdc01e04816224d56b3aeaeb59af4aebbG/Exoskeleton-Help-Walking-Knee-Booster-Fixed-Support-Menisci-Knee-Pad.jpg_50x50.jpg_.webp

Project: Drone design using Layered Composite for Prototyping

Objective: Design a control system to provide stability and 3-axes tilting capabilities of the rotor shaft for an existing design and prototype of an drone rotor/propeller mechanism.

Project Scope: Design a closed loop feedback control system for an existing drone rotor/propeller design and its prototype, implement a suitable control system for the rotor tilting mechanism and collect data from field trials.

Basic Requirements: Interested in drone rotor design and aerospace.
Good understanding of control system, basic statistics and data analysis, MATLAB coding, and rigid body dynamics.

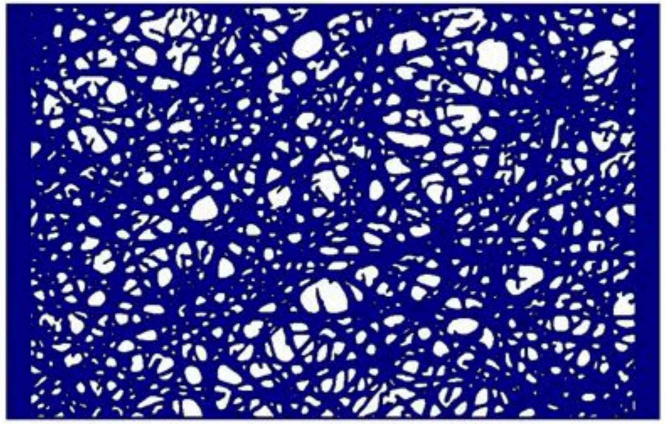


Student Research Opportunities in Microfluidics and Mechanics of Soft Materials

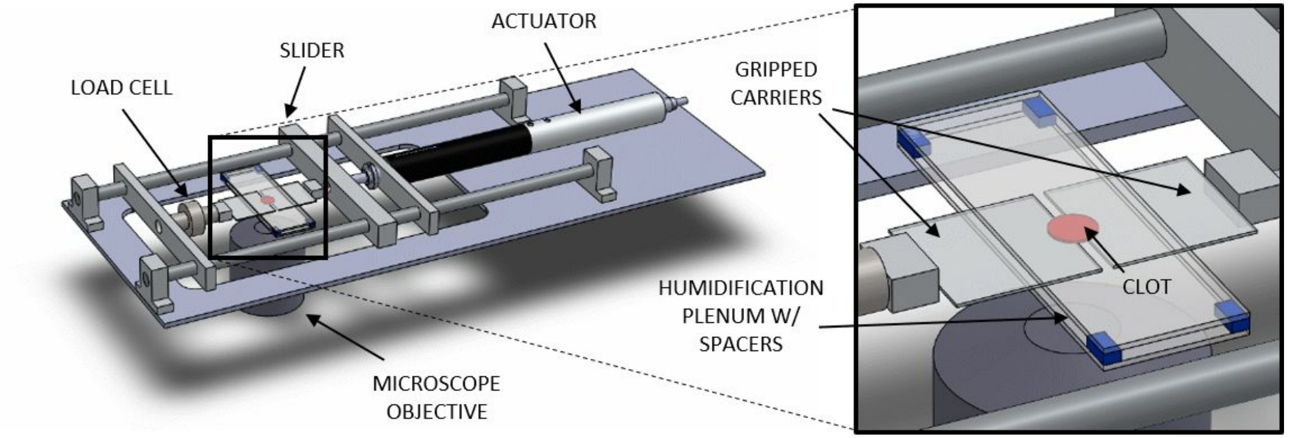
S. J. Lee
sang-joon.lee@sjsu.edu
San Jose State University
2023 Nov 07

Modeling and simulation of blood clot mechanics

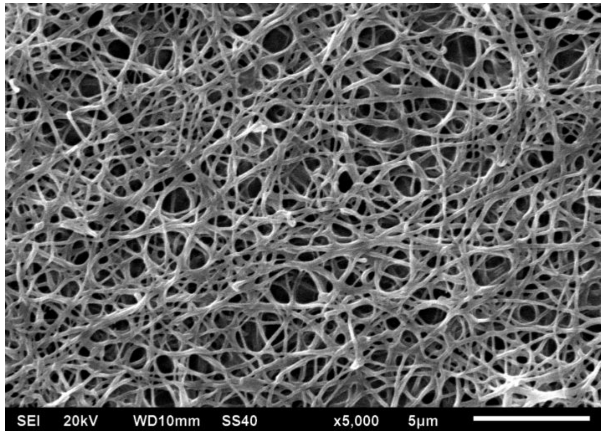
In collaboration with Dr. Ramasubramanian (Chemical Engineering), Dr. Dasbiswas (UC Merced) and Dr. Gopinath (UC Merced)



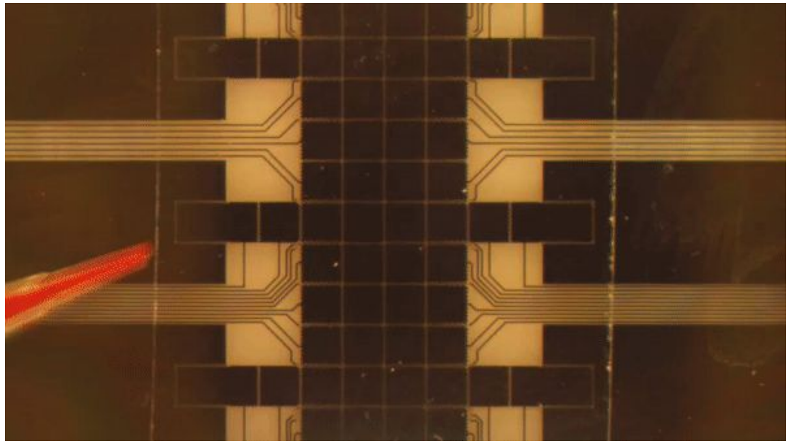
Finite element simulation of strain energy density* distribution through a fibrin network under tension



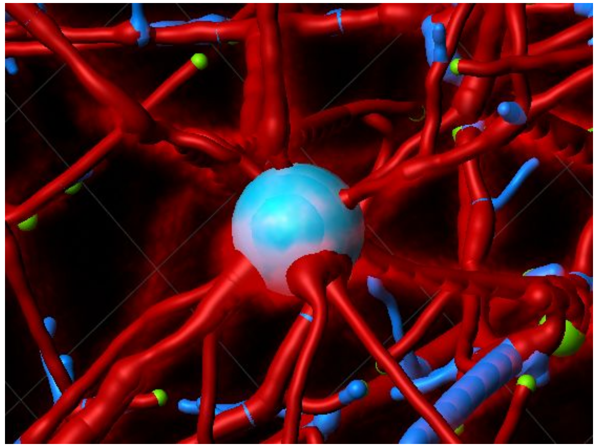
Design of apparatus for simultaneous extension and fluorescence microscopy.



Scanning electron microscope image of fibrin network



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

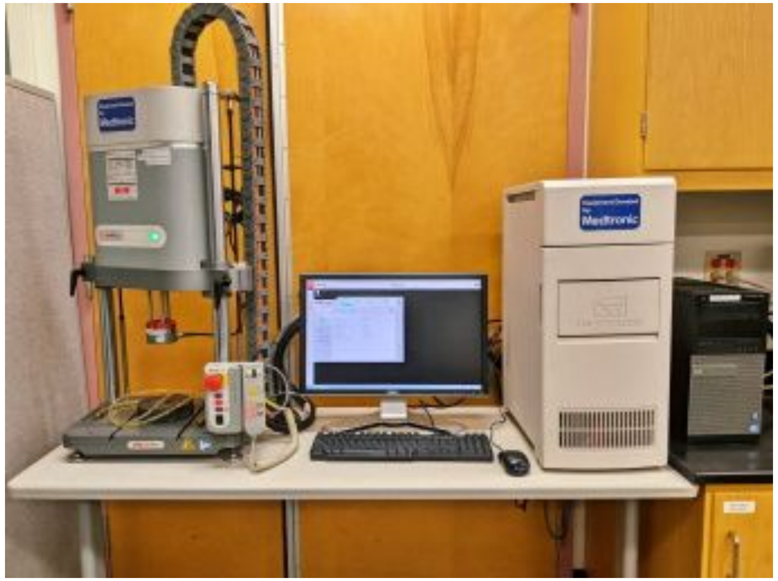


3-D feature recognition and topological reconstruction of network connectivity

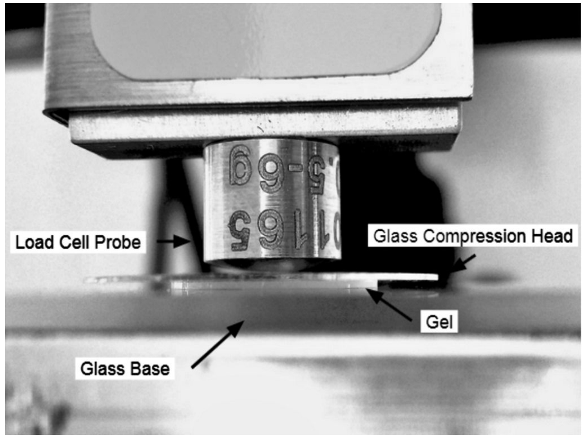
Early work sponsored by the American Heart Association, 2018-2020.
Related prior work: Lee 2020 https://doi.org/10.1007/s10237-019-01203-8, Pathare 2021 https://doi.org/10.1016/j.bpr.2021.100022, Zakharov 2023 https://doi.org/10.1101/2023.03.24.534185

Mechanics of battery polymer electrolytes

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



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



Simultaneous measurement of force and micron-scale displacement

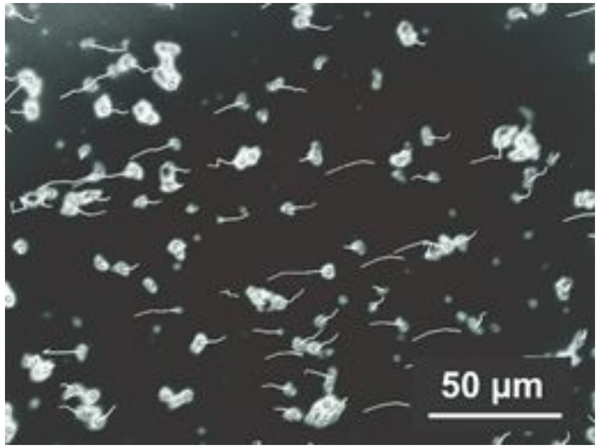
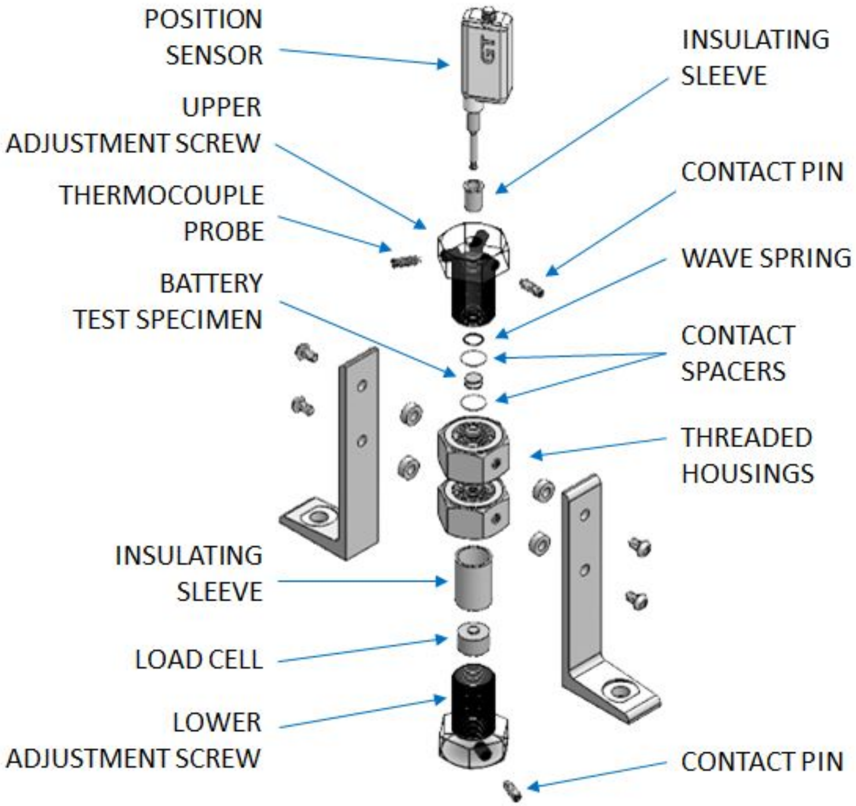


Image analysis and tracking of particle distribution in polymer matrix

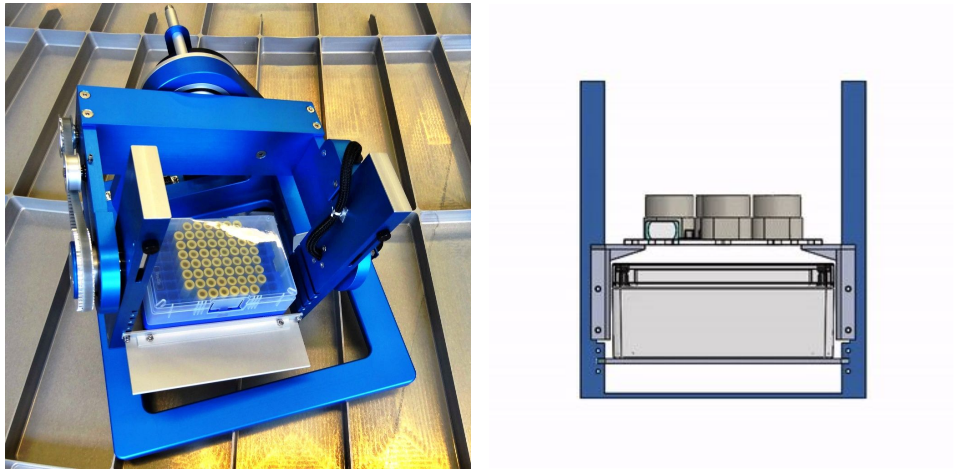


Multifunctional apparatus for simultaneous measurement of mechanical response and electrochemical performance

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

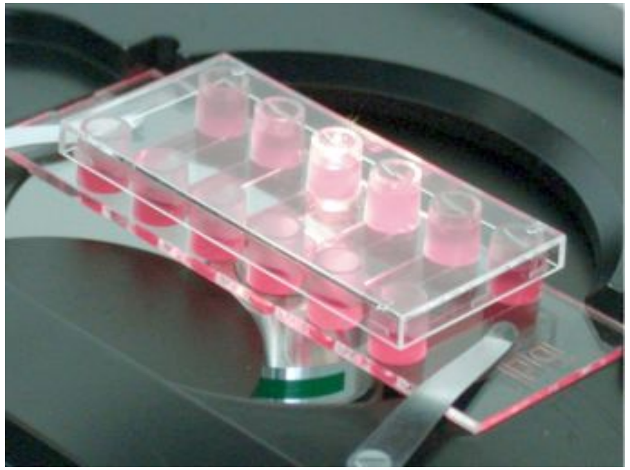
Hemodynamics and thrombosis in microgravity

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

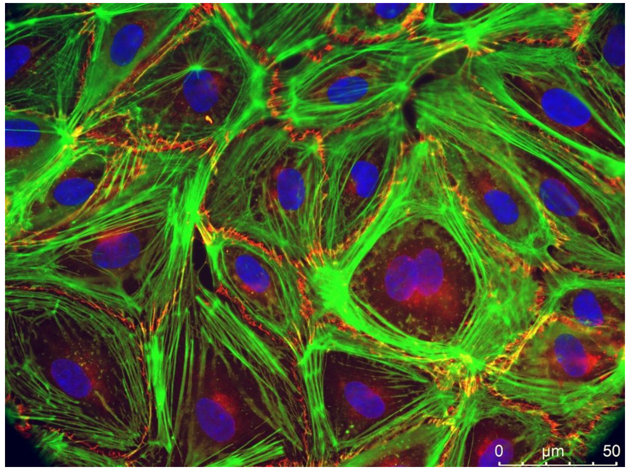


Random positioning machine for simulated microgravity

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

- An alarming incident occurred recently when an astronaut on the International Space Station (ISS) developed blood clotting in a jugular vein 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 6 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 (with planned offering in Fall 2023) is a hands-on lab class that is highly synergistic with research training.
- Paid lab assistantships are unfortunately rare for first-semester students, but limited opportunities may come open to more experienced lab members.

MSME Projects

Lin Jiang
Assistant Professor
Mechanical Engineering
lin.jiang@sjsu.edu

Areas of interests

Design and Development of Medical Devices

- Personalized design for equity healthcare
- Advanced manufacturing
- Smart materials
- Surgical Robot
- Bio-Fluid Structural Interaction (Bio-FSI)

Robotics and AI

- Haptic feedback
- Human-in-the-loop robot control
- Task-oriented Human-robot Interaction
- Autonomous Driving
- VR/AR

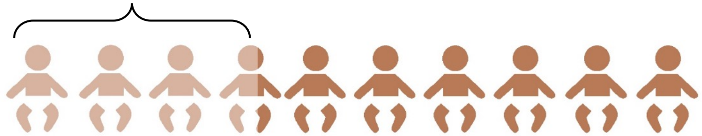
Medical Devices

lin.jiang@sjsu.edu

Maternal and Child Health

Effective breast milk delivery provides health for both Infants and Mothers

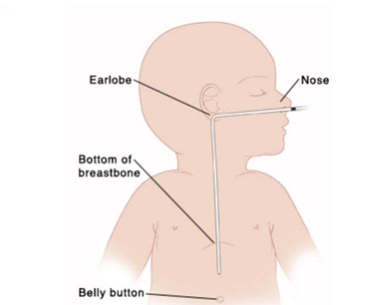
38 % exclusive breastfeed

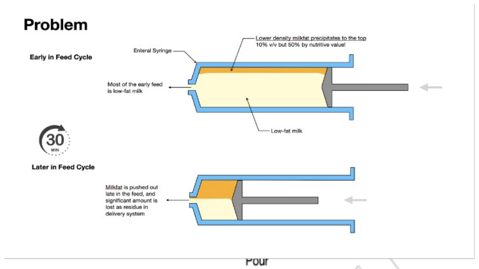


Maternal Factor
- Flat or Inverted Nipples
- Separated from infant
- Duct blockage
- Breast engorgement
- Mastitis/inflammation
- Breast surgery
- High fat breast milk
- Too slow/fast milk flow

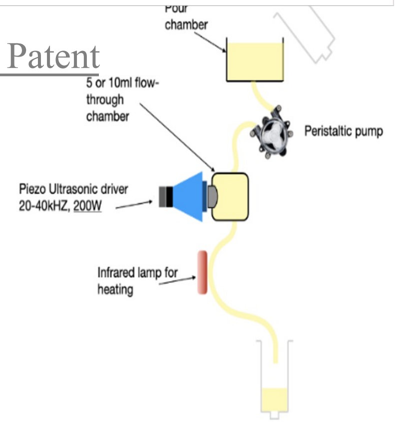
Infant Factor
- Premature Infants
- Tongue-Tie
- Cleft Lip
- Down Syndrome
- Neurological Problems
- Retracted jaw or tongue
- Excessive tongue-tip elevation
- Tongue protrusion/thrusting
- Excessive jaw excursion

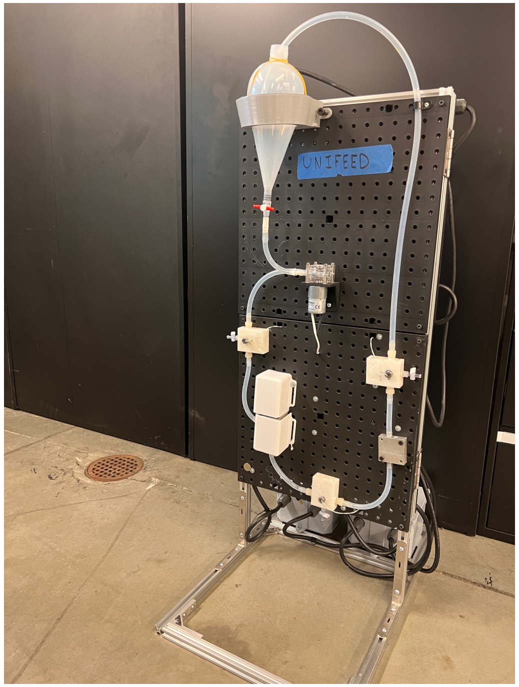
Human milk homogenizer for Pre-term Infants





US Patent





We have built an enteral syringe (UNIFEED) system that,

(a) creating a path for milk from the unprepared zone on top to flow to the homogenized syringe outlet;
(b) homogenizing the milk with piezo ultrasonic driver;
(c) Sampling out milk for further testing.

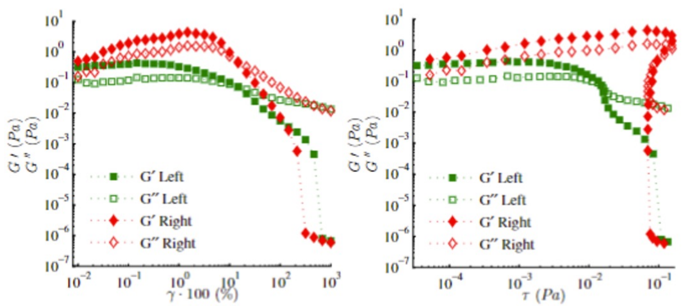
Collaborate with Dr. Yun Wang PhD, Biomedical Engineering Department at SJSU, Dr. Anant Mathur PhD, Kyzen LLC, Dr. Ish Gulati, MD, Kern Medical Center.

lin.jiang@sjsu.edu

Human Milk Rheology

Nutrients	Nutrient Requirements for preterm infants< $1500g$ [20]	$20kcal/oz$ Untreated BM [21]	$24kcal/oz$ BM + HMF [21]	$30kcal/oz$ High protein BM + HMF [21]	$20kcal/oz$ Enfamil Premature with Iron®[2] [22]
Fluids (ml/kg)	-	180	150	120	148
Energy $(kcal/kg)$	120	120	120	120	-
Protein (g/kg)	4	1.8	3	4.1	3.0
Fat (g/kg)	2.4	3.5	3.5	3.5	5.1
Calcium (mg/kg)	100-200	50	214	218	165

1. BM: Breast Milk; HMF: Human Milk Fortifier.
2. Used with permission of Mead Johnson & Company, Evansville, IN 47721. From Enfamil Family Products Handbook, Mead Johnson Nutritionals, Mead Johnson & Company. [23]



(a) Donor (participant #6) human milk shear strain **(b)** Donor (participant #6) human milk shear stress

Figure 2: Viscoelastic behavior of human milk. The crossover points on the strain graph show how much milk needs to deform to ensure homogeneous flow while the stress graphs show the required pressures. [27]

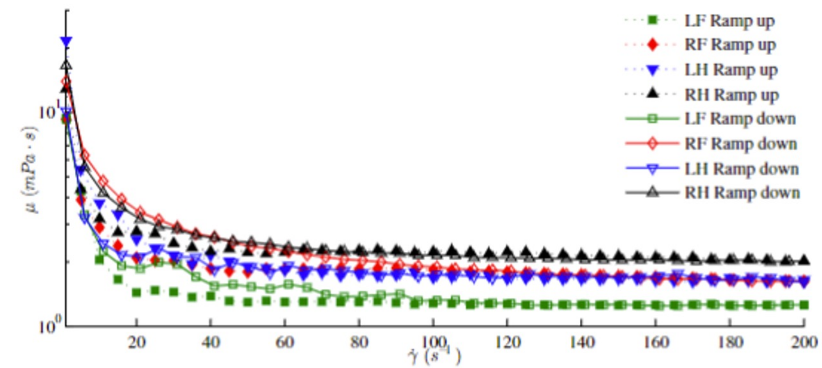
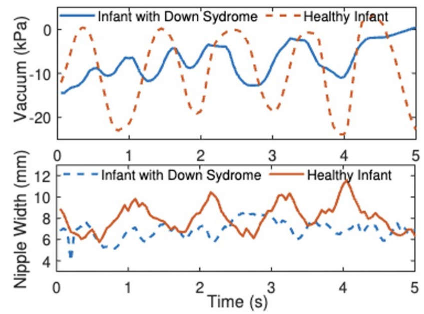
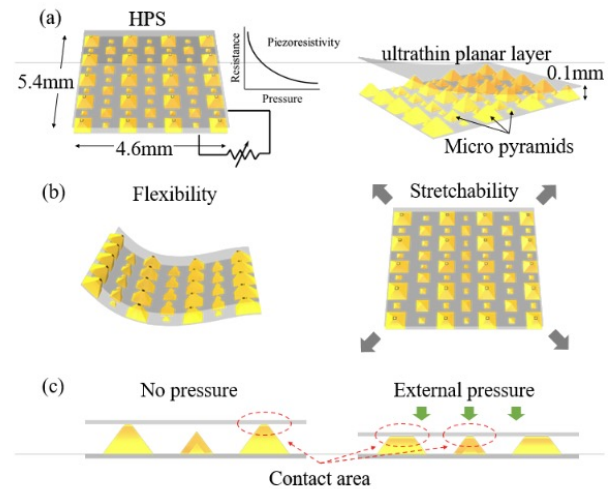


Figure 1: Evidence of time dependence for human milk flow properties. The loop test demonstrates time dependence for human milk for both pre-(foremilk: F) and post-expression (hindmilk: H). The viscosity of milk from the right breast (R) ended higher while milk from the left breast (L) ended lower. [19]

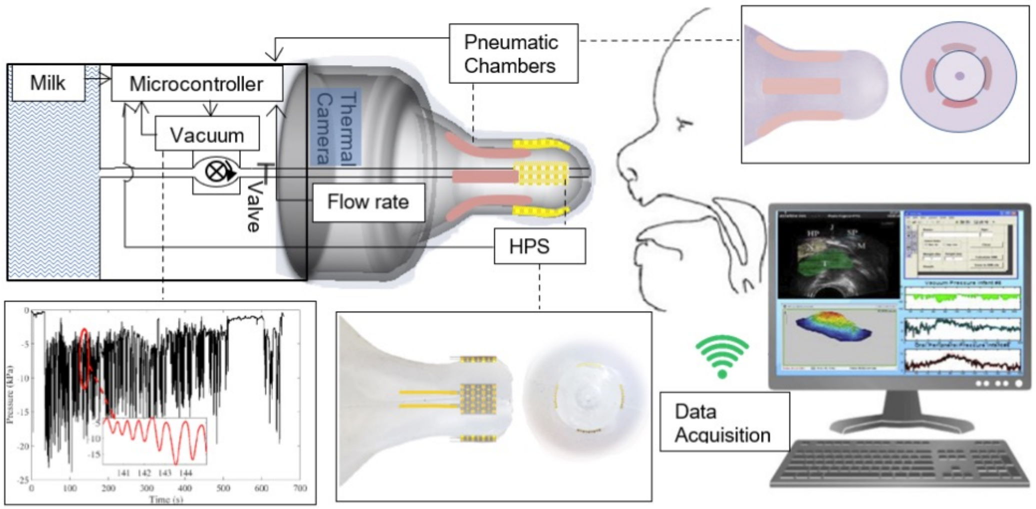
Determine the variation in flow behavior of untreated human milk and infant formula with and without different degrees of thickening

Robotic Milk Bottle for NICU Nutrition Delivery



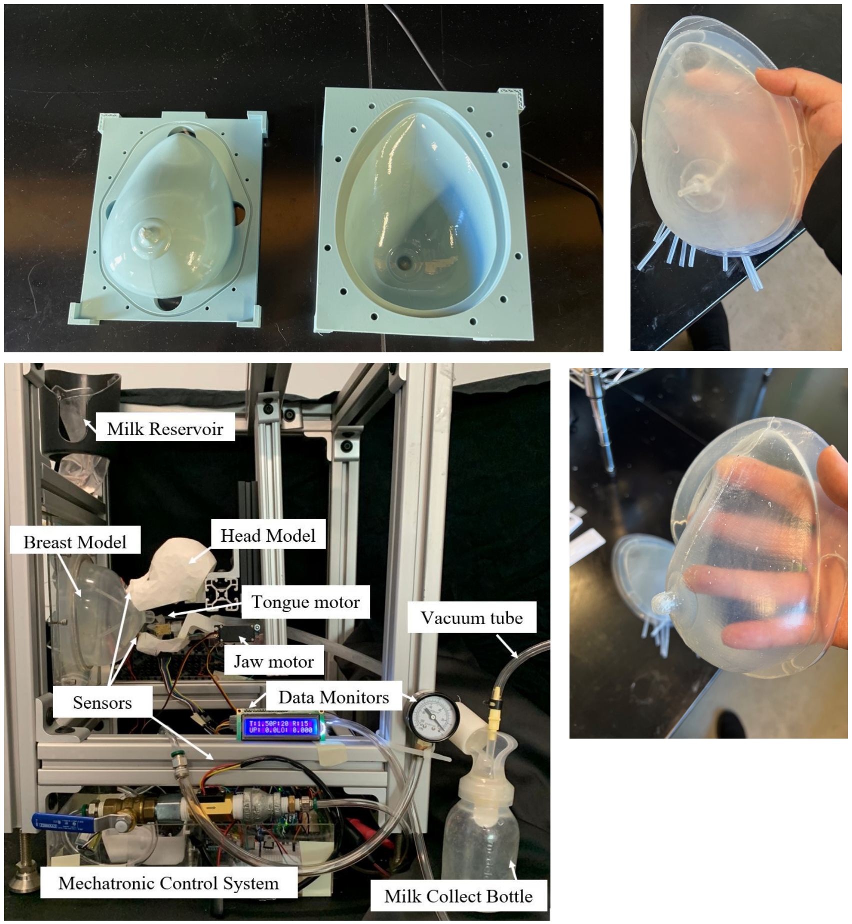


Integrate cut pattern conductive strain sensors to the bottom of the pneumatic controlled soft actuators to decouple the mechanical deformation and sensing for actuators

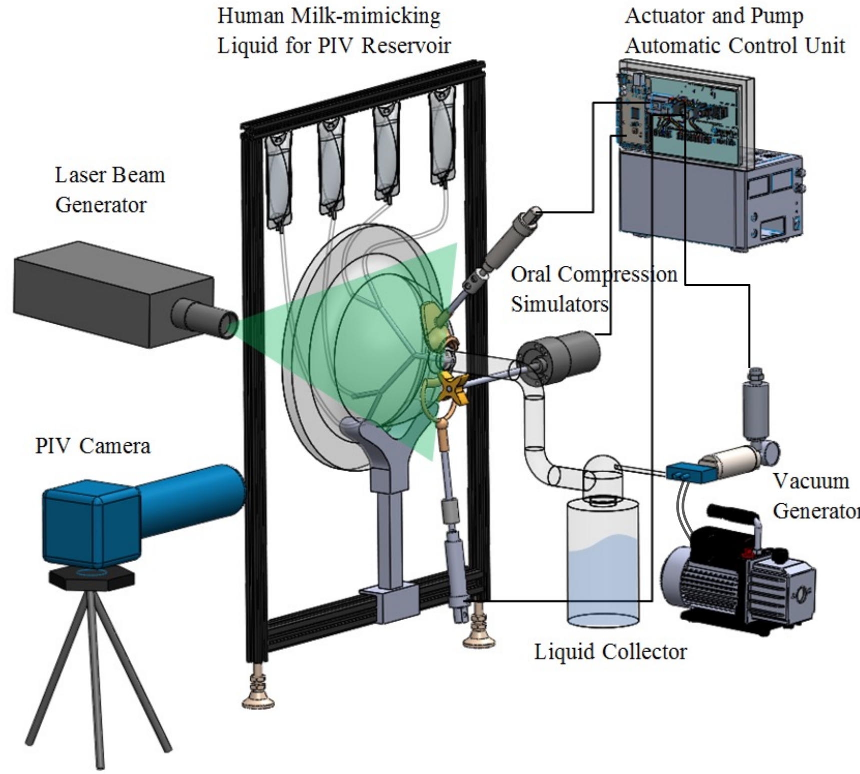


Integrated with conductive polymer sensors, the soft actuated artificial nipple will be able to capture intra-oral motion dynamics and observe the infant’s developmental progress. Another purpose to design artificial muscle strips on the milk bottle is to provide intra-oral neurostimulation for preterm infants; helping train infants’ oral development at early intervention.

Observe and Measure the Bio-fluid Mechanics in Synthetic Organs



Bio-inspired Synthetic Simulator
Design and Fabrication

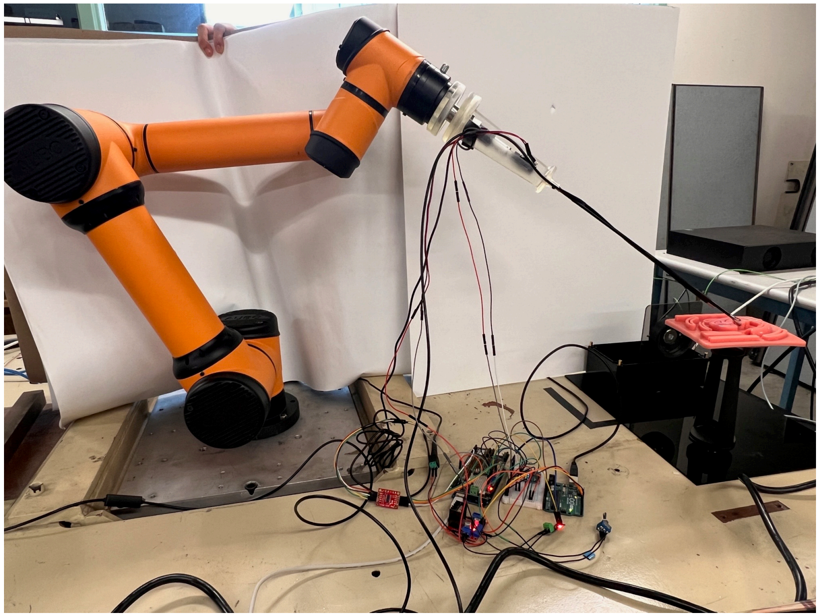


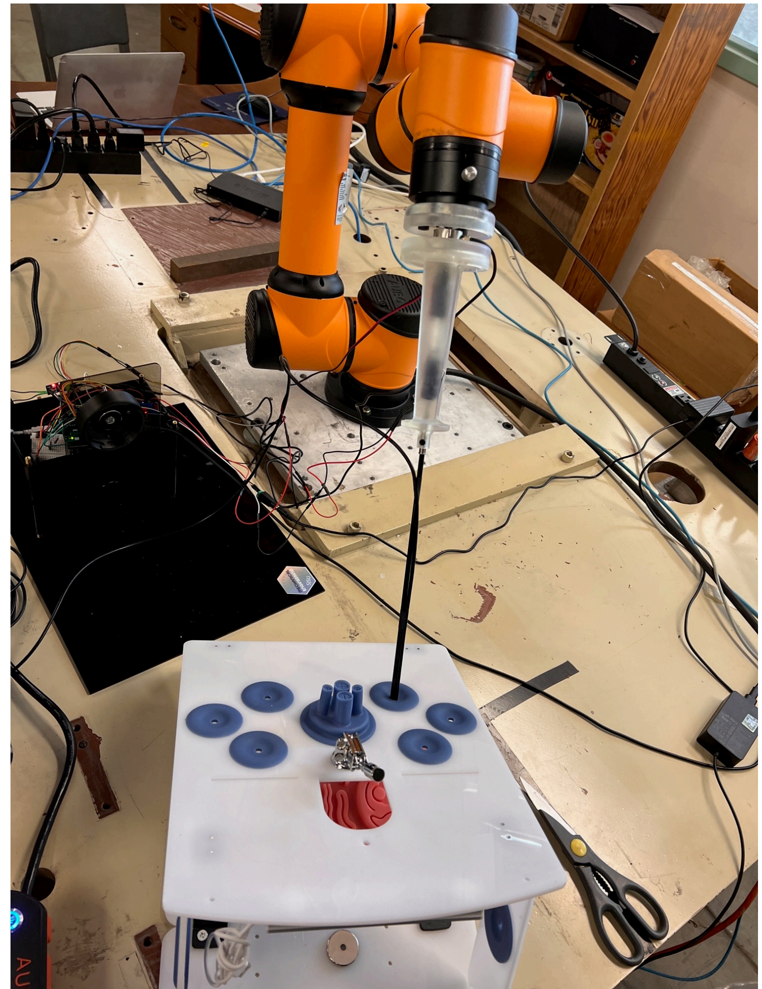
Micro-PIV experiments
in Flexible and Bifurcated Channels

Sponsored by CSUPERB

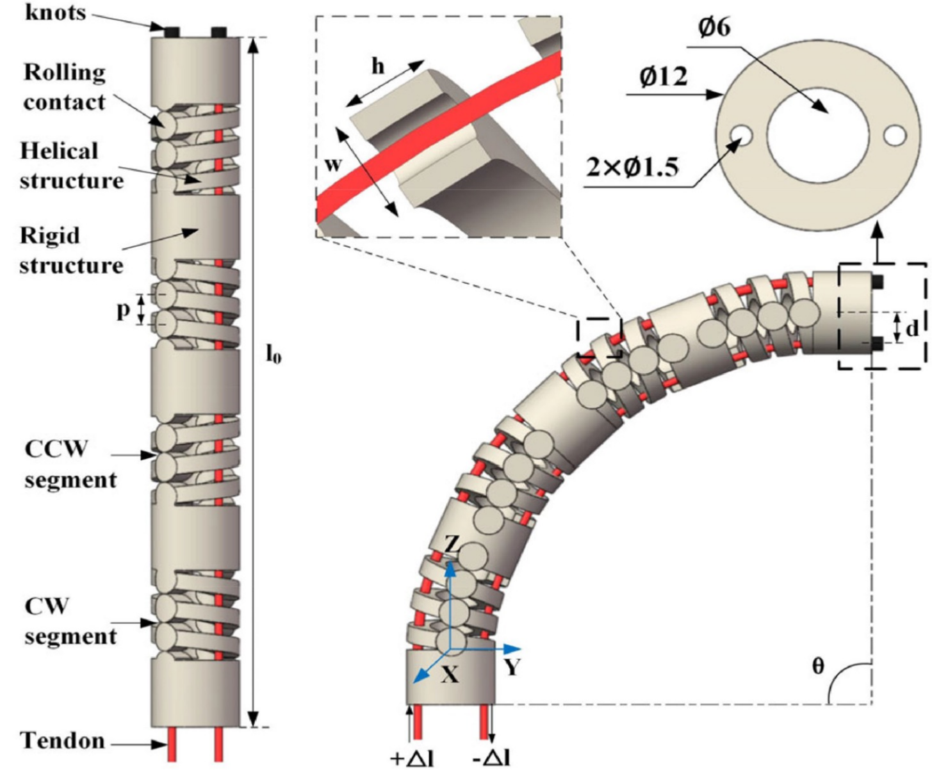
Robotics & Human-Robot Interaction

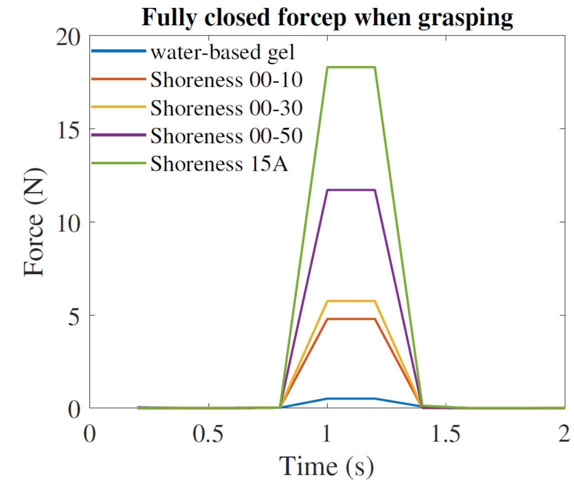
Closed Loop Impedance Control for haptic controller Design in Immersive Tele-Surgery

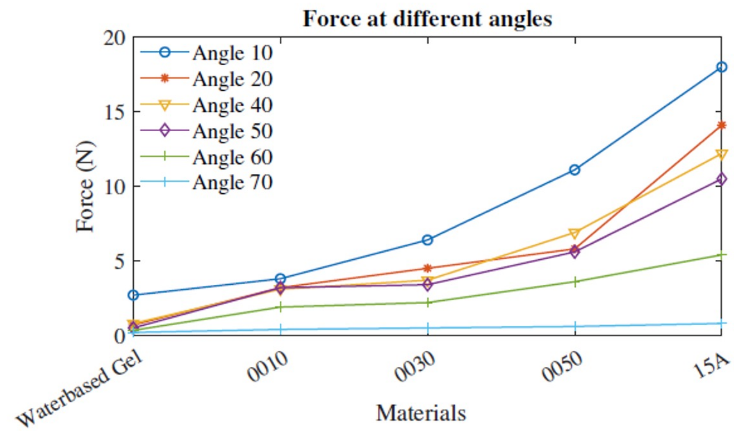




Artifical Flexible Tendon Helical Structure

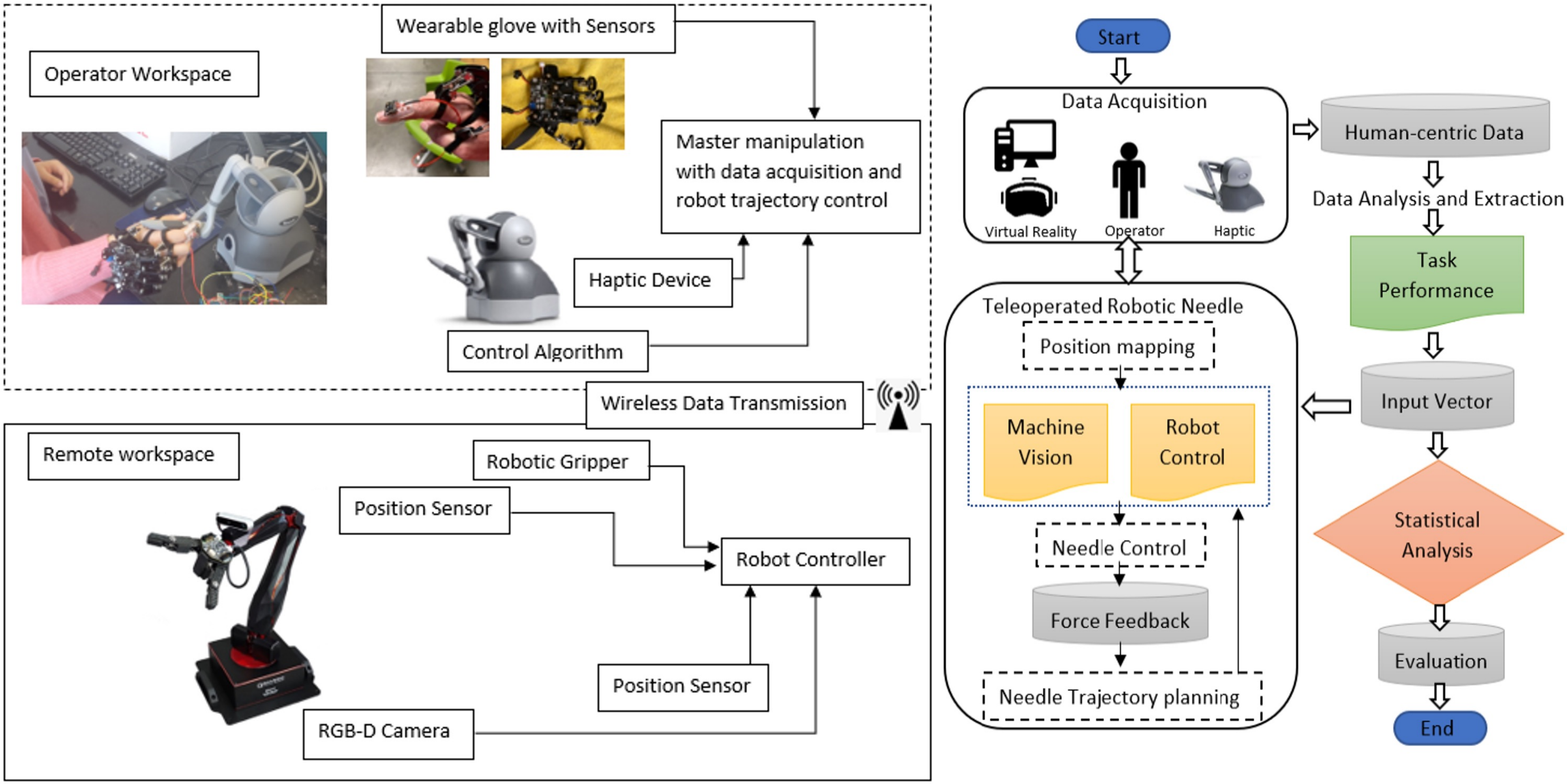






- Detecting hidden tumors using machine vision and stiffness feedback
- Creating a flexible muscle as an attachment to the forceps end in order to create 2 degrees of freedom during surgery.
- Provide better sensorimotor feedback to the operator, i.e. haptics

Bilateral Robot Teleoperation

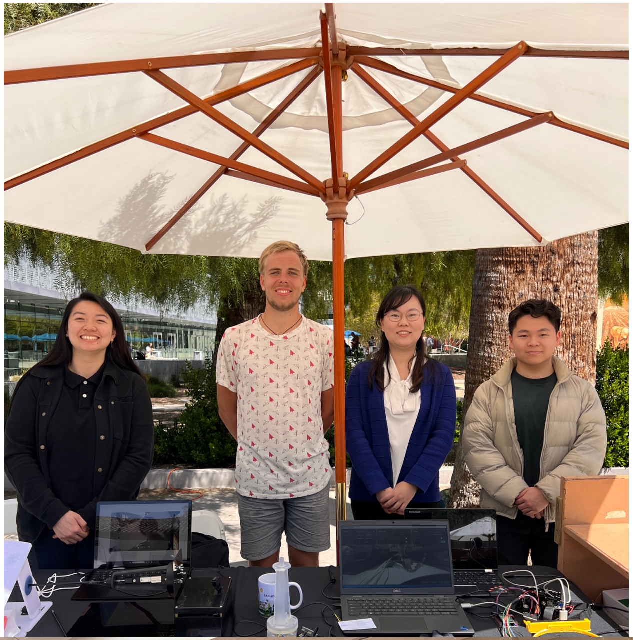


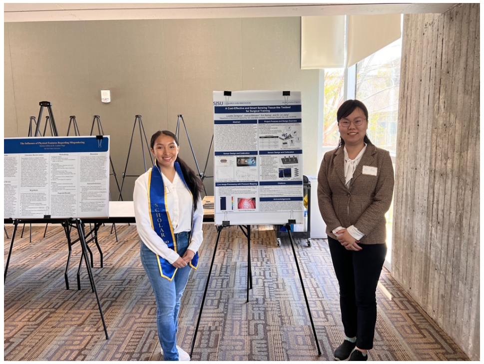
RoboTAXI (Teleoperated Autonomous XR Interface for driving)

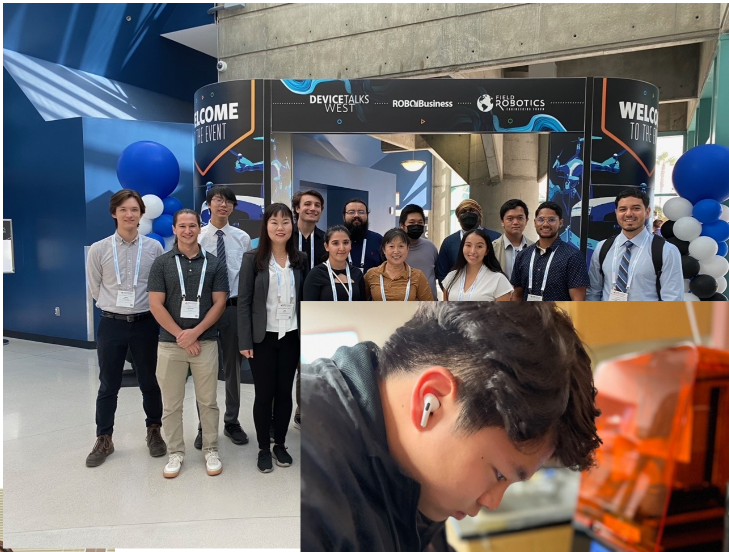
Sponsored by Honda Foundation

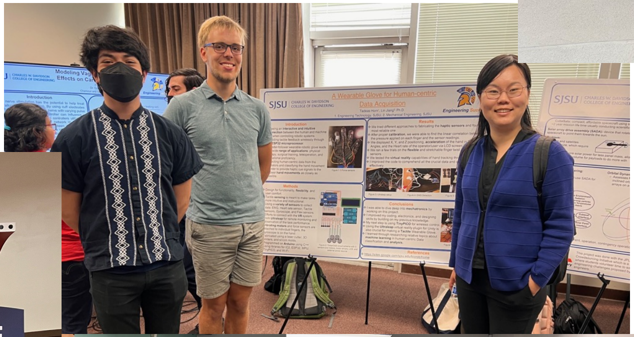
Research Projects

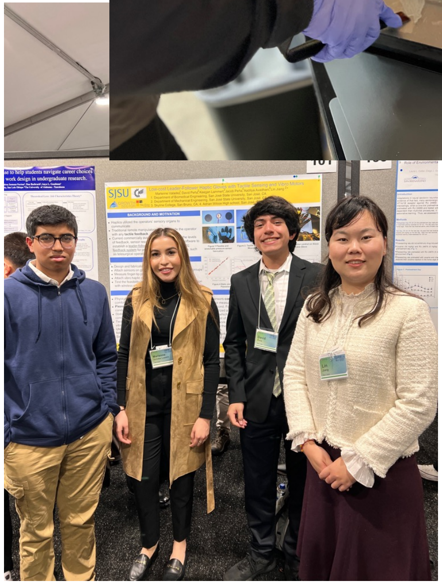
lin.jiang@sjsu.edu











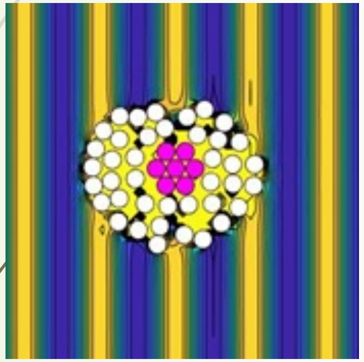
Thank you!

Lin Jiang

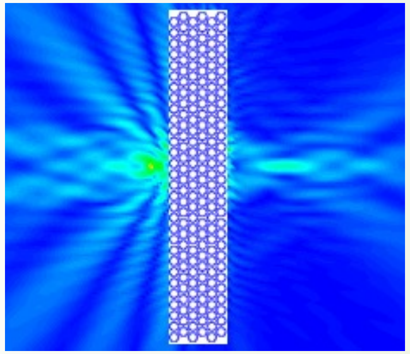
Assistant Professor

Mechanical Engineering

lin.jiang@sjsu.edu



Research Interests and Proposed TopicS



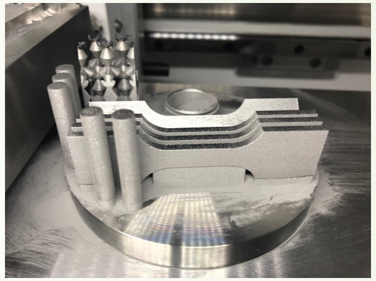
Feruza A. Amirkulova, PhD
feruza.amirkulova@sjsu.edu

Department of Mechanical Engineering
San Jose State University

Nov 16 2023

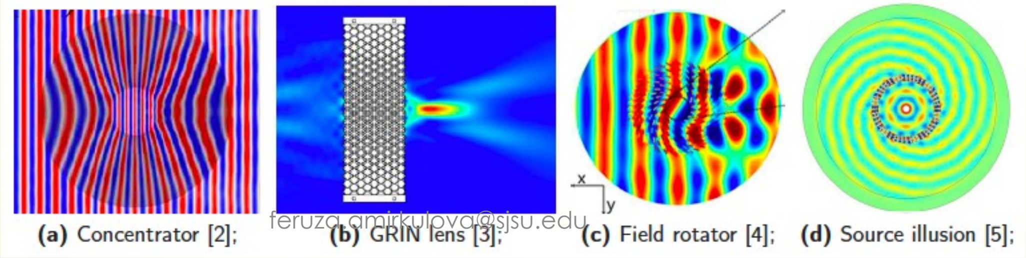
Inverse Design, Manufacturing, and Testing of Acoustic and Elastic Metamaterials

- 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

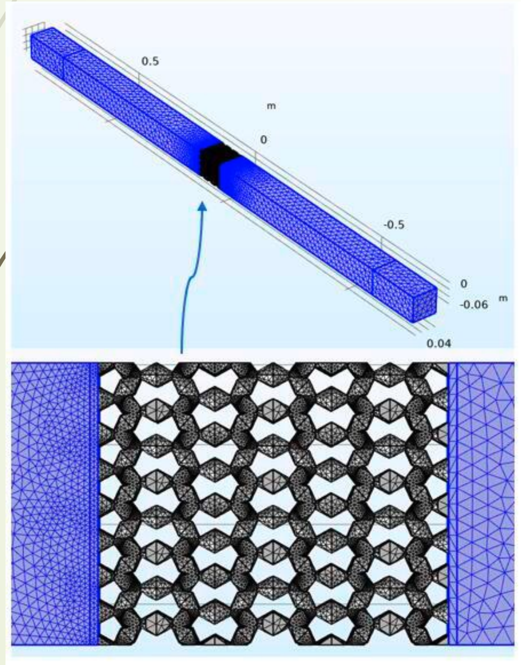


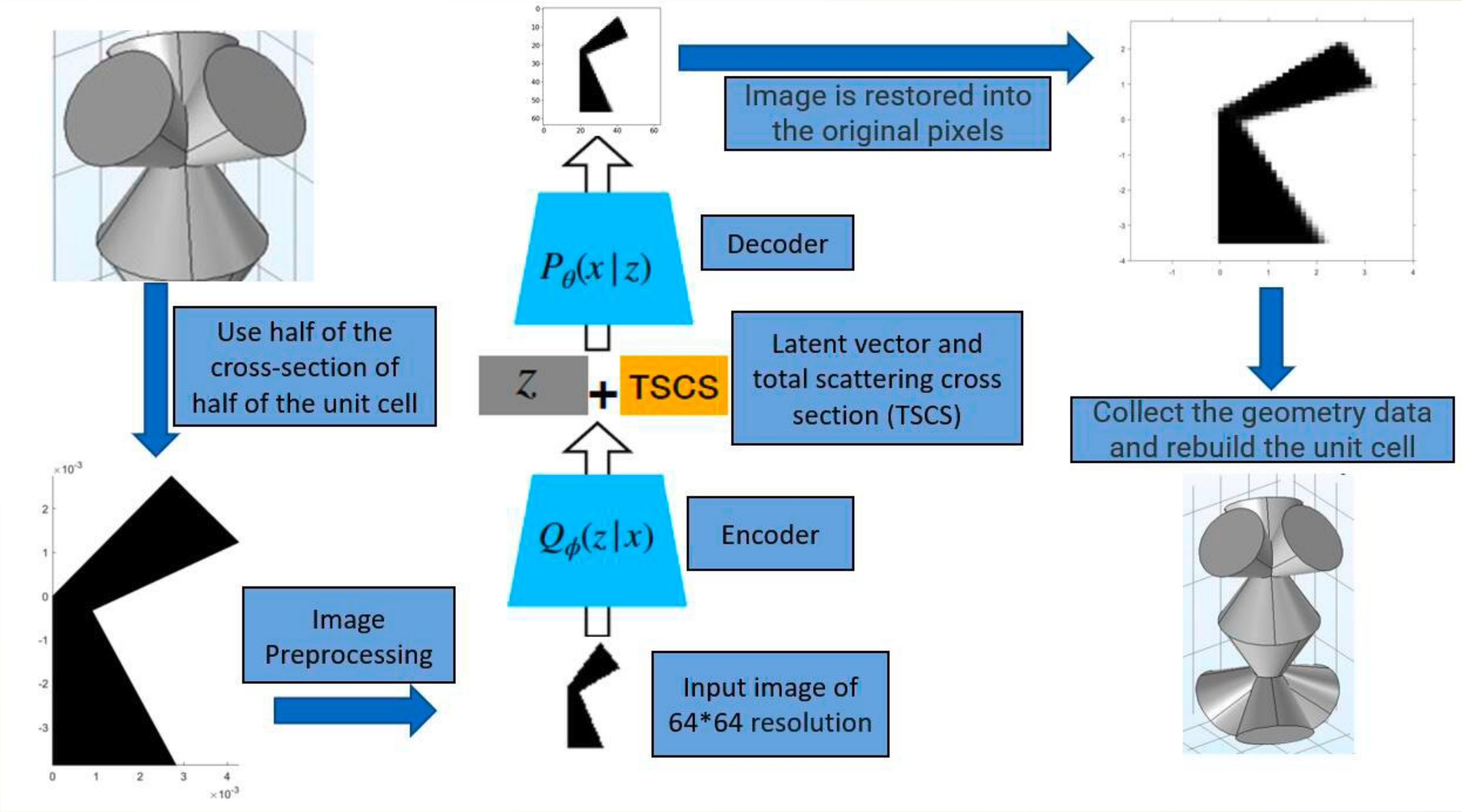
The examples of transformation acoustics devices.

feruza.amirkulova@sjsu.edu

Design of pentamods and transformation acoustics devices using DL and RL

- Full wave simulations, Optimization and Surrogate Modeling on COMSOL Multiphysics
- Deep Learning (DL) and Generative modeling: CNN, VAE, WGAN & RL algorithms
- Manufacturing of Metamaterials using selective laser melting (SLM) metal additive manufacturing system





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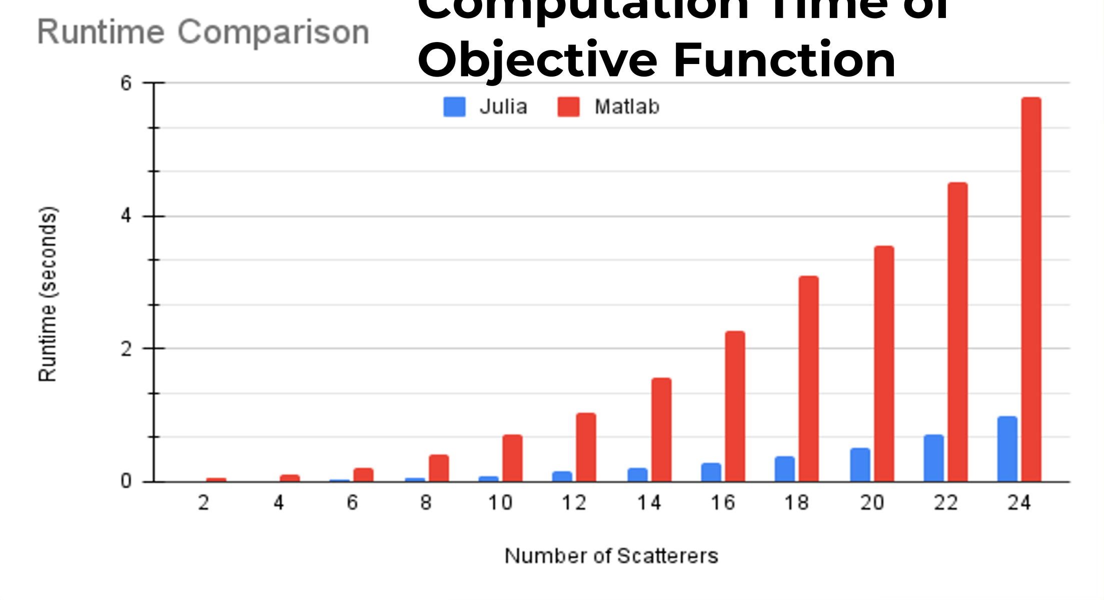
VAE model for pentamode unit cell

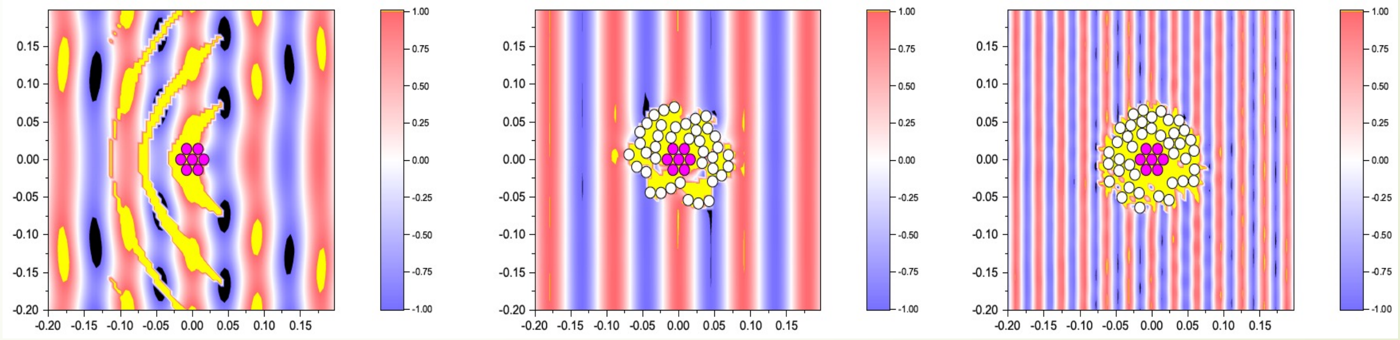
Design of Metamaterials Using Gradient Based Optimization

- **Julia programming**

Computation Time of Objective Function



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

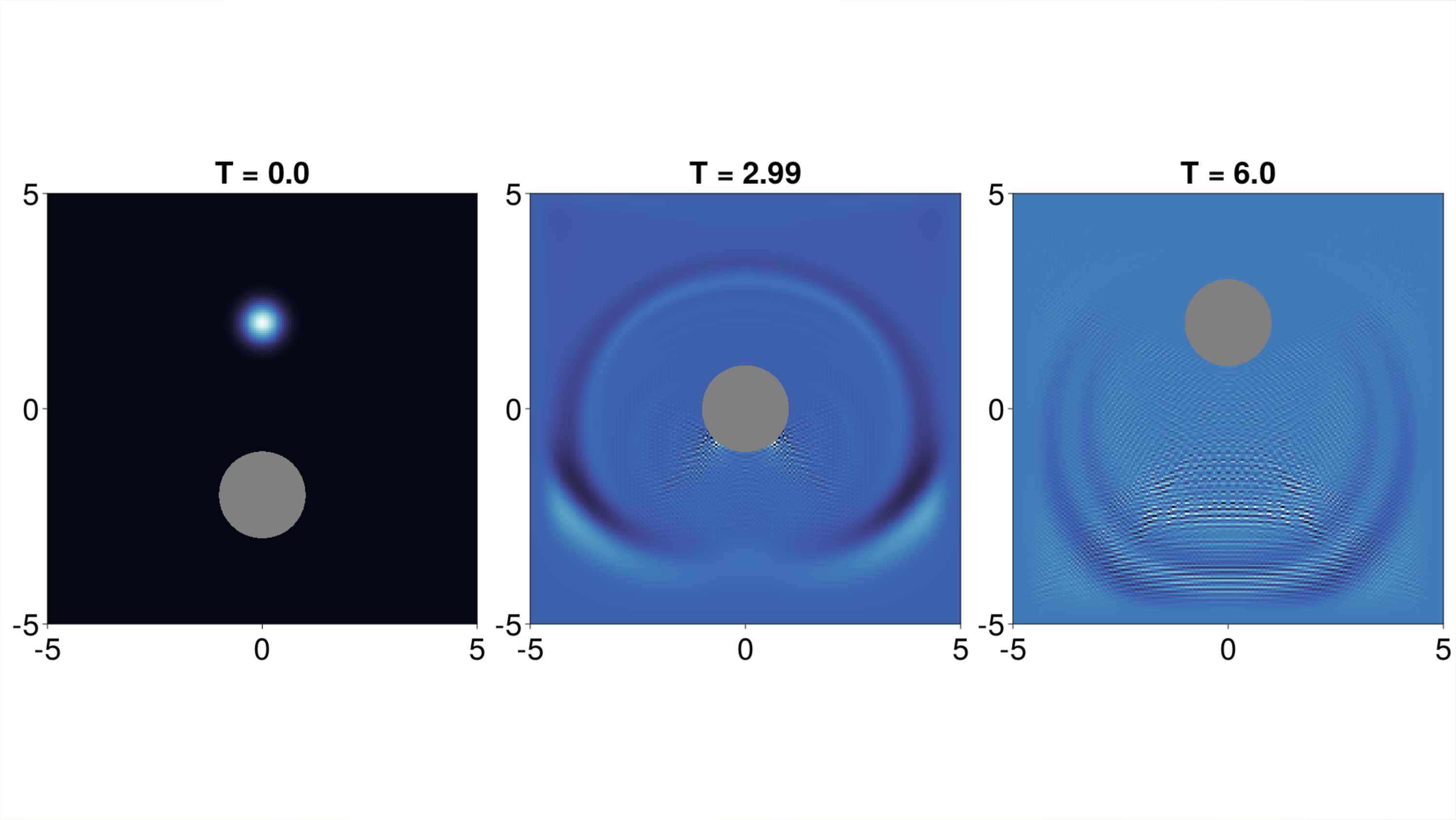


(a) No cloak: $\sigma = 0.12595$ (b) $ka = 0.525, \sigma_r = 1.4106e - 04$ (c) $ka = 1.5, \sigma_r = 0.0126$

feruza.amirkulova@sjsu.edu

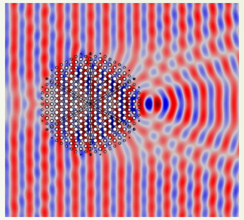
Design of Metamaterials Using Model Predictive Control and Reinforcement learning

- **Four-dimensional acoustics using time-varying metamaterials and bianisotropic materials**
- **Julia programming**



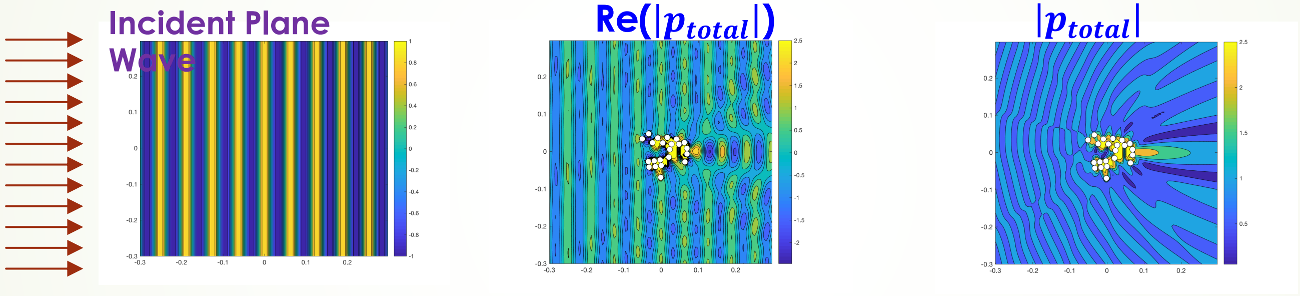
feruza.amirkulova@sjsu.edu

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

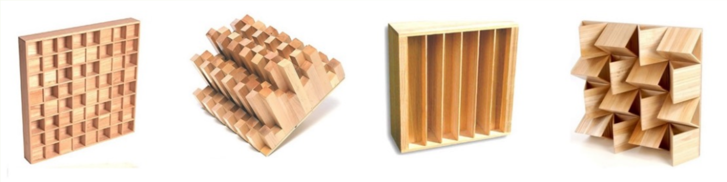


Amirkulova et al. (*JASA*, 143(3), 2018)

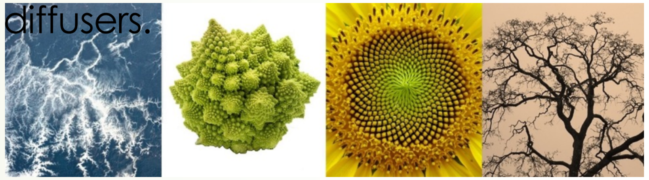
- 3D Volume Sound Diffusers: Maximizing the diffusivity coefficient
- Positioning of offshore floating structures: Minimizing the scattered wave energy and wave drift force
- Optimized 2D and 3D multilayered metamaterials and phononic crystal structures can be realized by defining the gradients WRT to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

Sound Diffusers

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

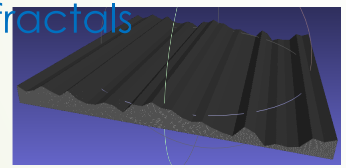


Examples of different types of geometric diffusers.



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.

4

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 and RL (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

ME-232: Deep Learning in Mechanical Engineering offered in Spring 2024

feruza.amirkulova@sjsu.edu

EXTRA

Our Recent Publications

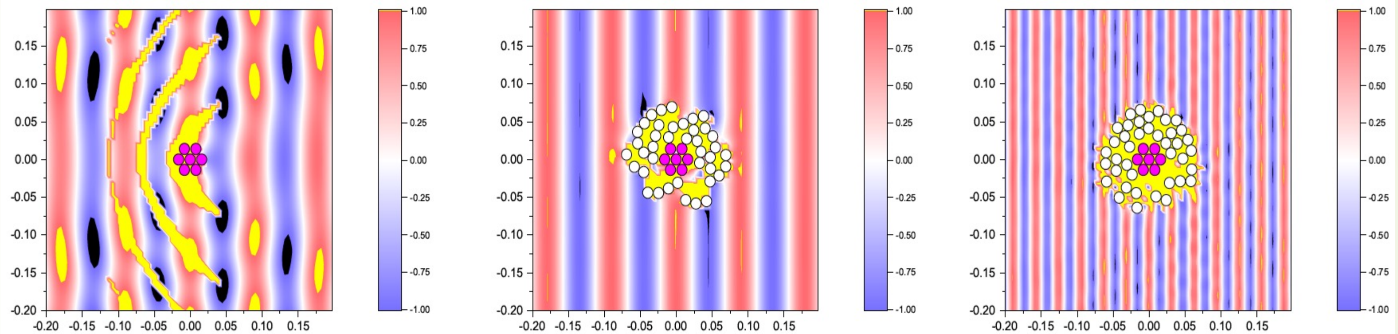
Metamaterials Through Multi-scattering and Gradient-based Optimization

- **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) $ka = 1.5, \sigma_r = 0.0126$

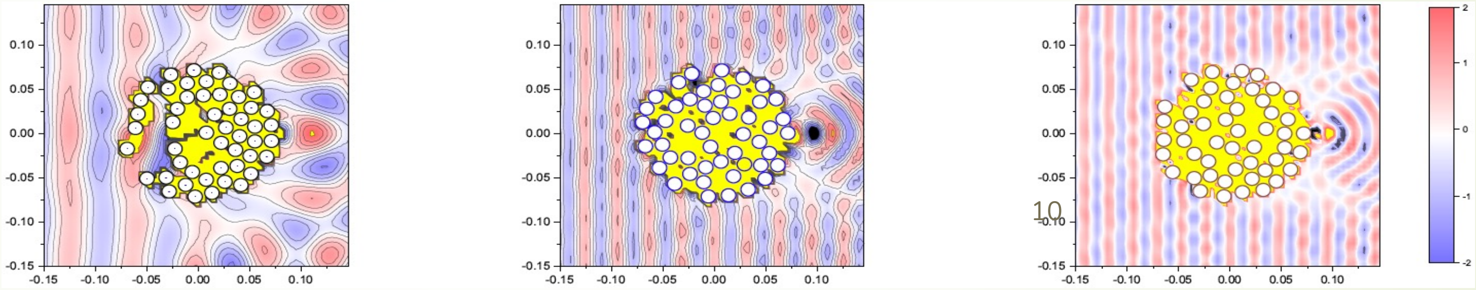
Amirkulova & Norris. The Gradient of Total Multiple Scattering Cross-Section and Its Application to Acoustic
Cloaking. *JTCA* 2020: 1950016. doi: 10.1142/s2591728519500166

- **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)

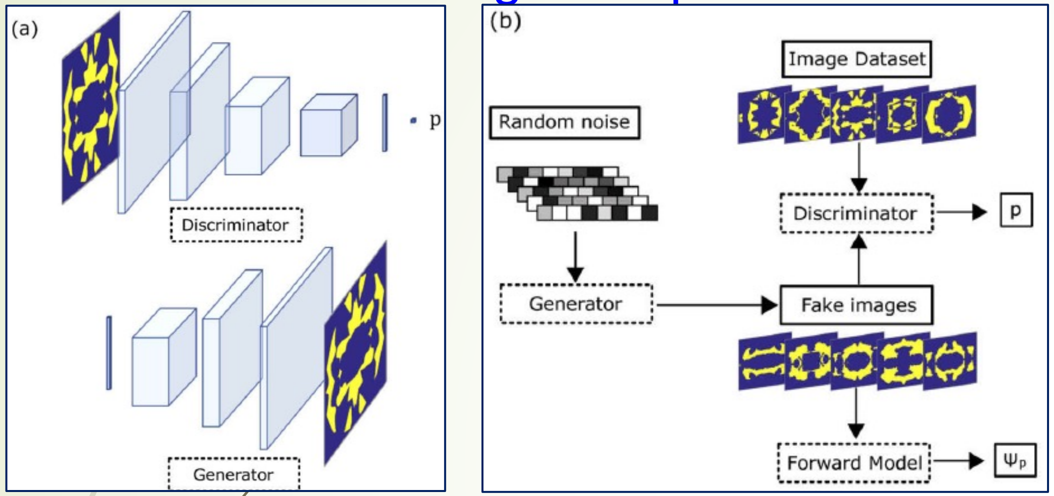
- **Sound Diffusers**

Optimize diffusion coefficient d_ψ

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

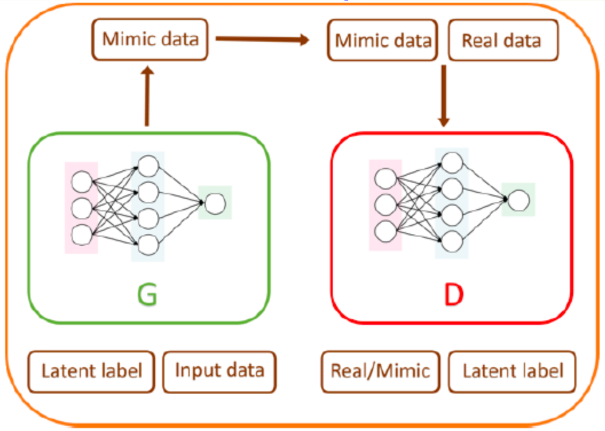
Applications of Generative Adversarial Networks (GAN)

GAN for design of optical cloak



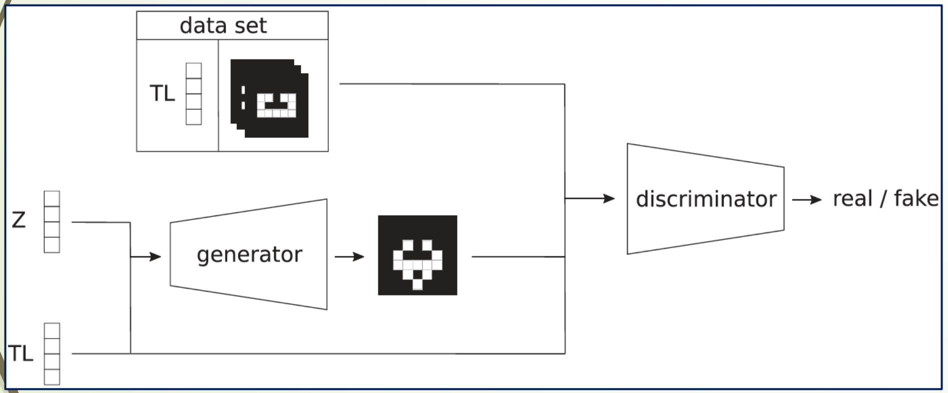
Blanchard-Dionne & Martin, OSA Continuum 2020.

Conditional WGAN for protein solubility prediction

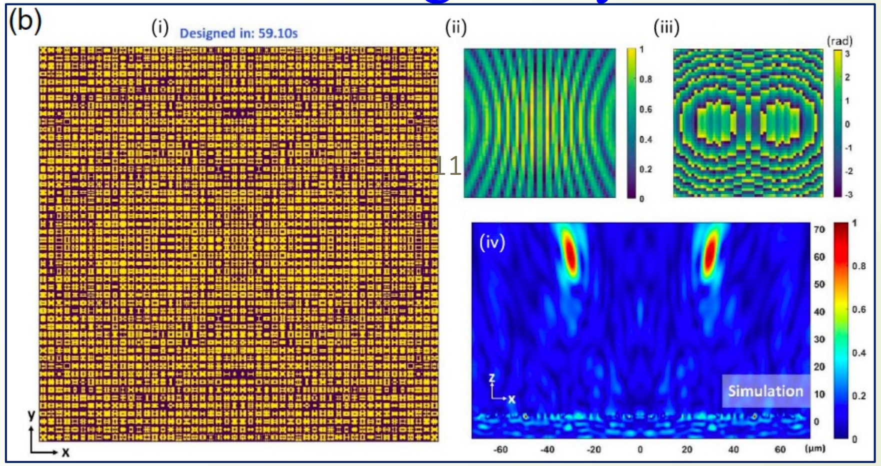


Han et al. InfoMat 2020

Conditional GAN for design of acoustic metamaterial



Double-focus flat lens designed by conditional WGAN



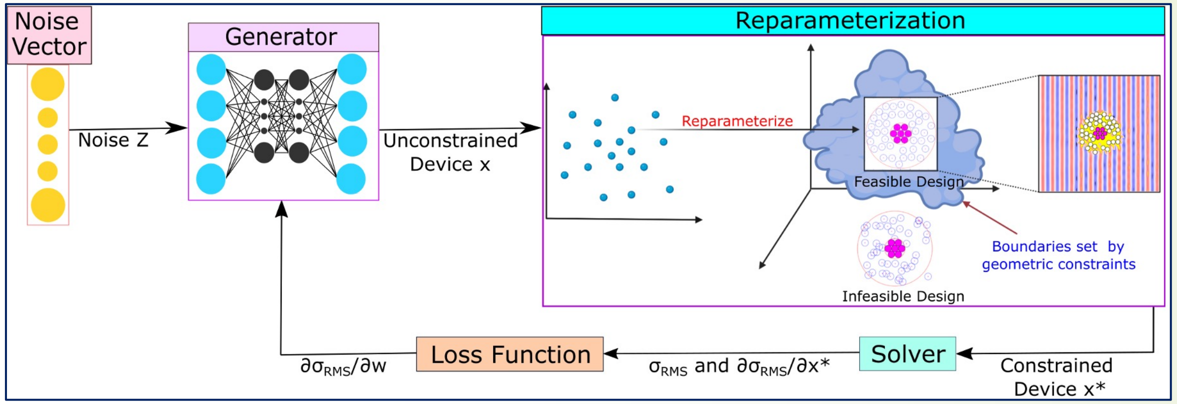
An et al., Advanced Optic. Mater. 2021

Our Recent Publications

2D-GLOnets Model Based Generative Modeling and Gradients

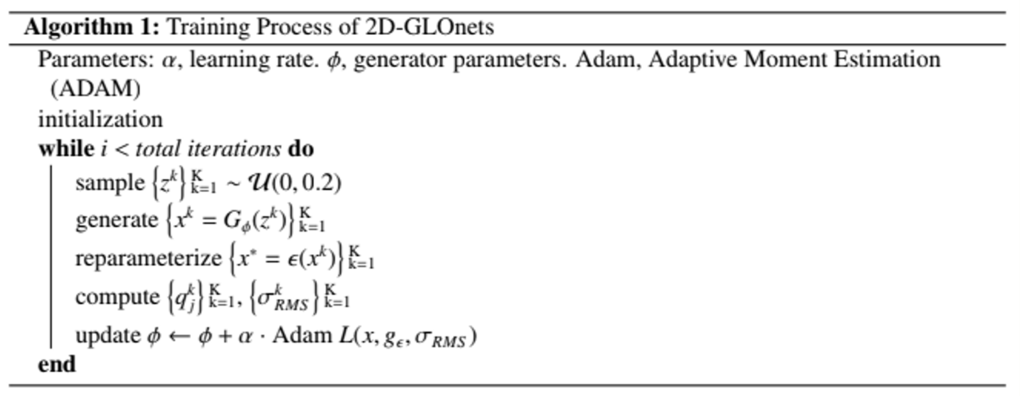
Noise Vector
- Gaussian Noise

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 $\{q_j^k\}_{k=1}^K, \{\sigma_{RMS}^k\}_{k=1}^K$

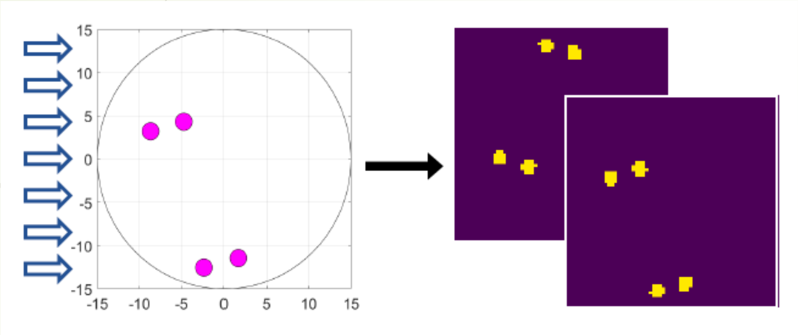
  update $\phi \leftarrow \phi + \alpha \cdot$ Adam $L(x, g_\epsilon, \sigma_{RMS})$

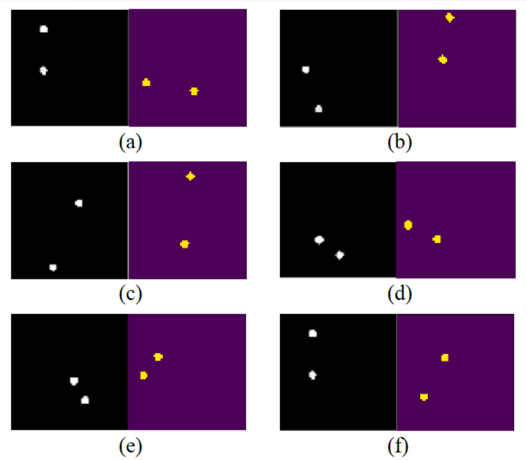
end

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

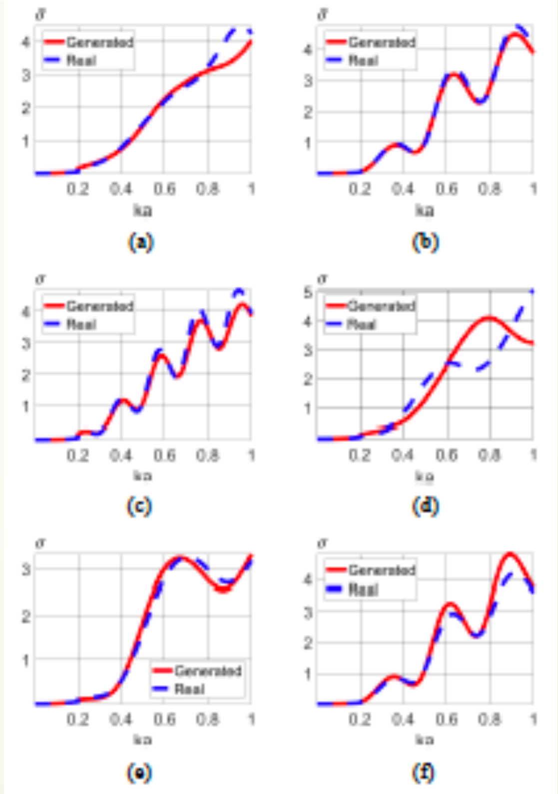
Our Recent Publications

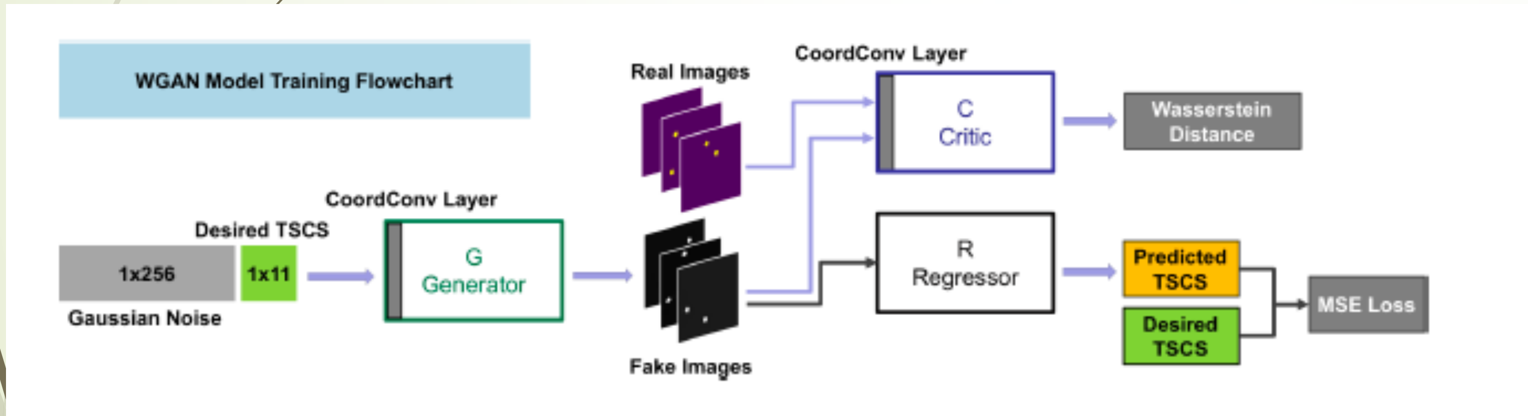
Conditional WGAN model





TSCS



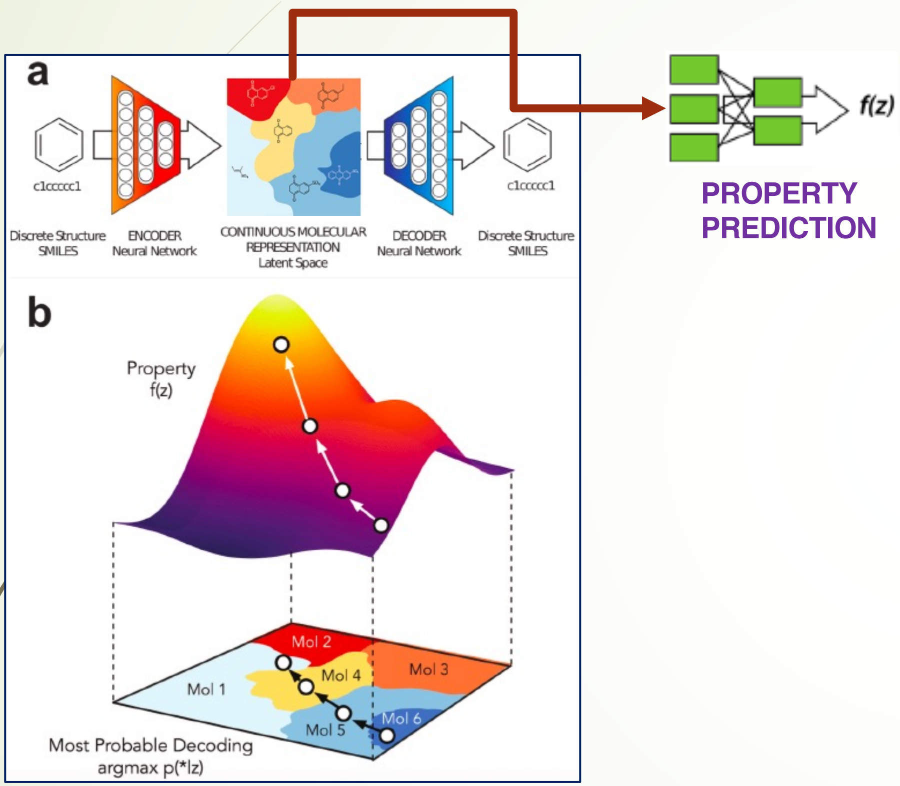


Lai* P., **Amirkulova F.**, Gerstoft P. Conditional Wasserstein Generative Adversarial Networks Applied to Acoustic Metamaterial Design. *J. Acoust. Soc. Am*, accepted 2021

feruza.amirkulova@sjsu.edu

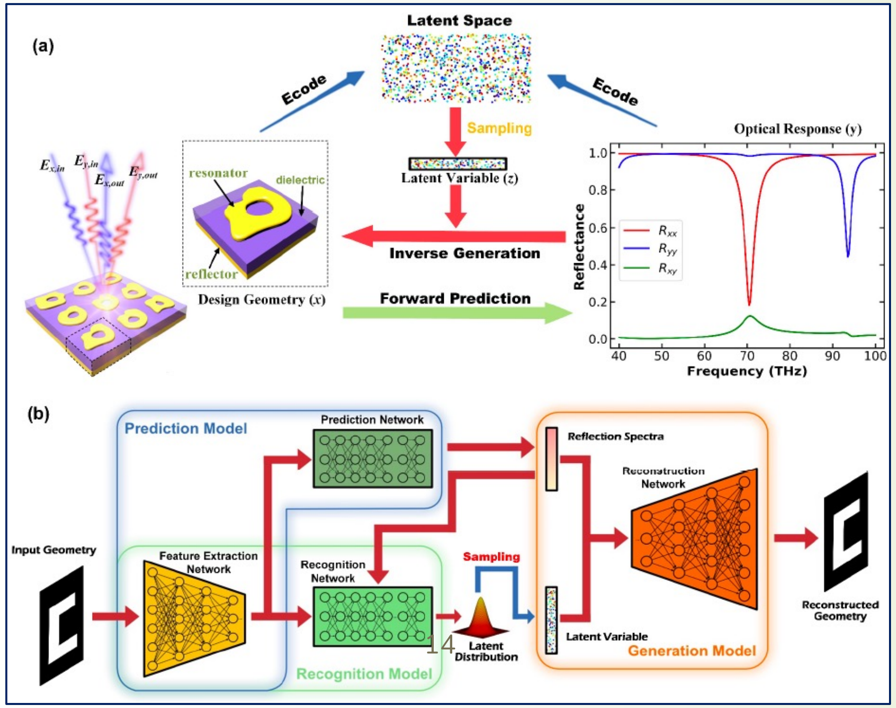
Applications of Variational Autoencoders (VAE)

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

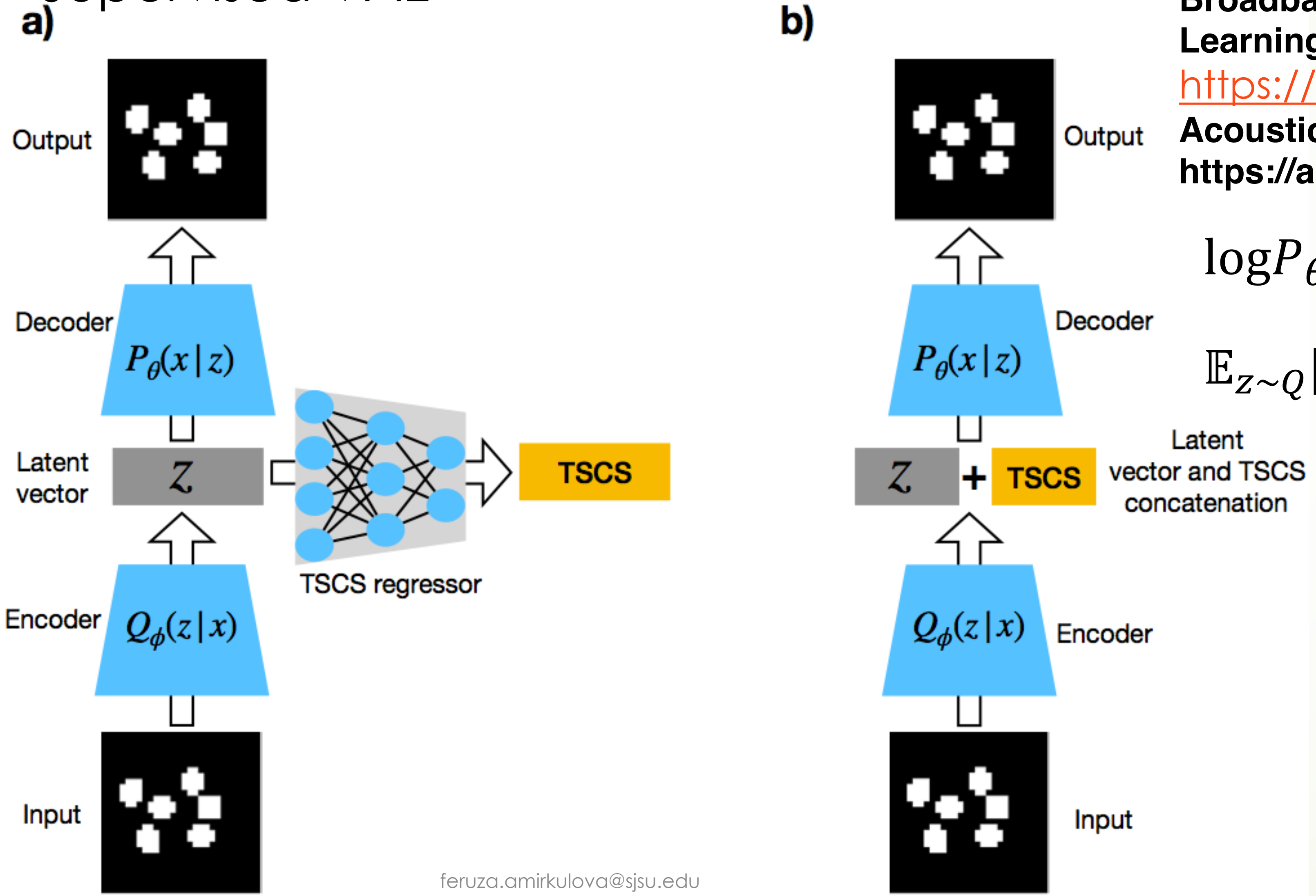
Application of CNN and VAE to acoustic metamaterial design:

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

Supervised VAE

Conditional VAE



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**

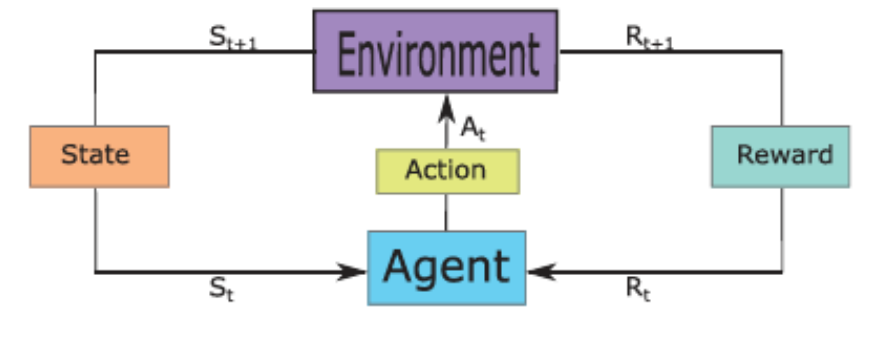
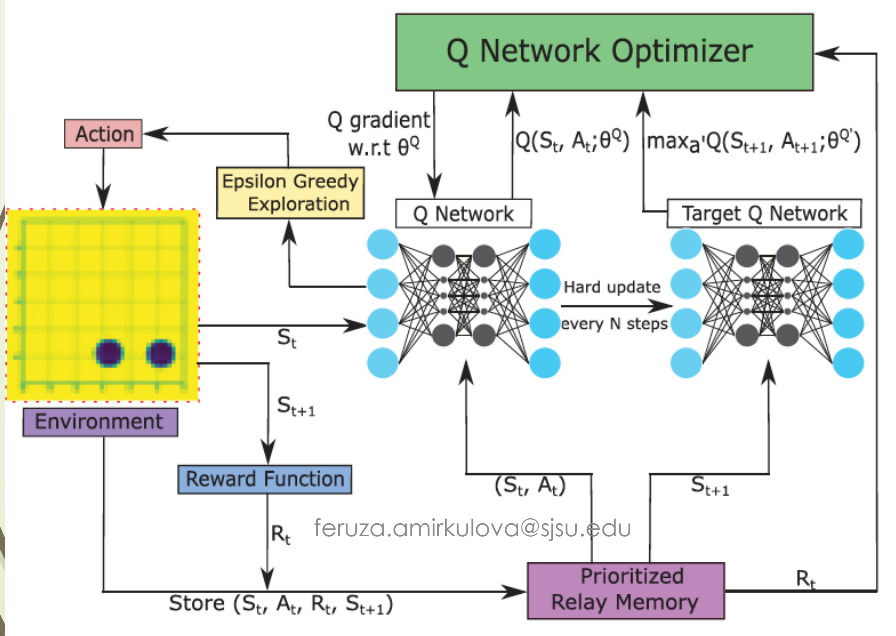
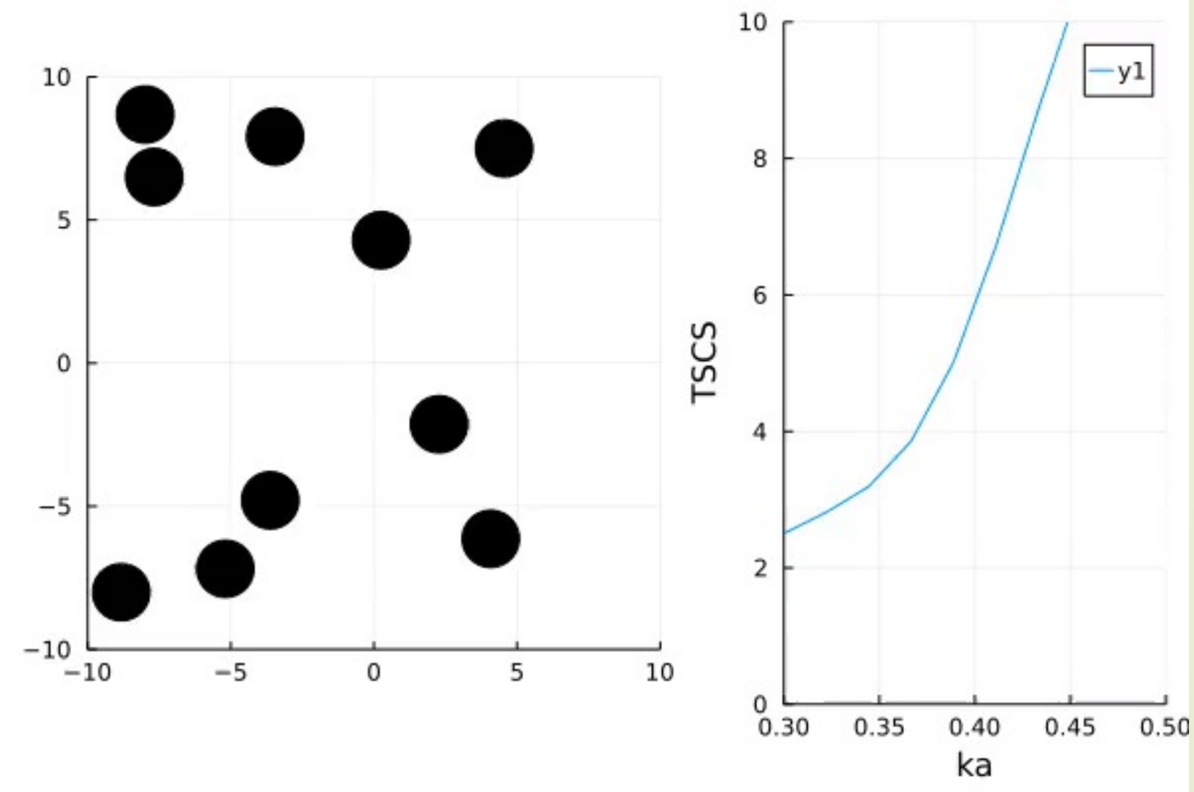


FIG. 1. (Color online) Agent interacting with environment in a MDP.



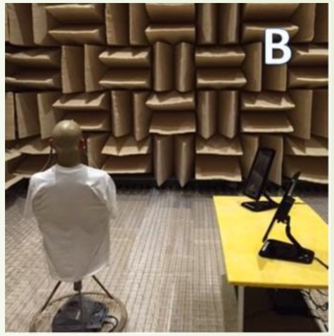


feruza.amirkulova@sjsu.edu

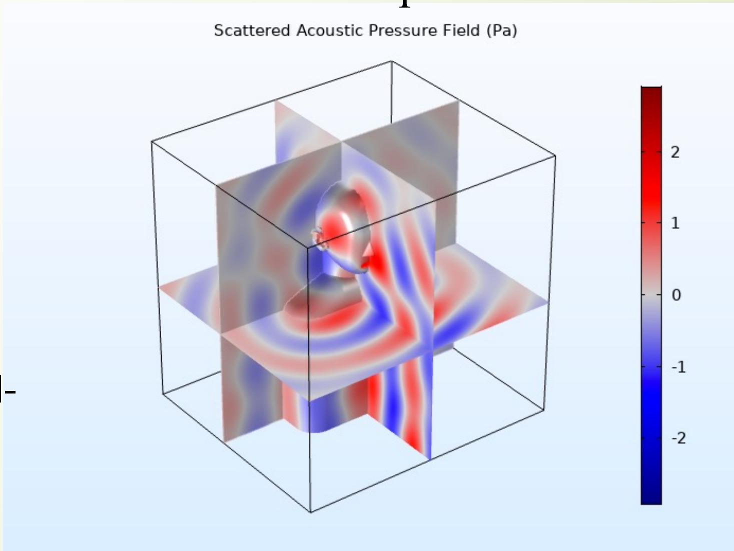
Investigation of human directional hearing in a semi-anechoic environment

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/

Potential Projects for Graduate Students:

Development and Control of Assistive Robotic Systems (exoskeletons and walkers)

Mojtaba Sharifi

Assistant Professor

Department of Mechanical Engineering,

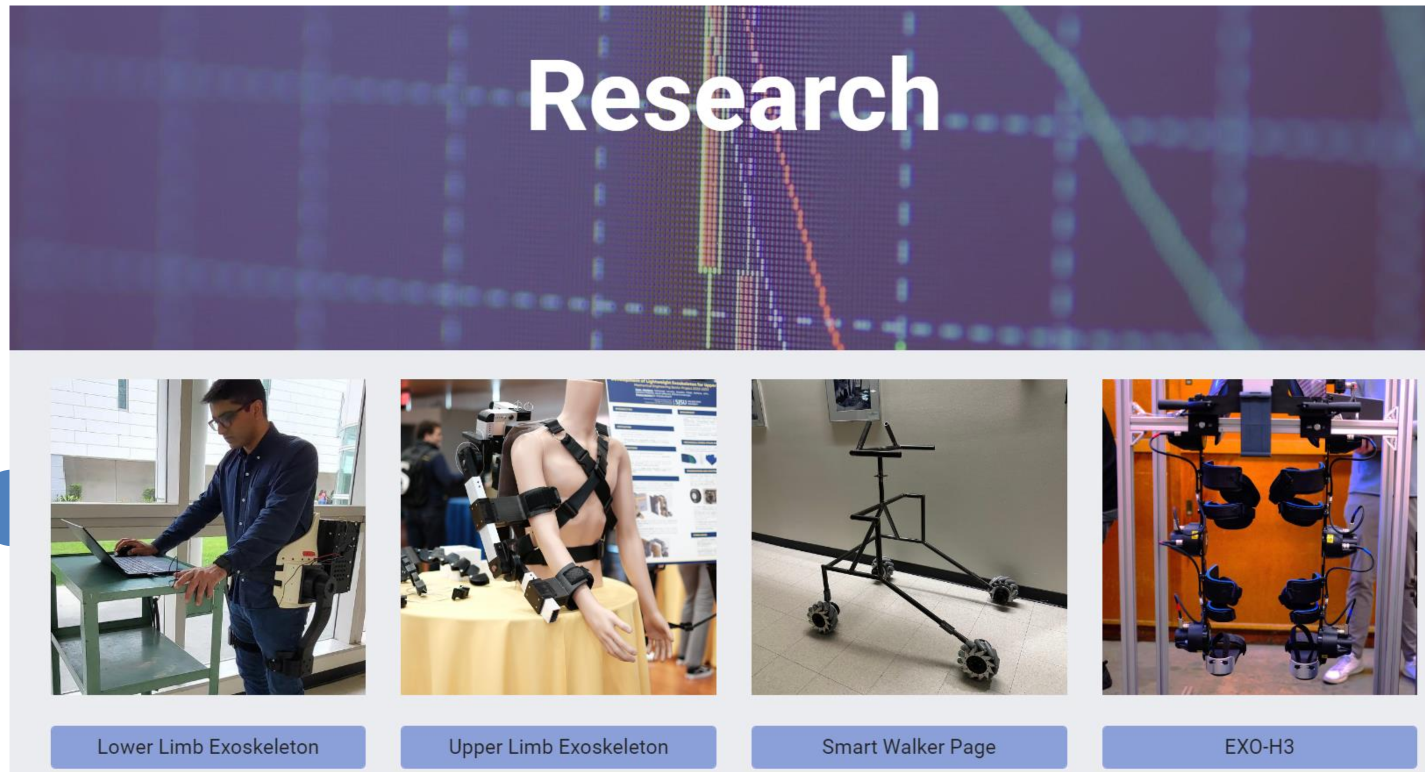
San Jose State University, CA, USA

Nov 16, 2023

Visit the ARMS Lab page

sites.google.com/sjsu.edu/armslab/research

↑ Check available projects ↑



Inform Dr. Sharifi about your interest

Email: mojtaba.sharifi@sjsu.edu, Phone: +1-408-898-8254

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

ResearchGate: researchgate.net/profile/Mojtaba_Sharifi3

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

MSME Research Projects

ME295A for Spring 2024

Crystal Han

crystal.m.han@sjsu.edu

Microfluidics for purification of biosamples

- **ITP:** Electric field-based focusing and separation technique for charged molecules (ions, RNA, DNA, proteins)
- **Applications:** Biosensing, controlling the bio- or chemical- reaction, disease diagnosis, food monitoring, etc.
- **Techniques and equipment used in research:** Fluorescence microscopy, CCD camera, basic wet lab skills, MATLAB based image analysis, photolithography, soft lithography
- Projects are hands-on, which require in-person commitment in the lab.

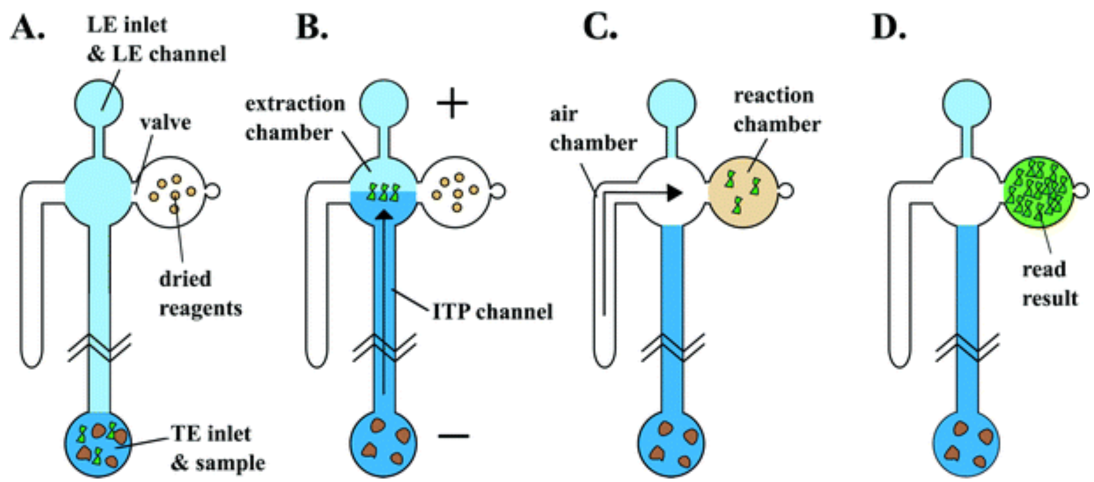
ITP focusing of fluorescent dye

- Use the link below for a typical ITP protocol: https://www.jove.com/video/3890/on-chip-isotachophoresis-for-separation-ions-purification-nucleic
- Email: crystal.m.han@sjsu.edu

On-chip DNA extraction and amplification

Background: Amount of DNA can be increased by an enzymatic reaction that requires temperature control. Integrating ITP extraction and DNA amplification in a single microfluidic chip is needed for high sensitivity point-of-care diagnosis.

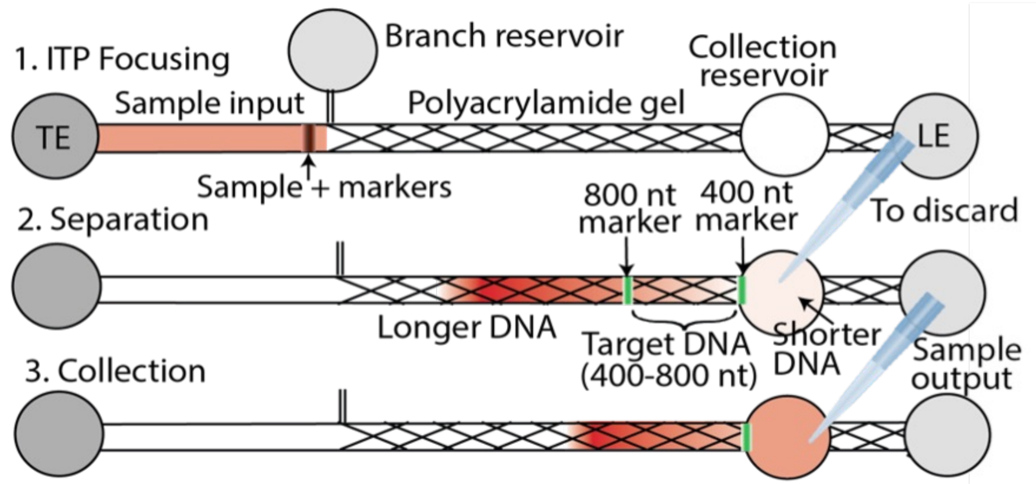
Borysiak et al. Lab on a Chip 15, no. 7, 2015, 1697–1707 https://doi.org/10.1039/c4lc01479k



Goals

1. Perform on-chip ITP extraction, and post-ITP DNA amplification in the reservoir.
2. Literature study to determine the reasonable target DNA and reaction.
3. Produce standard curves (off-chip, on-chip reservoir, on-chip channel).
4. Development of temperature controller for microfluidic reservoir heater.
5. Quantify the extraction efficiency and limit of detection.

Microfluidic DNA purification of Next Generation Sequencing samples



Background: Next generation sequencing, i.e., sequencing by synthesis, requires the purified and size-selected DNA sample as the input. The current method relies on bead-based size selection, which is laborious and costly.

Goals

1. Develop an on-chip method to perform accurate size selection for DNA in the size range of 400 – 800 bp.
2. Compare the quality (size distribution and yield) of the purified DNA between the ITP and conventional methods using Bioanalyzer.

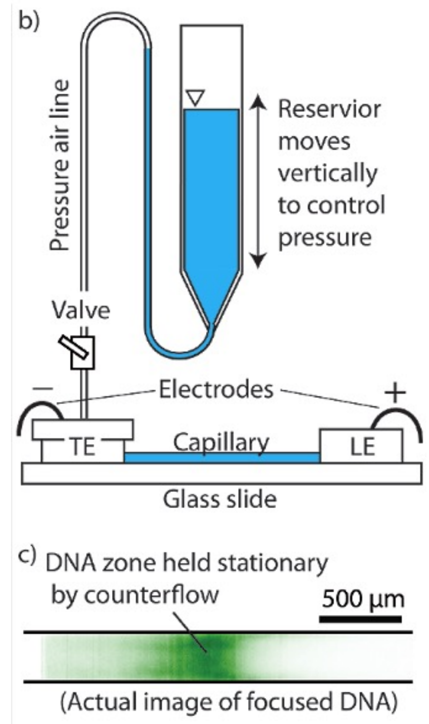
Related paper: https://pubs.rsc.org/en/content/articlelanding/2019/LC/C9LC00311H

DNA extraction from a continuous flow sample for food monitoring

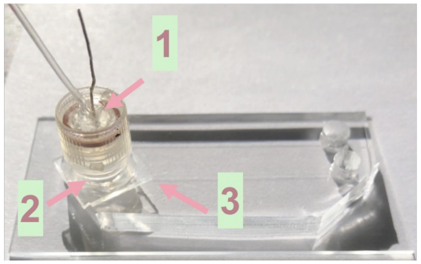
Background: The sample volume for ITP extraction is typically limited by the volume of microchannel. This project tries to develop a method to perform ITP-based DNA extraction from a larger volume of sample using stationary ITP (a.k.a. counter-flow ITP).

Goals

1. Develop a method to focus DNA from a continuously flowing sample solution at the stationary ITP zone.
2. Develop a method to collect extracted DNA at the TE reservoir.
3. Measure efficiency of DNA extraction from known amount of spike-in DNA.
4. Demonstration of the method with food sample (e.g. milk).



Anal.Chem.2011, 83, 9715–9718



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

SJSU SAN JOSÉ STATE UNIVERSITY

Wildfire Interdisciplinary Research Center

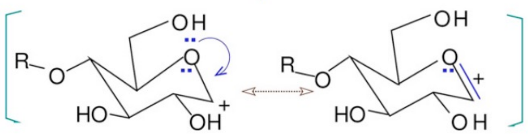
November 16, 2023

Modeling (Wild)fire Behavior and Impacts

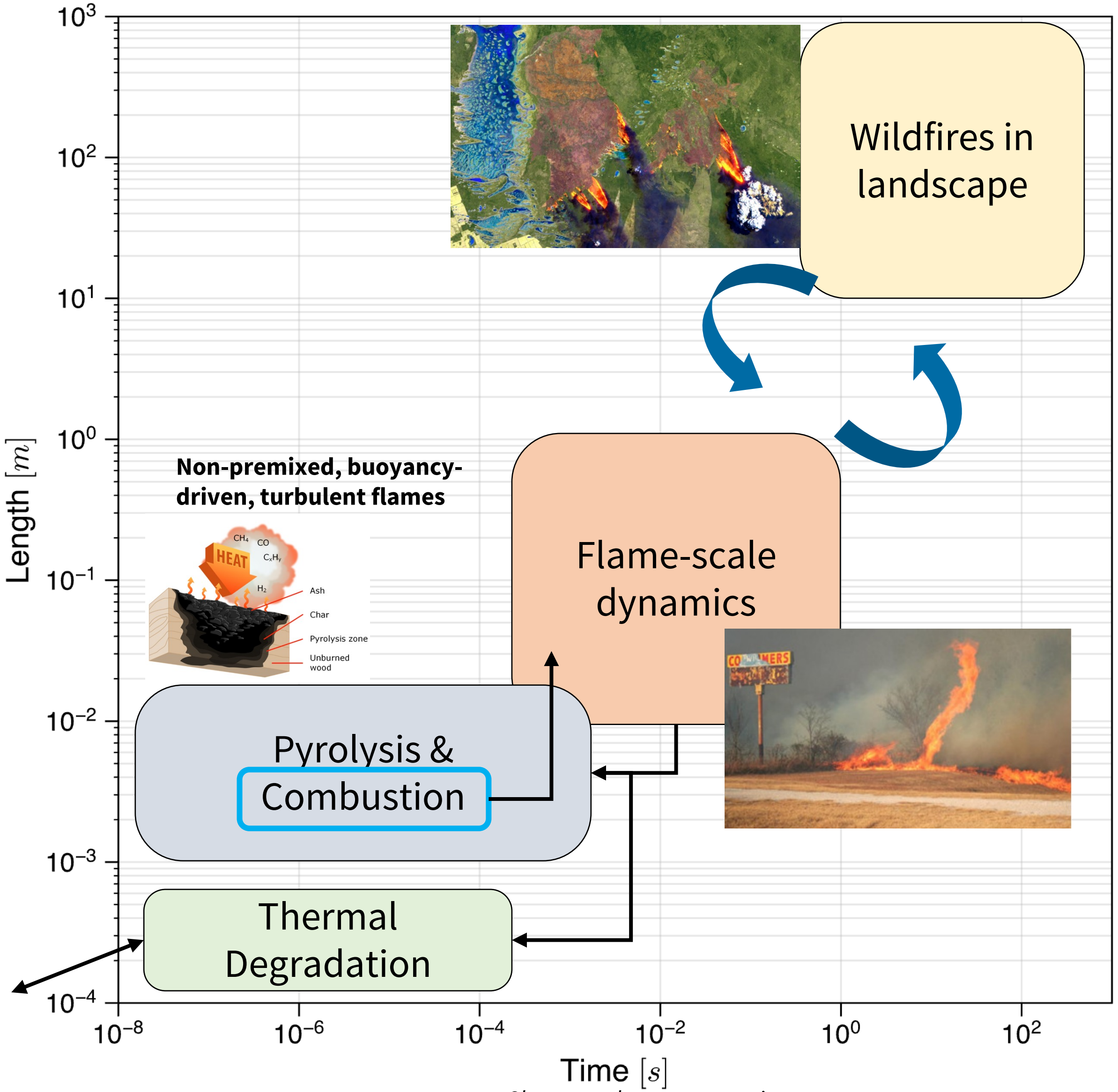
- Multi-scale and Multiphysics nature of (wild)fires
  - Boundary layer evolution in fire scenarios
  - Dominant modes of heat transfer
  - Fuel types and specific reactions
  - …

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]

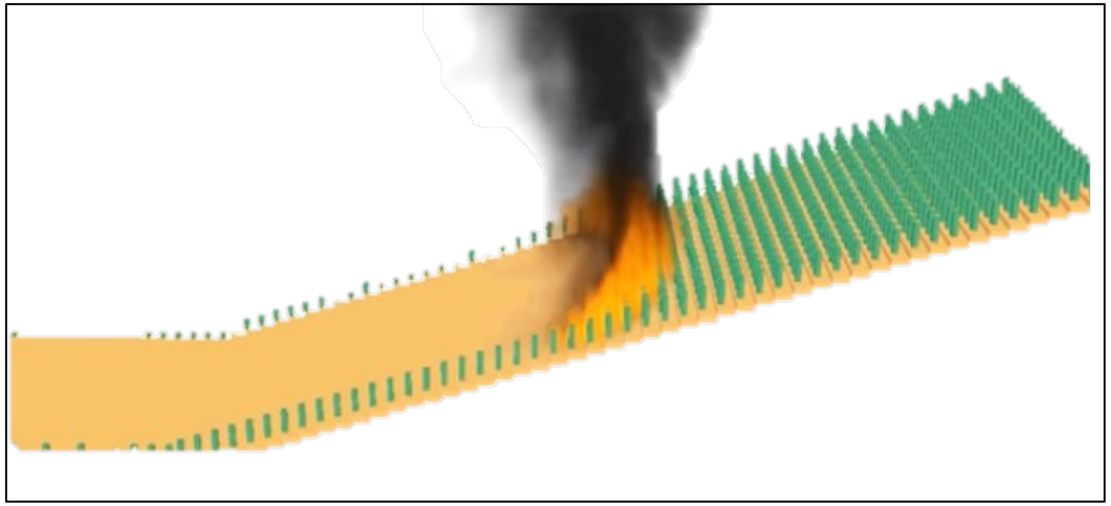


Shown scales are approximate.

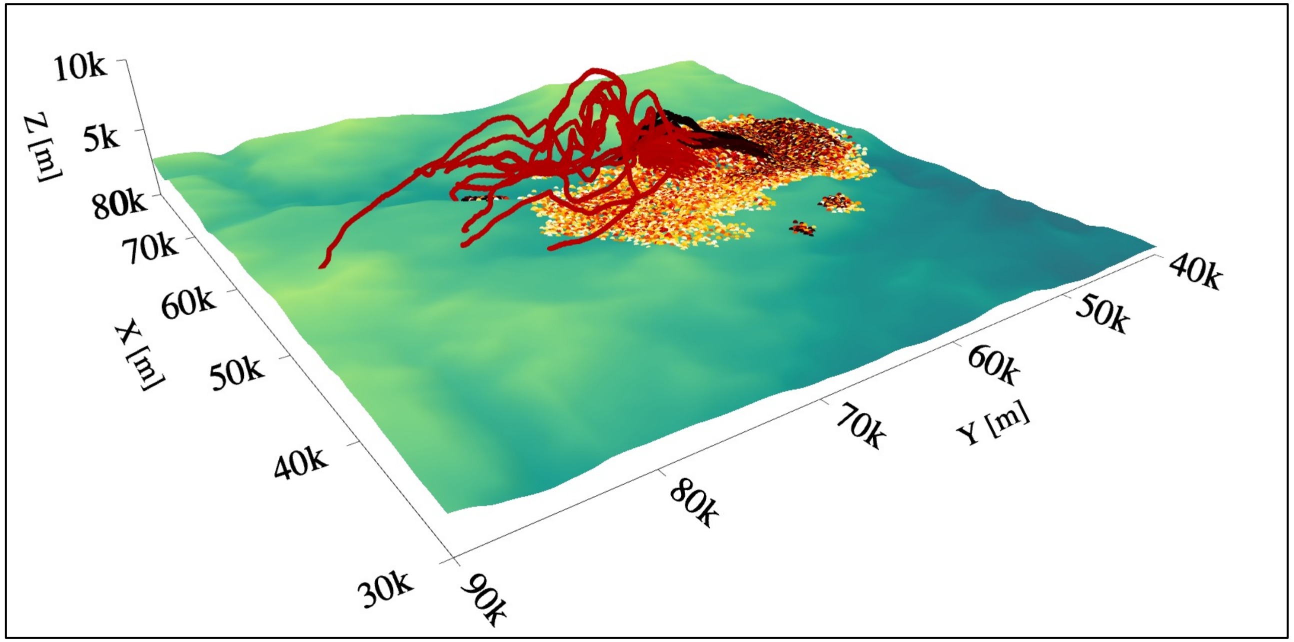
[1] A. L. Sullivan, R. Ball, *Atmospheric Environment*. **47**, 133–141 (2012).

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

High-fidelity CFD & Combustion models



Particle Transport Model

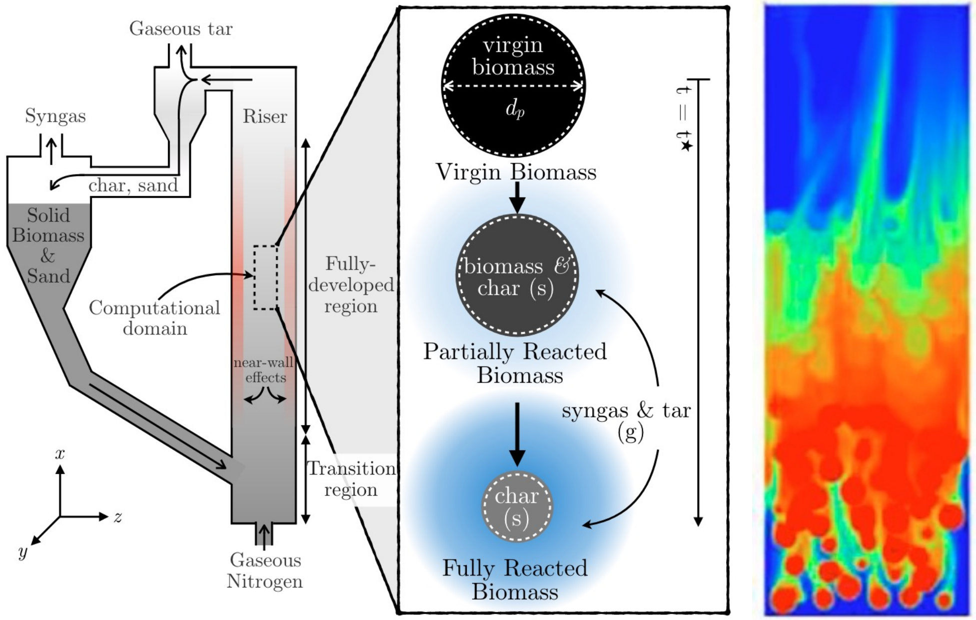


<u>Project Goals</u>
- Simulate fire spread in canopy and urban areas
- Couple the in-house particle transport model with the simulation outputs
- Conduct data-driven parameterization of the results
- Derive insights from the simulations

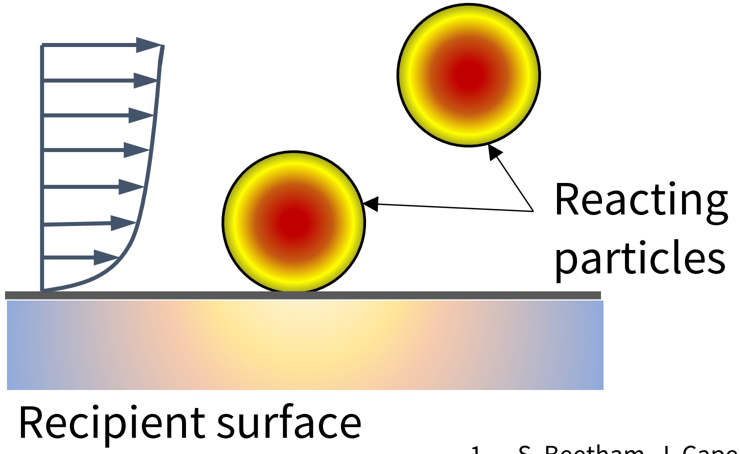
<u>Learning Outcomes</u>
- Become an expert in Fire Modeling
- Learn about high-performance scientific computing
- Learn data-driven statistical analysis

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].



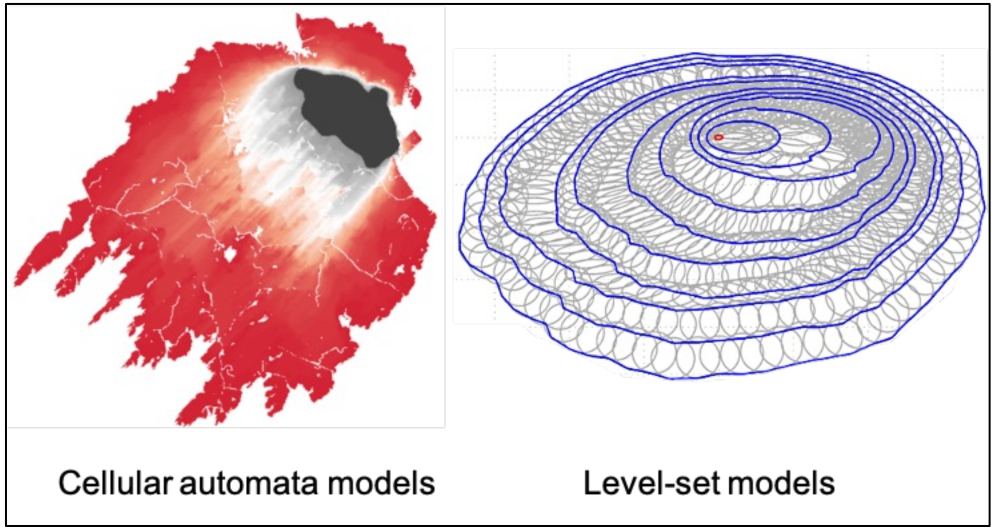
Learning Opportunities

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

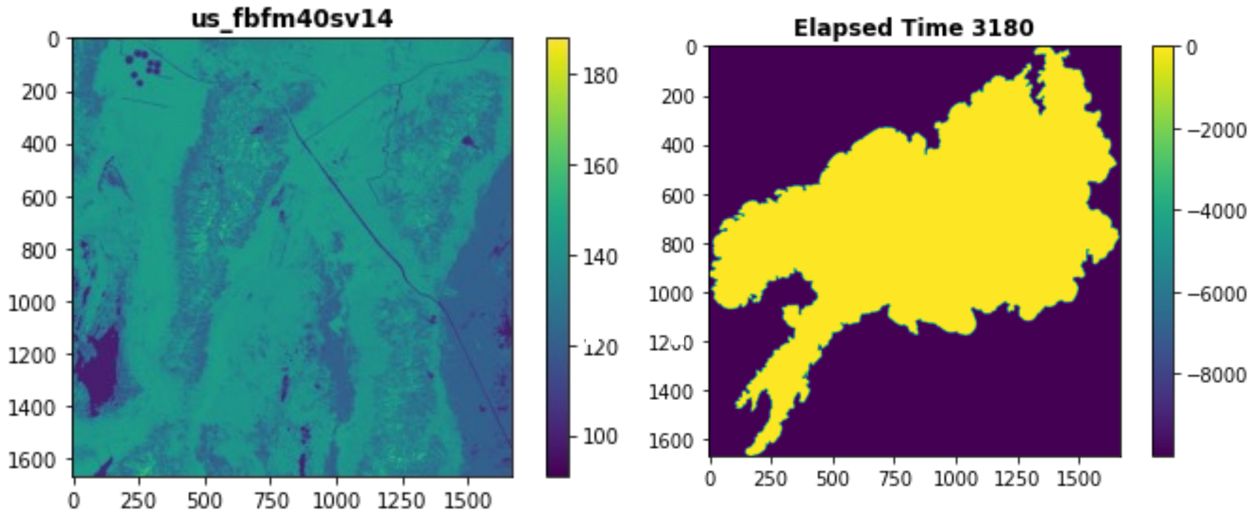
1. S. Beetham, J. Capecelatro, *Renewable Energy*. **140**, 751–760 (2019).
2. L.-T. Zhu, Y.-X. Liu, Z.-H. Luo, *Chemical Engineering Journal*. **374**, 531–544 (2019).

Project 3: Application of Deep Learning in Wildfire Modeling

Empirical Rate of Spread models



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

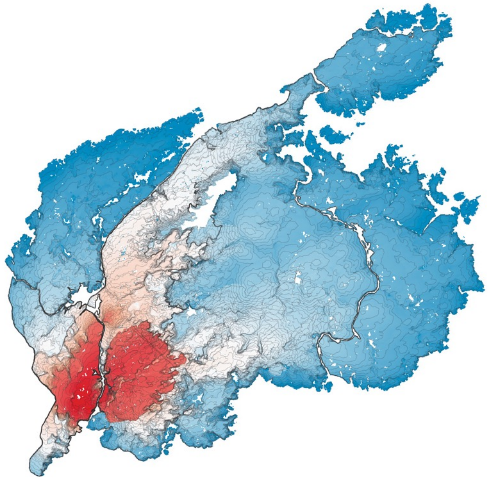


Project Goals

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

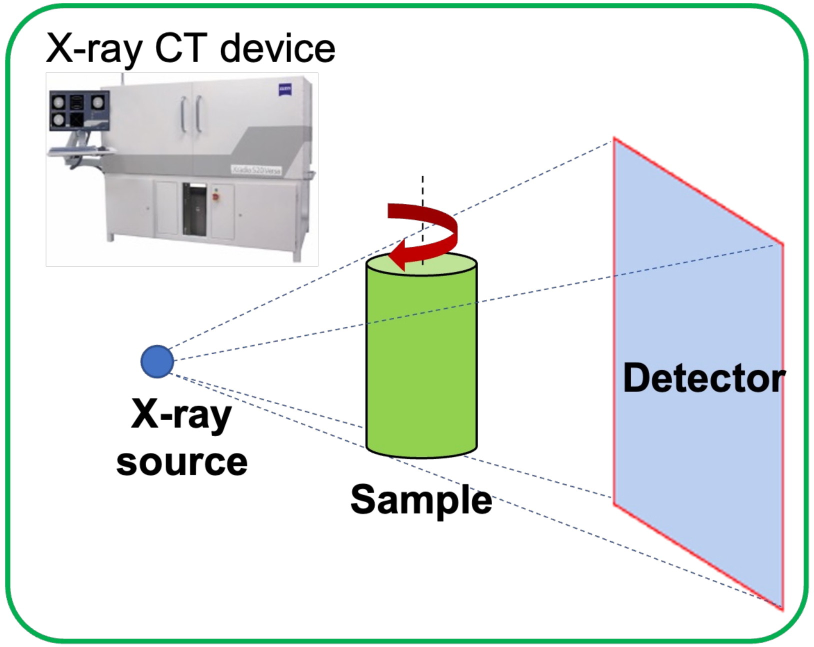
Learning Opportunities

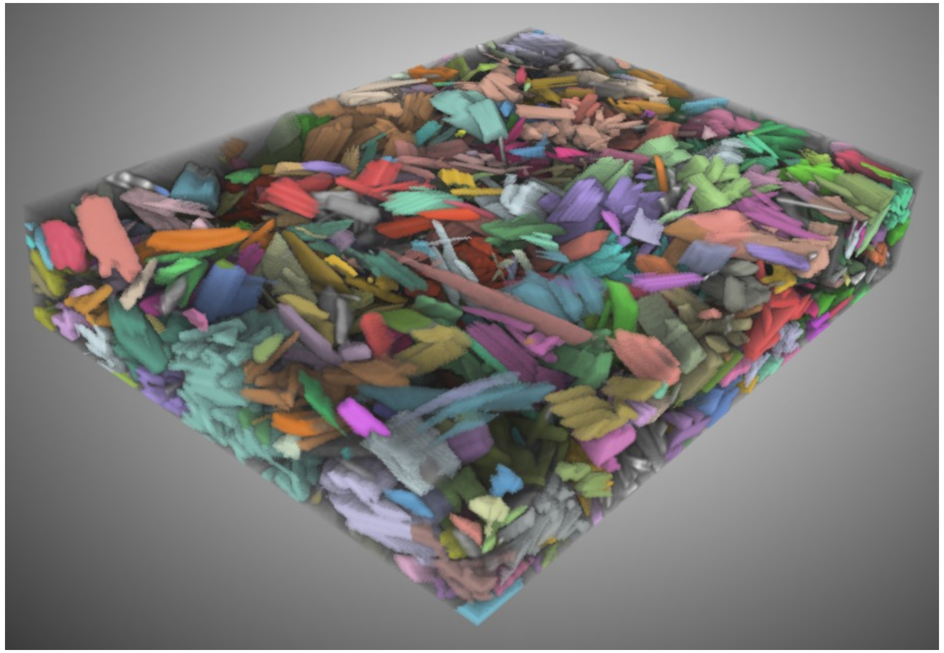
- Hands-on experience in developing deep learning models
- Experience in multi-scale modeling of wildfires
- Working experience with high-performance scientific computing (HPSC)

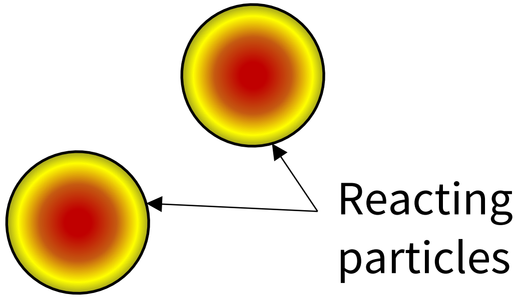


83,200 simulations are available

Project 4: X-Ray Image Analysis of Surface Fuels







Learning Outcomes

- Heat Transfer
- Porous Media
- Taking X-ray scans in the lab
- Computational Data Analysis
- Digital Image Processing
    - MATLAB
    - Python
    - Julia
    - …

If you have your own project in thermo-fluids area, email me at ali.tohidi@sjsu.edu

Dr. Vimal Viswanathan
vimal.viswanathan@sjsu.edu

Primary Research Interests

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

Recent projects

Design automation (concluded - in publication)
AI/ML in design (ongoing project)
Design of rehabilitation devices (ongoing project)
Improving the efficiency of 3D/4D printing processes (ongoing project)
New products and systems for green energy harvesting (ongoing project)
New products and systems for improving safety (ongoing projects)
The Spartan Hyperloop (ongoing projects)

ME295A/B – Available MS Projects

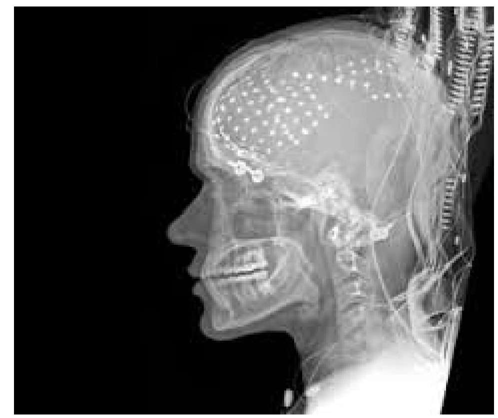
Winncy Du

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

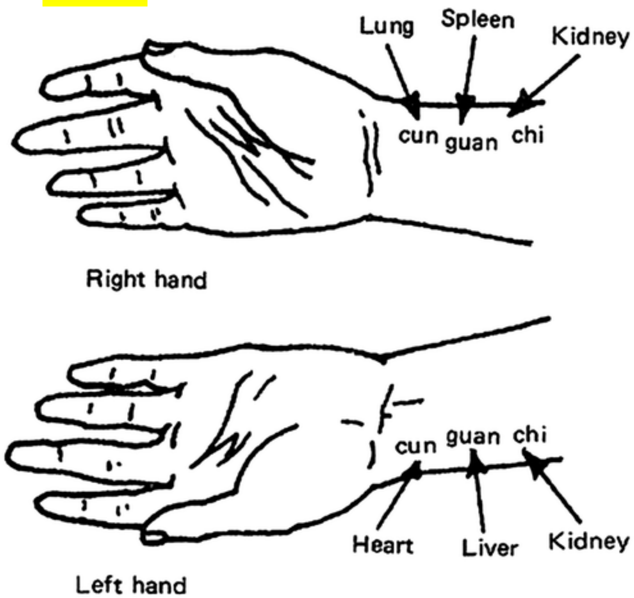
Electrical & Computer

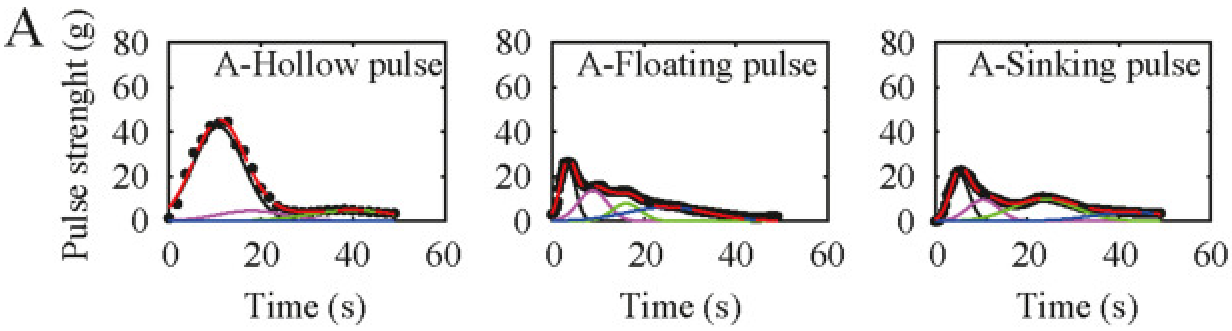
- Testing data acquisition
- Data analysis & findings

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)