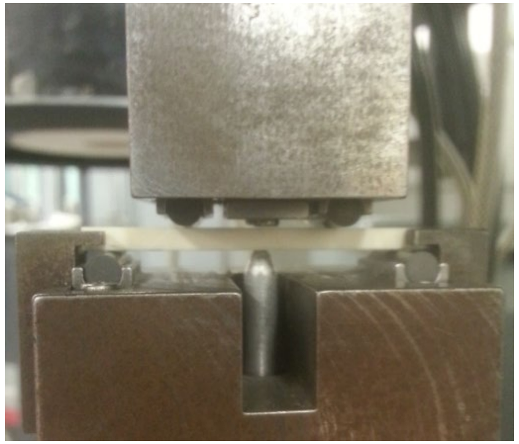
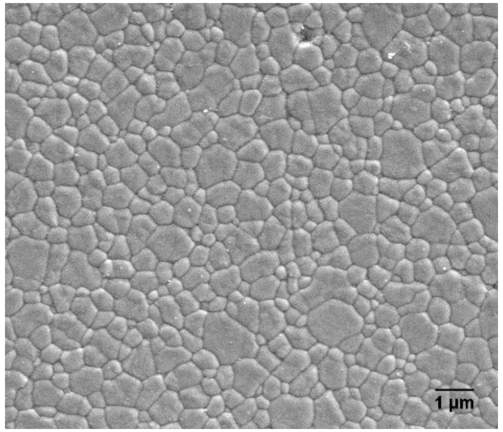
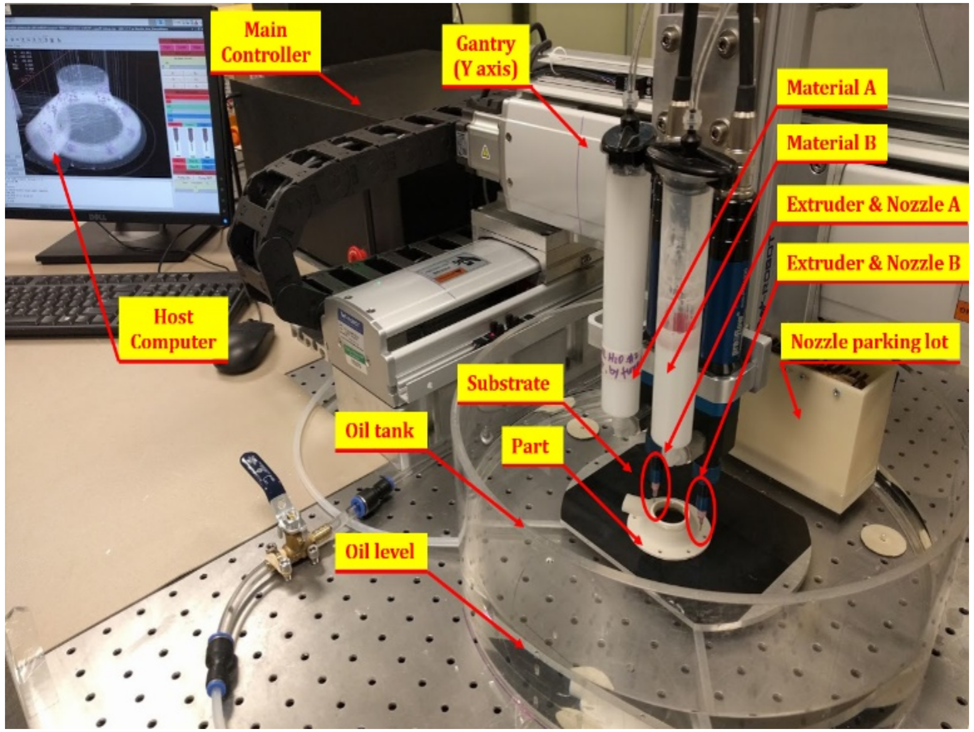
Additive Manufacturing & Material Characterization

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

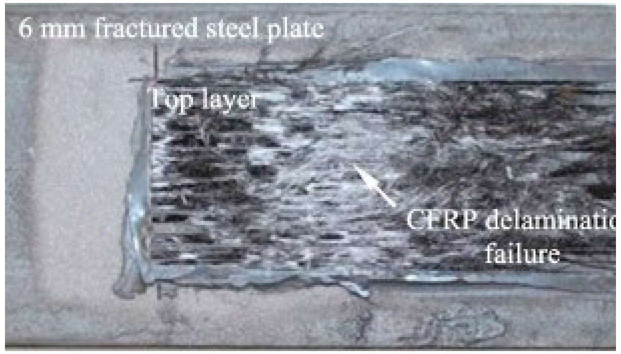


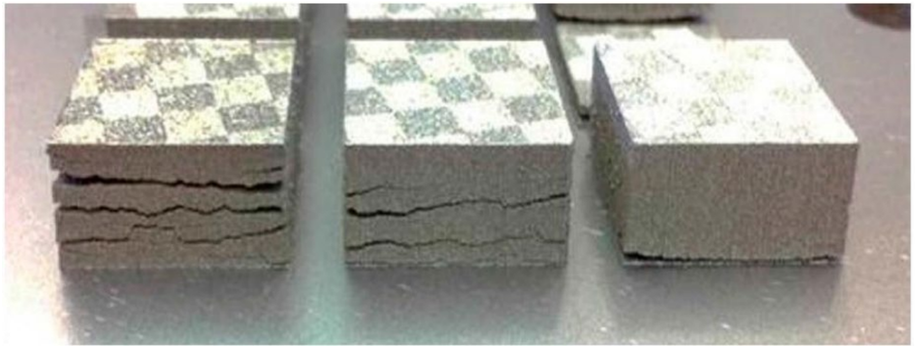


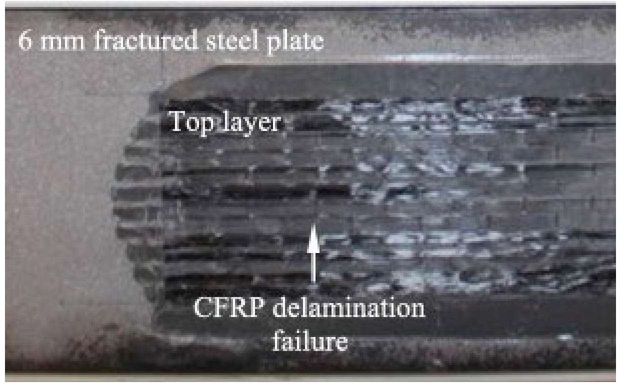


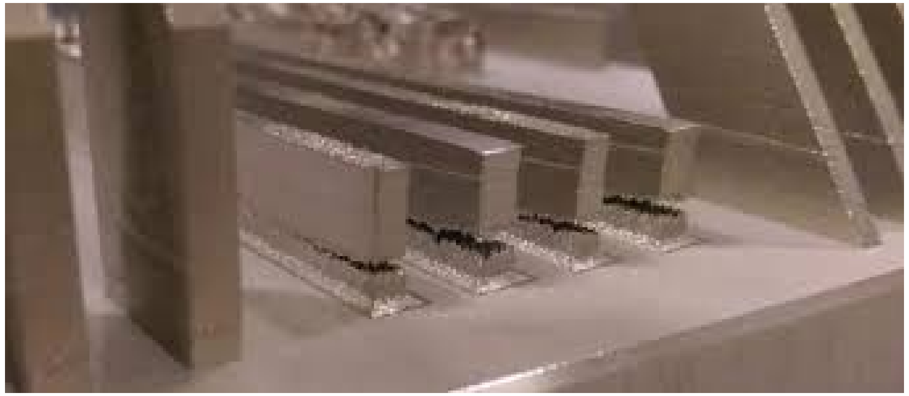
Improving AM with ML

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



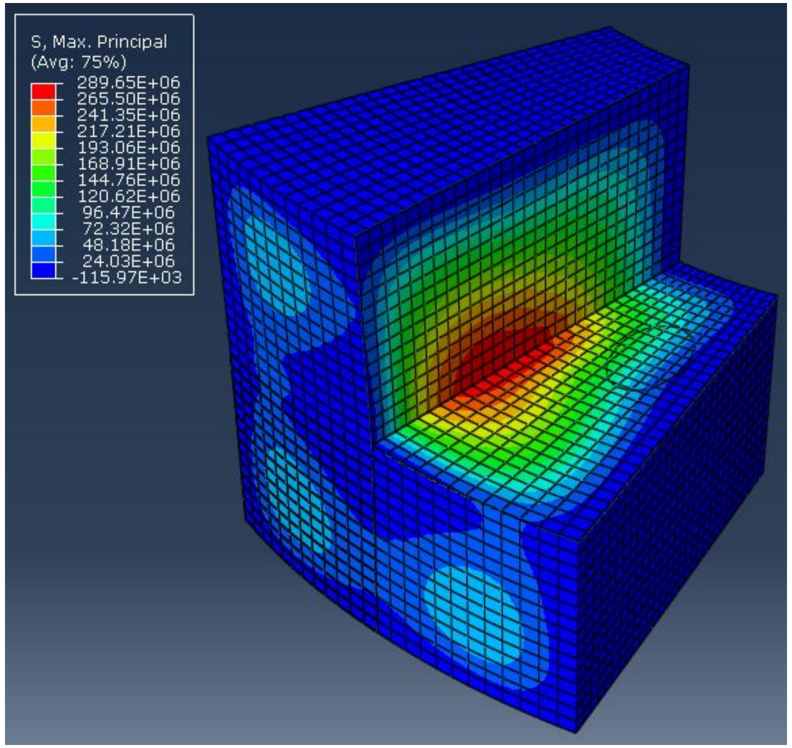


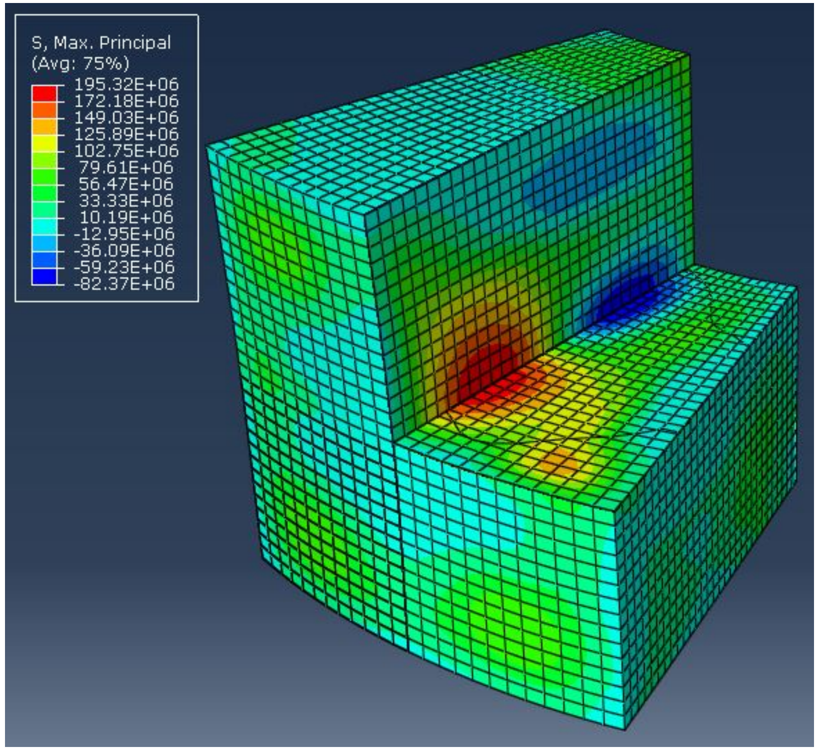




Design of Functionally Graded Materials for 3D Printing

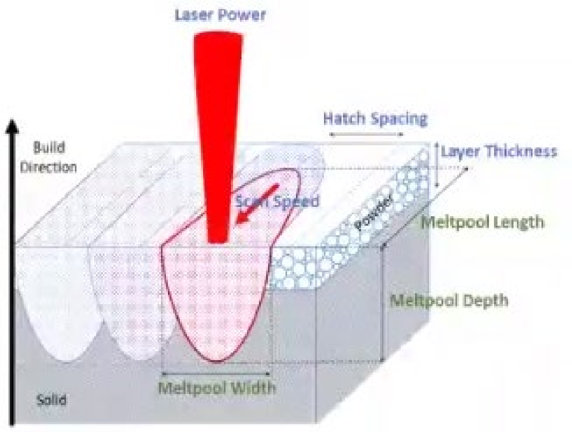
- **Numerical** project with ANSYS & MATLAB
- Material distribution can be optimized

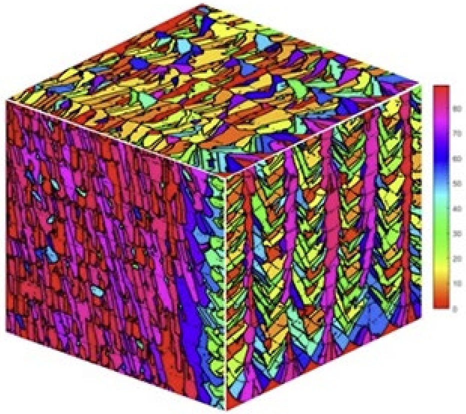


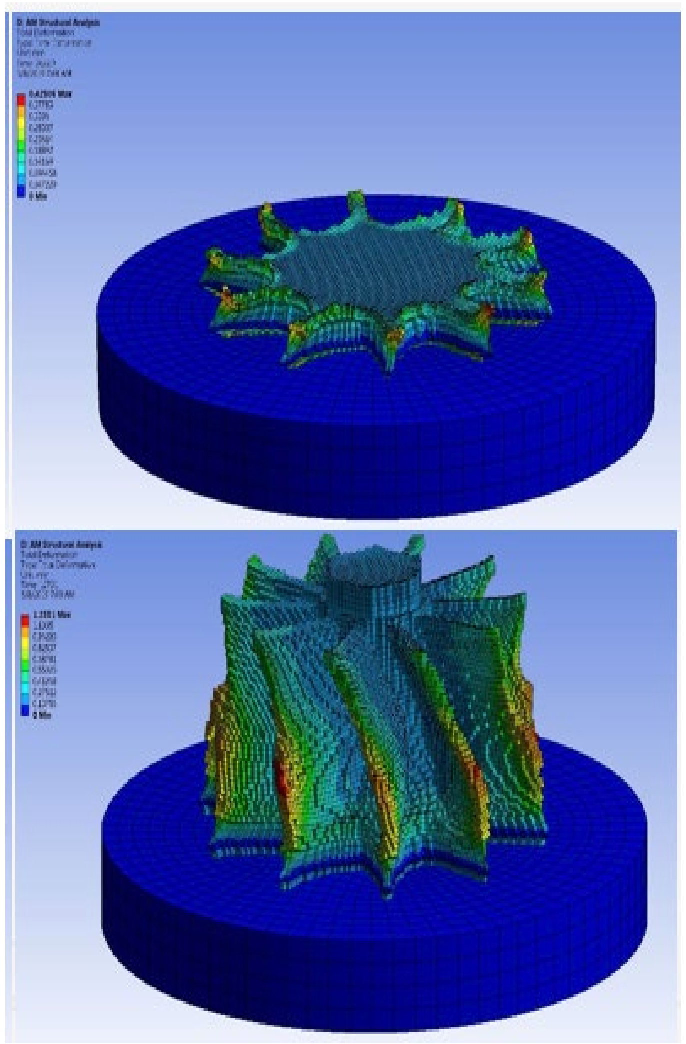


Simulation of Superalloy 3D Printing

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

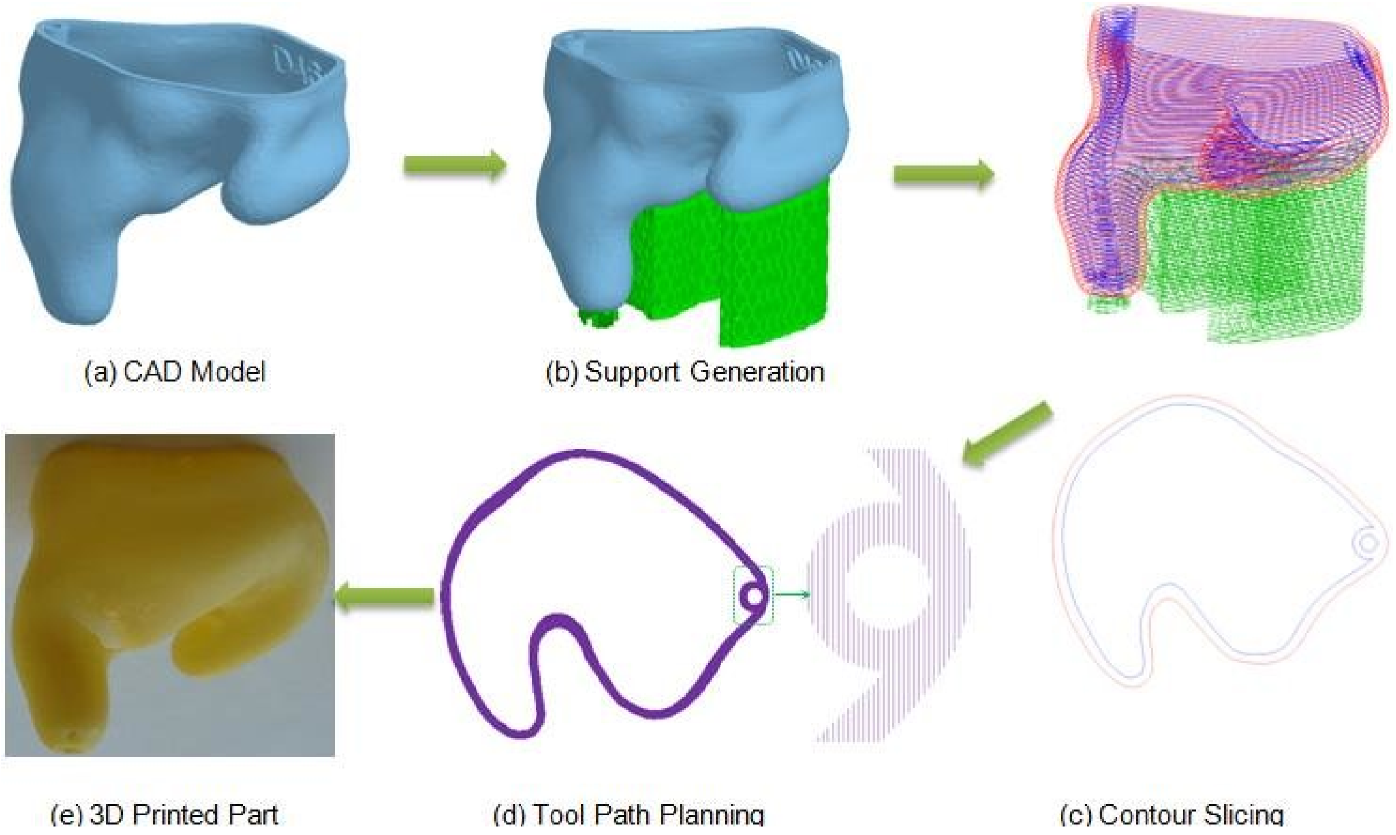






Tool-path Planning for 3D Printing

- **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

SJSU SAN JOSÉ STATE UNIVERSITY

Available Research Projects for MSME Students

FARZAN KAZEMIFAR

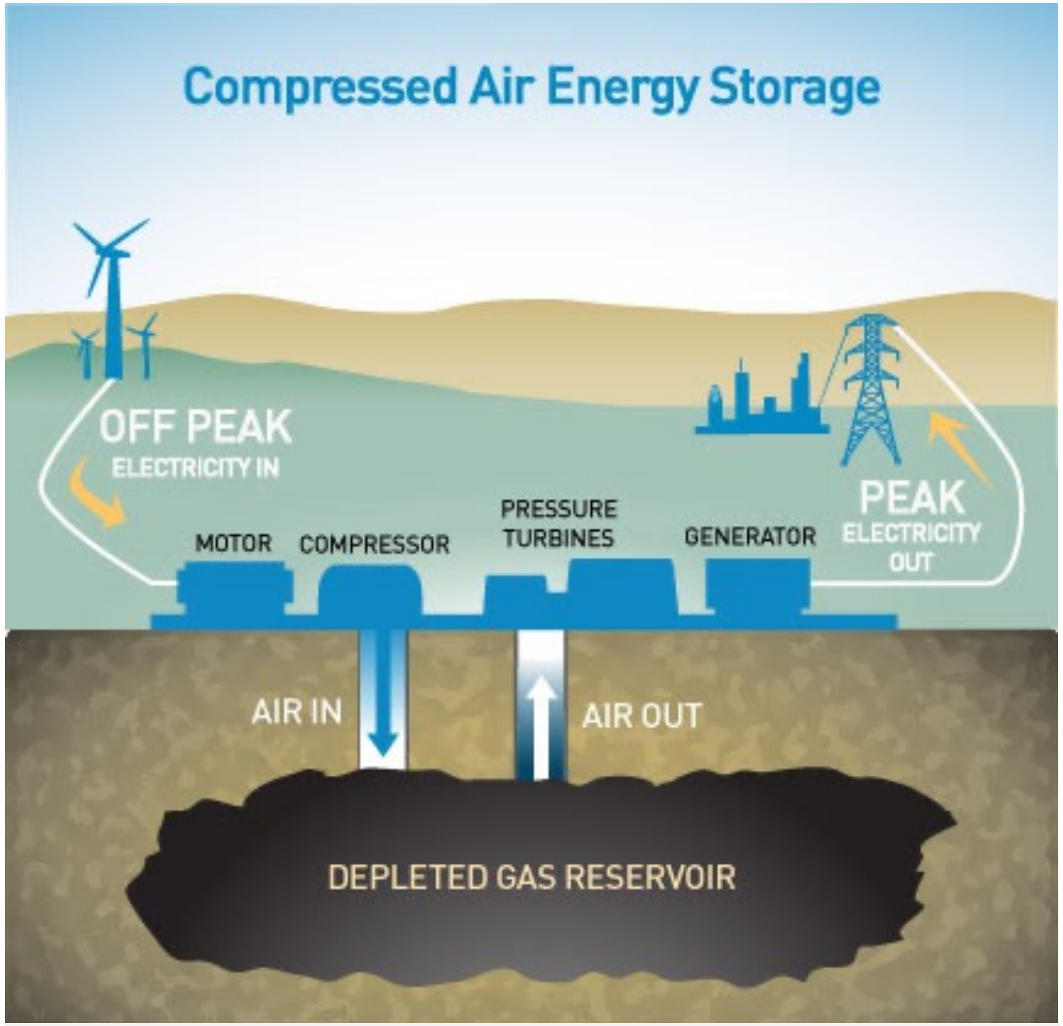
DEPARTMENT OF MECHANICAL ENGINEERING

SAN JOSÉ STATE UNIVERSITY

Feb 2, 2024

Physical Modeling of Energy Storage Systems

- **Long Duration Energy Storage (LDES)** systems. Including energy analysis and fluid and thermal simulations (COMSOL, Ansys Fluent, etc.)
- Conceptual design of a system and analysis of its performance using numerical simulations
- Different system that can be considered:
  - Liquid CO_2
  - Compressed air
  - Liquid air
- Tools: CFD software (Ansys, COMSOL, etc.)
- Relevant coursework: Thermodynamics, Heat transfer, Fluid mechanics, Controls

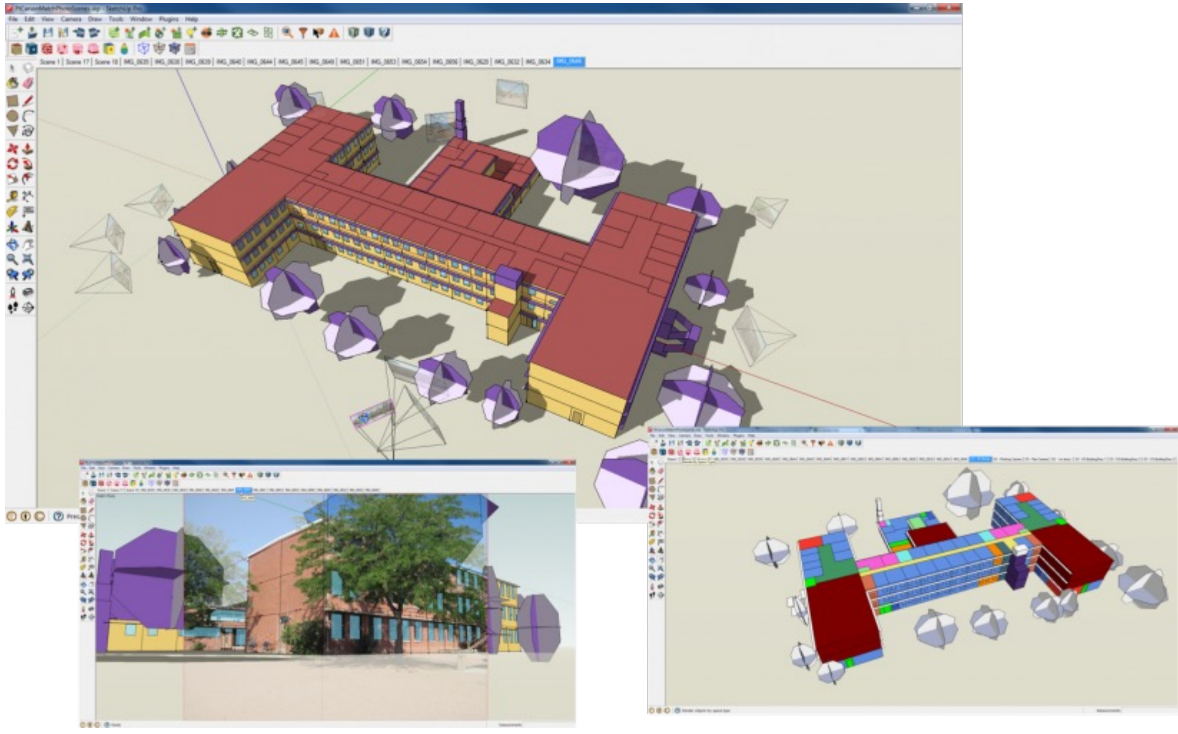


PG&E

Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

Building Energy Modeling and Assessment

- Focused on existing SJSU campus buildings
- Analyze energy use trends in the building
- Identify retrofit opportunities for energy savings
- Model the building energy use to quantify potential energy savings
- Develop strategies to reduce carbon footprint
- Tools: Building energy modeling software (EnergyPlus, eQuest, etc.), MATLAB



U.S. Department of Energy

Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

Energy Systems Modeling

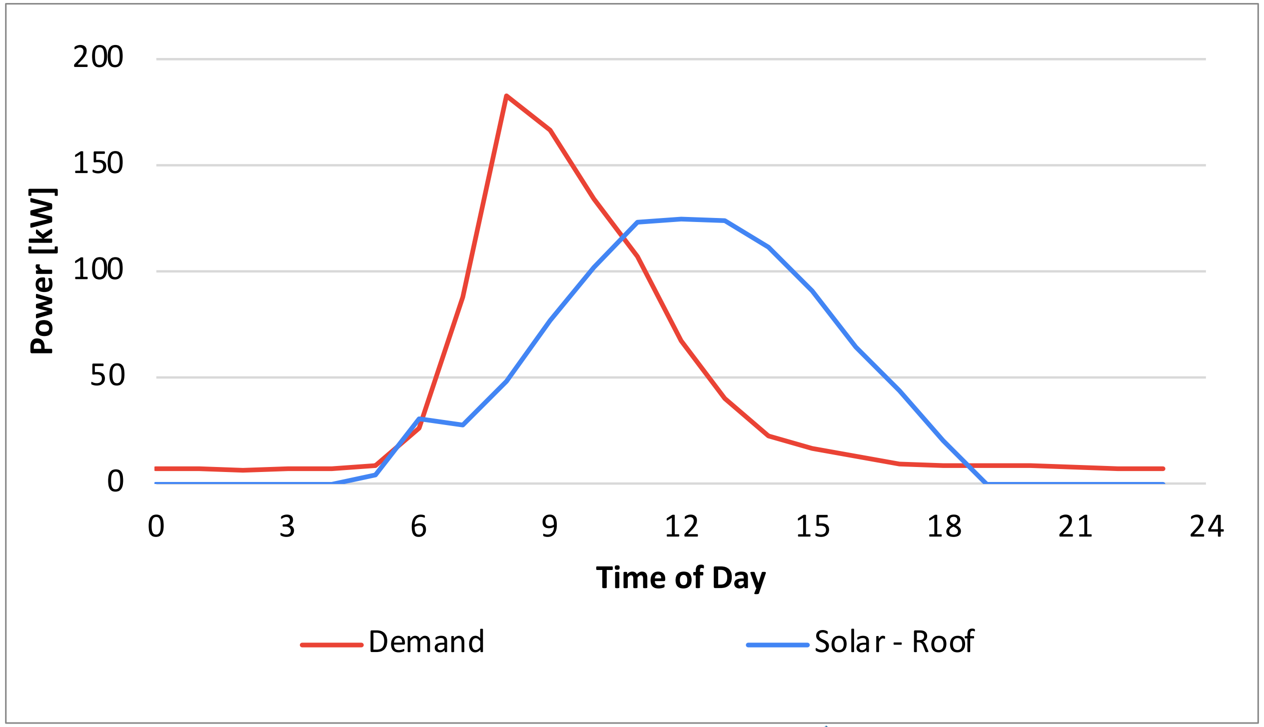
- Hybrid systems consisting of solar + wind + battery
- Energy demand forecasting models for various facility types (office buildings, different manufacturing facilities, etc.)
- Determine system size to minimize the energy costs for a given facility type
- Tools: MATLAB, EES
- Coursework: Diff. Eq, Controls

Shutterstock

Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

Optimizing Thermal Energy Storage in Manufacturing Plants

- Renewable energy generation with solar PV often times does not coincide with electricity demand at the plant
- Surplus electricity is sold to the grid at a significant discount compared to purchased electricity.
- Thermal storage can be a cost-effective energy storage for use in process heating/cooling and plants.
- The goal is to develop optimum sizing and control of energy storage for a factory.
- This project will use real data collected from a manufacturing plant in CA.



Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY

- Students who work on energy systems 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

Student Research Opportunities in Microfluidics and Mechanics of Soft Materials

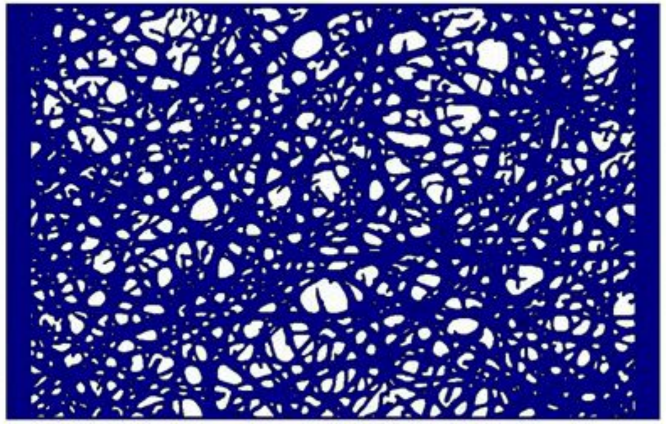
S. J. Lee
sang-joon.lee@sjsu.edu
San Jose State University
June 5, 2024

General Notes

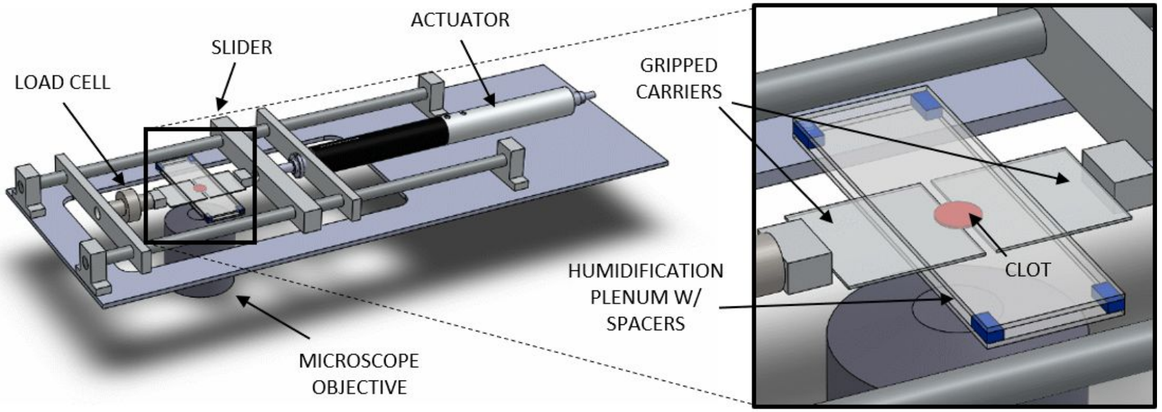
- ❑ Much of the research is in a **collaborative, multidisciplinary team environment**. There are typically 3 or 4 projects in any given semester, with 3 to 5 students on any given project team (including undergrads, graduate students, and faculty across multiple departments).
- ❑ Student **publications** (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.
- ❑ I typically advise **theses (ME 299) only** rather than projects (ME 295). Most theses are co-advised with at least one committee member who has expertise beyond mechanical engineering (e.g., biology, electrochemistry, physics, or otherwise).
- ❑ **Paid assistantships are available but very selective**. Paid positions are rare for first-semester students, but occasionally justifiable for exceptionally qualified and highly dedicated individuals for in-person laboratory work.
- ❑ **ME 168** Microfluidics Fabrication and Design (not offered Fall 2024) and **ME 283** Manufacturing Process Control (offered Fall 2024) are the top two recommended classes for skills that are directly related to many of my my research projects.

Modeling and Simulation of Blood Clot Mechanics

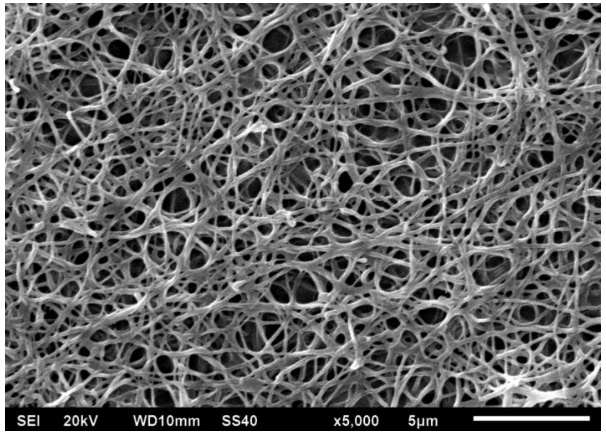
In collaboration with Dr. Ramasubramanian (Chemical Engineering), Dr. Dasbiswas (UC Merced) and Dr. Gopinath (UC Merced)



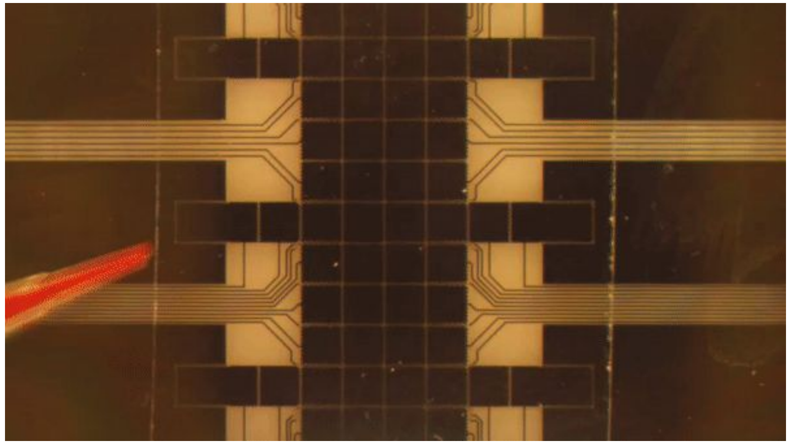
Finite element simulation of strain energy density distribution through a fibrin network under tension



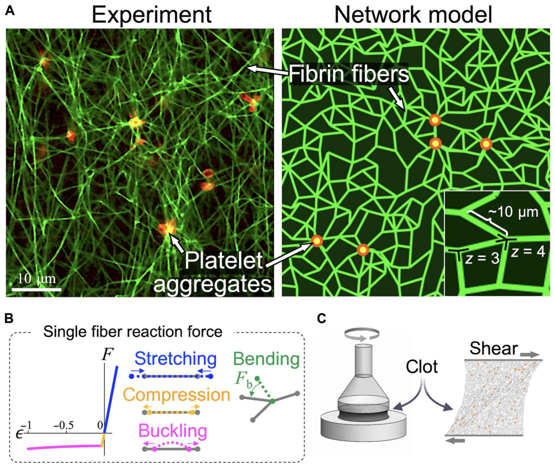
Example of apparatus for simultaneous extension, force measurement, and imaging. A more advanced system for microbead rheology is currently under development.



Scanning electron microscope image of fibrin network



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



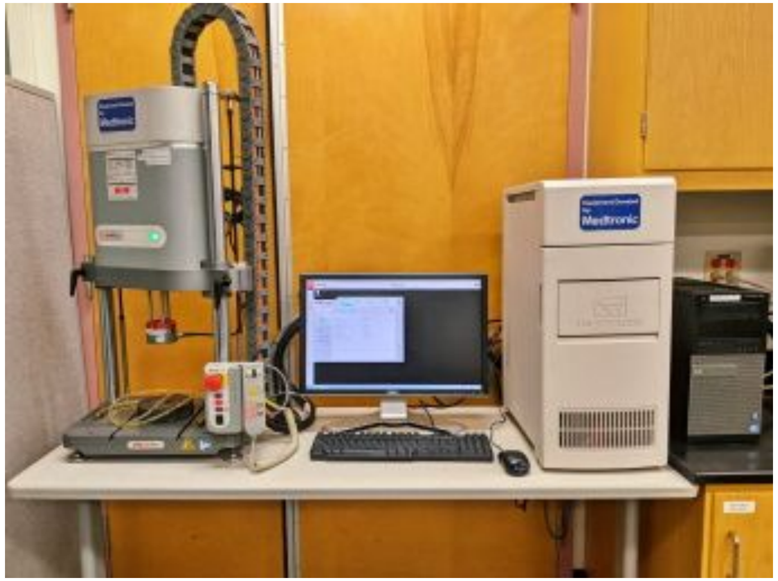
Modeling of nonlinear behavior of fibers and contractile nodes (Zakharov 2023)

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

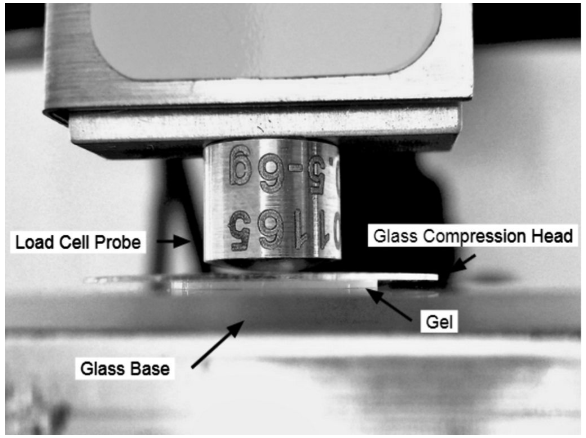
Related prior work: Lee 2020 https://doi.org/10.1007/s10237-019-01203-8, Pathare 2021 https://doi.org/10.1016/j.bpr.2021.100022, Zakharov 2023 https://doi.org/10.1101/2023.03.24.534185

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 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.



Simultaneous measurement of force and micron-scale displacement

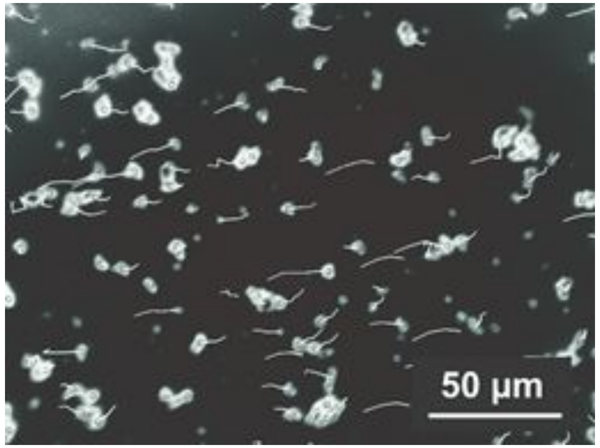
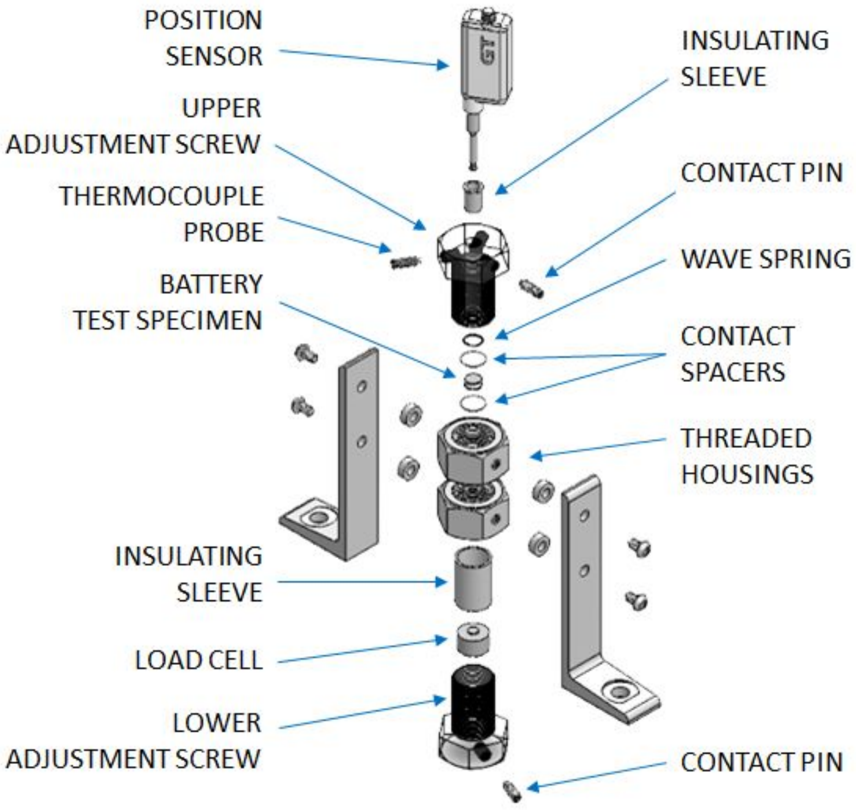


Image analysis and tracking of particle distribution in polymer matrix



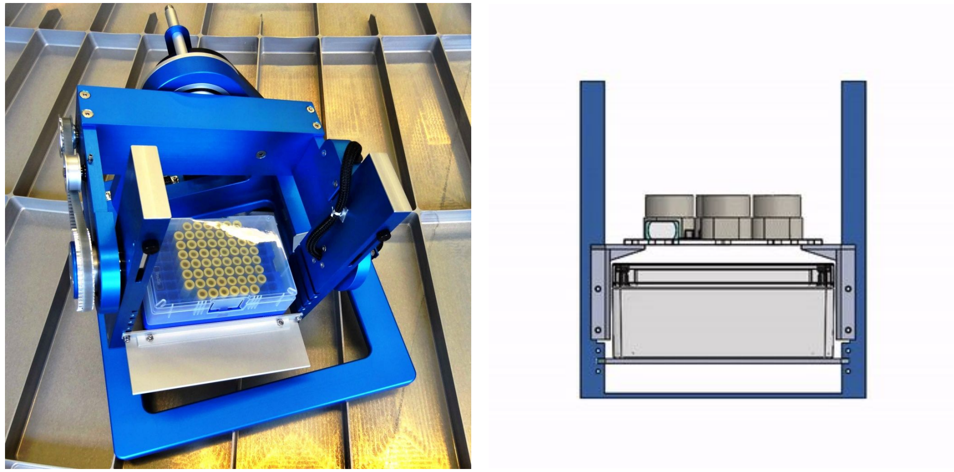
Multifunctional apparatus for simultaneous measurement of mechanical response and electrochemical performance

Sponsored by the National Science Foundation, 2022-2024.

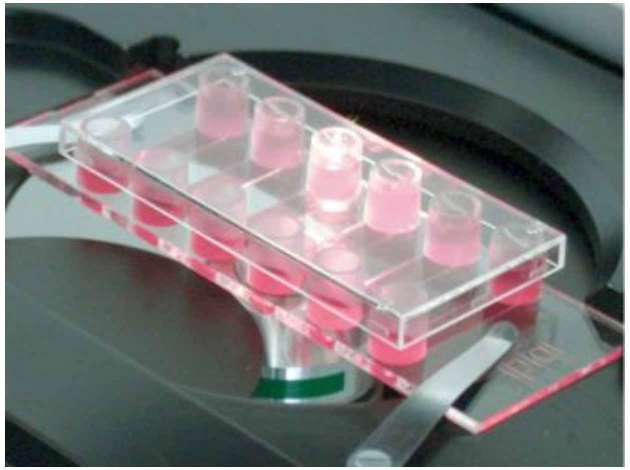
Related prior work: Mulay 2022 https://doi.org/10.1115/IMECE2021-69196, Yoon 2023 https://doi.org/10.1021/acsaem.3c01357, Jadhav 2024 https://ecs.confex.com/ecs/245/meetingapp.cgi/Paper/185103

Hemodynamics and Thrombosis in Microgravity

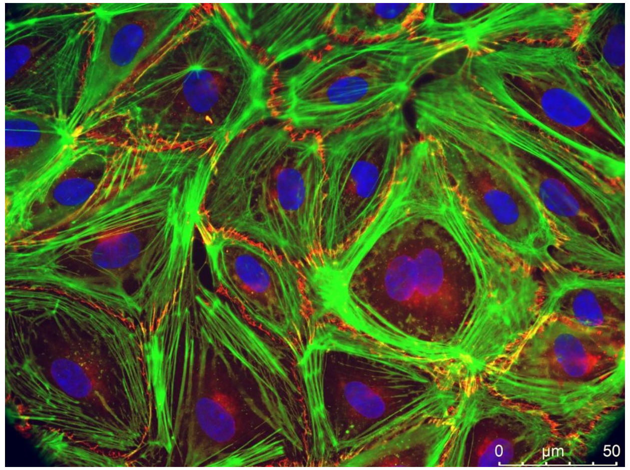
In collaboration with Dr. Anand Ramasubramanian (Chemical Engineering)



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.

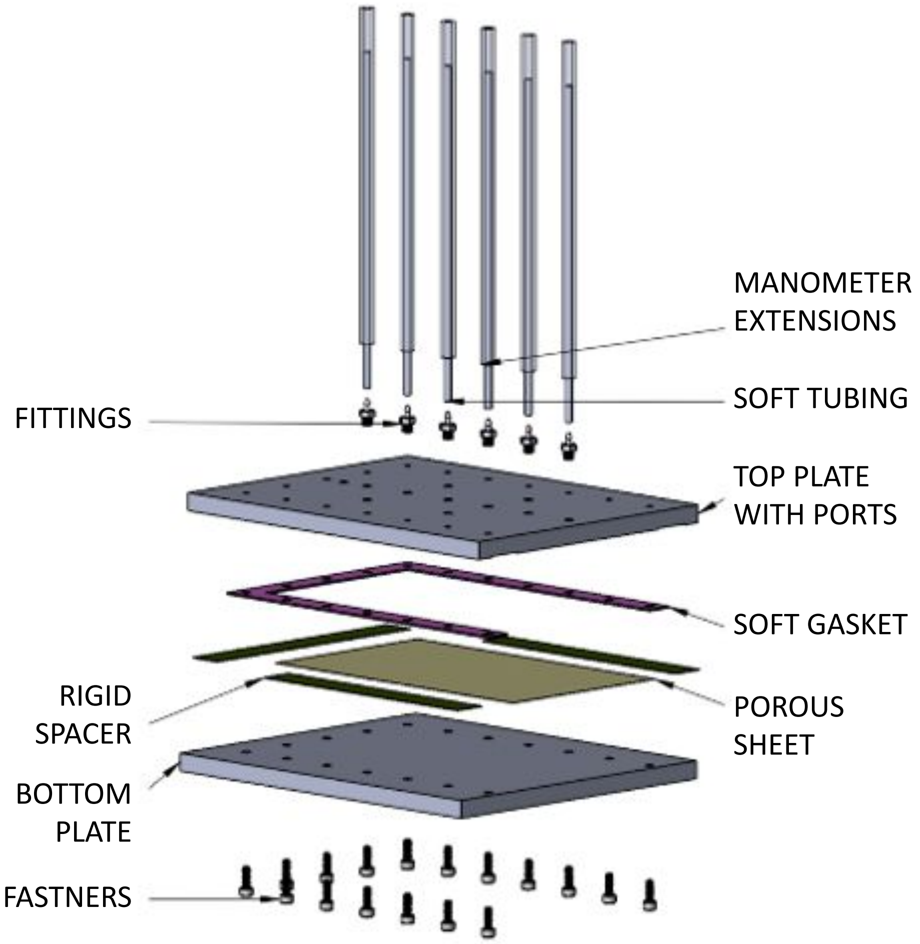
Sponsored by NASA Space Biology, 2021-2024. First manuscript in preparation.

Recent Theses

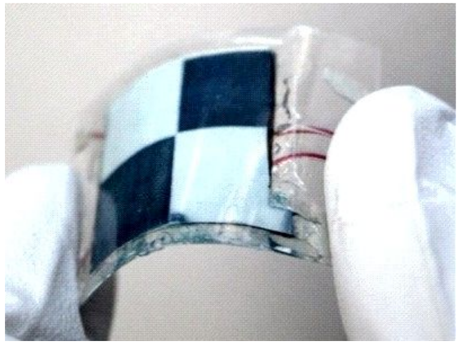
- Jericko Baltazar 2024: "Effect Of Compressive Strain on Bulk Resistance and Ionic Conductivity of PEO-LiTFSI Solid Polymer Electrolytes" (approved June 2024 for May 2024 thesis cycle)
- Valeria Perez 2023: "Interdependence of Salt Concentration and Filler Particles on Crystallinity and Mechanical Behavior of PEO-LiTFSI Electrolytes for Lithium-Ion Batteries", https://doi.org/10.31979/etd.b244-8d94
- Tamara Kawa 2023 "Effect of Spatial Uniformity of Platelet Aggregates on the Stress-Strain Behavior of Blood Clots", https://doi.org/10.31979/etd.6ykn-9wws
- Max Kim 2023: "Bubble Detection under Microgravity in a Closed-Loop Microchannel Perfusion System", https://doi.org/10.31979/etd.34sf-xebe
- Nishad Mulay 2022: "Mechanical Stabilization by Cyclic Compression of Composite Polymer Electrolytes for Lithium-Ion Batteries", https://doi.org/10.31979/etd.xk97-css3

Hydraulic resistance in thin porous media

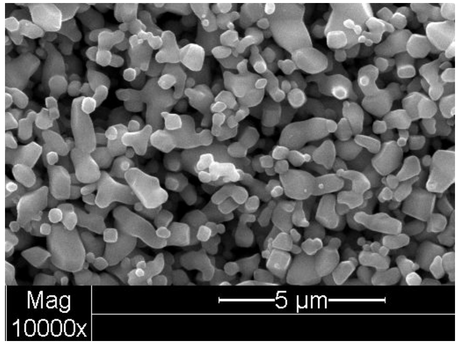
In collaboration with Dr. Kazemifar (Mechanical Engineering)



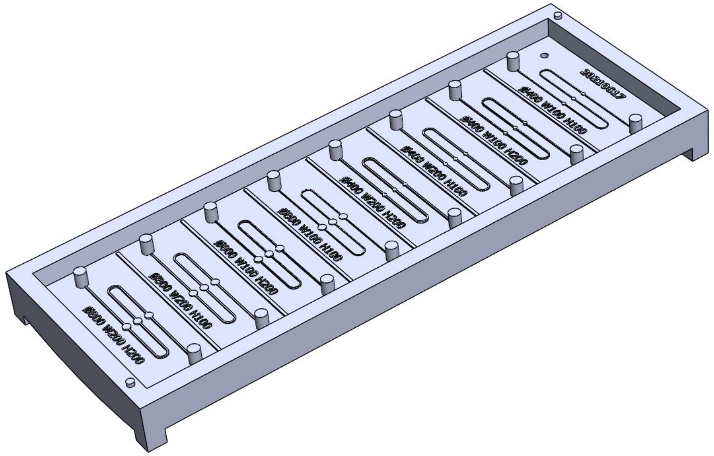
Example of low-pressure measurement using manometers distributed across a thin sheet



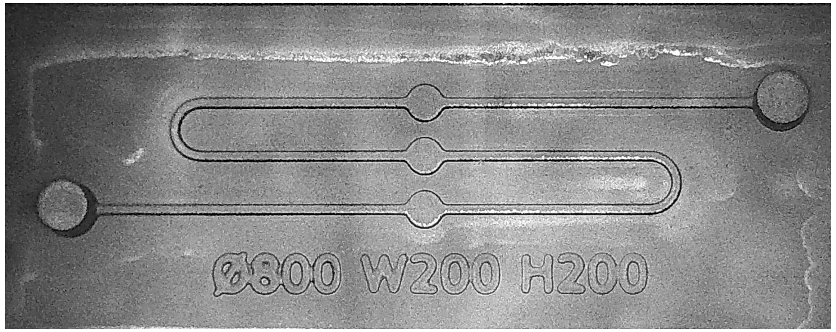
Four-pixel demonstration prototype for low-power "electronic paper" display.



Electron microscope image of thin porous media sheet fabricated from bonded titanium dioxide.



CAD design of a 75 mm x 25 mm mold for casting parametrically varied microfluidic chips.



Microscope image of 200 µm wide microchannel with three Ø 800 inline diaphragms,

Related: S. Doser and S. J. Lee, "In-plane hydraulic resistance through paper-thin porous media",
Proc. of the ASME 2018 5th Joint US-European Fluids Engineering Summer Conference, July 2018, Montreal, Quebec, Canada, 2018, Paper FEDSM2018-83262.

MSME Research Projects
ME295A for Spring 2025

Crystal Han
crystal.m.han@sjsu.edu

Implementation and evaluation of remote industrial energy assessment

SJSU Industrial Training and Assessment Center (ITAC)

I am an assistant director of ITAC. We provides energy assessment to local manufacturing industry to help them save energy and cost. A team of faculty and students regularly perform these assessments on-site. https://iac.university/

Background

As a Western ITAC Center of Excellence, we plan to develop and evaluate new methods of performing energy assessment. A remote or virtual assessment is needed for industries located in hard-to-reach areas or for facilities that poses health or safety risks.

Goals

1. Research, test and implement new technologies applicable.
2. Develop assessment protocols and templates for virtual assessment.
3. Conduct virtual energy assessments.
4. Generate recommendations as well as energy and cost saving calculations.
5. Analyze and compare the virtual vs. on-site assessment results.

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

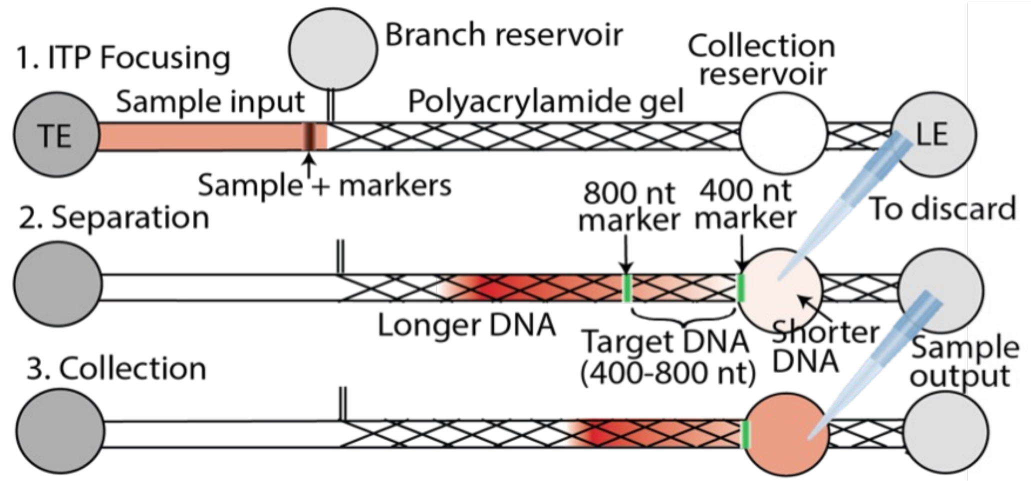
1. Analyze learning outcomes and physical parameters involved with the current SJSU thermal lab modules and other university's.
2. Develop low-cost, custom laboratory units for each specific topic.
3. Create a laboratory protocol and sample results.
4. Identify and assess learning outcomes of the lab.

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.

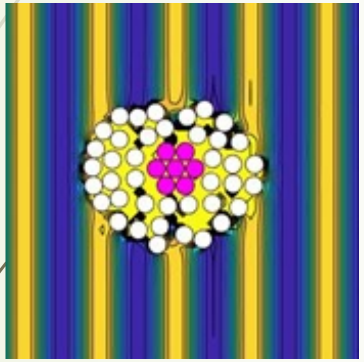
Goals

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.

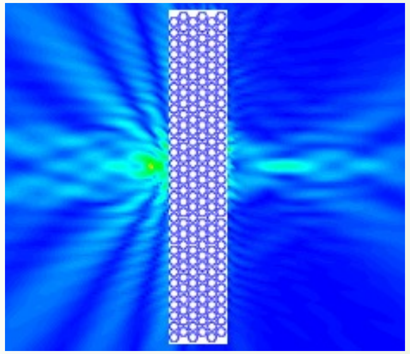


- **ITP:** Electric field-based focusing and separation technique for charged molecules (ions, RNA, DNA, proteins)
- **Techniques and equipment used in research:** Fluorescence microscopy, CCD camera, basic wet lab skills, MATLAB based image analysis, photolithography, soft lithography

Related papers: [1] https://pubs.rsc.org/en/content/articlelanding/2019/LC/C9LC00311H ,
[2] https://www.nature.com/articles/s41586-023-06228-9



Research Interests and Proposed TopicS



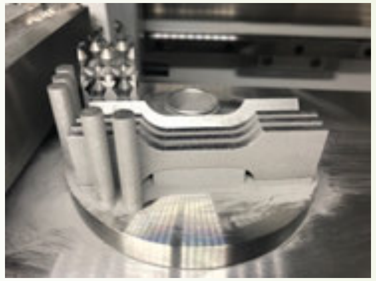
Feruza A. Amirkulova, PhD
feruza.amirkulova@sjsu.edu

Department of Mechanical Engineering
San Jose State University

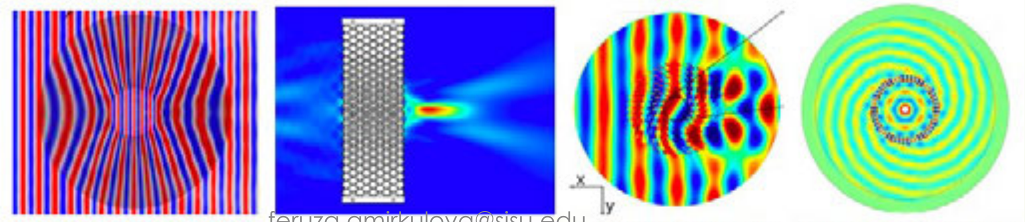
Aug 30 2023

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.



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



(a) Concentrator [2]; (b) GRIN lens [3]; (c) Field rotator [4]; (d) Source illusion [5];

feruza.amirkulova@sjsu.edu

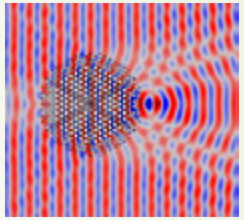
The examples of transformation acoustics devices.

Our first build using EOS SML system

feruza.amirkulova@sjsu.edu

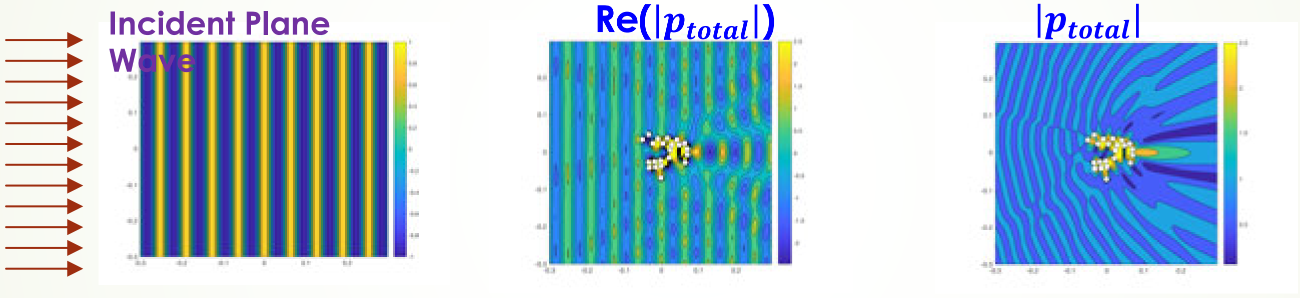
3

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



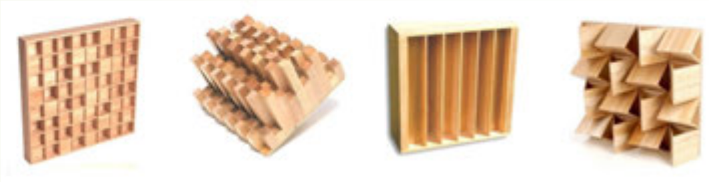
Amirkulova et al. (*JASA*, 143(3), 2018)

- 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

feruza.amirkulova@sjsu.edu

Sound Diffusers

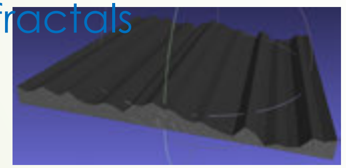
Diffusers are a type of acoustic treatment installed in acoustically sensitive environments such as performing arts spaces, concert halls, and classrooms.



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

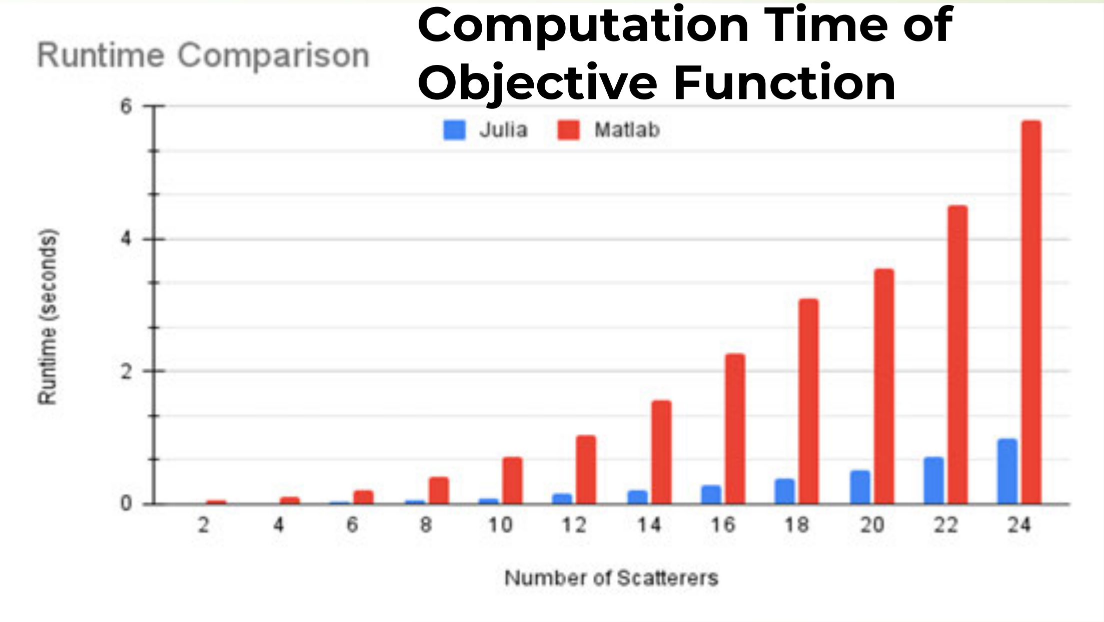
Students will Perform numerical simulations, manufacture the diffusers, and measure sound pressure level using state-of-the-art sound & vibration analyzer platform from Brüel & Kjær.

feruza.amirkulova@sjsu.edu

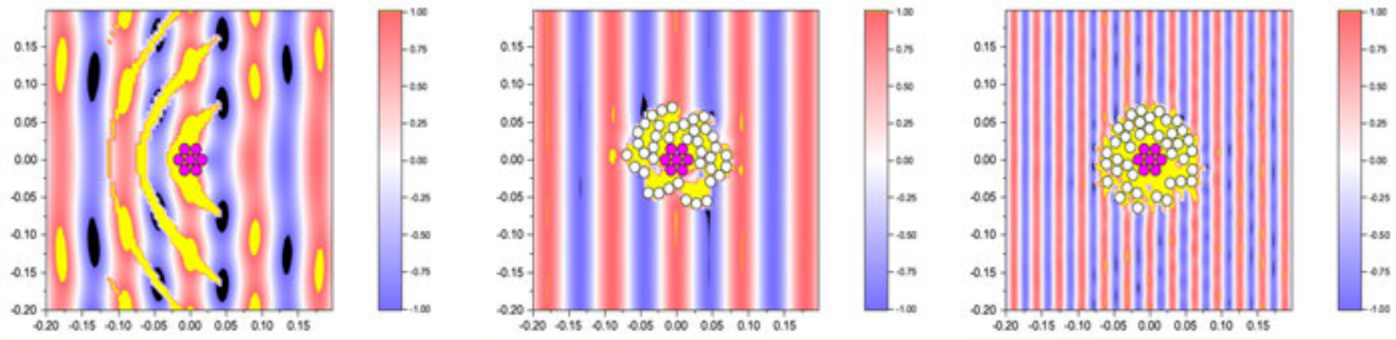
Design of Metamaterials Using Gradient Based Optimization

- Julia programming

Computation Time of Objective Function



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

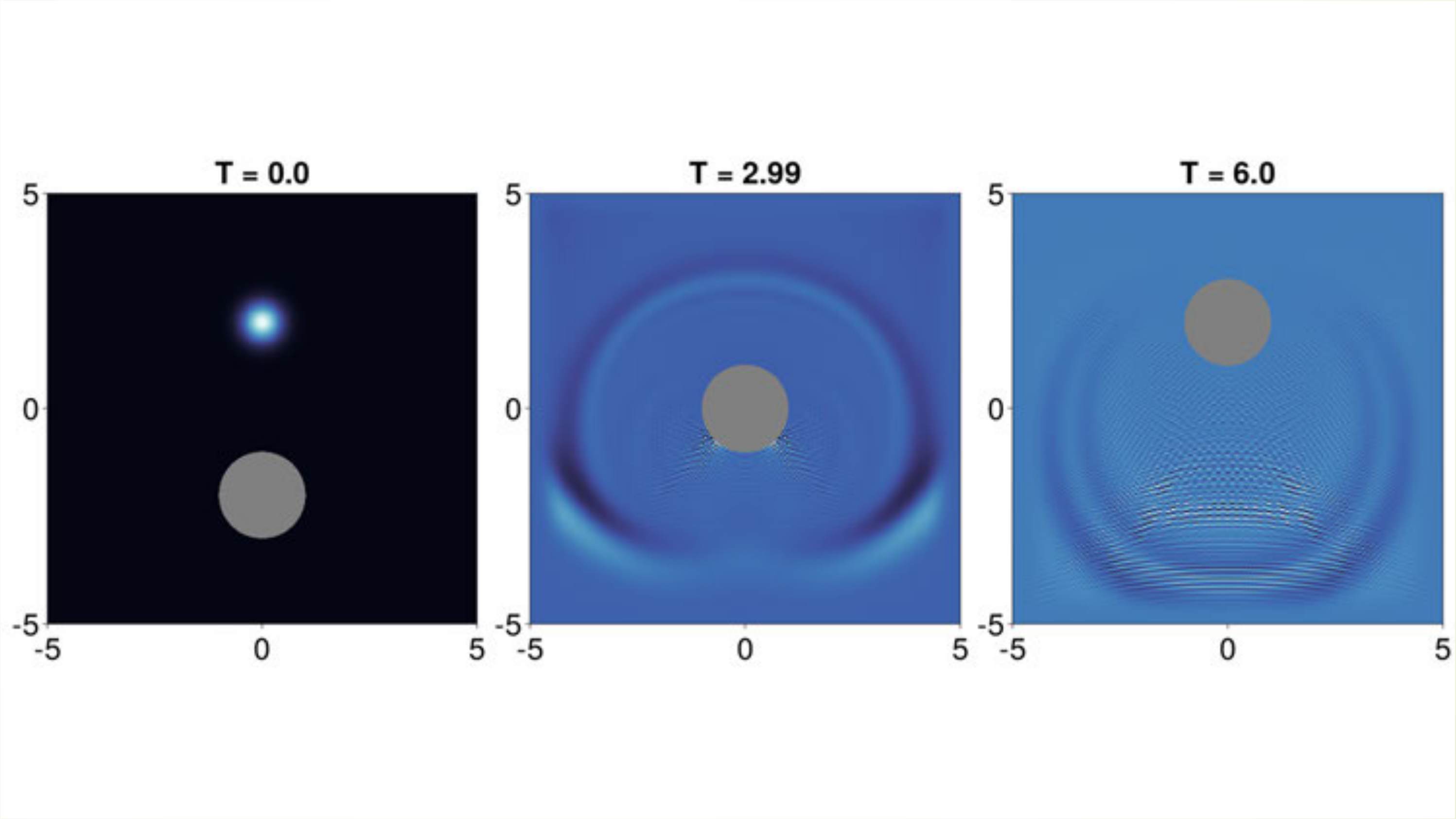


(a) No cloak: $\sigma = 0.12595$ (b) $ka = 0.525, \sigma_r = 1.4106e-04$ (c) $ka = 1.5, \sigma_r = 0.0126$

feruza.amirkulova@sjsu.edu

Design of Metamaterials Using Model Predictive Control and Reinforcement learning

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



feruza.amirkulova@sjsu.edu

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

ME-231: Machine Learning and Optimization in Mechanical Engineering offered in FALL 2023

feruza.amirkulova@sjsu.edu

EXTRA

Our Recent Publications

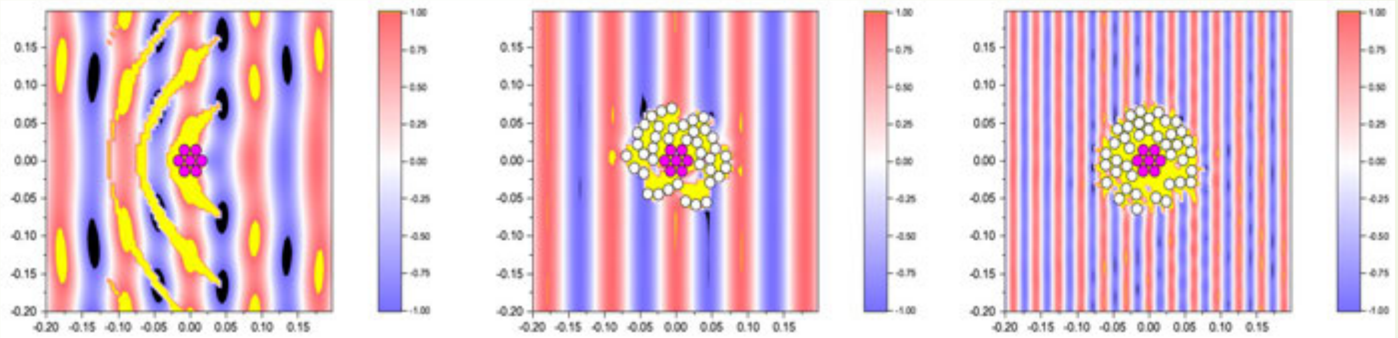
Metamaterials Through Multi-scattering and Gradient-based Optimization

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

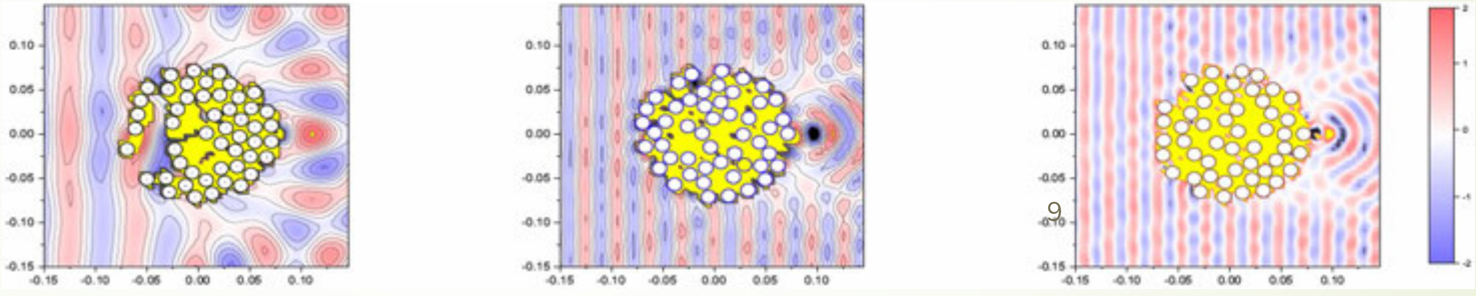
Amirkulova & Norris. The Gradient of Total Multiple Scattering Cross-Section and Its Application to Acoustic Cloaking. *JTCA* 2020: 1950016. doi: 10.1142/s2591728519500166

- **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)

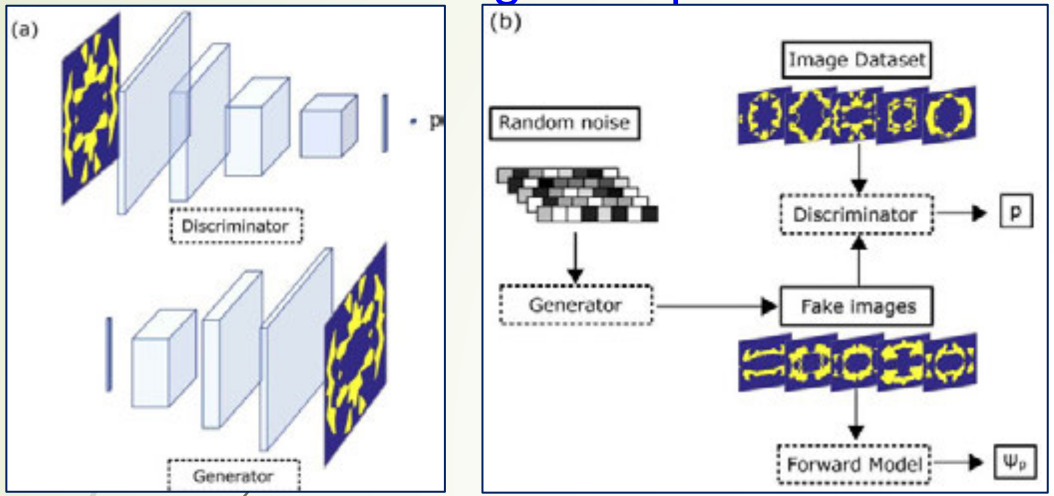
- **Sound Diffusers**

Optimize diffusion coefficient d_ψ

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

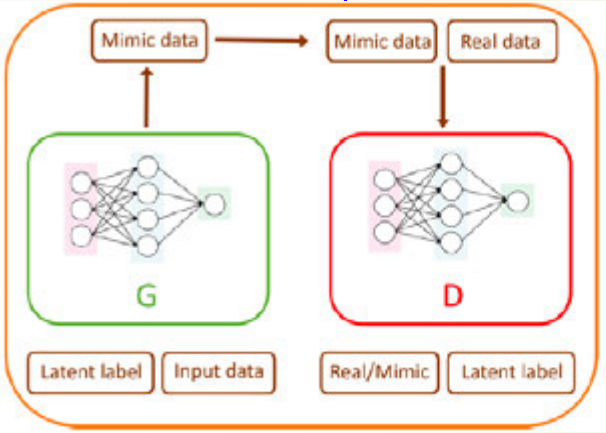
Applications of Generative Adversarial Networks (GAN)

GAN for design of optical cloak



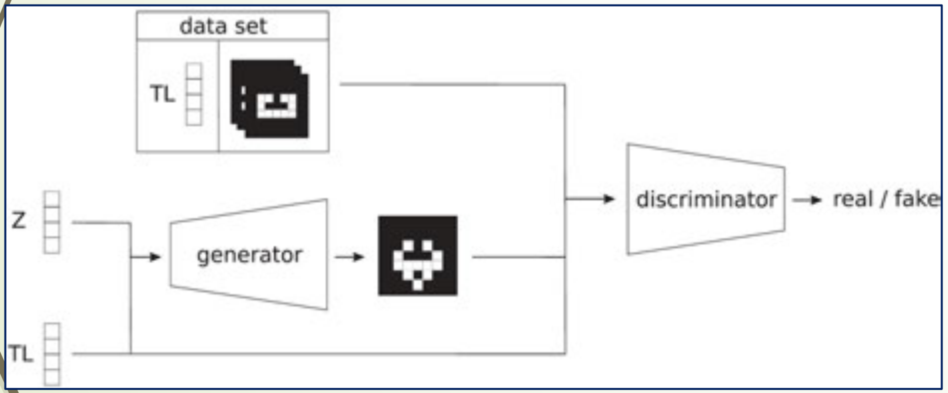
Blanchard-Dionne & Martin, OSA Continuum 2020.

Conditional WGAN for protein solubility prediction

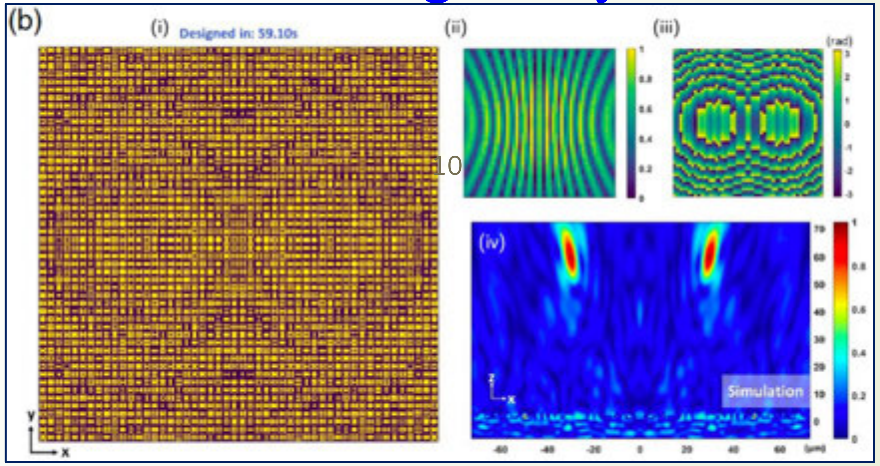


Han et al. InfoMat 2020

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

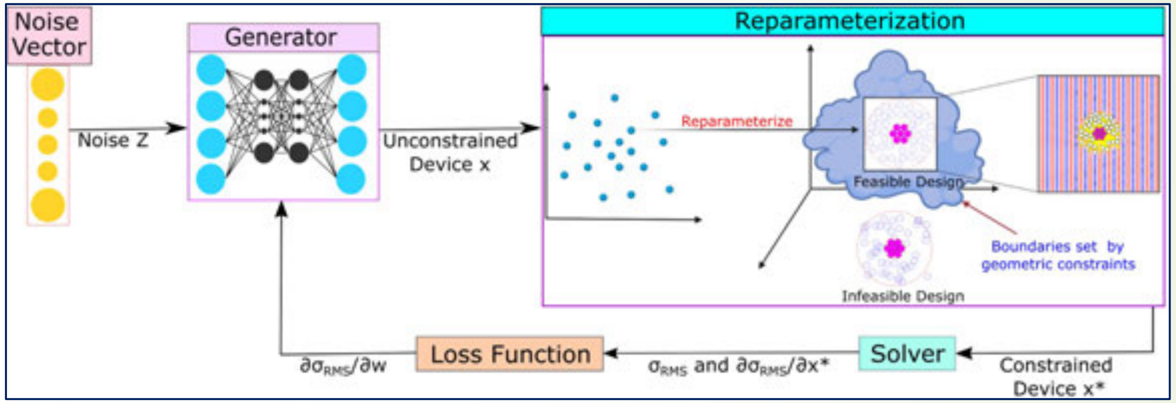
2D-GLOnets Model Based Generative Modeling and Gradients

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

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 $L(x, g_e, \sigma_{RMS})$
end

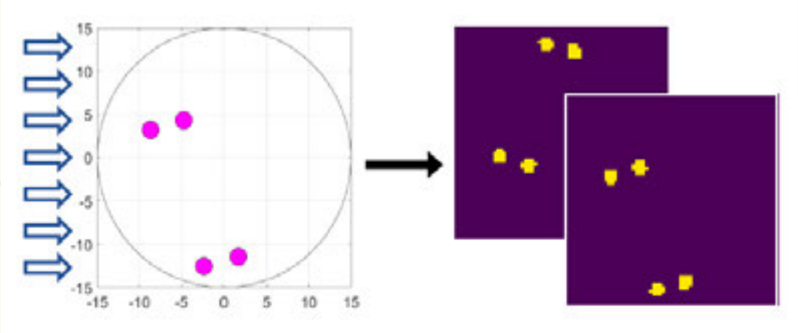
Loss Function

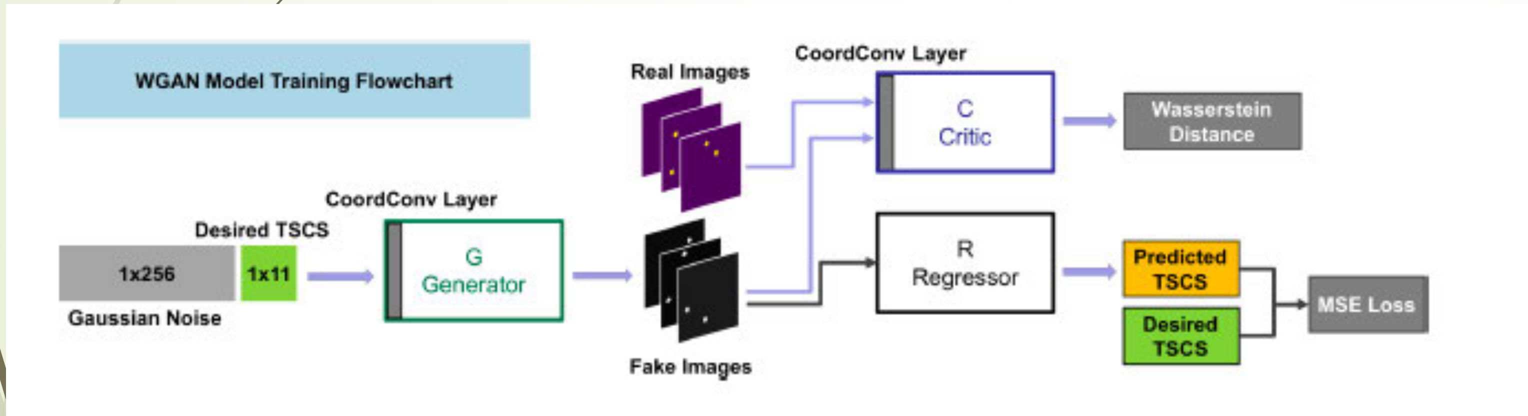
- Search and refine the optimized design space

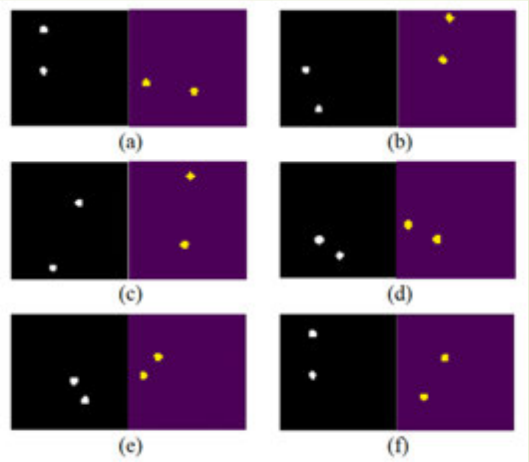
Zhuo* L., & Amirkulova, F. (2021). Design of Acoustic Cloak Using Generative Modeling and Gradient-Based Optimization. InterNoise21, Washington, D.C., USA, 263(3), 3511–3522, **2021** https://doi.org/10.3397/in-2021-2431

Our Recent Publications

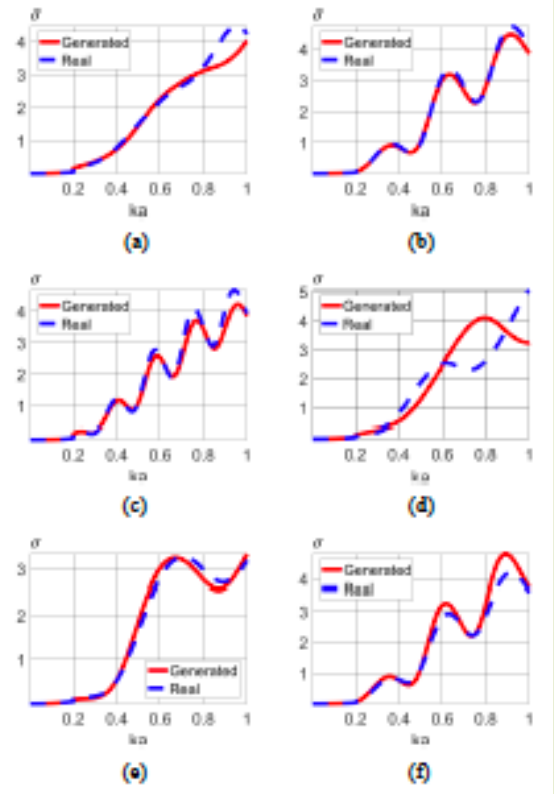
Conditional WGAN model







TSCS

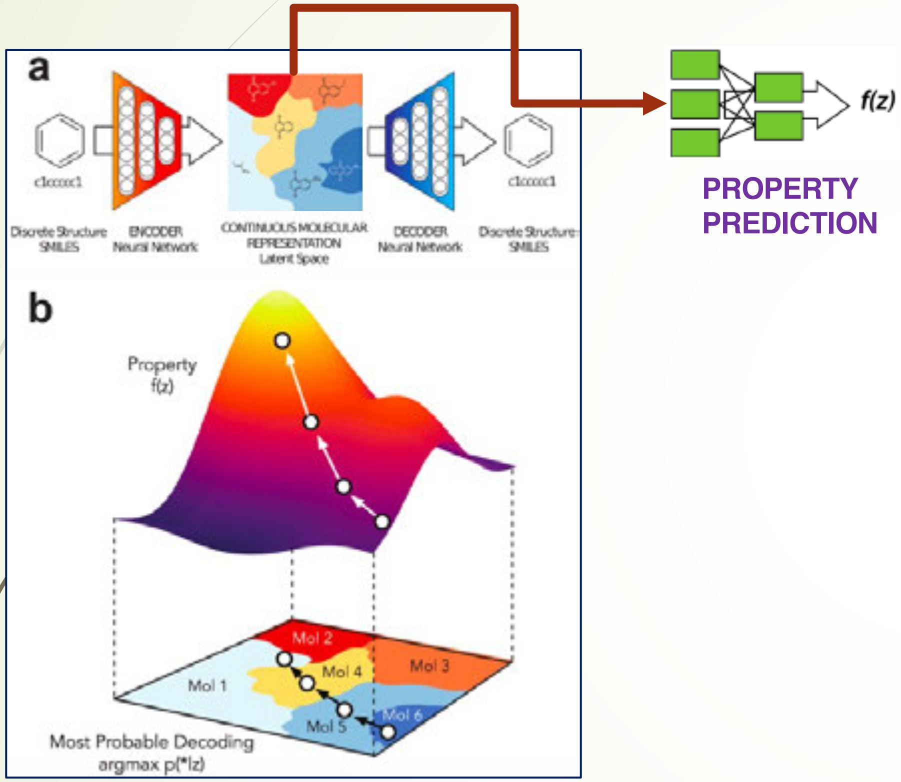


Lai* P., **Amirkulova F.**, Gerstoft P. Conditional Wasserstein Generative Adversarial Networks Applied to Acoustic Metamaterial Design. *J. Acoust. Soc. Am*, accepted 2021

feruza.amirkulova@sjsu.edu

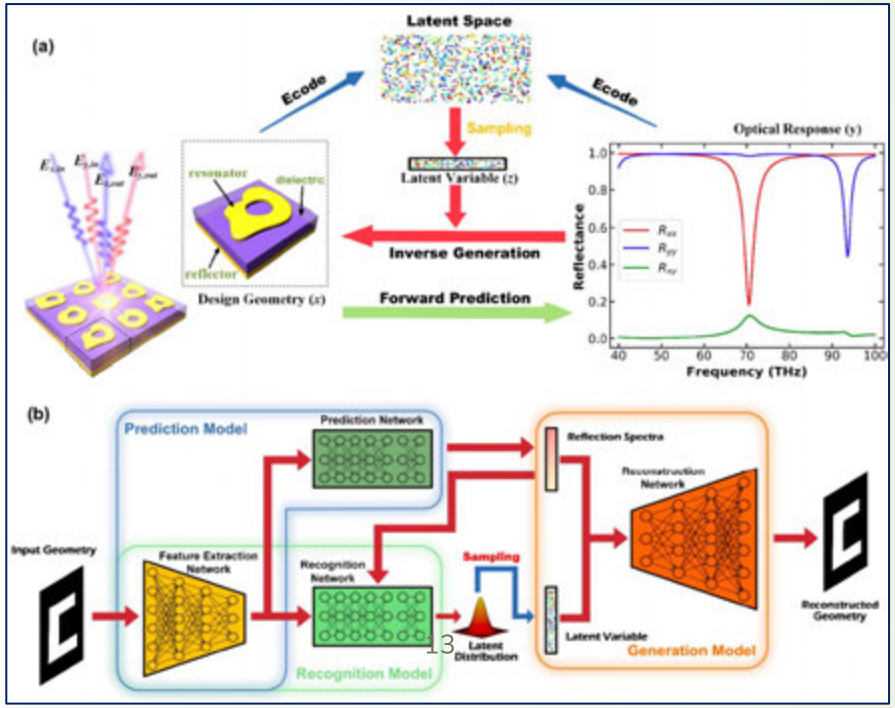
Applications of Variational Autoencoders (VAE)

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:



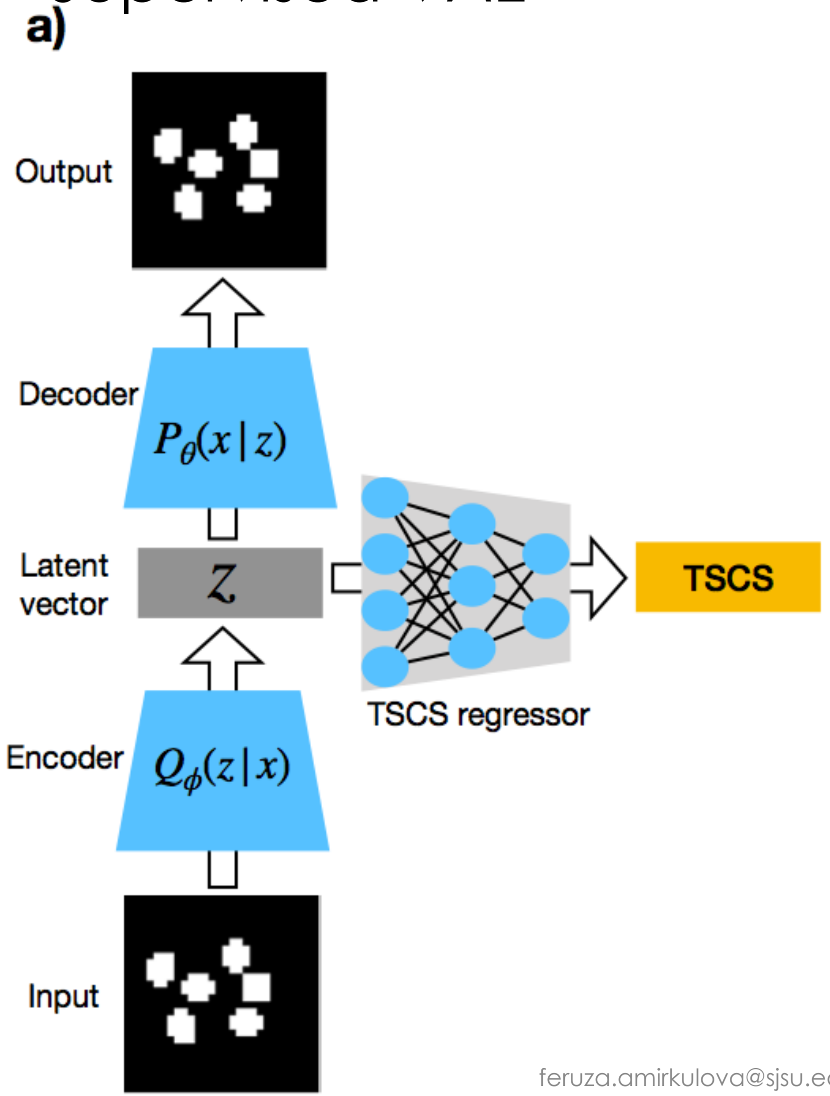
Ma et al. Adv. Mater. 2019

Application of CNN and VAE to acoustic metamaterial design:

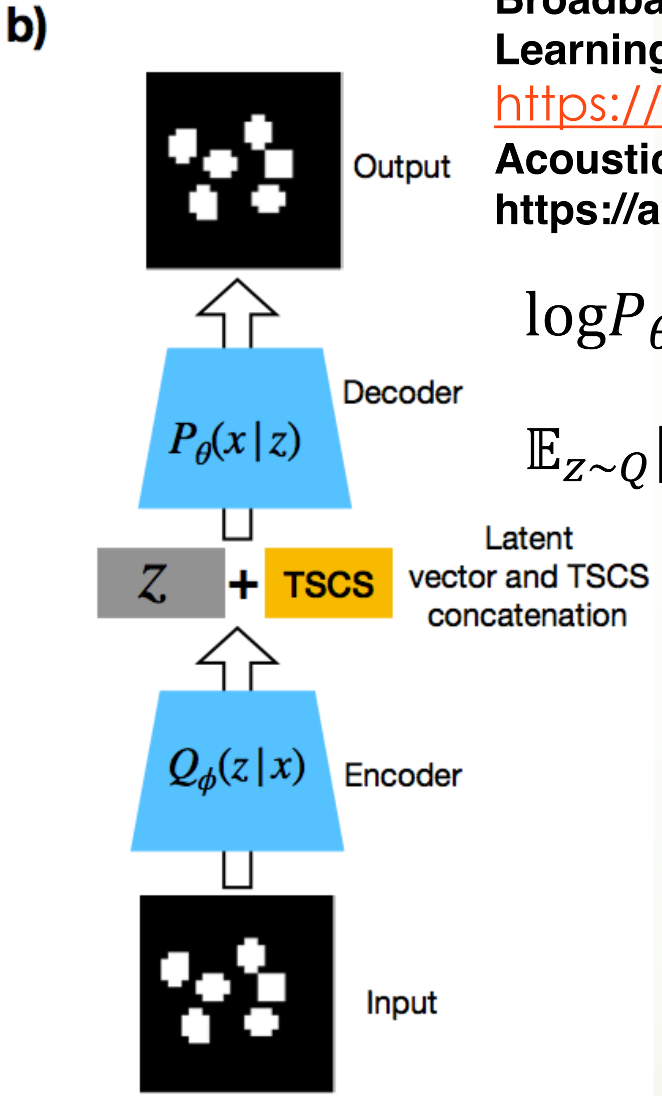
T. Tran et al. 3aSA6: Total multiple scattering cross section evaluation using convolutional neural networks for forward and inverse designs of acoustic metamaterials. ***AiF, ASA Spring Virtual Meeting, June 10 2021***

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**

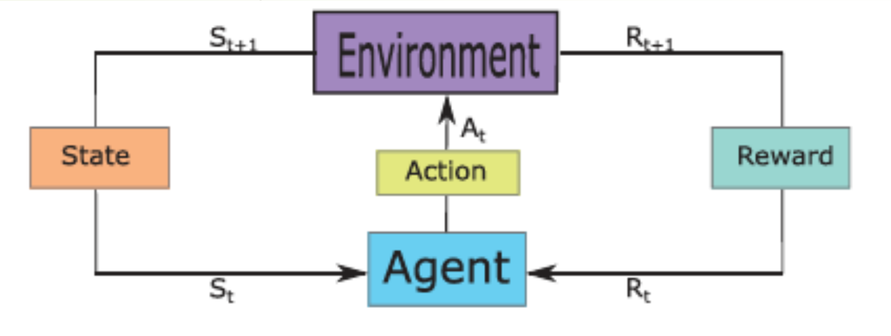
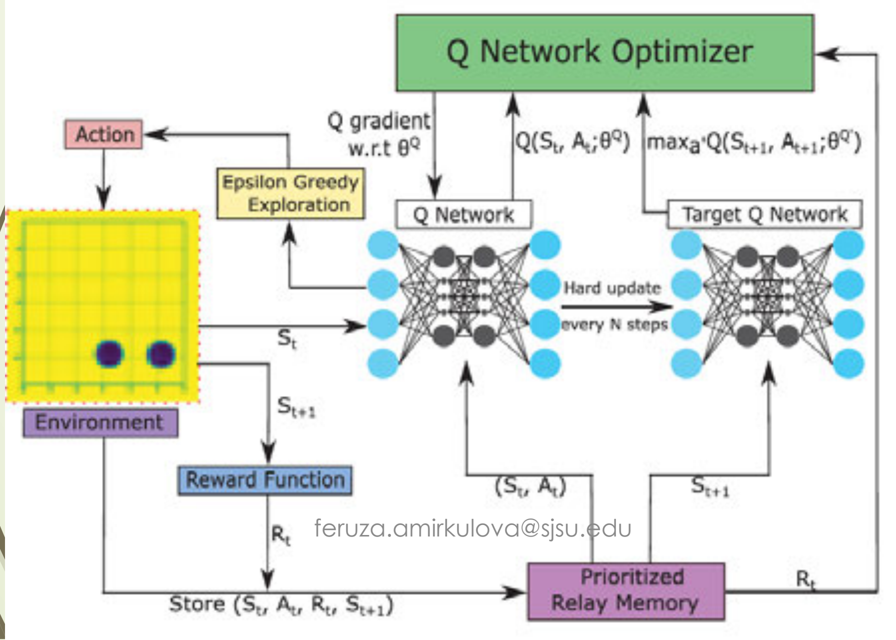
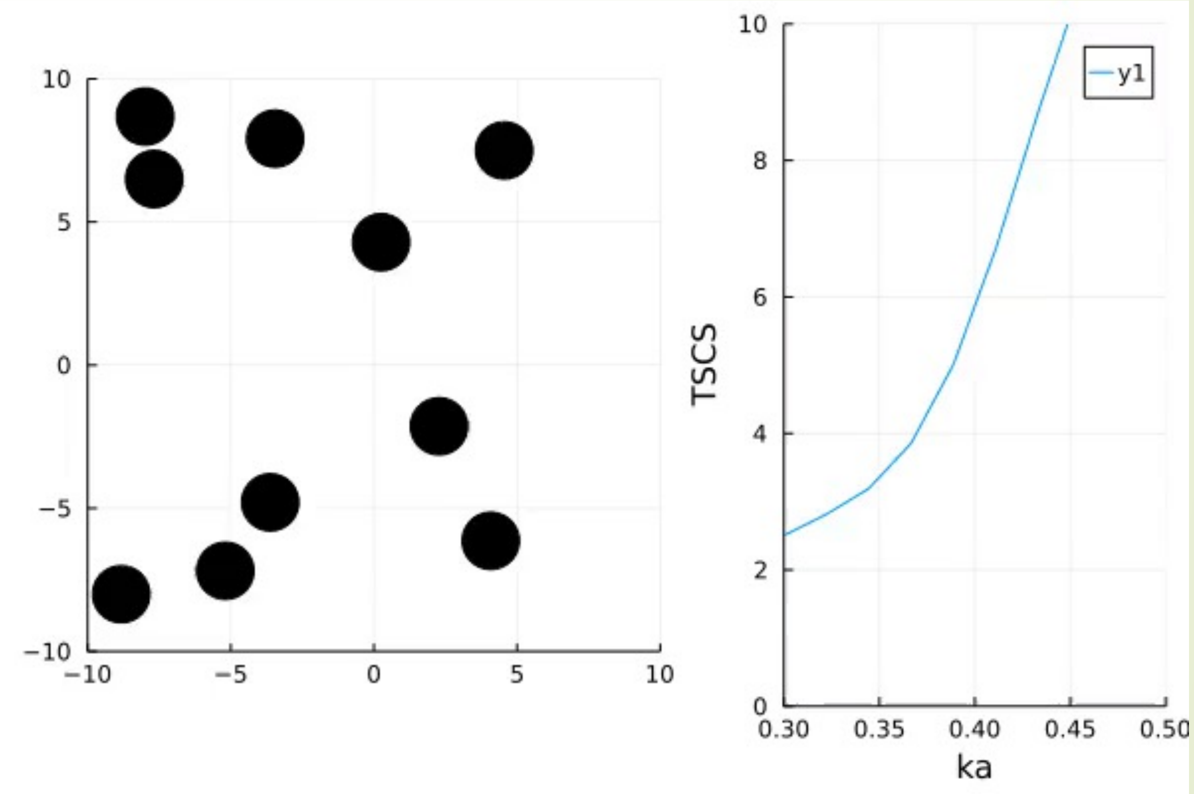


FIG. 1. (Color online) Agent interacting with environment in a MDP.



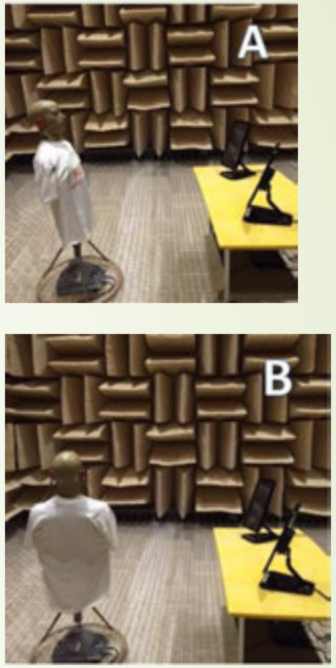


feruza.amirkulova@sjsu.edu

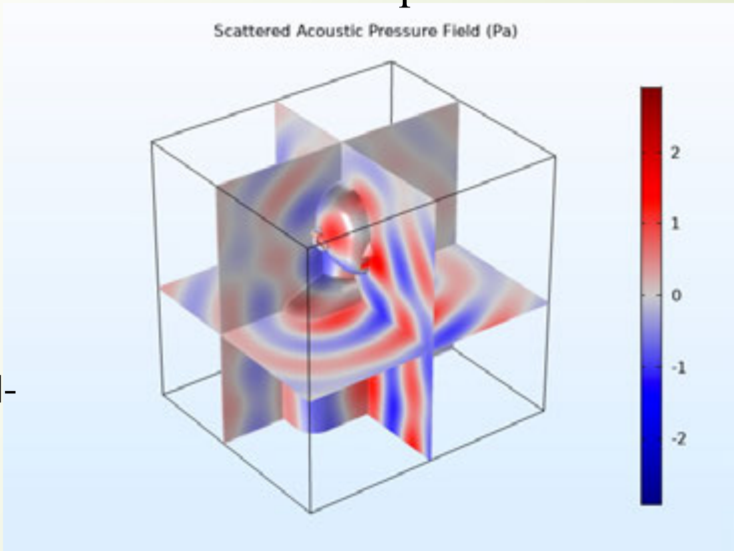
Investigation of human directional hearing in a semi-anechoic environment

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

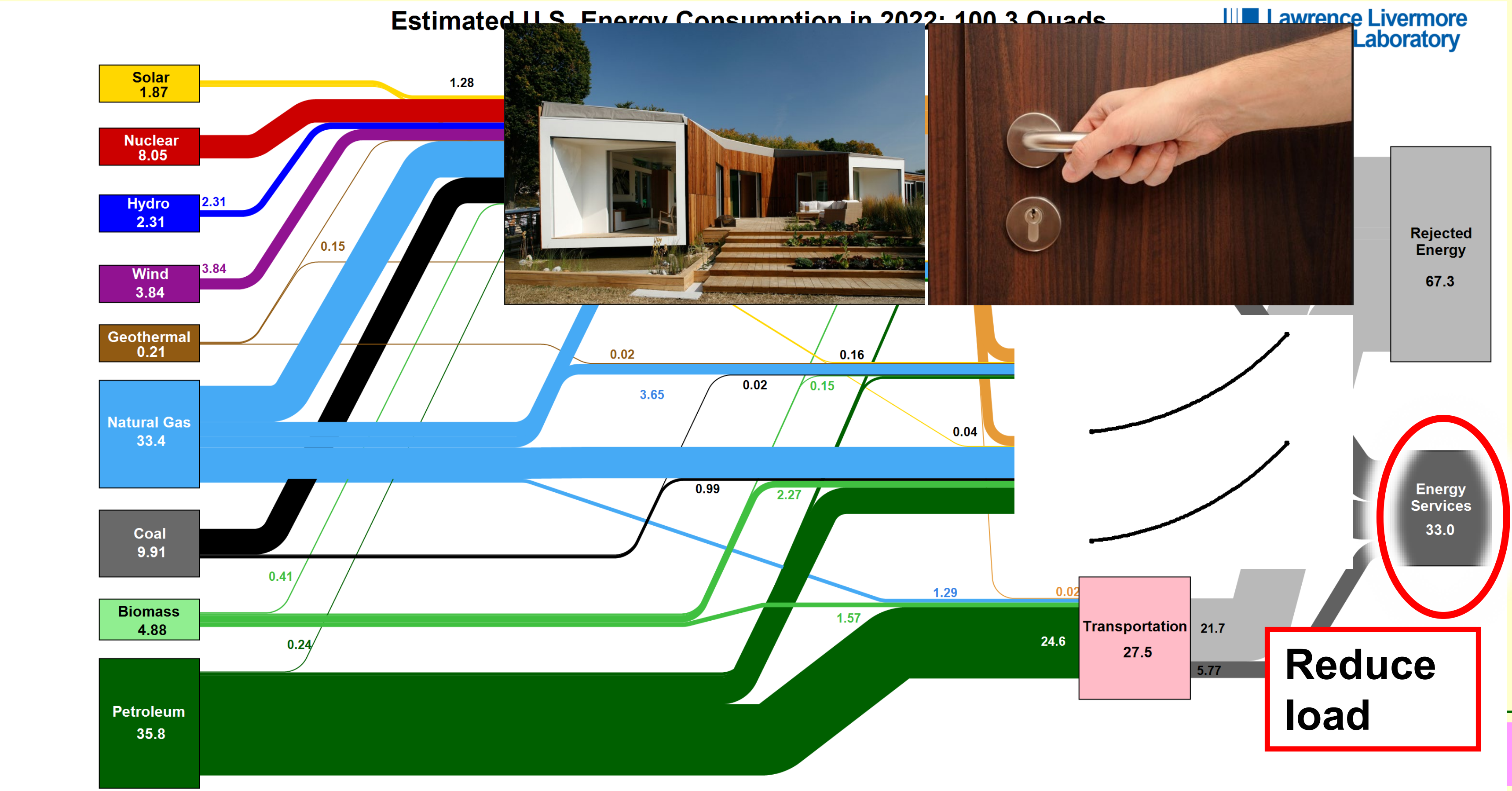


A mannequin test

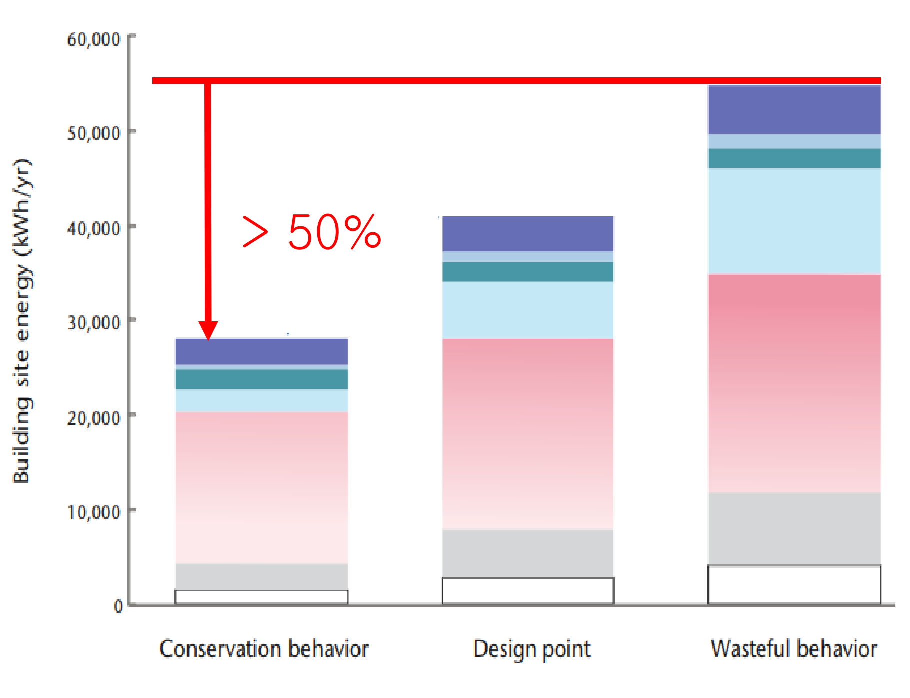


References:
1. Gary Dagastine. On the Cutting Edge of Hearing Aid Research. COMSOL News 2017. https://spectrum.ieee.org/consumer-electronics/audiovideo/on-the-cutting-edge-of-hearing-aid-research
2. https://www.comsol.com/blogs/analyzing-the-acoustics-of-a-head-and-torso-simulator/

End Usage Reduction

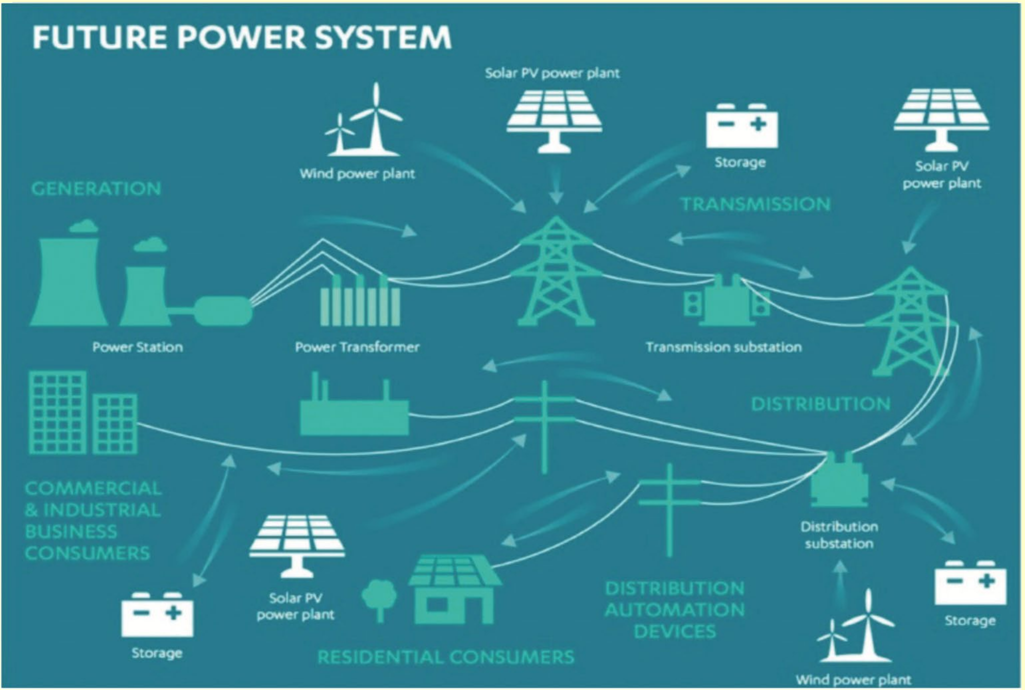


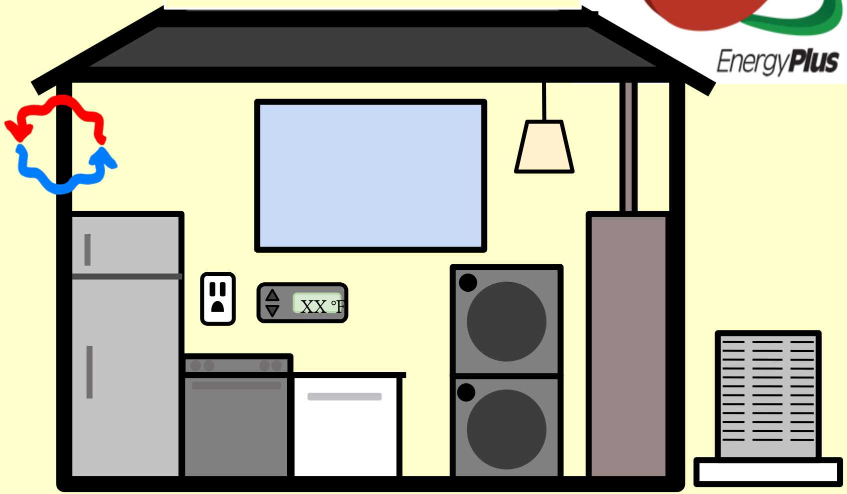
Engage People into Energy Saving Practices



Nguyen, T. A., and Aiello, M., 2013, "Energy intelligent buildings based on user activity: A survey," Energy and Buildings, 56

Equitable Power Distribution

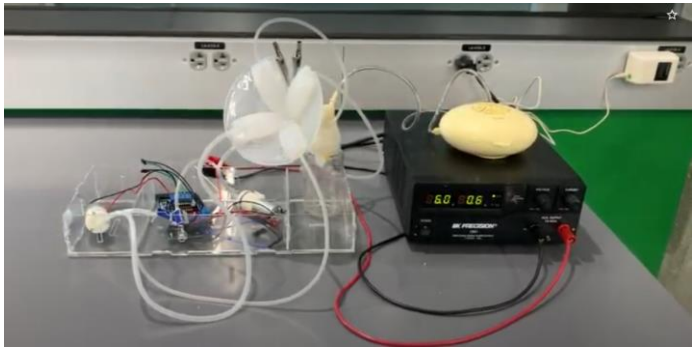
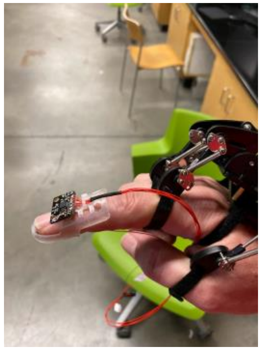


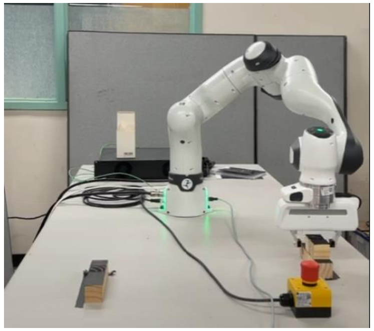


Skills/Benefits

- Skills
  - Large data analysis ; Energy/Heat Transfer; Model Predictive Control; Sensor & Actuation; Data Collection; Material Selection; Data Presentation
  - Building simulation tools (EnergyPlus); Co-simulation platform
  - Python; C; Matlab; LabView
- Benefits
  - Collaborative research environment: exposure with machine learning; AI; game theory
  - Professional conference presentation or journal articles
  - Federal funded research experience

Biomechanics and Robotics Lab



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

Biomechanics and Robotics

Medical Device

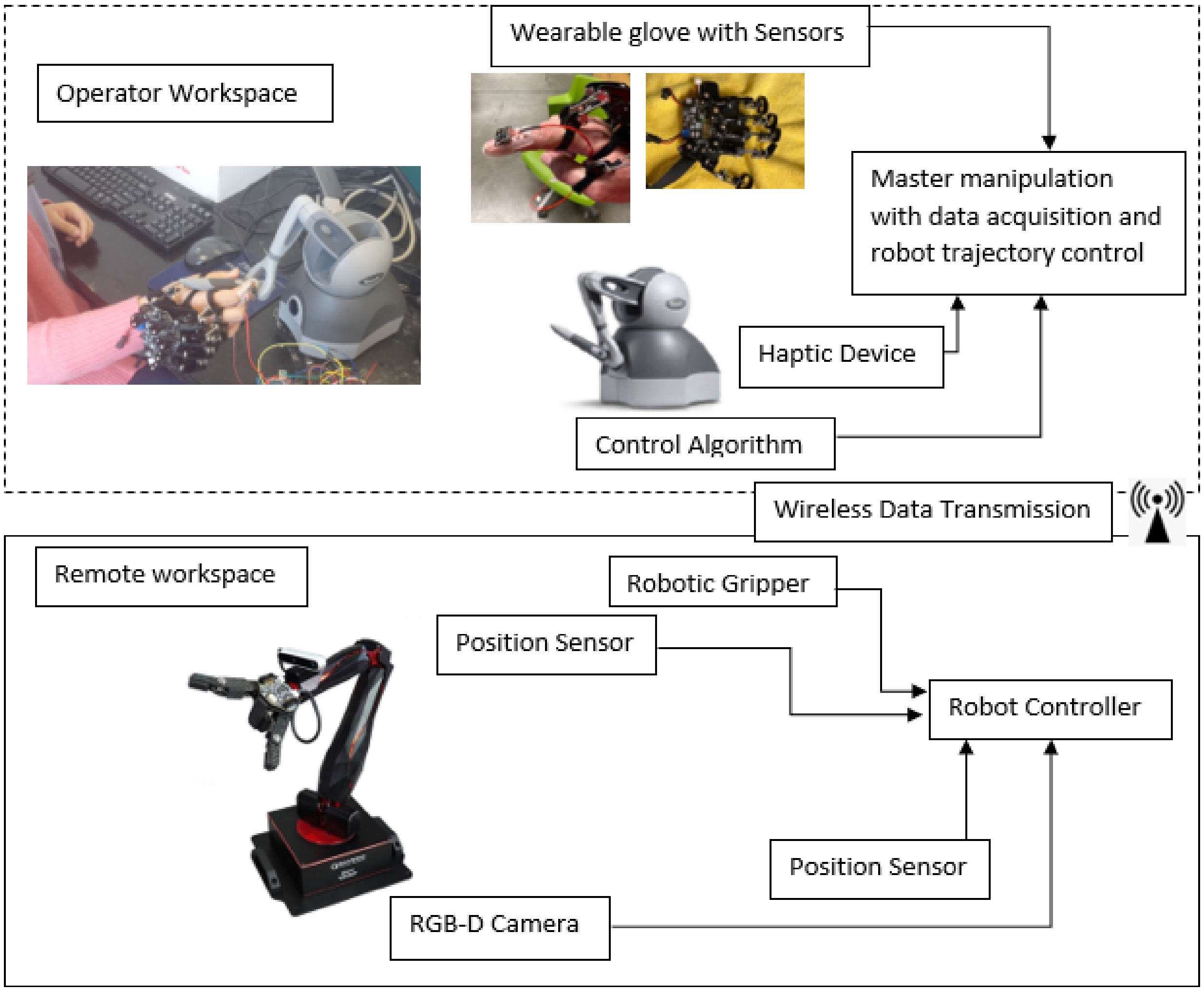
- Non-invasive assessment systems
- Medical Simulator
- Medical Devices for Maternal and Child Health
- Tissue-mimicking materials

Human-Robot Interaction, Human-Robot Collaboration

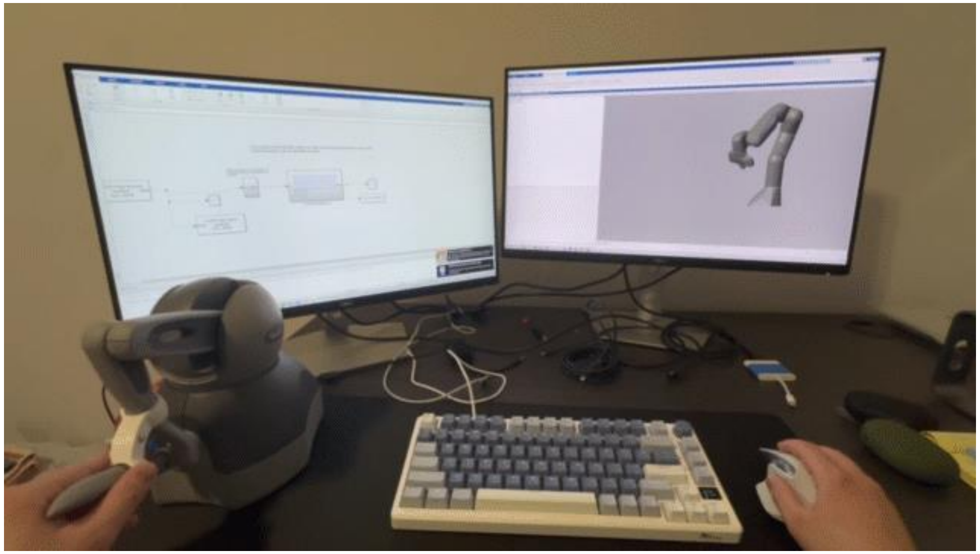
- Digital Twin platform for HRI
- Automation and Intelligence Control (AI in robot control)
- Multi-robot communication and co-adaptation
- Mixed Reality HRI

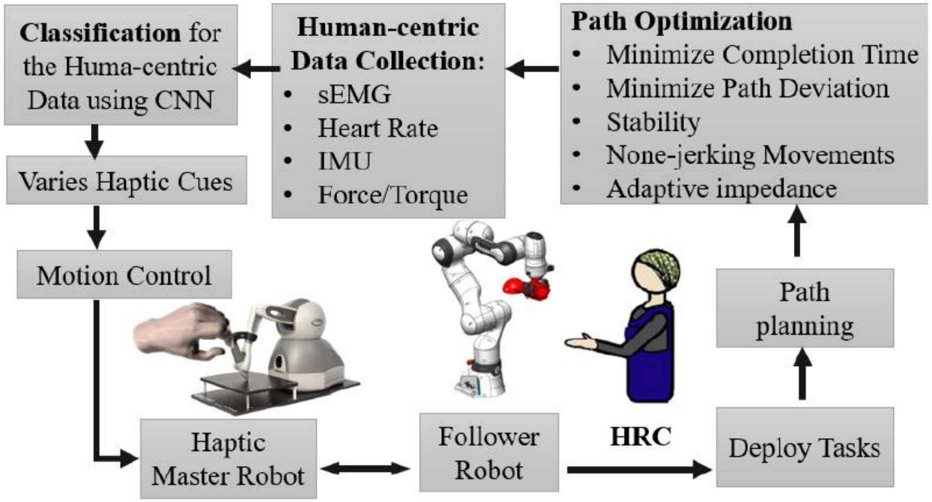
Available Projects

Bilateral Human Robot Interaction for Telemanipulation



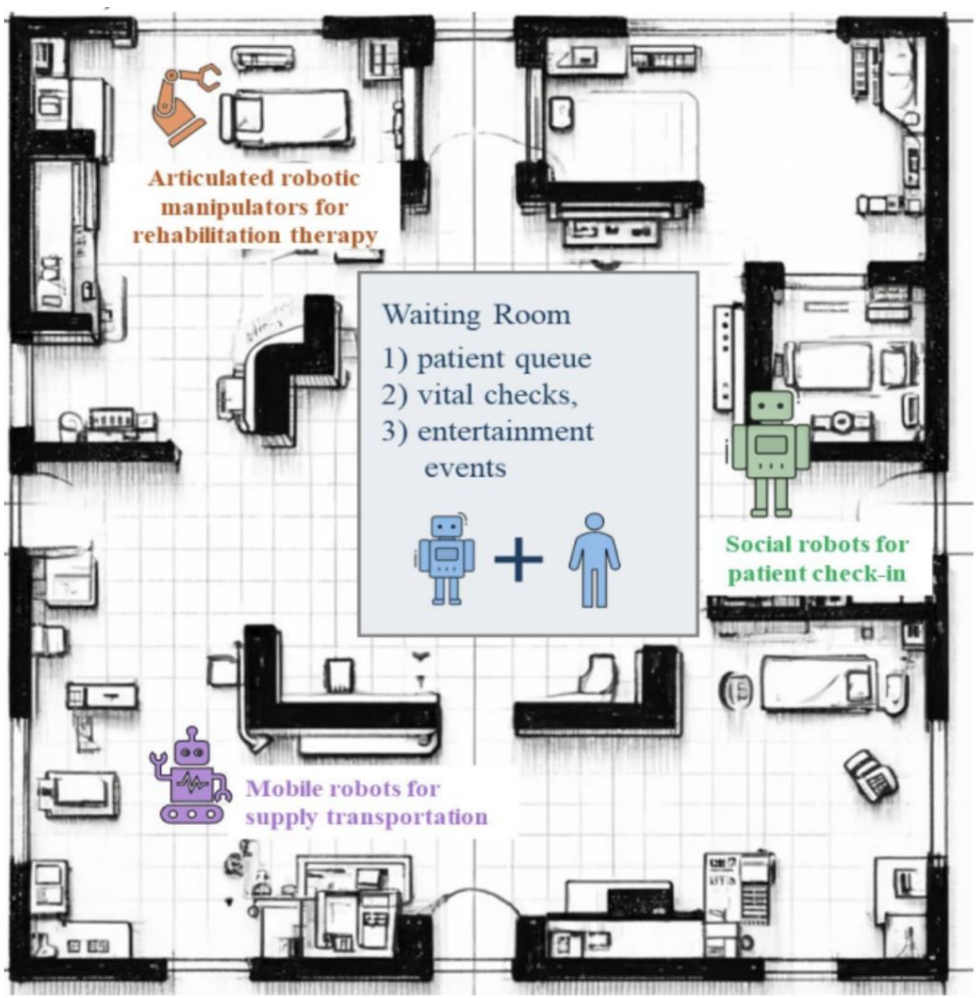
Robot Assist Rehabilitation

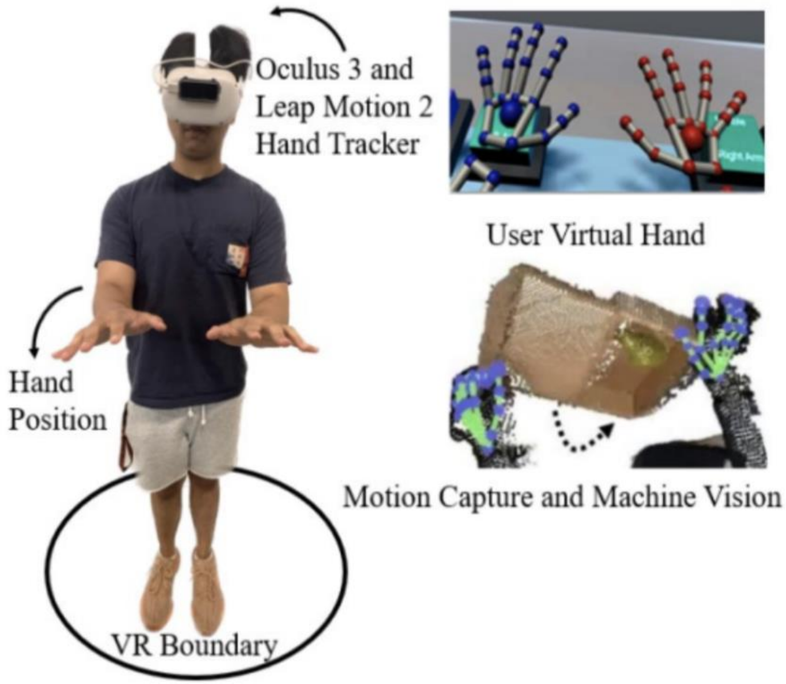




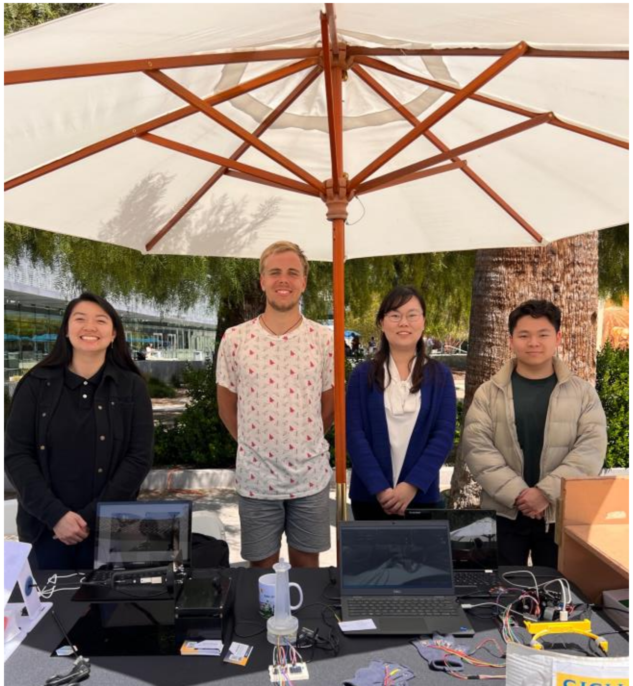
lin.jiang@sjsu.edu

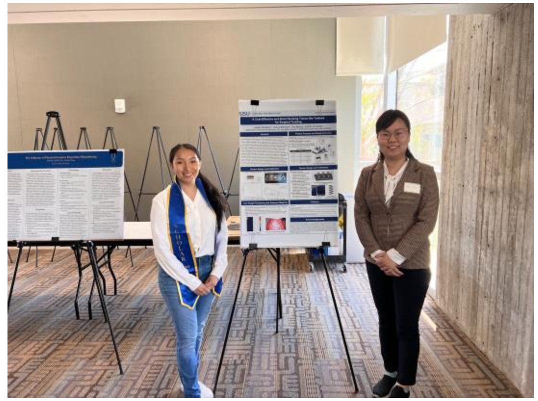
Mixed Reality Human-Robot Interaction

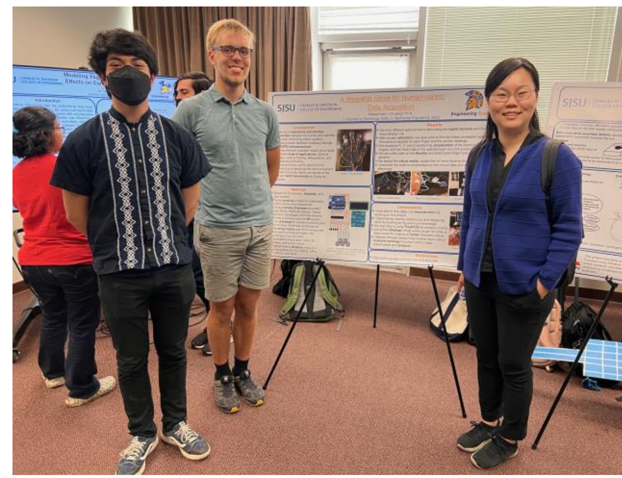


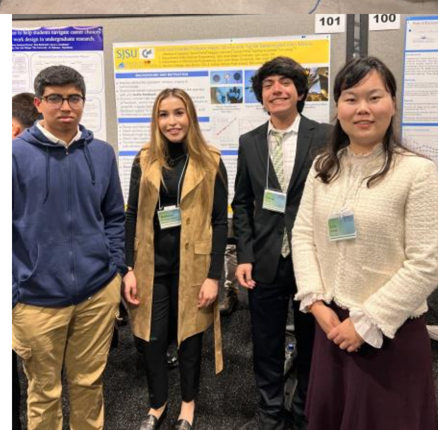


lin.jiang@sjsu.edu









Thank you!

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

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

RSCA IN 5

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

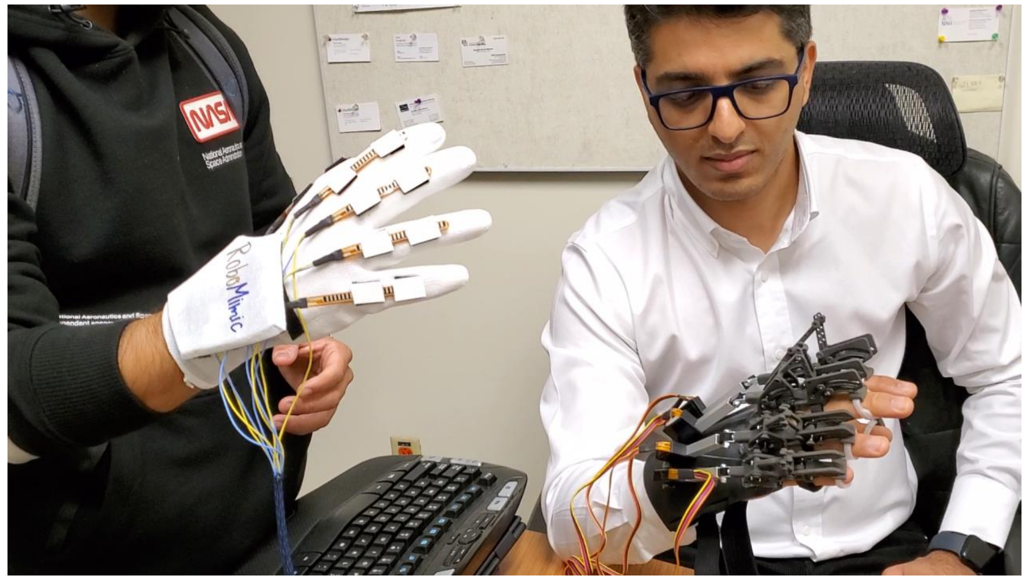
ARMS LAB
Assistive Robotics and Medical Systems Lab

SJSU

ARMS Lab Products

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

Most Innovative Project at CoE Showcase 2024



Most Engaging Project at CoE Showcase 2023

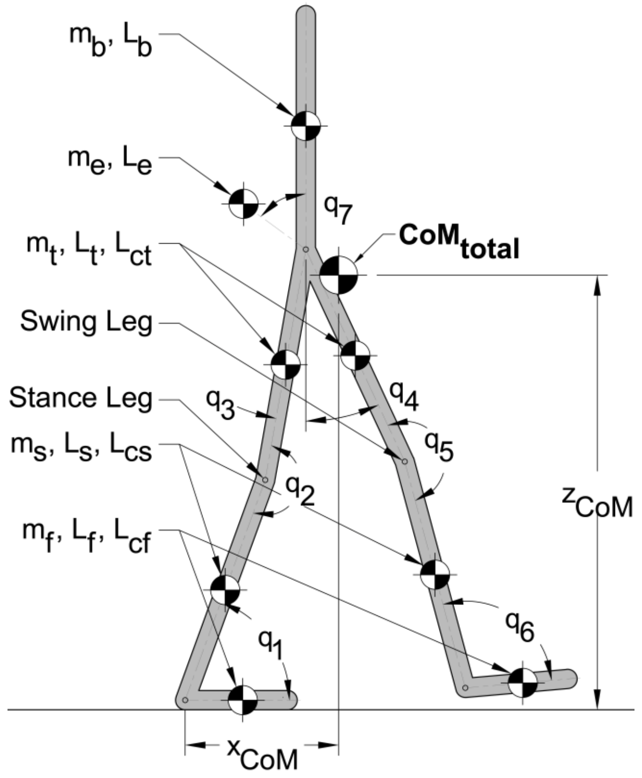
Lower limb exoskeletons

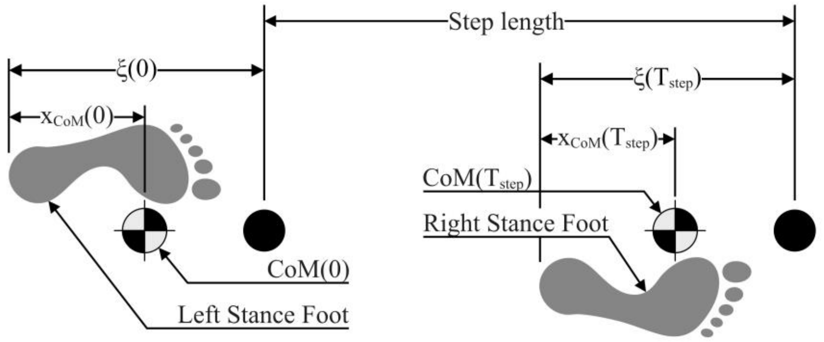
Upper limb exoskeletons

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**





ARMS LAB
Assistive Robotics and Medical Systems Lab
SJSU

RSCA IN 5

ARMS LAB
Assistive Robotics and Medical Systems Lab

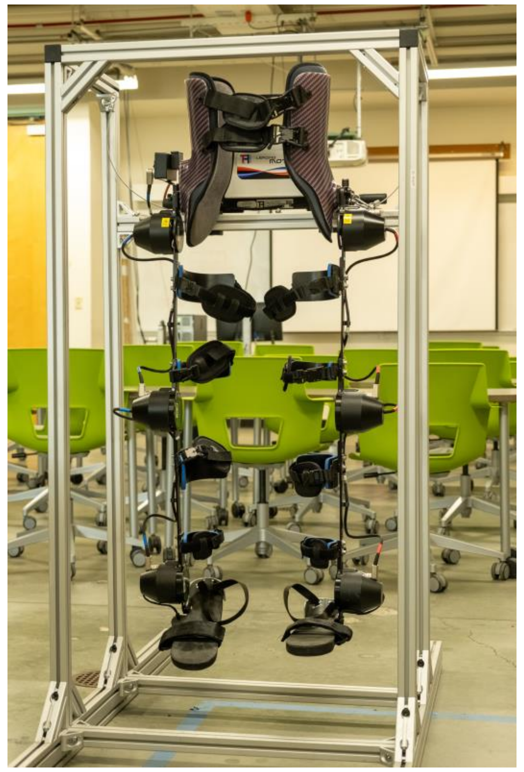
SJSU

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



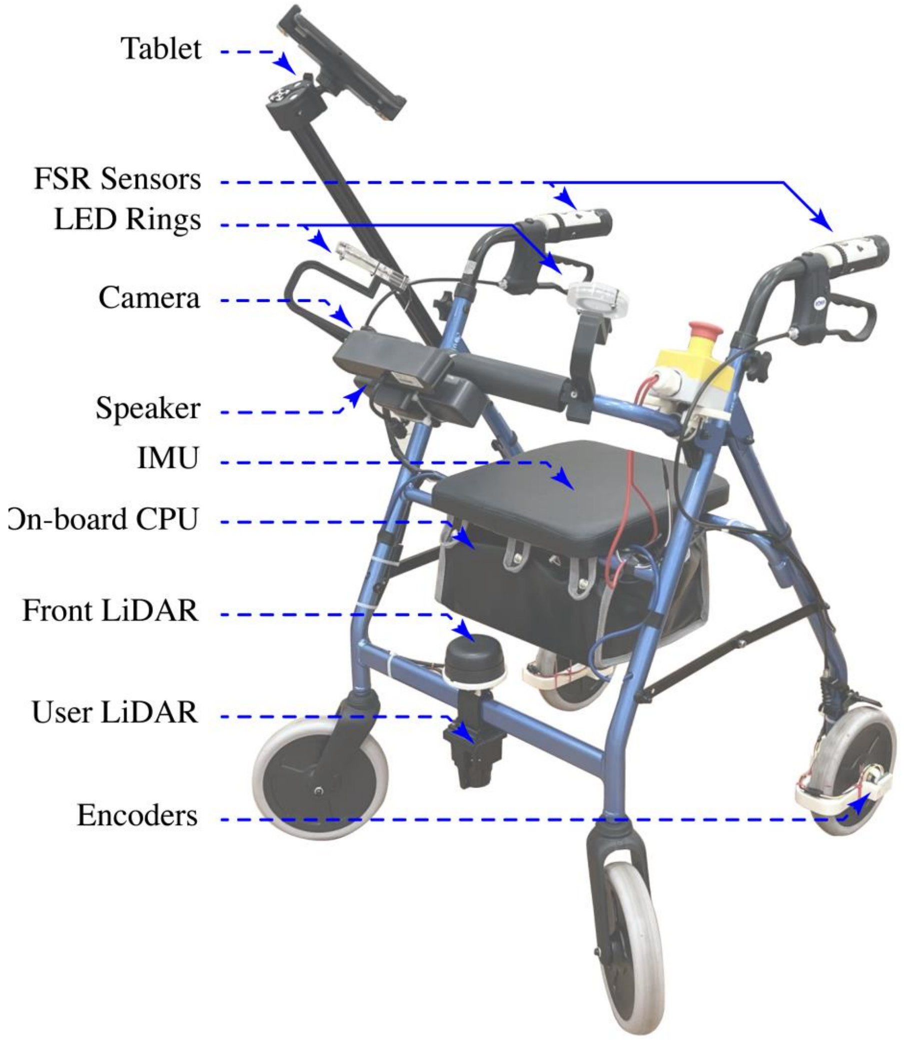
RSCA IN 5

ARMS LAB
Assistive Robotics and Medical Systems Lab

SJSU

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

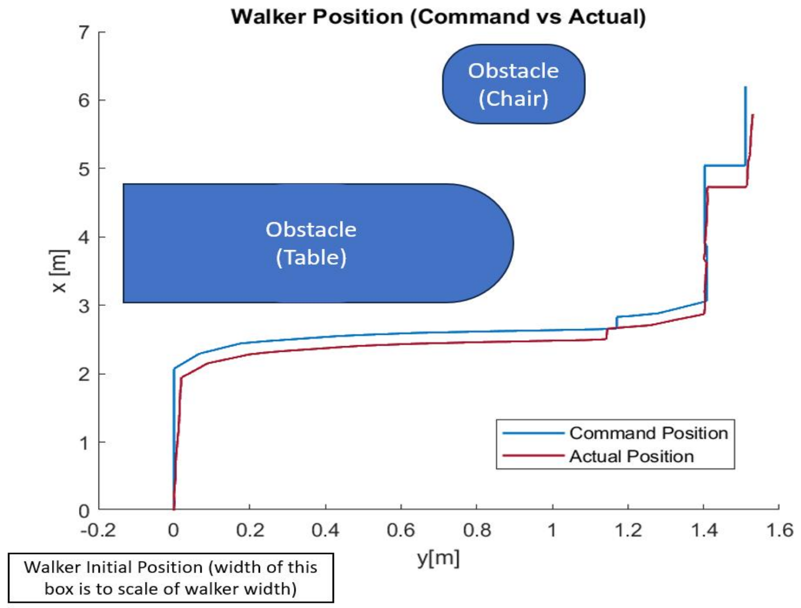


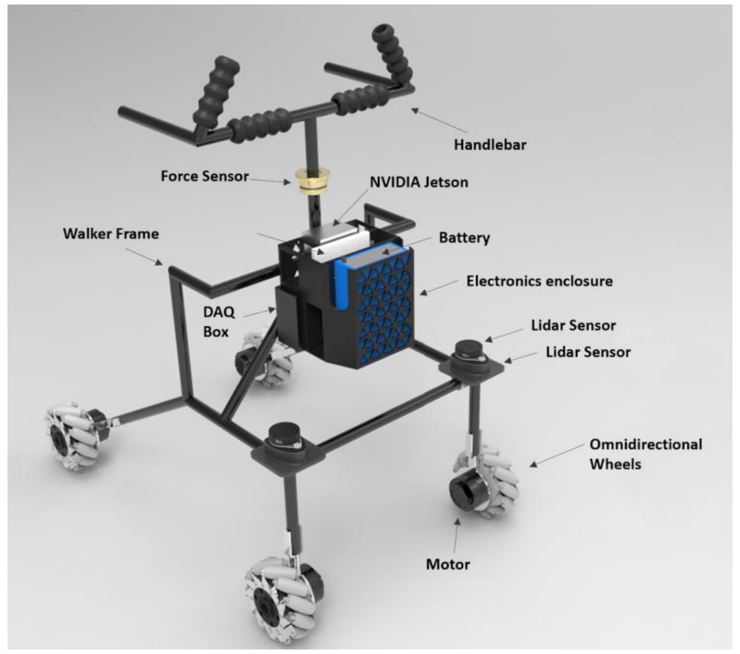
RSCA IN 5

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



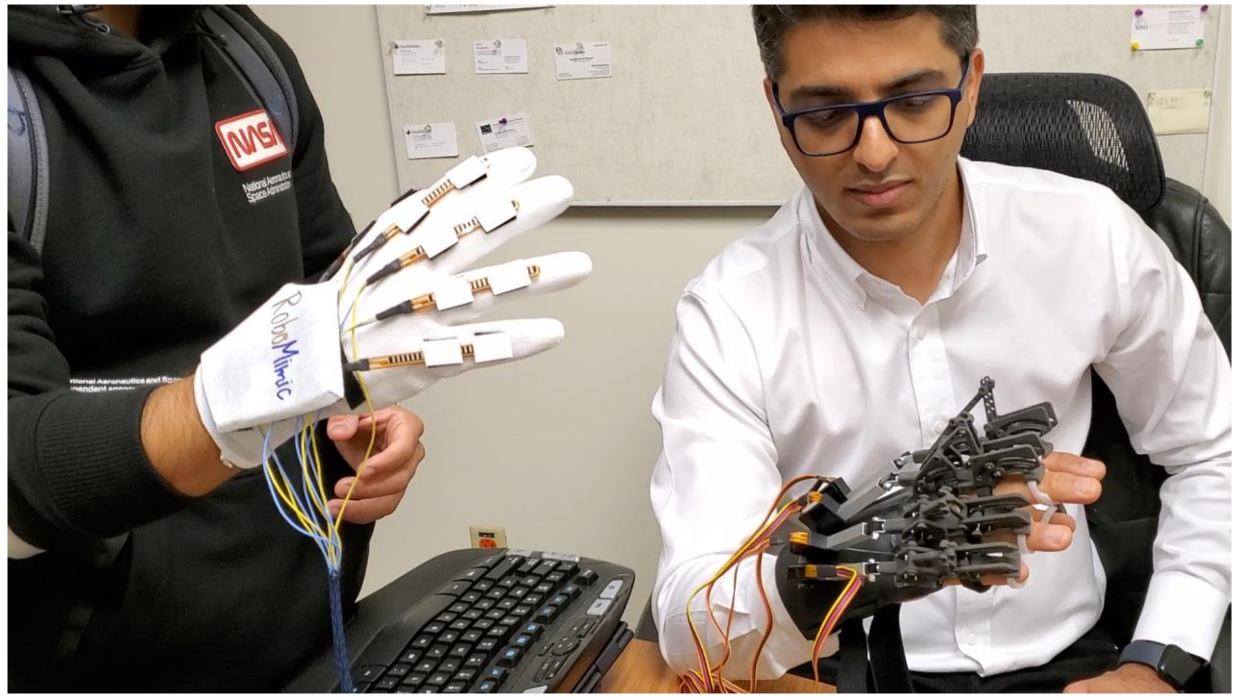


ARMS LAB
Assistive Robotics and Medical Systems Lab
SJSU

RSCA IN 5

Research Projects 5
Mechatronics and Control

- **Modification and control of wearable robotic systems**
  - Add sensors, soft parts, and mechatronic system
  - Implement motion controllers for DC motors
  - Prepare the prototype for user studies



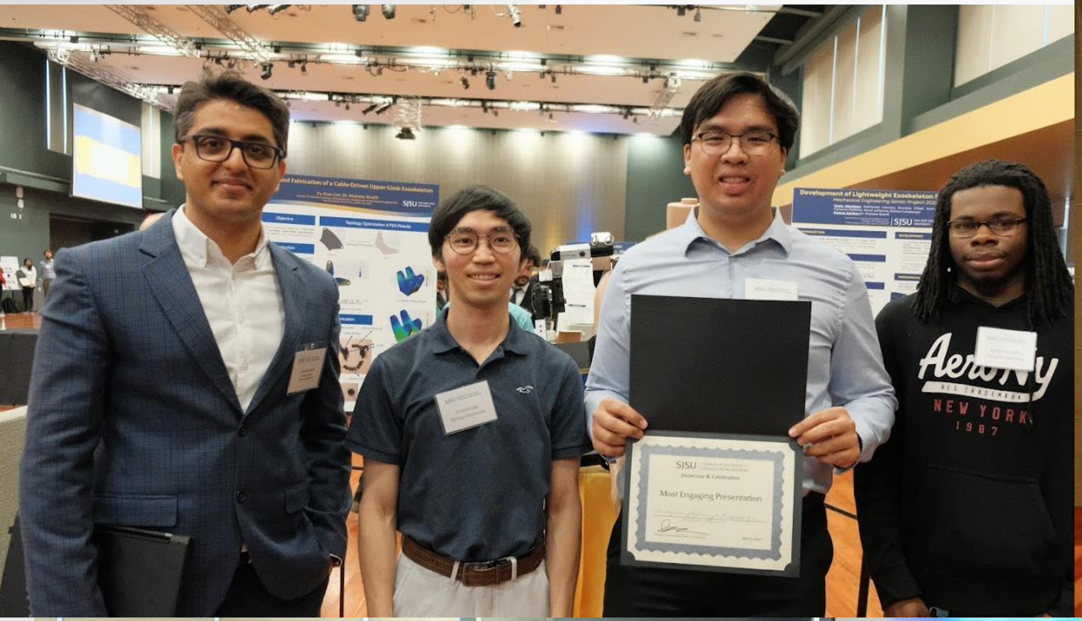
Hand exoskeleton

Upper limb exoskeleton

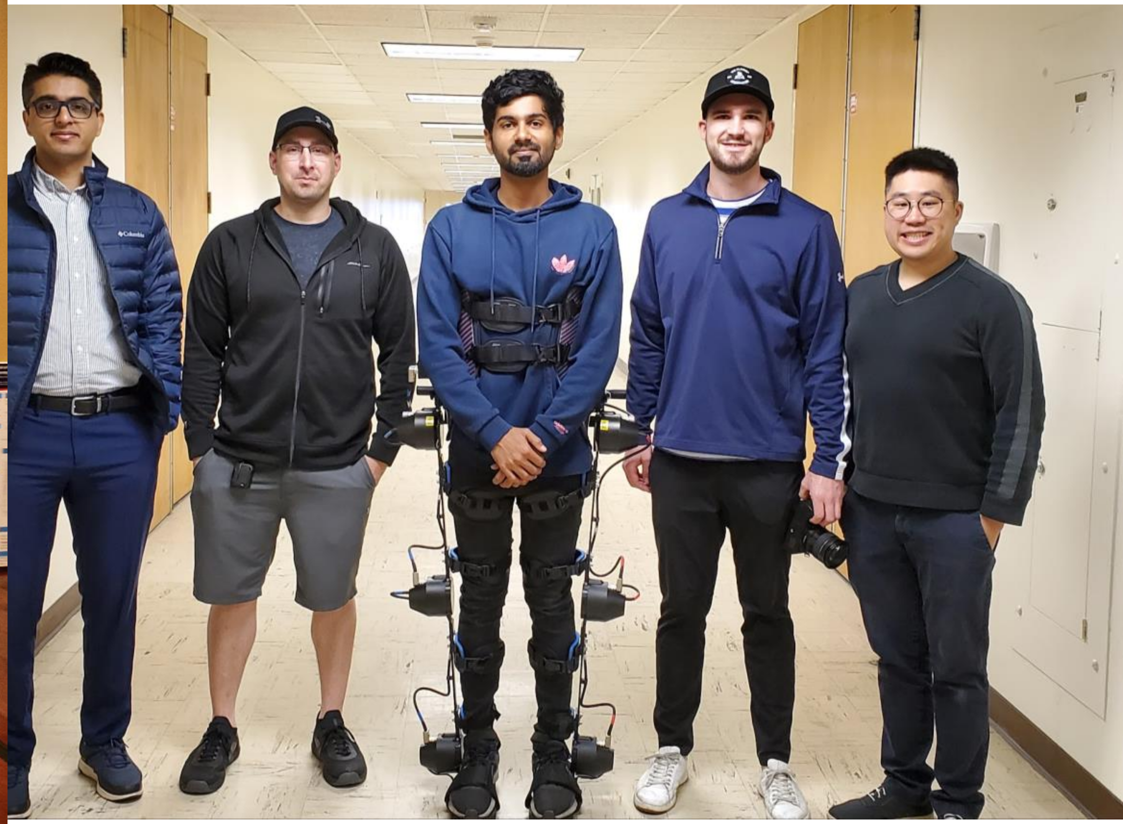
Lower limb exoskeleton

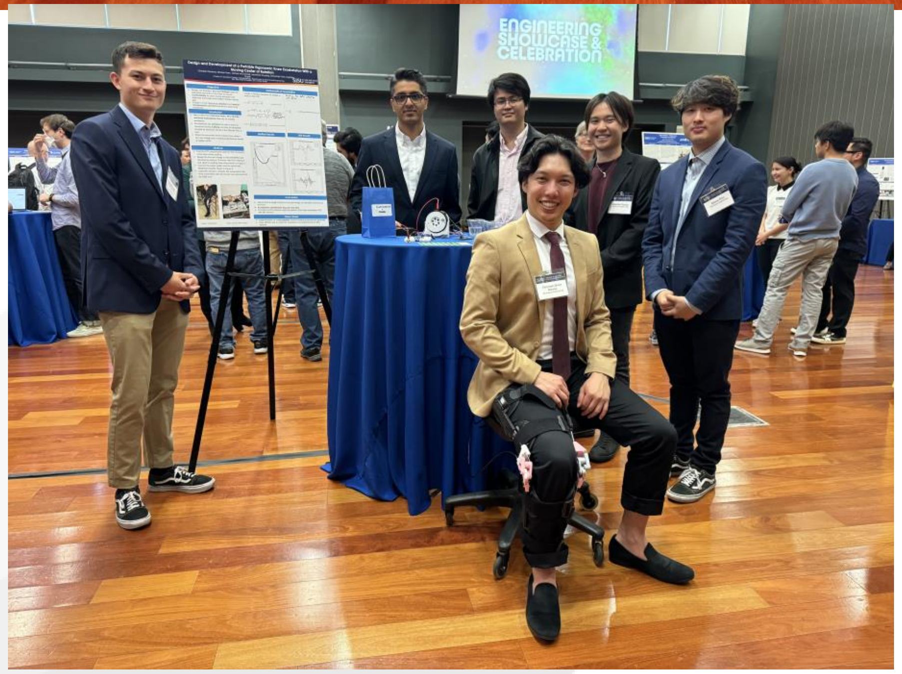
ARMS LAB
Assistive Robotics and Medical Systems Lab
SJSU

ARMS LAB
Assistive Robotics and Medical Systems Lab



ARMS LAB
Assistive Robotics and Medical Systems Lab





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

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

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

Available Projects for Spring 2025

Dr. Vimal Viswanathan
Associate Professor
Mechanical Engineering

IDEA Lab
Innovations in Design Engineering & Analyses

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 (ongoing projects)
The Spartan Hyperloop (ongoing projects)

IDEA Lab
Innovations in Design Engineering & Analyses

Available Project 1: 3D printing with bio-degradable natural fibers

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

Collaborators:

Dr. Supradip Das, Indian Institute of Technology, Guwahati

IDEA LAB
Innovations in Design Engineering & Analyses

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

Mahammad Khalid Shaik Vadla [1], Mahima Agumbe Suresh [2] and Vimal K. Viswanathan [1,*]

[1] Mechanical Engineering Department, San Jose State University, San Jose, CA 95192, USA; khalidvadla@gmail.com
[2] Computer Engineering Department, San Jose State University, San Jose, CA 95192, USA; mahima.agumbesuresh@sjsu.edu
* Correspondence: vimal.viswanathan@sjsu.edu; Tel.: +1-(408)-924-3841

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; cu

check for updates

Citation: Shaik Vadla, M.K.; Suresh, M.A.; Viswanathan, V.K. Enhancing Product Design through AI-Driven Sentiment Analysis of Amazon Reviews Using BERT. *Algorithms* 2024

IDEA LAB
Innovations in Design Engineering & Analyses

My contact information

- vimal.viswanathan@sjsu.edu

ME295A/B – Available MS Projects

Winncy Du

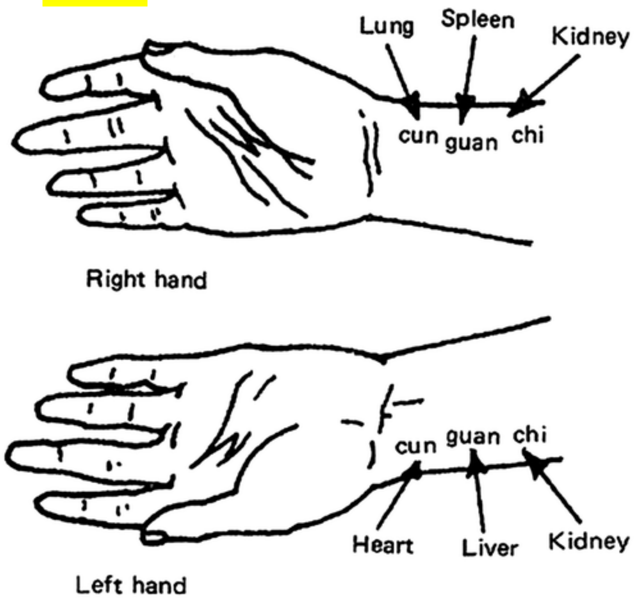
Vista Robotics' Spine Surgical Projects

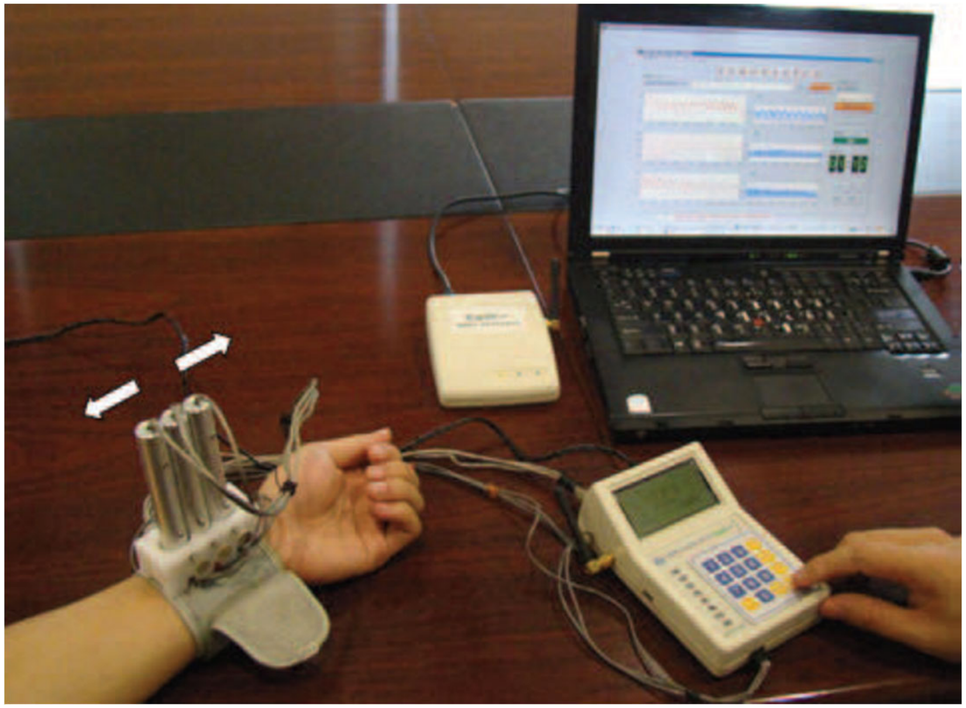
Presented by Vista Robotics

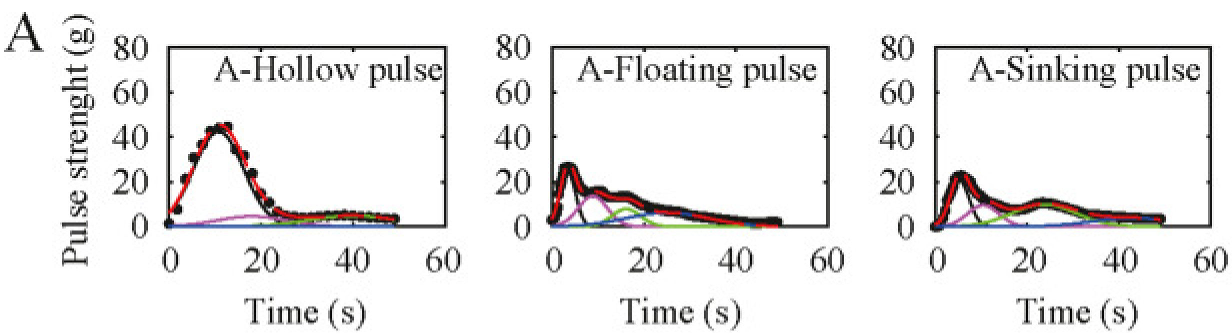
Remote Control of an Industry Robot for Robotic Education

- 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

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

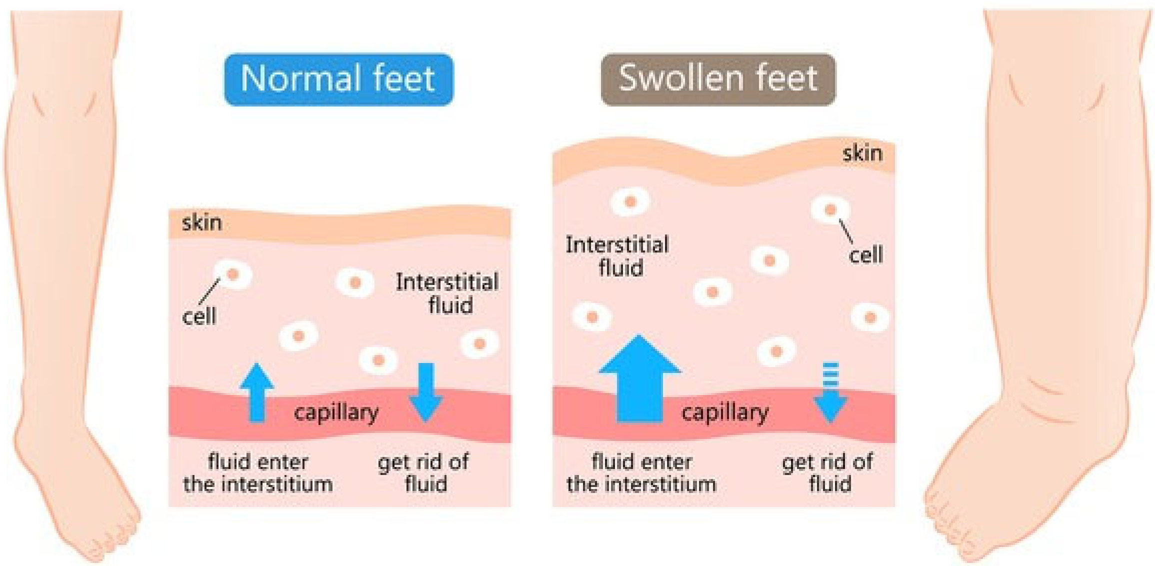






Water Retention Associated with Cardiovascular Mortality

- **Establish the relationship between fluid retention Associated with Cardiovascular**
- **Identify a typical problem and underneath mechanism**



SJSU SAN JOSÉ STATE UNIVERSITY

MSME Research Projects

for Fall 2024

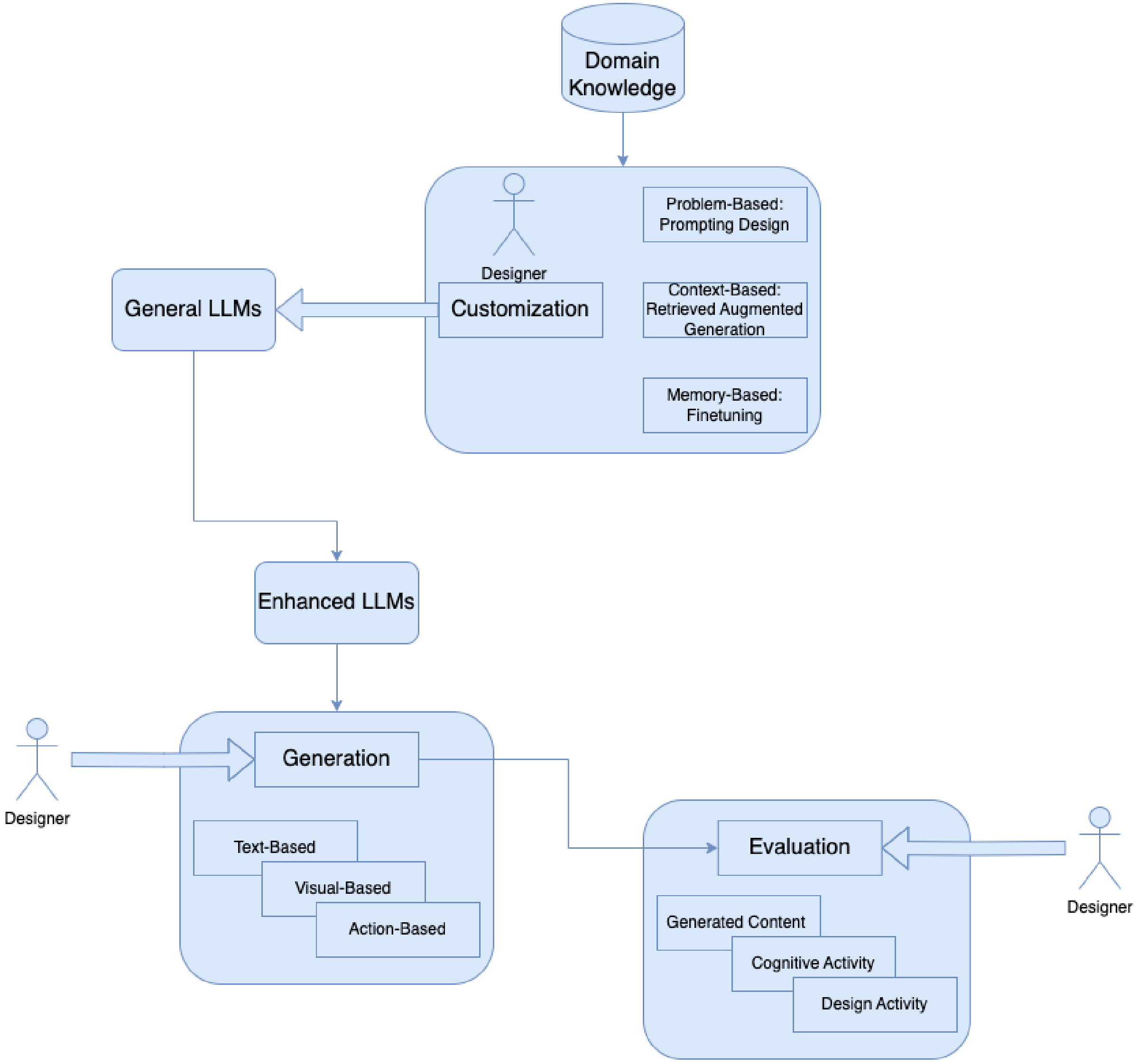
Yunjian (Jojo) Qiu

Yunjian.qiu@sjsu.edu

Assistant Professor, Department of Mechanical Engineering

San Jose State University

Motivation



- The engineering design domain relies on past experience and domain knowledge.

- How can we customize AI tools with human knowledge to enhance different activities, such as solution generation?

Project 1: Explore Customization Methods with Domain Knowledge Infusion

- **Customization**
  - Integrating human knowledge into general LLMs
  - Types:
    - Prompt;
    - Retrieved-Augmented Generation (RAG);
    - Finetuning

- **Research Questions**
  - *How can knowledge be organized into input instructions?*
  - *How can the intentions of designers be effectively represented?*

- **Tool**
  - GPT-4 Large Language Model
  - Python Programming
  - Design Knowledge, including conceptual design and detailed design

Project 2: Solution Generation for Optimizing Robot Design

- **Generation**
  - Types: Text; Image; Action.
  - More like a case-by-case generation.

- **Research Questions**
  - *How can a desired design solution be generated?*
  - *How can AI be used as a collaborator and guidance to help engineers explore the solutions?*

- **Tool**
  - GPT-4 Large Language Model
  - Python Programming
  - Design Knowledge, including using Solidworks, etc.
  - Mechanics

Exoskeleton example from Dr. Mojtaba Sharifi's Lab

SJSU SAN JOSÉ STATE UNIVERSITY

Thank you!

Yunjian (Jojo) Qiu

Email: yunjian.qiu@sjsu.edu

Phone: 408-924-3504

ME295A/B Project
Sponsored faculty: Dr. Raymond K. Yee
Email: raymond.yee@sjsu.edu

Background: The number of Americans ages 65 and older is projected to nearly double from 52 million in 2018 to 95 million by 2060. The same age group among the total population will rise from 16 percent to 23 percent [U.S. Census Bureau, Population Projections]. This age group (the baby boom generation) could have a more than 50 percent increase in the number of Americans requiring nursing home care, from 1.2 million in 2017 to about 1.9 million by 2030 [Data from the U.S. Census Bureau, American Community Survey and Population Projections]. Demand for elderly care will also be driven by a steep rise in the number of Americans living with Alzheimer's disease, which could more than double by 2050 to 13.8 million, from 5.8 million at present [Alzheimer's Association, 2019 Alzheimer's Disease Facts and Figures]. Population aging will stretch resources in communities, healthcare systems, and aged care providers.

This **research project** explores the development of an interdisciplinary Geriatric Healthcare Engineering/Technology that can be used to help older people. Robotics integrated with A.I. technology (aka assistive technology) could be helpful in better supporting older adults and freeing up healthcare resources to handle the current traditional services. The study aims to identify what curriculum should be developed to equip a new generation of engineers with the knowledge and skills to design and manufacture intelligent healthcare robotics systems/devices for industries serving senior populations. The process may begin with exploring the need, precedents, and data from literature/senior living centers for target individuals 60 to 90+ years of age. The economics of aging necessitates training engineers to design and implement systems/devices that drastically reduce senior costs related to healthcare, preserve independent living, and maintain reasonable quality of life.

Research contents may include:

- Physical (e.g., falling prevention), emotional (e.g., loneliness), and mental (e.g., forgetfulness) needs of aging populations
- Search/Develop suitable tools and devices to assist elders in maintaining their quality of life & living independently
- Integrate A.I. technology into hardware for daily living necessities and convenience.
- Built-in voice command capability, scheduled activity reminder system, and companionship features seem relevant.