Project Initiation meeting

Available Projects

SJSU SAN JOSÉ STATE UNIVERSITY

SJSU | WILDFIRE INTERDISCIPLINARY RESEARCH CENTER

Project Initiation meeting,

Spring 2021

Student Research Opportunities and Related Recent Projects in Microfluidics and Micromechanics

S. J. Lee
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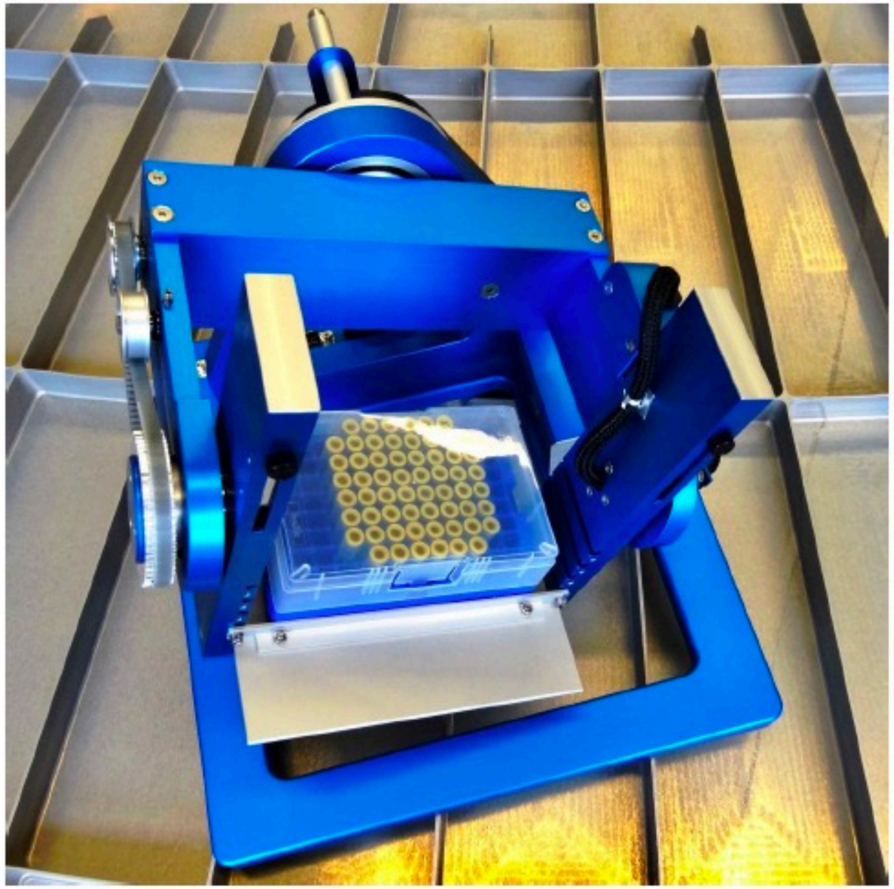
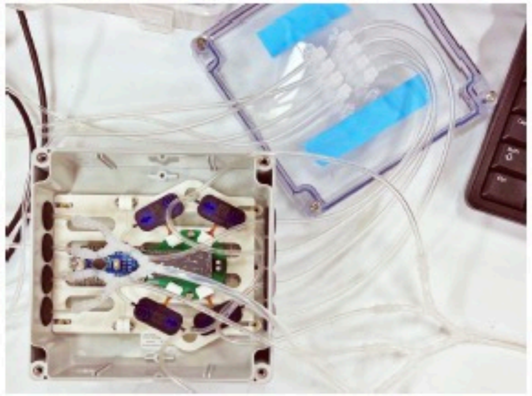
San Jose State University
2021 April 23

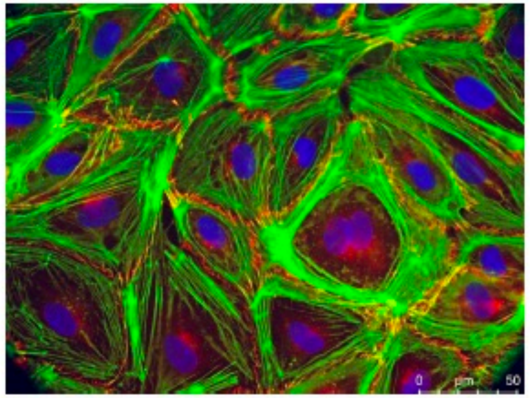
Hemodynamics and thrombosis in microgravity



Random positioning machine for simulated microgravity
Image courtesy of Airbus Defence and Space Netherlands B.V. Used with permission, November 2020
Video available at https://www.youtube.com/watch?v=iMVb_TTKfeM



Closed-loop, four-channel micropump perfusion system



Fluorescence microscope image of endothelial cells

- An alarming incident occurred in 2019, when an astronaut on the International Space Station (ISS) developed a internal jugular vein (IJV) thrombus during a mission [doi: 10.1056/NEJMc1905875].
- This NASA-sponsored project uses a random positioning machine (left) and perfused microchannels (similar to above) to study how the absence of constant gravitational direction affects endothelial cell behavior and the formation of blood clots.

In collaboration with Dr. Anand Ramasubramanian (Chemical Engineering) and Dr. Wendy Lee (Computer Science).
Related thesis investigation in progress by M. Kim.

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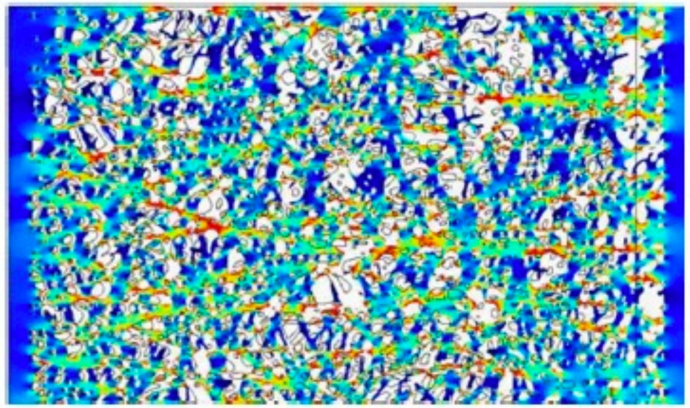
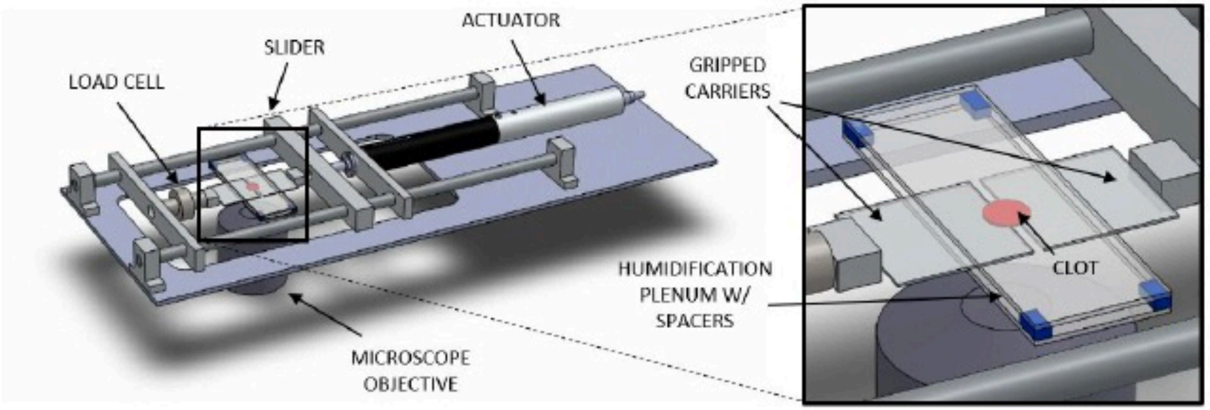
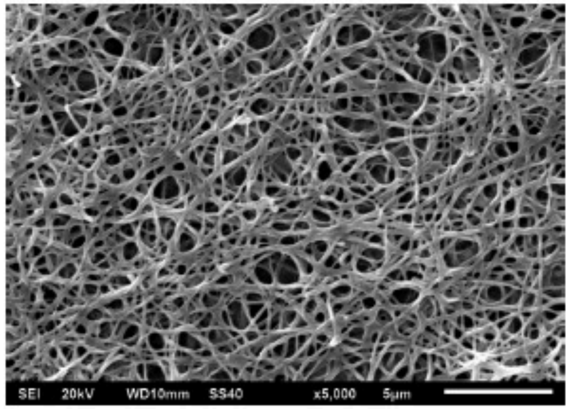
Modeling and simulation of blood clot mechanics



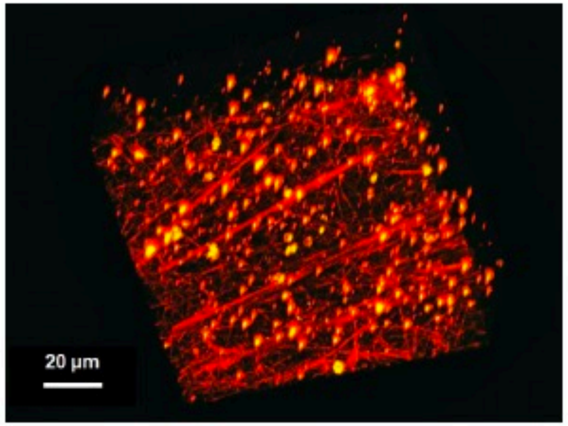
Finite element simulation of strain energy density*



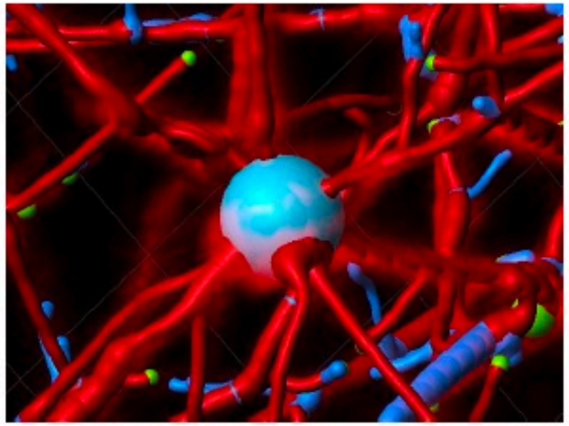
Design of apparatus for simultaneous extension and fluorescence microscopy.



Scanning electron microscope image of fibrin network



Laser-scanning confocal image of platelet distribution

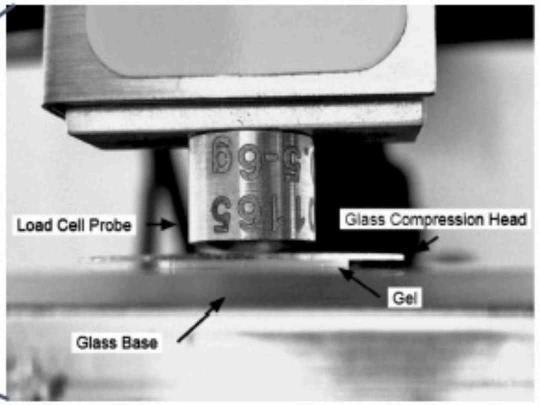


3-D feature recognition and topological reconstruction of network connectivity

*S.J. Lee, D.M. Nguyen, H.S. Grewal, C. Puligundla, A.K. Saha, P.M. Nair, A.P. Cap and A.K. Ramasubramanian, "Image-based analysis and simulation of the effect of platelet storage temperature on clot mechanics under uniaxial strain." Biomechanics and Modeling in Mechanobiology 19.1 (2020): 173-187.

3

Mechanics of polymer electrolytes for Li-ion batteries



Simultaneous measurement of force and micron-scale displacement

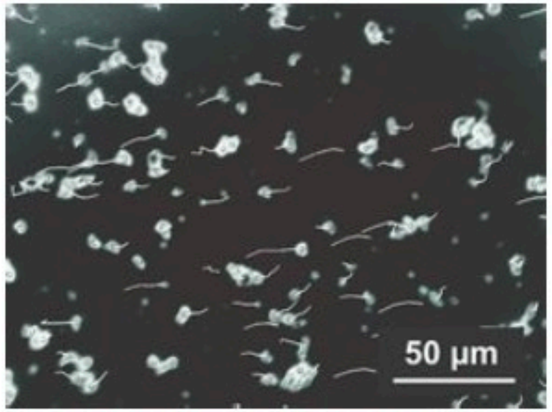
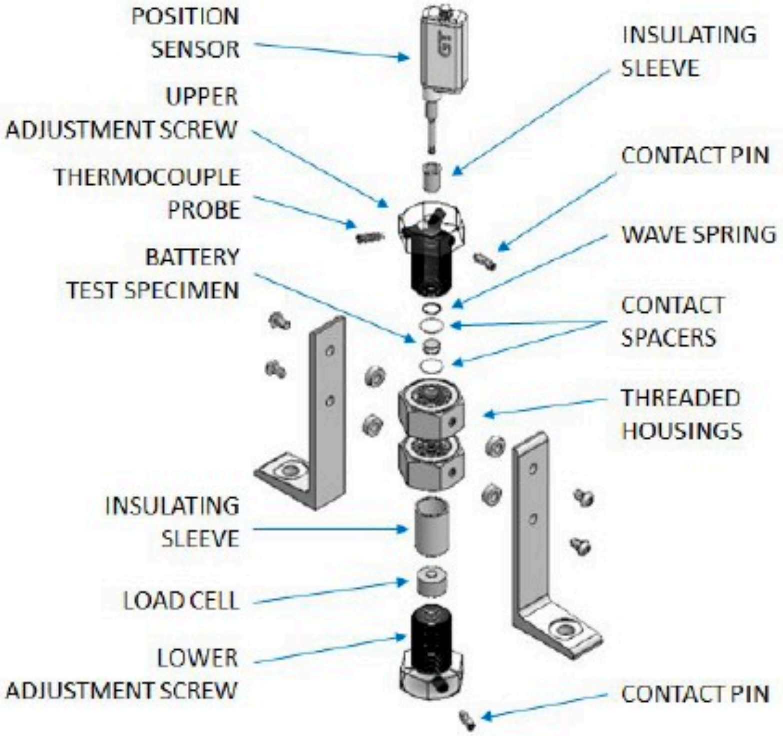


Image analysis and tracking of particle distribution in polymer matrix



Multifunctional apparatus for simultaneous measurement of mechanical response and electrochemical performance

- This investigation quantifies ceramic particle redistribution within a thin polymer 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.

In collaboration with Dr. Dahyun Oh (Materials Engineering) and Dr. Min Hwan Lee (Mechanical Engineering, UC Merced).
MSME thesis completed 2020 by I. Halabi. Contributions from Y. Barati (BS MatE 2020), M. Freitas (BSME 2020), and S. Lienhart (BS MatE). New MSME thesis 2021 by N. Mulay.

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Available Master's Projects

Dr. Armani A.

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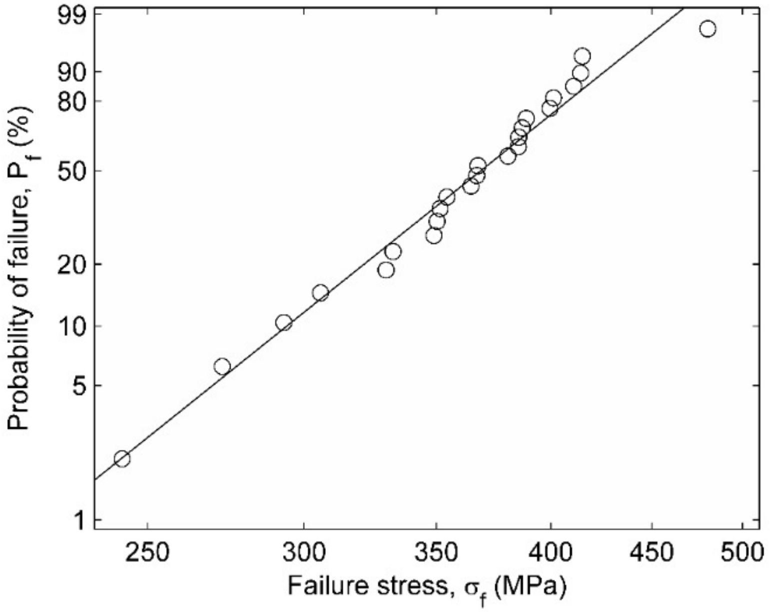
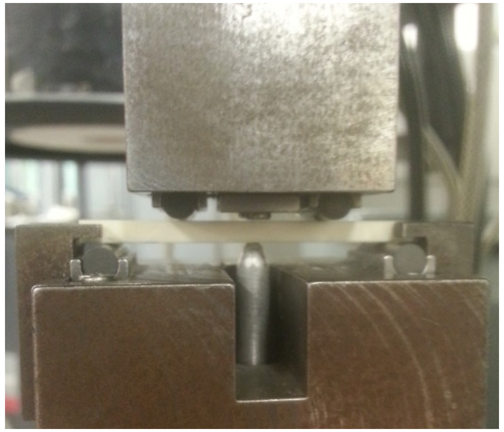
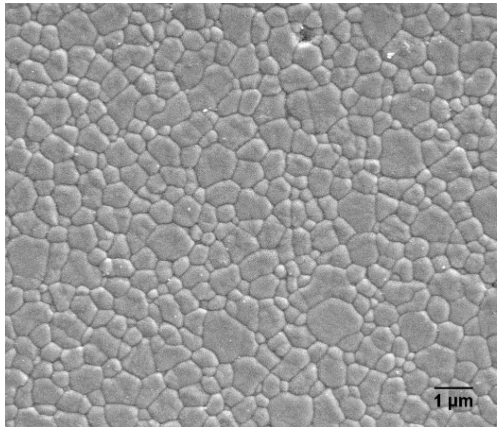
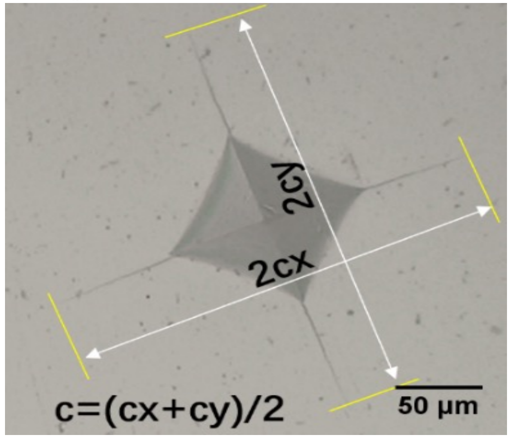
Mechanical Properties of AM Parts

- Strength
- Fracture toughness
- Hardness
- Microstructure
- Young's modulus
- Weibull modulus



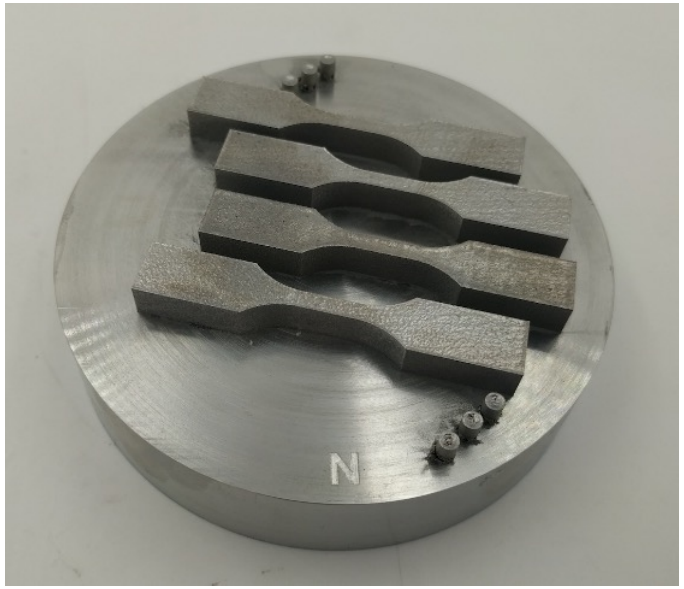


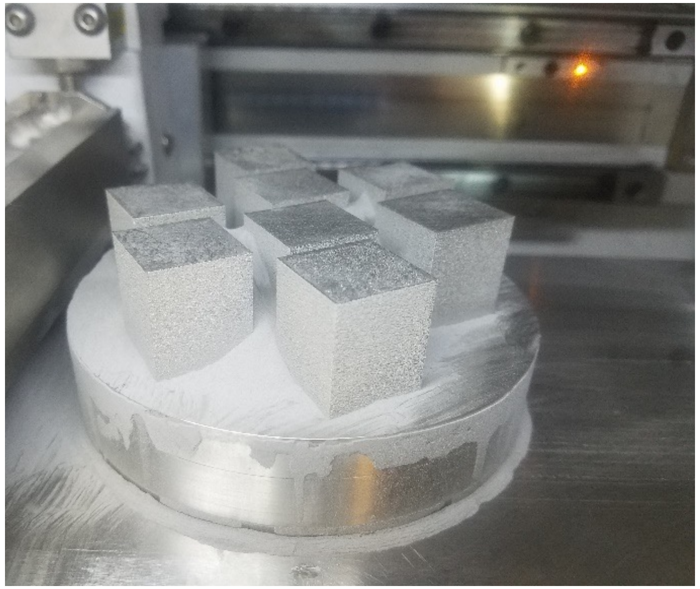




Thermal Properties of AM Parts

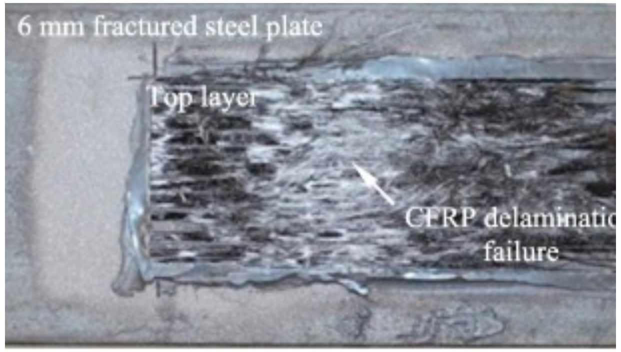
- Controlling thermal properties of additively manufactured metals via adjustment of process parameters
- Joint project with Drs. Okamoto and Kazemifar

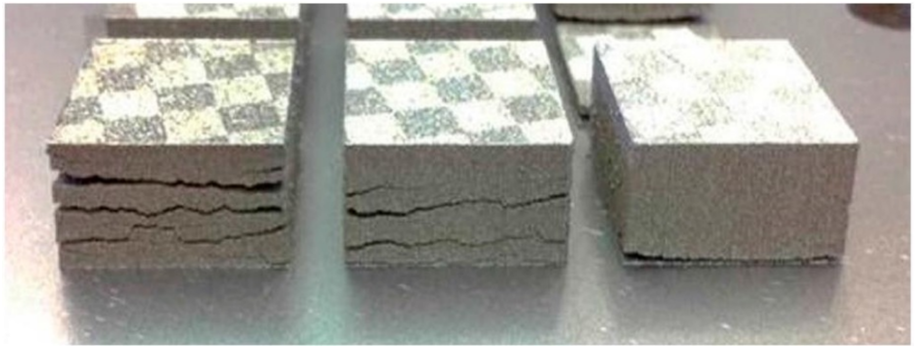


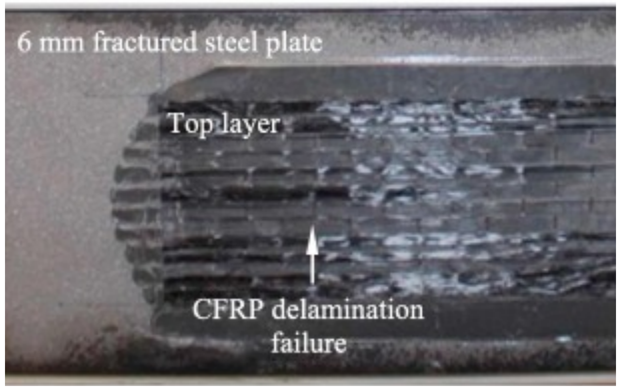


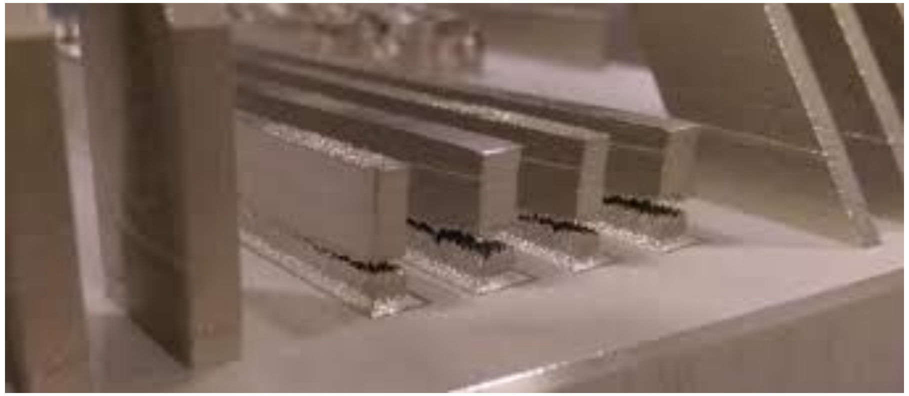
Improving AM with ML

- Applying machine learning algorithms to improve the quality of additively manufactured parts



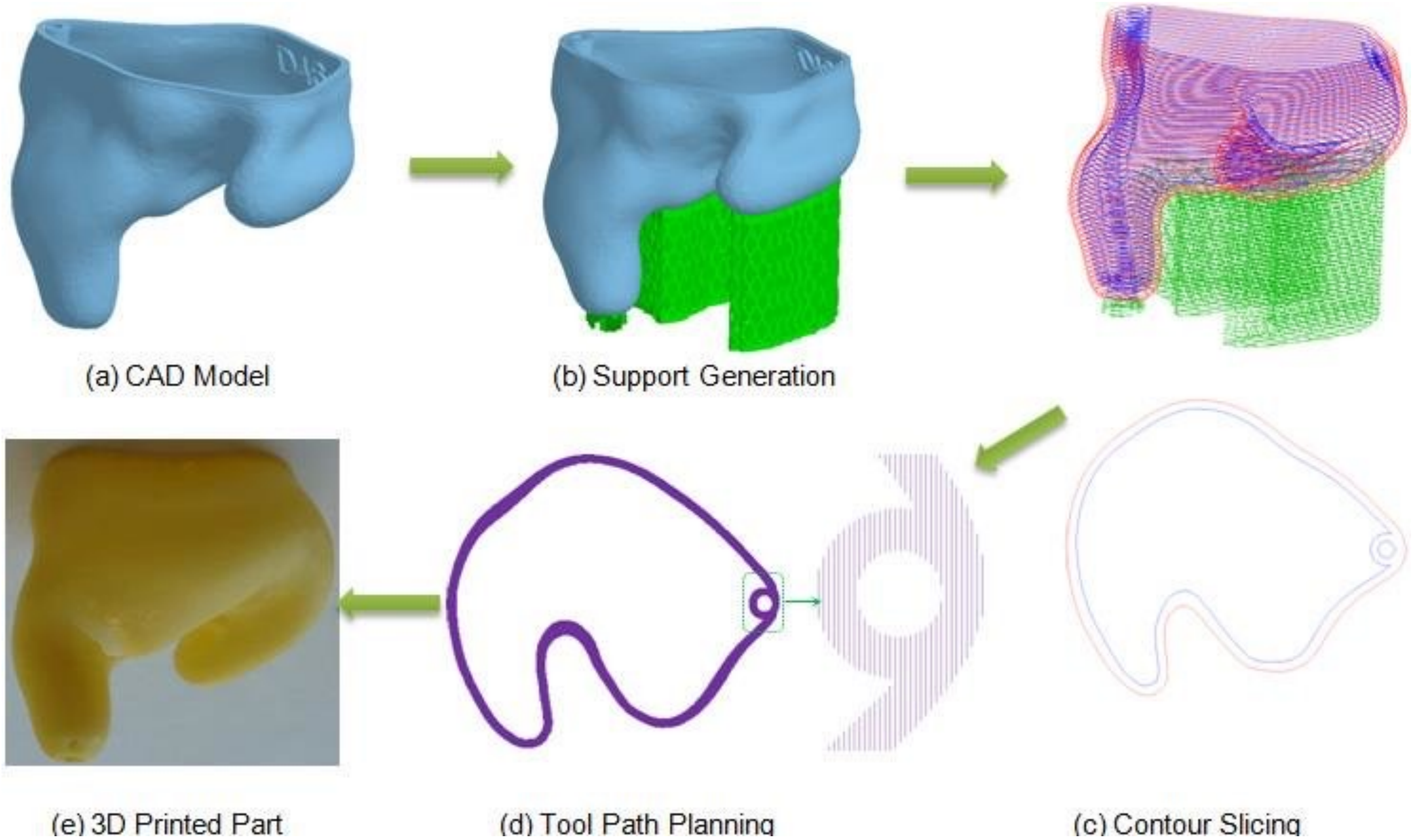






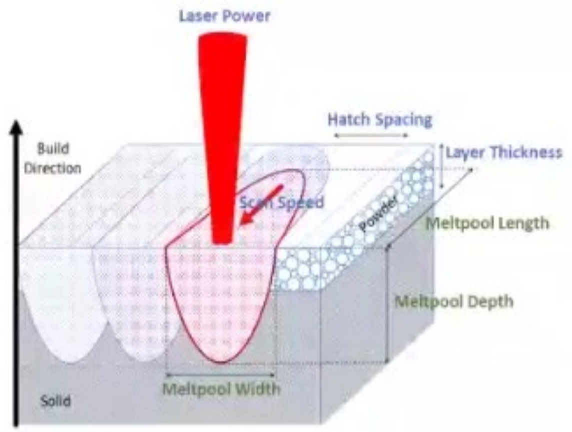
Tool-path Planning for 3D Printing

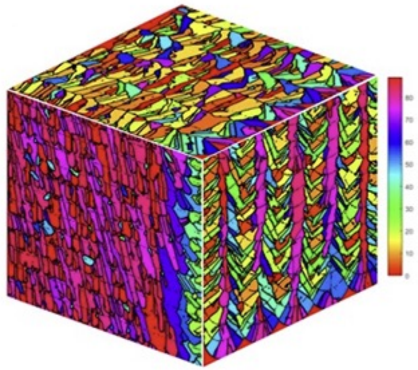
- Improving the productivity and/or accuracy of AM system

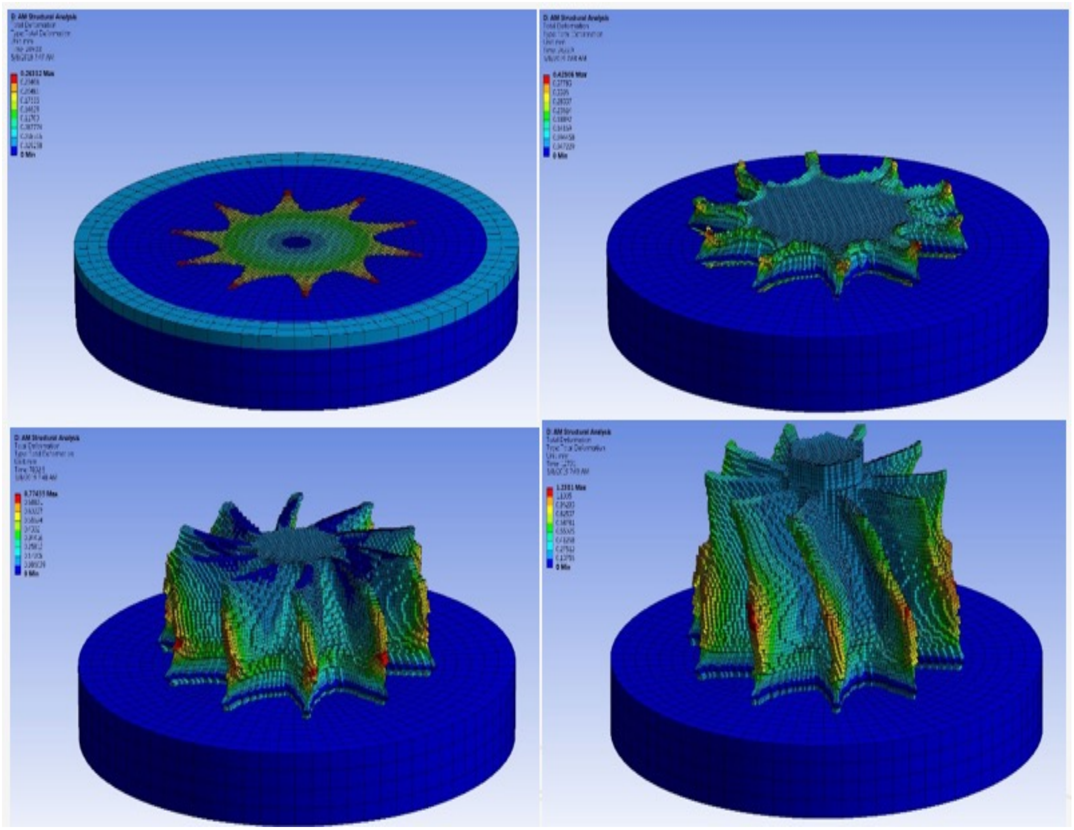


Simulation of Superalloy 3D Printing

- Working with MolyWorks company

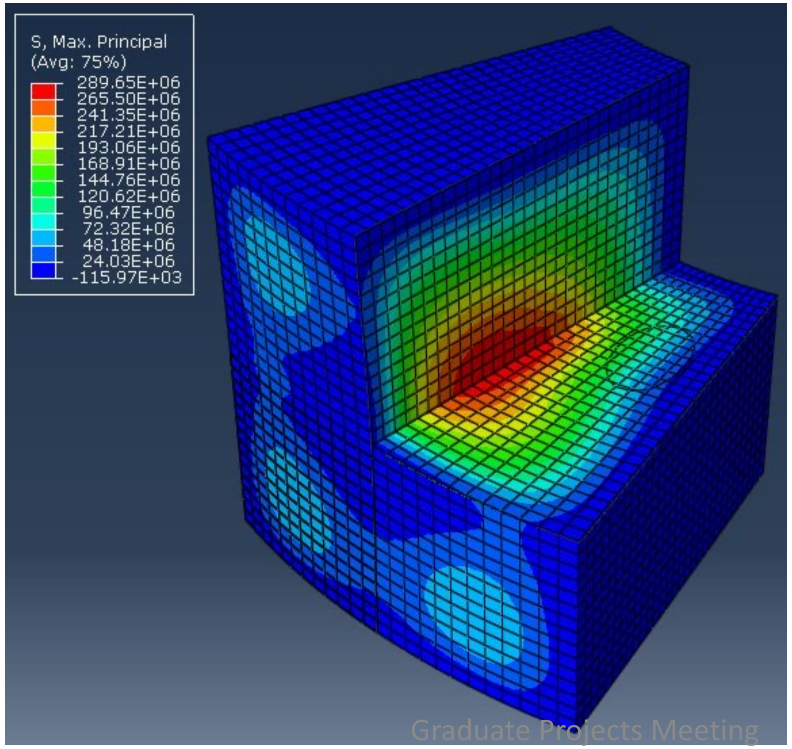


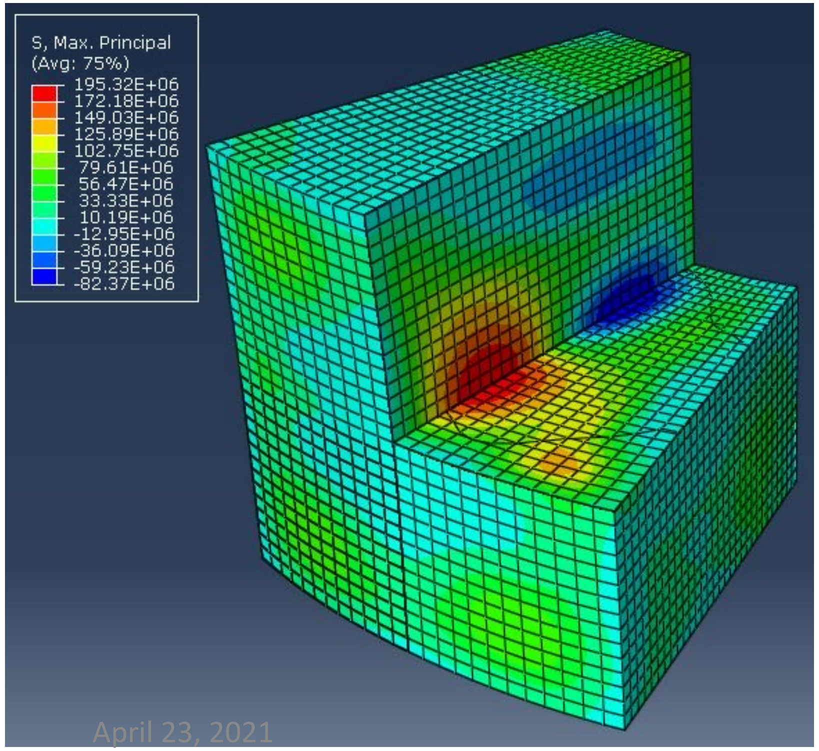




Design of FGM for 3D Printing

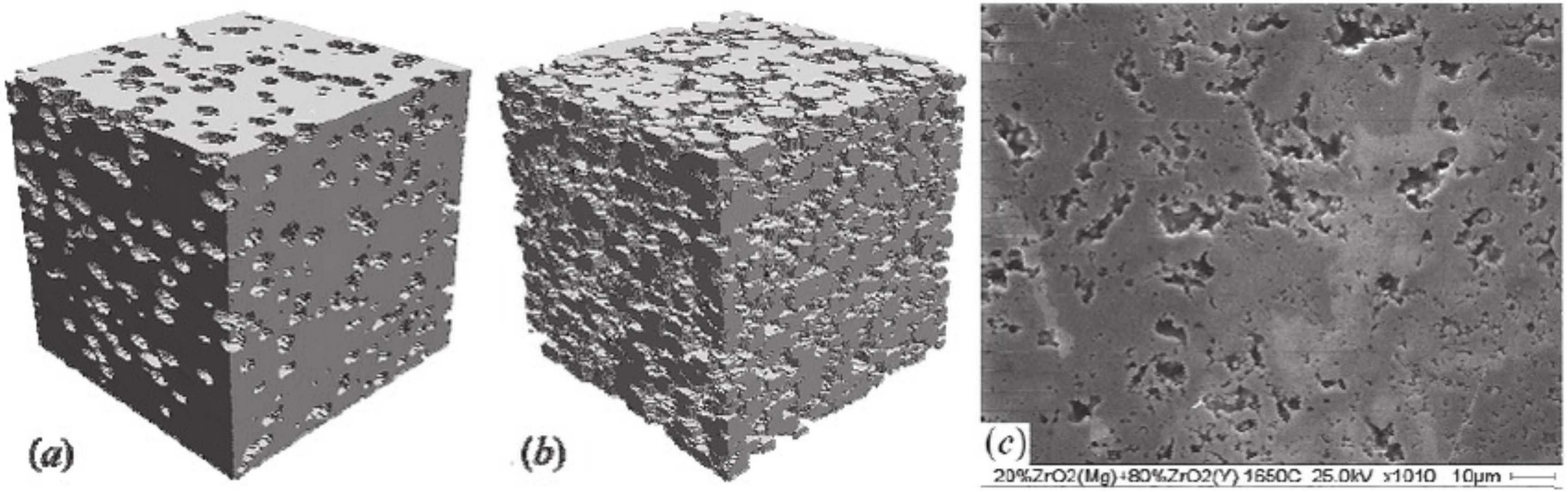
- Continuously varying composition
- Material distribution can be optimized





Probabilistic Design of Brittle Materials

- Estimating the failure probability of geometrically complex parts made of brittle materials



Other Projects

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Available Master's Projects

Dr. Okamoto N.

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My areas of research

- Topics
  - HVAC systems
  - Thermal management of electronics
- Methods
  - Experimental thermal component testing; understanding of experimental methods, data acquisition, sensors in addition to heat transfer/thermo/fluids needed
  - Modelling of thermal systems
    - Computational Fluid Dynamics (FLUENT, Icepak)
    - Analytical and/or empirical modelling

- Chu, E.*, Okamoto, N., and Zaidi, S., 2021, "Start-Up Power Requirements for an Axial Grooved Thermosyphon," 5-6th Thermal and Fluids Engineering Conference.
- Drake, E.*, Okamoto, N., and Thurlow, E., 2020, "The Use of CFD to Analyze and Predict the Pressure Drop Along Flat Oval Duct Fittings," ASHRAE Transactions, Vol. 26(2), 493-500.
- Tran, M.*, Okamoto, N, Kabbani, H., and Bashash, S., 2020, "Determination of Cost Savings Using Variable Speed Fans for Cooling Servers," Proceedings of Semi-Therm 36, San Jose, CA.
- Werdowatz, A.*, Okamoto, N., and Kabbani, H., 2018, "Developing an Empirical Correlation for the Thermal Spreading Resistance of a Heat Sink," Proceedings of Semi-Therm 34, San Jose, CA.

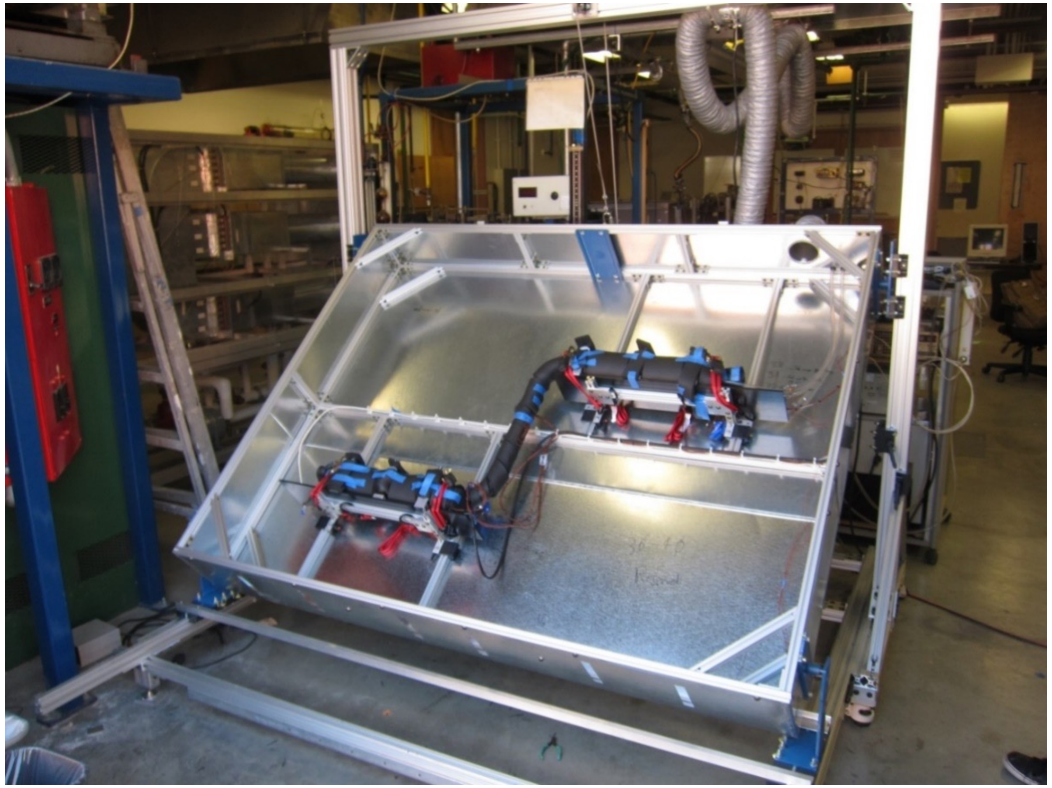
Thermal-Fluids Projects -- Computational

- Analysis of increase in air exchange rates due to an open door
  - Capacity of in-person classes at SJSU is currently limited to 150 ft^2/person
  - Assuming that a room has a standard minimum required ventilation rate (by ASHRAE specs) with the door closed, how much does this improve when a standard sized door is left open? How is this affected by room size? And how much does the door and vent locations affect dead zones? Focus on typical classroom and lab sizes.
  - Background research of natural ventilation will help provide a background for this project.
  - Requirement: Enrollment in ME 271 in Spring 21 or prior experience with CFD

- Applications of Heat Pipes and Vapor Chambers in Environmental Closed-Loop Life Support System – Collaboration with NASA
  - Strong modelling skills would be needed to model bent vapor chambers
  - This project is still under discussion and is pending NASA funding. Specific details cannot be shared yet due to confidentiality issues.

Thermal-Fluids MS Projects -- Experimental

- Analysis of start-up power requirements for S-shaped thermosyphons (using existing experimental apparatus) – an extension of a recently concluded project that is doing this for grooved heat pipes.
    - This is a heavy-duty experimental project, with much of the work taking place on campus.
    - Expertise with sensors and data acquisition will be helpful.

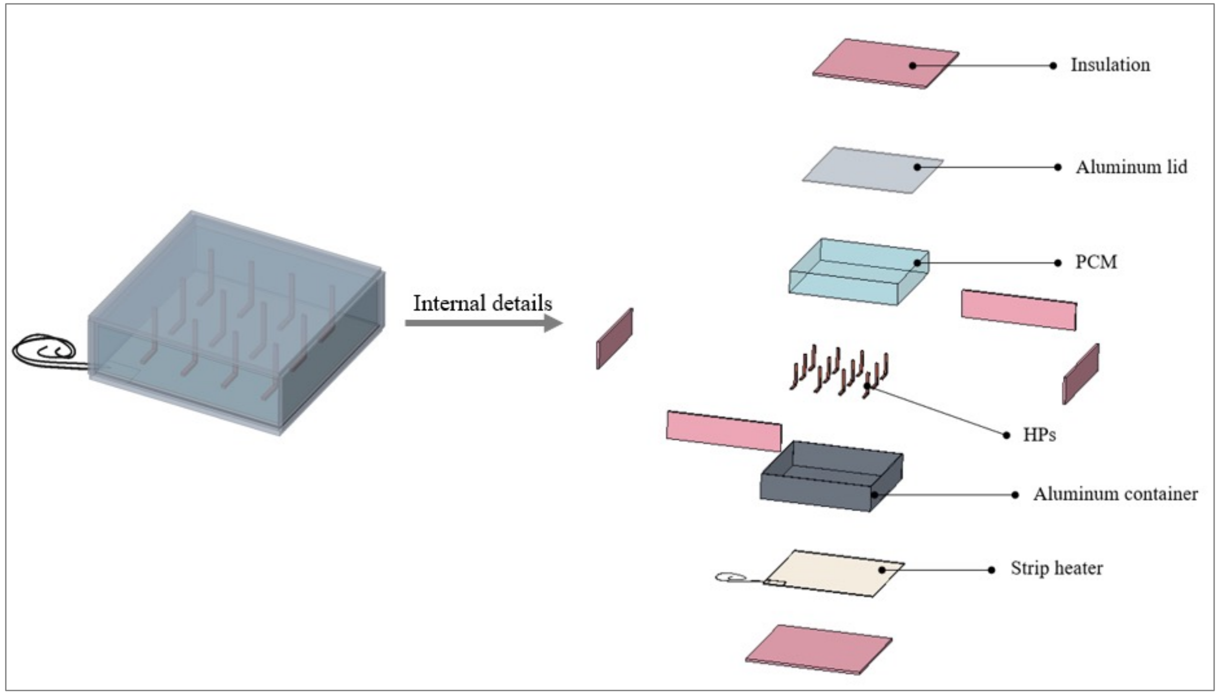


Thermal-Fluids MS Projects -- Experimental

- Effect of 3D printing processes on thermal conductivity (2 students, jointly supervised by Drs. Armani and Kazemifar
  - Design area: Student working with Prof. Armani would work on generating 3D printed samples using a variety of manufacturing processes.
  - Thermal area: Student would need to revamp a thermal resistance tester that we have, including designing and installing new electronics. We do not have a manual for the equipment. Student would need to experimentally determine the machine accuracy before testing 3D printed samples for thermal conductivity.

Experimental Projects, cont.

- Use of heat pipes and phase change material to reduce temperature spikes in e-vehicle batteries
  - Extension of recently completed project
  - Revamp of experimental setup and acquisition of data



Available Master's Projects

Dr. Fred Barez

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MS Projects Sponsored by Dr. Fred Barez

Area of Interest 1: Automotive, Electric Vehicles, Batteries

a) Electric Vehicle Battery Aging (under normal usage)

b) Electric Vehicle Battery Thermal Abuse (Battery Characterization under accelerated Conditions)

c) Design of a Battery Management System Demonstrator

d) Design of a Simple CANBUS (Vehicle Network System) Demonstrator

e) Challenges and Opportunities Facing Self-driving Vehicles

Area of Interest 2: Aviation Technology and Space Exploration

a) Study of Alternative Aviation Fuel to Replace the Leaded Fuel for Piston Engine Aircraft

b) Feasibility of Electric Powered Commercial Aircraft

c) Design of a Safe Runway to Avoid Collision of Incoming and Outgoing Aircraft

d) Design of Habitation Systems for Moon and Mars

MS Projects Sponsored by Dr. Fred Barez

Area of Interest 3: Electronics Packaging and Design

a) Product Reliability Determination through Failure Oriented Accelerated Testing

b) Thermal stress failures in electronic packaging: prediction and prevention

c) Electronics Packaging for Automotive Applications: Design and Challenges

d) The Benefits of Accelerated Testing in Electronics Packaging

e) Burn-in Testing in Electronic Product Manufacturing

Area of Interest 4: Bio Mechanics and Bio Devices

a) Simulation of bone strength Degradation Due to Aging

b) Health Monitoring using Human Skin Quality

Area of Interest 5: Mechanical Design

a) Material Characterization of 3D Printed Products using Powder and Filament

Active Research Projects

Ali Tohidi[1], email: ali.tohidi@sjsu.edu

[1]Assistant Professor, Mechanical Engineering Department,

Charles W. Davidson College of Engineering

SJSU SAN JOSÉ STATE UNIVERSITY

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Project Initiation meeting,

Spring 2021

April 23, 2021

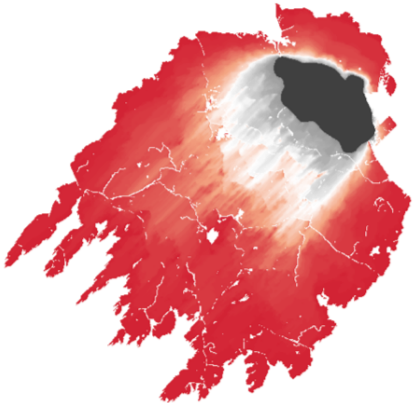
Project 1: Data-Driven Wildfire Spread Model

Motivation: Current operational fire models neither consider combustion processes nor any feedback from the interactions of fire with the environment!

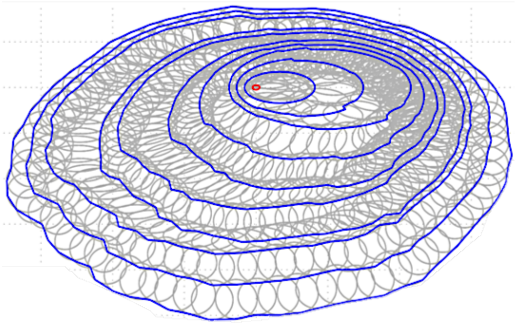
Project Goals

I. Provide consistent, scalable, and reliable observational data for wildfires

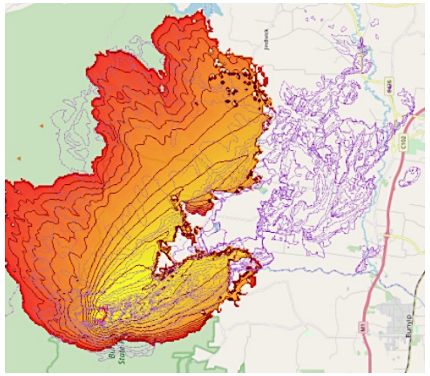
II. Inform the forecast models



Cellular automata models



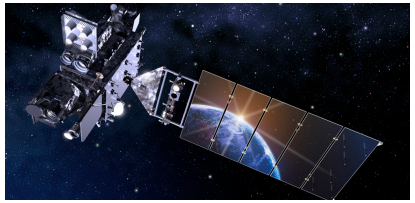
Level-set models



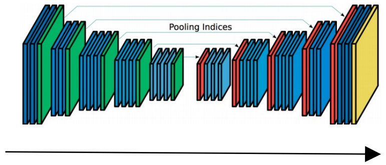
Red contours are actual fire lines and **purple lines** are forecasted fire lines

Catastrophe

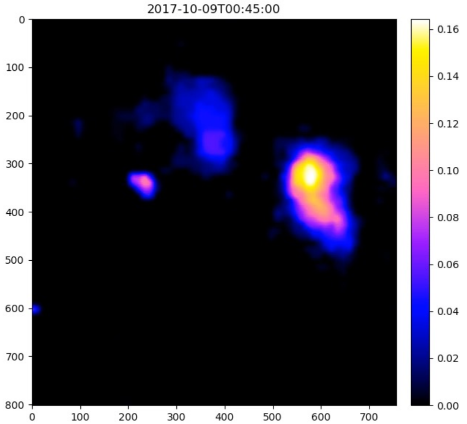
Observations

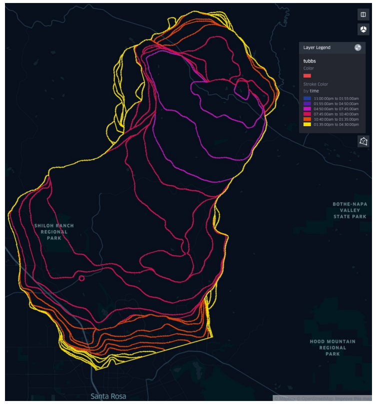


https://www.nasa.gov/content/goes-overview/index.html

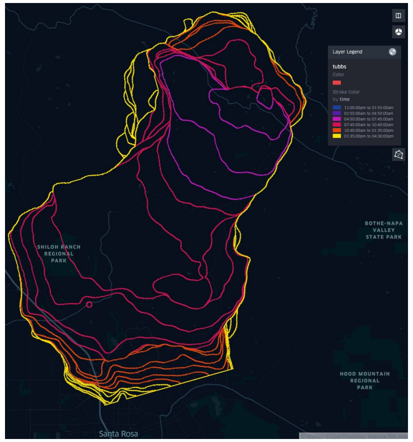


Deep learning

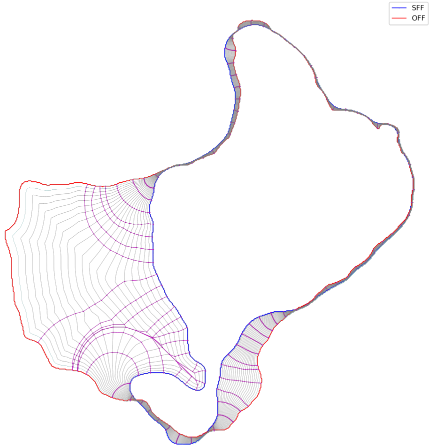




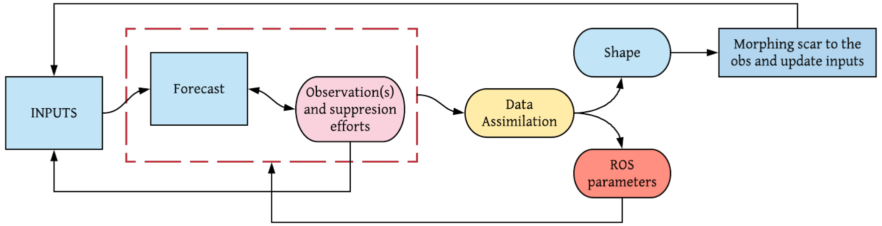
Project 1: Data-Driven Wildfire Spread Model

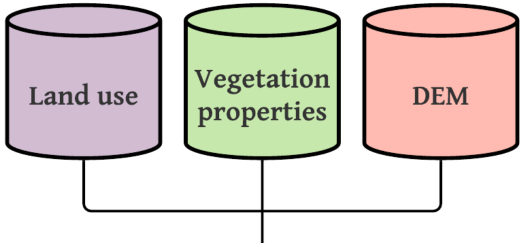


Observations



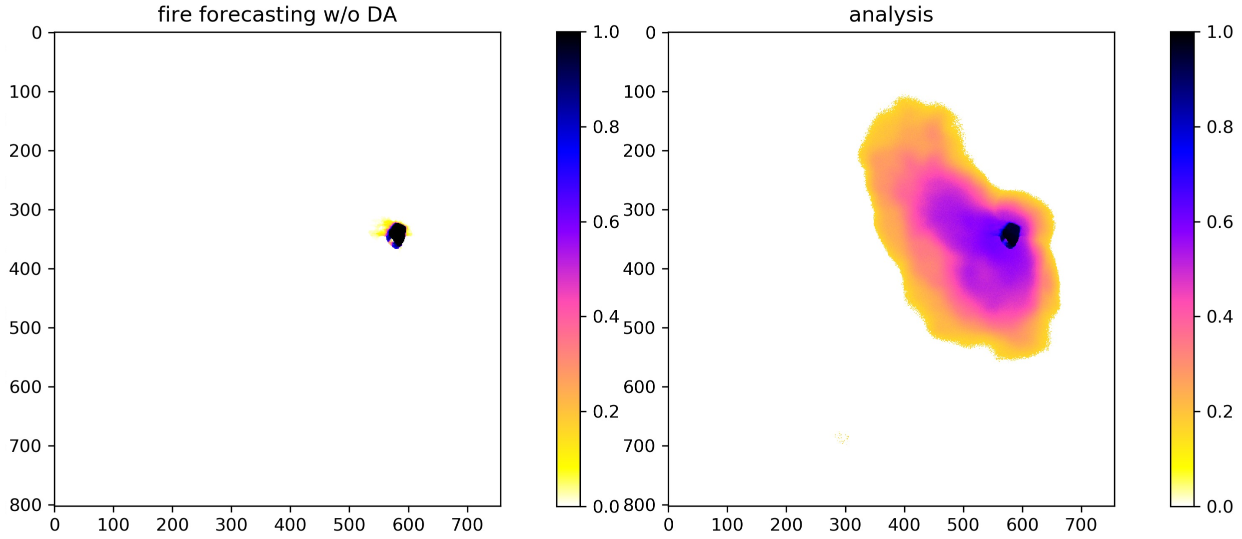
Residual distance

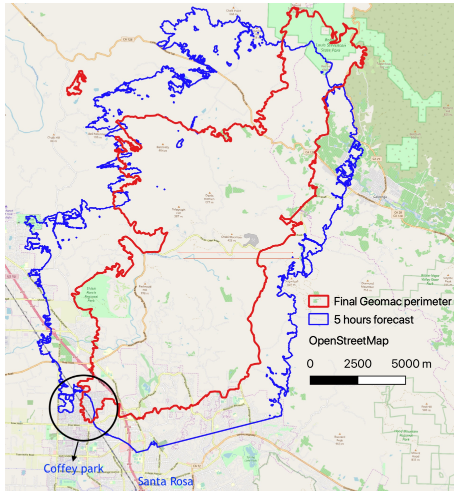




Fire perimeter forecasts (left) operational fire model (right) operation model with feedback loop using UKF.

Coupling (feedback loop) + Relevant data layers





Final perimeter

Responsibilities

- Work in a cross-disciplinary group with faculties and students from College of Science
- Learn and apply the methodologies in
  - Computer vision
  - Control
  - Machine learning and Optimization
  - Reinforcement learning

  to wildfire related datasets.
- Write scientific reports and prepare presentations

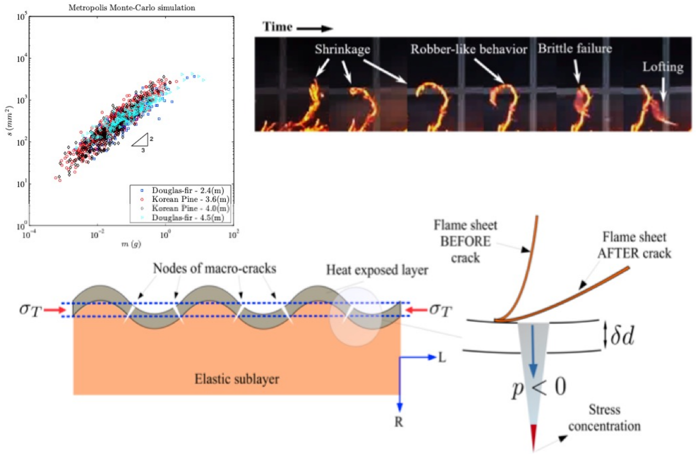
Qualifications

- SJSU student at the College of Engineering
- Highly motivated to learn new concepts and methods
- Ability to work with large datasets (experience with geospatial data is a plus)
- Experience and/or introductory knowledge of machine learning
- Excellent written, verbal, and communication skills
- Experience in Python, Julia, C++, or MATLAB (working experience with Scikit libraries, OpenCV, TensorFlow, JAX, Flux, or PyTorch is a plus)

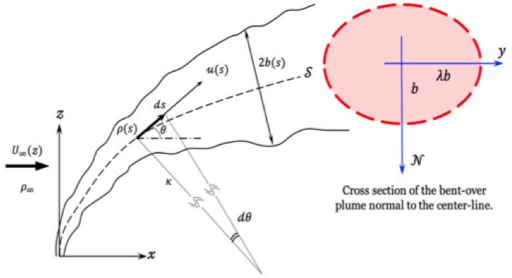
Financial support is available for this project for the minimum of one year. For application or inquiries contact Dr. Tohidi via email at ali.tohidi@sjsu.edu before **May 24, 2021.** In your email, briefly state why you are interested in this project, include your **CV** and a copy of your **(un)official transcripts**. The subject of the email MUST include "SJSU-RA-SP-2021" string without the quotation marks.

Other research projects

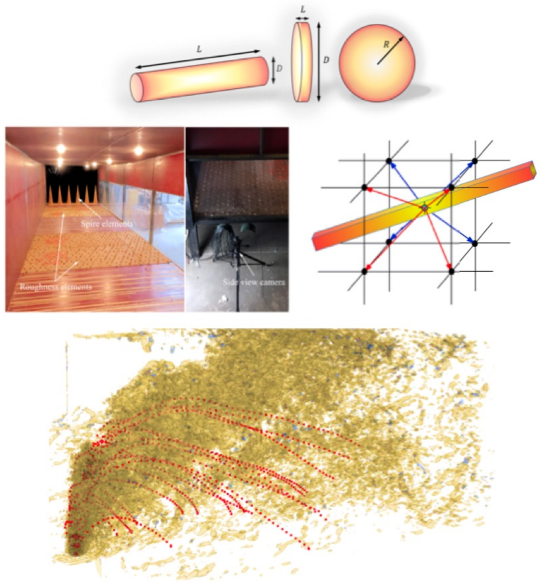
Firebrands physical properties & formation mechanisms



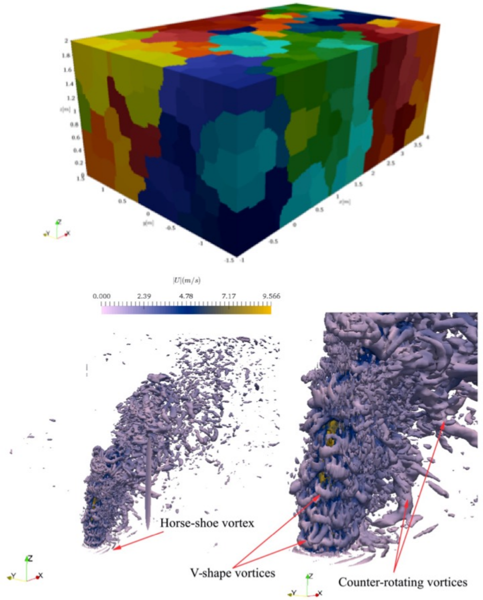
Near-field dynamics of plumes



Firebrands (debris) transport

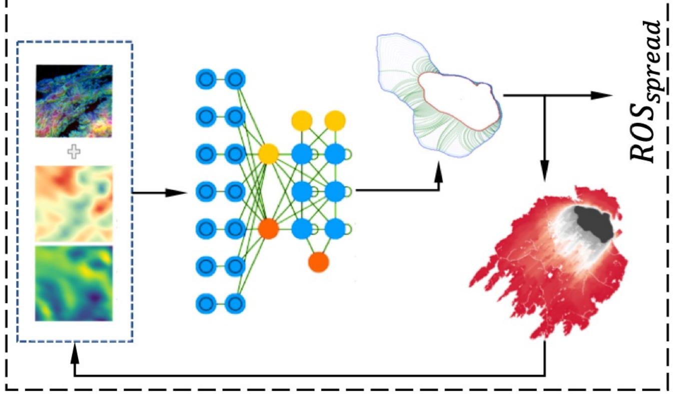


LES of jets in cross flow



Fire Whirl Dynamics

Data-driven wildfire modeling



References

- Tohidi, Ali, and Nigel Berkeley Kaye. "Aerodynamic characterization of rod-like debris with application to firebrand transport." *Journal of Wind Engineering and Industrial Aerodynamics* 168 (2017): 297-311.
- Tohidi, Ali, and Nigel B. Kaye. "Stochastic modeling of firebrand shower scenarios." *Fire Safety Journal* 91 (2017): 91-102.
- Rochoux, Mélanie C., Sophie Ricci, Didier Lucor, Bénédicte Cuenot, and Arnaud Trouvé. "Towards predictive data-driven simulations of wildfire spread–Part I: Reduced-cost Ensemble Kalman Filter based on a Polynomial Chaos surrogate model for parameter estimation." *Natural Hazards and Earth System Sciences* 14, no. 11 (2014): 2951-2973.
- Lohse, Detlef, Kai Leong Chong, Chong Ng, Naoki Hori, Rui Yang, and Roberto Verzicco. "Extended lifetime of respiratory droplets in a turbulent vapor puff." *Bulletin of the American Physical Society* (2020).
- Tohidi, Ali, Michael J. Gollner, and Huahua Xiao. "Fire whirls." *Annual Review of Fluid Mechanics* 50 (2018): 187-213.
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MSME Research Project

Mechanical Engineering Department
ME295A
For Fall 2021
Professor Raymond K. Yee
raymond.yee@sjsu.edu

Project: Crash Test Numerical Simulation (Dr. Yee)

High strain-rate deformation for safety study to save lives.

ATD Sled Experimental data for Numerical Simulation

Background: Calibration and verification of numerical models of several Crash Test Dummies, referred to as an **Anthropomorphic Test Device** (ATD), is critical to use simulation for design of vehicles. There are many different models to represent people based upon their sizes. The 50th Percentile Hybrid III Male ATD is a standard model used for vehicle design both for personal and military vehicles. Finite element model in the IMPETUS software using 50th Percentile Hybrid III Male ATD has been applied & verified for crash using the SAE J2856 automotive tests.

Recently, the National Institute for Aviation Research (NIAR) provided the sponsor company (CertaSIM) with experimental data for a sled test that they performed with a Male ATD physical dummy. This project includes analyzing the experimental data and development of the corresponding numerical model of the sled test in conjunction with the FEA Crash Test Model within the IMPETUS Program.

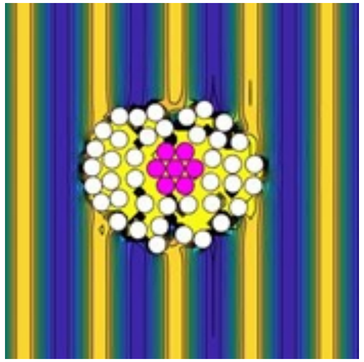
The final report of this project will be included in the documentation for the IMPETUS ATD.

Project Main Tasks are:

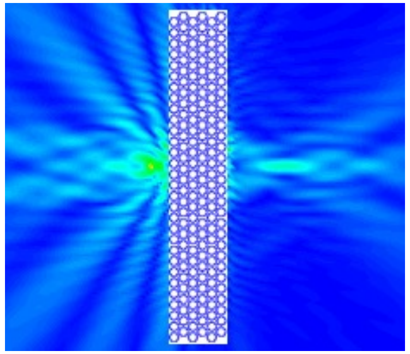
- Perform literature research on ATD's, study sled tests and IMPETUS Finite Element.
- Study the experiments from National Institute for Aviation Research (NIAR).
- Develop a FE Model of the applied sled test set-up at NIAR.
- Verify the IMPETUS ATD for sled tests. Perform inverse engineering of material constants as needed.

The student will learn about the IMPETUS Solver, study Experimental Techniques and spend some time using CertaSIM's in-house software to learn more about finite element simulation technology.

Sponsor: CertaSIM, LLC, Morten. R. Jensen, Ph.D.



Research Interests and Proposed Topics



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Department of Mechanical Engineering

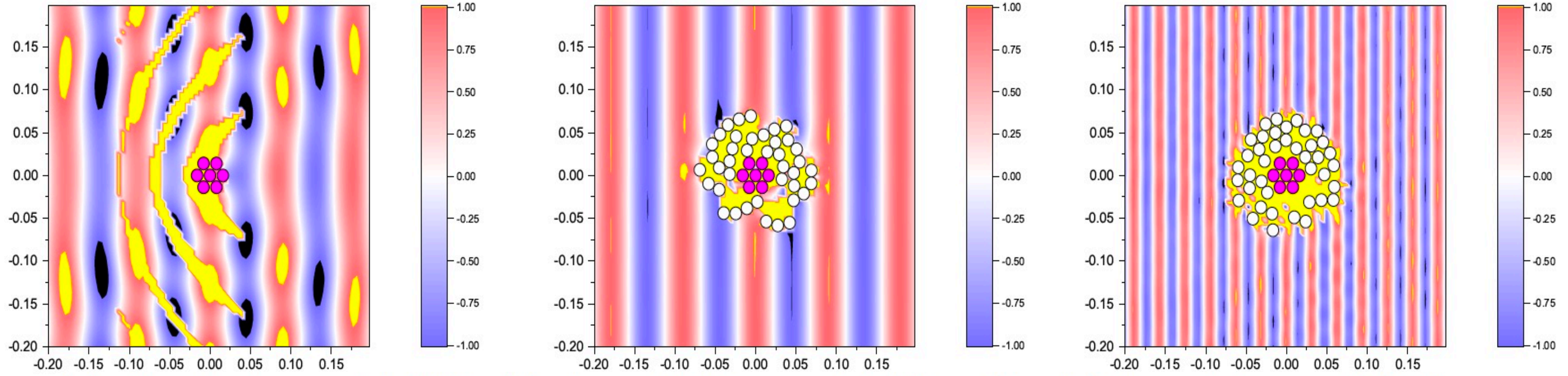
San Jose State University

April 23 2020

Metamaterial Design Through Multi-scattering and Gradient-based Optimization

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

Acoustic cloak renders an object invisible to incident waves



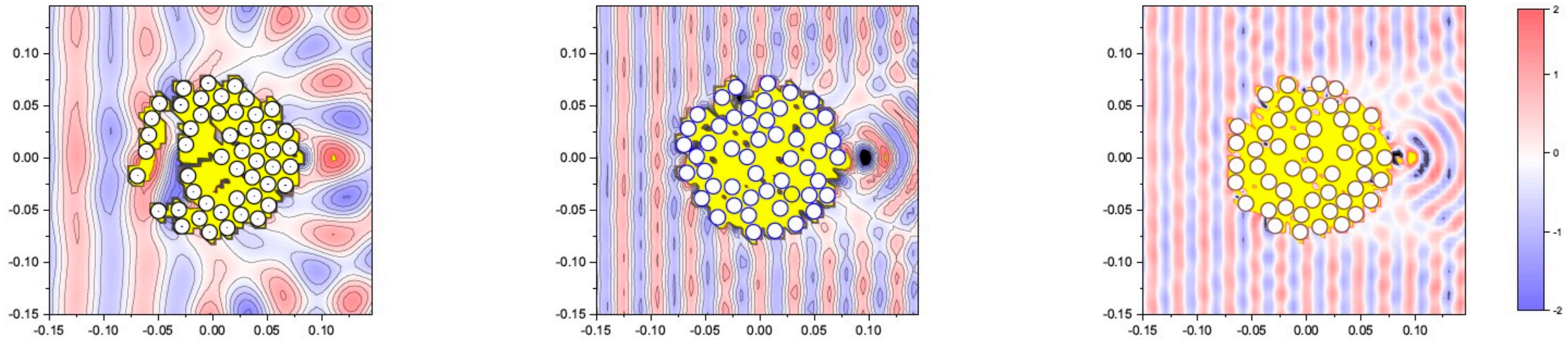
(a) No cloak: $\sigma = 0.12595$ (b) $ka = 0.525, \sigma_r = 1.4106e-04$ (c) $ka = 1.5, \sigma_r = 0.0126$

[1] Amirkulova FA, Norris AN. The Gradient of Total Multiple Scattering Cross-Section and Its Application to Acoustic Cloaking. *Journal of Theoretical orris AN. and Computational Acoustics* 2020: 1950016. doi: 10.1142/s2591728519500166

- **Sound Localization**

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

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



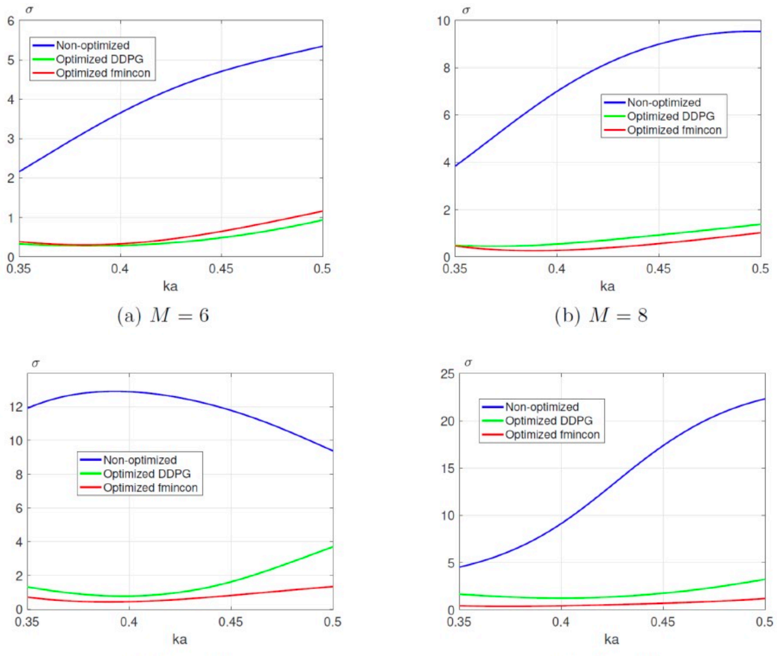
a $ka = 0.75$ **b** $ka = 1.5$ **c** $ka = 2$

[2] F. Amirkulova, S. Gerges, A. N. Norris. Sound Localization Through Multi-scattering and Gradient-based Optimization (submitted to IJNME, 2021)

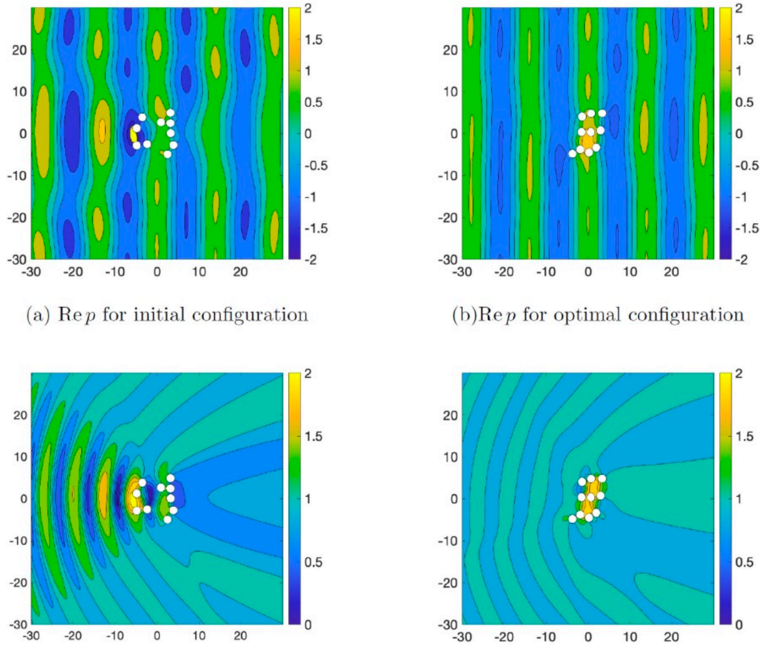
Total Multiple Scattering Cross Section (TSCS) Minimization Using Reinforcement Learning (RL)

- RL agent controls over design parameters of a planar configuration of cylindrical scatterers in water.

Variation of TSCS vs ka



(a) $M = 6$ (b) $M = 8$ (c) $M = 10$ (d) $M = 12$



(a) $\mathrm{Re}\, p$ for initial configuration (b) $\mathrm{Re}\, p$ for optimal configuration (c) $|p|$ for initial configuration (d) $|p|$ for optimal configuration

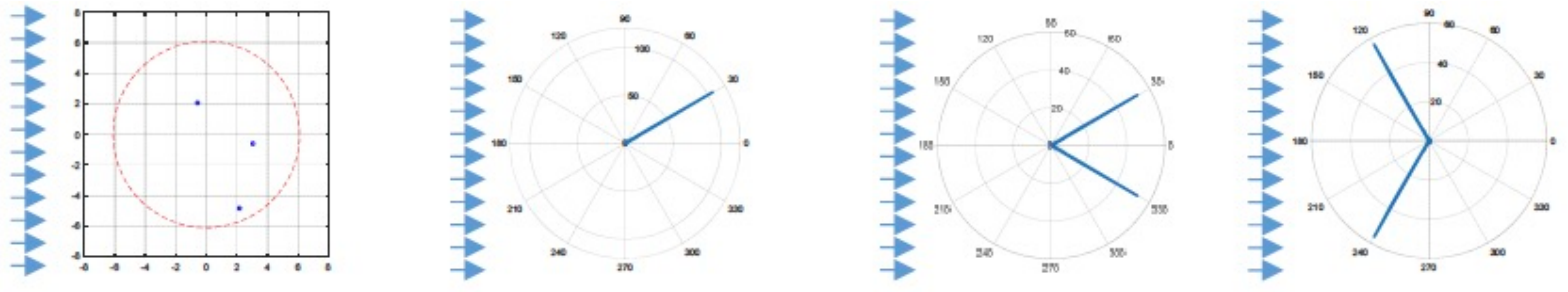
Real part of total acoustic pressure, $\mathrm{Re}\, p$, and absolute total pressure |p| at wavenumber ka = 0.45 for $M = 10$ rigid cylinders

https://youtu.be/dxB5

- Part of this RL research was conducted as Final project for ME297-01: Deep Learning in Engineering course in Fall 2021

Shah T.,* Zhuo L.,* Lai P.,* Rosa – Moreno A., ‡* **Amirkulova F.**, Gerstoft P. Reduction of Total Multiple Scattering Cross Section Using Reinforcement Learning, (submitted to the special issue on "Machine Learning in Acoustics" of *the Journal of the Acoustical Society of America*, 2021)

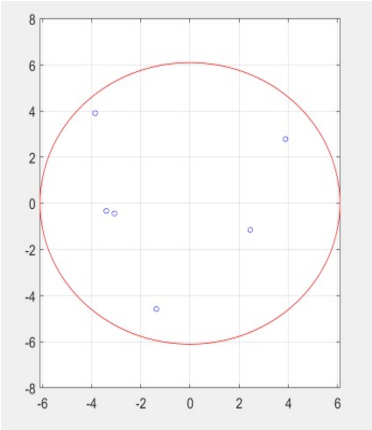
Sound manipulation and control of acoustic and elastic wave



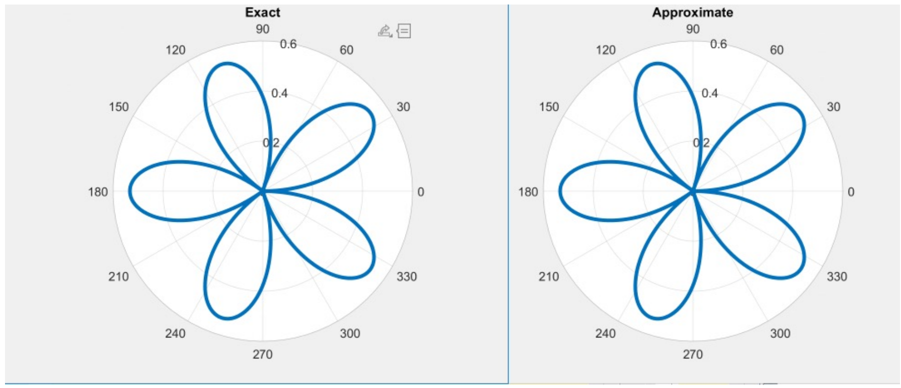
(a) M= 3 cylinders (b) $\theta = \pi/6$ (c) $\theta = \pm\pi/6$ (d) $\theta = \pm 2\pi/3$

Directivity patterns produced by a configuration of M= 3 fluid cylinders located inside of homogeneous water medium. (a) Random configuration of M= 3 cylinders denoted by small blue circles. (b) Unidirectional pattern for an incident plane wave steered; (c)-(d) Bidirectional symmetric patterns.

- Use generative networks, DL, and RL algorithms to minimize the error and to find configurations producing the desired scattering patterns and to automate the design process



Configuration of cylinders: $M = 6$

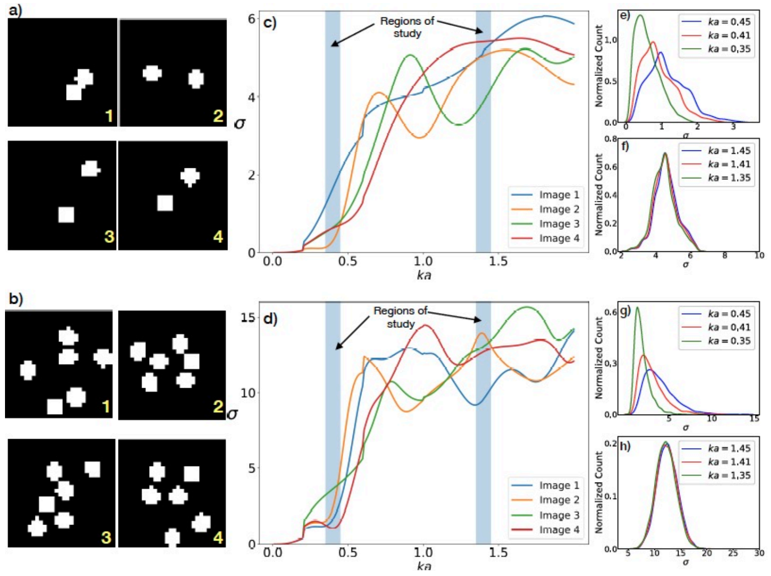


Pentapole

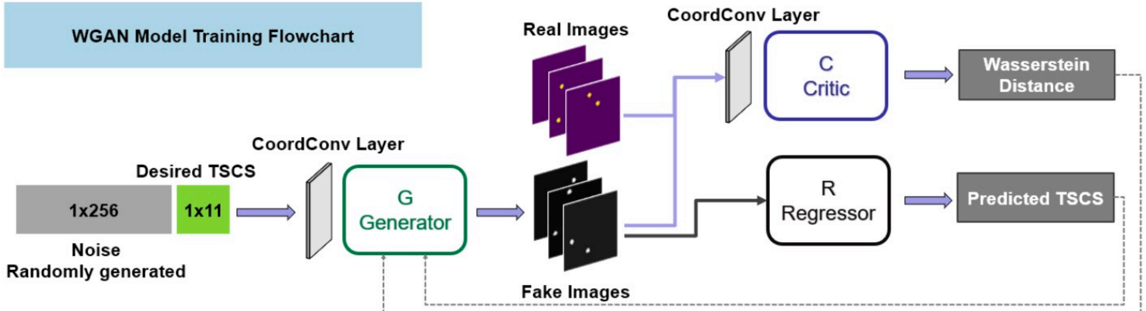
SGP grant: DL-Based Design of Metamaterials and Metadevices

- **Objectives**
  - Develop DL and gradient-based optimization assisted framework to design metaclusters for an acoustic and elastic wave manipulation. Design of metamaterials:
    - using NN, CNN, autoencoders, WGAN, and VAE.[2],[3]
    - using generative modeling and optimization: GloNet [1],[4]

- **Research outcome**
  - Two peer-reviewed conference publications. One journal paper[1] is under review, one journal paper[2] to be submitted to JASA this month, two papers[3],[4] in prep.
  - One YP Student grant to participate at INTER-NOISE2021
  - SPIE2020, ASA2020, ASME IMECE2020, Noise-Con2020, MLSE2020, and ASA2021(invited) presentations
  - **Future Research**
  - *Deep reinforcement learning (RL) models* (single and multiagent RL (MARL) models using DDPG and DDQN algorithms)



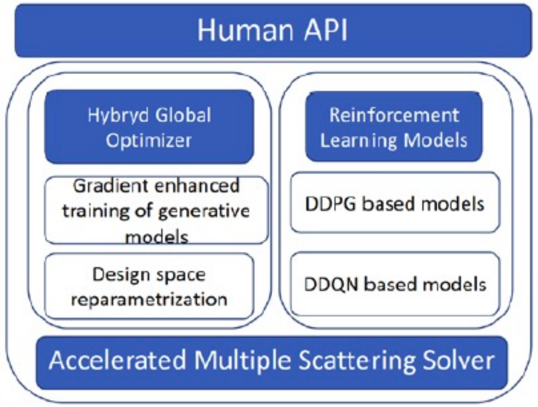
Random configurations generated in binary images & corresponding TSCS

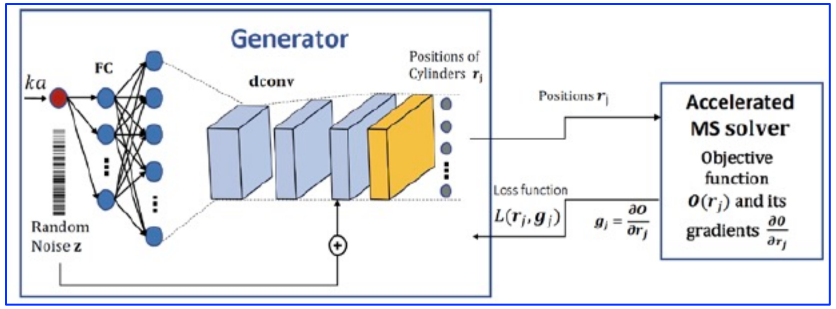


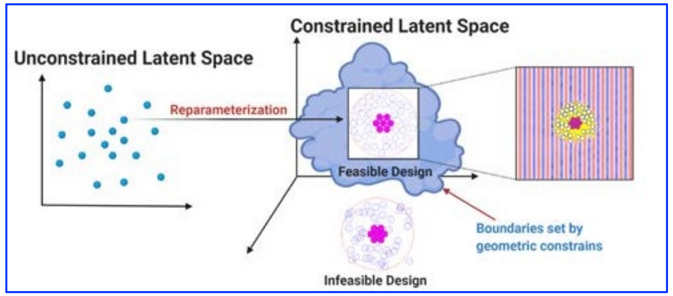
[1] F. Amirkulova, S. Gerges, A. N. Norris. Sound Localization Through Multi-scattering and Gradient-based Optimization (submitted to IJNME, 2021)
[2] P. Lai, F. Amirkulova, P. Gerstoft. Total Scattering Cross Section Reduction Using Conditional Wasserstein Generative Adversarial Networks. (to be submitted to JASA)
[3] T. Tran, E. Khatami , F. Amirkulova. Convolutional Neural Network Representation of the Total Multiple Scattering Cross Section. (in preparation)
[4] L. Zhou, F. Amirkulova. Acoustic cloak design using global optimization and generative networks (in preparation)

GPU-accelerated machine learning framework for multi-scattering simulations and metamaterial design

- *Implementation of fast GPU-accelerated algorithms for solving multiple scattering (MS) problems*
  - In-house-built MATLAB MS Solver to run concurrently on CPUs.
  - Modify codes to run on distributed GPUs using fast direct solvers and iterative methods on MATLAB.
  - New system, box with Dual NVLink NVIDIA Quadro GV100 was purchased from Dell and being installed to obtain preliminary data for a proposal to NSF CSSI .
- *Hybrid global optimization solver for modeling metaclusters using generative networks*
- *Design space reparametrization* for embedding nonlinear constrains into inverse metacluster design.
- *Deep reinforcement learning (RL) models* (single and multiagent RL (MARL) models using DDPG and DDQN algorithms)
  - It takes long time to run current RL models and train agents
  - Modify RL models using MARL and run on distributed GPUs



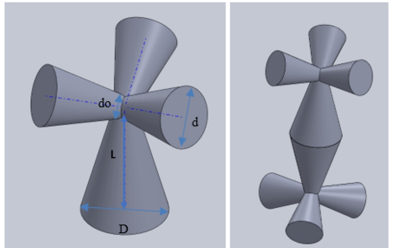




Pentamode (PM) metamaterial design via deep learning

Data Generation

- The PM cell models are made on COMSOL MultiPhysics and the dispersion curve for each cell is used for calculating shear and bulk modulus and its acoustic impedance.
- The csv file is built corresponding to each unit cell with 9 parameters- L, s, alpha, theta, volume ratio, ρ, B, G, Z (impedance).



	Parameters	Description
1	L	The height of the cones
2	r = D/2	The radius of the base cone
3	alpha	The ratio of height to base radius
4	s	The ratio of base cone radius to small cones base radius
5	$do = 2(r/4)$	The cone tip diameter

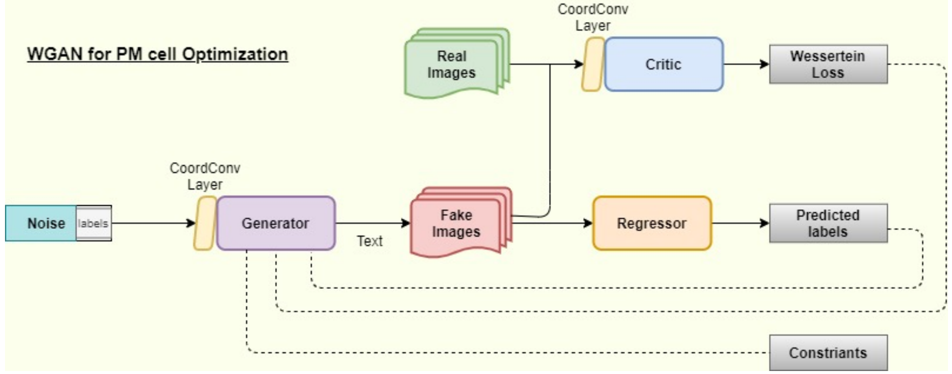
name	alpha	L	s(cone1:cc	angle	volume ra	density	shear	bulk	Z (10^6)	B/G ratio
1	1.3	0.0038	1.3	135	0.24246	1074.097	3.15E+08	1.1E+10	3.430122	34.77153
2	1.35	0.0038	1.3	135	0.234933	1040.755	2.82E+08	1.06E+10	3.32283	37.6761
3	1.4	0.0038	1.3	135	0.227688	1008.656	2.53E+08	1.03E+10	3.221504	40.66607
4	1.45	0.0038	1.3	135	0.220536	976.9765	2.27E+08	9.96E+09	3.120036	43.80774
5	1.5	0.0038	1.3	135	0.213708	946.7255	2.06E+08	9.66E+09	3.023864	46.9104
6	1.55	0.0038	1.3	135	0.207114	917.5146	1.86E+08	9.36E+09	2.930961	50.25125
7	1.6	0.0038	1.3	135	0.200757	889.3543	1.7E+08	9.08E+09	2.842302	53.44973
8	1.65	0.0038	1.3	135	0.194679	862.4269	1.54E+08	8.8E+09	2.7554	57.04672
9	1.7	0.0038	1.3	135	0.188812	836.4371	1.4E+08	8.53E+09	2.67077	60.81618
10	1.75	0.0038	1.3	135	0.183192	811.5396	1.28E+08	8.27E+09	2.590156	64.5692
11	1.8	0.0038	1.3	135	0.177775	787.5438	1.17E+08	8.02E+09	2.513652	68.29241
12	1.3	0.0039	1.3	135	0.242171	1072.818	3.14E+08	1.09E+10	3.42397	34.82837
13	1.35	0.0039	1.3	135	0.234932	1040.749	2.81E+08	1.06E+10	3.321673	37.72015
14	1.4	0.0039	1.3	135	0.227616	1008.337	2.52E+08	1.03E+10	3.219205	40.72885

The Regressor

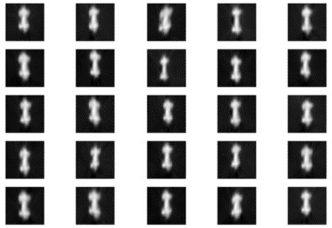
- The images from COMSOL are converted to grayscale and ten resized to 64x64. The images and labels are normalized and reshaped for Regressor's training.
- RMSprop is used as optimizer and CNN is run for 10000 epochs

WGan Model

- The WGAN model consists of a generator that receives a noise vector concatenated with labels. It generates images that are received by the Critic to evaluate.
- A CoordConv layer is attached to the Critic and Generator to improve coordinate identification of the images.
- The critic calculates the Wasserstein distance, between the real dataset and the generated dataset samples.
- The generated images are passed on to the regressor model to better evaluate the labels.
- The constraints that is the MSE between the predicted and desired value of impedence is calculated and miminized.



- The images generated with 10000 epochs are shown.

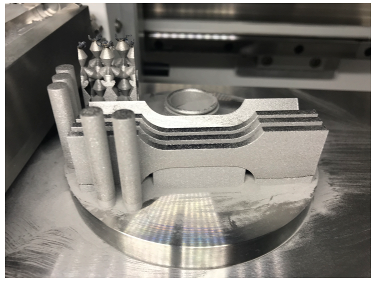


Inverse Design, Manufacturing, and Testing of Acoustic and Elastic Metamaterials

- Design of broadband Acoustic and Elastic Metamaterials using generative neural network and global based optimization
- 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:
    - Matlab programming, including Matlab Global Optimization, Parallel Computing, Reinforcement Learning and Deep learning Toolboxes;
    - TensorFlow and PyTorch Python libraries, high performance computing on COE HPC cluster and AWS computing resources;
    - Developing deep reinforcement models
    - Numerical simulation tool such as COMSOL Multiphysics, BEM++;
    - 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.

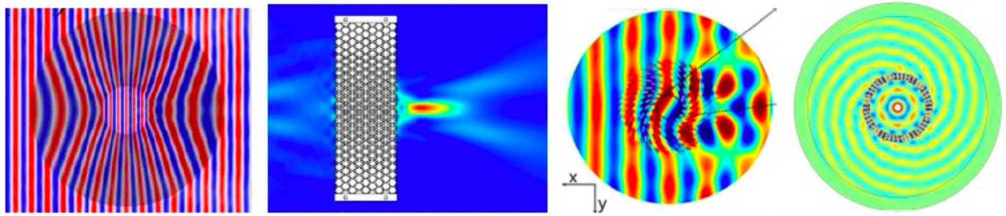
NSF MRI Award #1920363 2019, Co-PI

SGP project supported by CoE SJSU, PI



Our first build using EOS SML system

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];

The examples of transformation acoustics devices.

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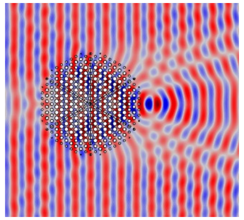
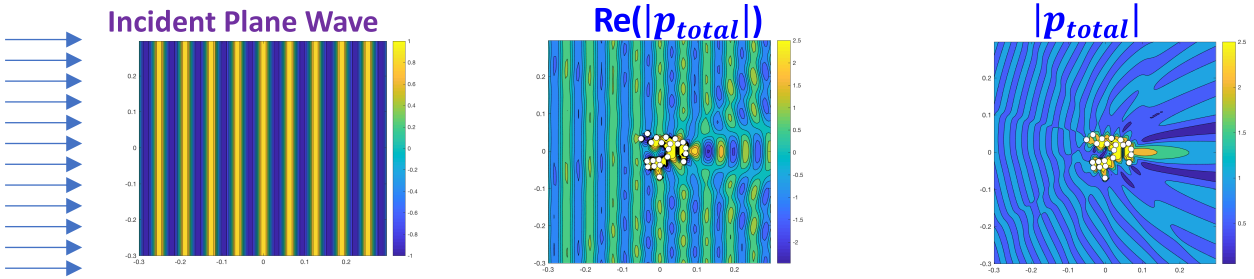
Design of some other devices



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

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

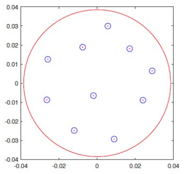


Amirkulova et al. (*JASA*, 143(3), 2018)

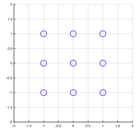
- 3D Volume Sound Diffusers: Maximizing the diffusivity coefficient
- Positioning of offshore floating structures: Minimizing the scattered wave energy and wave drift force
- Optimized 2D and 3D multilayered metamaterials and phononic crystal structures can be realized by defining the gradients WRT to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

Design of Metaclusters for Active Control Of Acoustic, Elastic and Flexural Waves

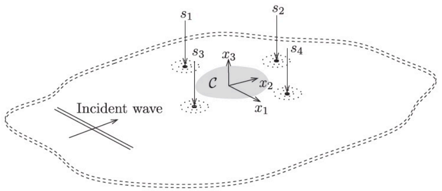
- Development of framework for the full active control of the wave energy flow using metacluster of a finite number of active sources
- IDEA: model and use a finite cluster of a finite number of multipole sources to channel the incident energy toward a desired direction.
- Problems to consider:
  - active control of acoustic wave in fluids
  - active control of elastic wave in solid materials
  - active control of flexural waves in plates



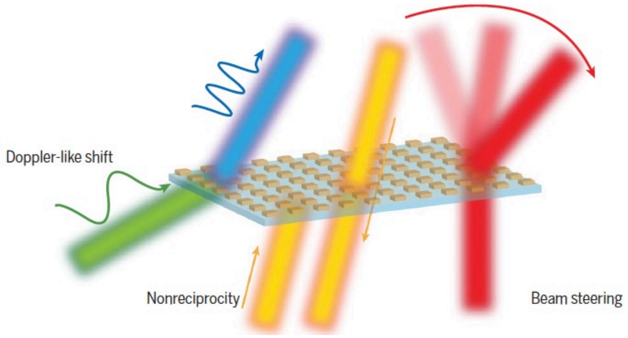
M=10



M=9



M=4



Shaltout et al. Spatiotemporal light control with active metasurfaces. 2019 http://dx.doi. org/10.1126/ science.aat3100

- Development of generative models using fully connected NN, CNN and RNN
- Development of deep reinforcement models

G. Futhazar and W. J. Parnell, A. Norris, Active cloaking of flexural waves in thin plates. *J. Sound Vib.* , **356**, 1-19, 2015
A. Norris, F. A. Amirkulova and W. J. Parnell. Active elastodynamic cloaking, *Math. Mech. Solids*, **19**, 603-625, 2013

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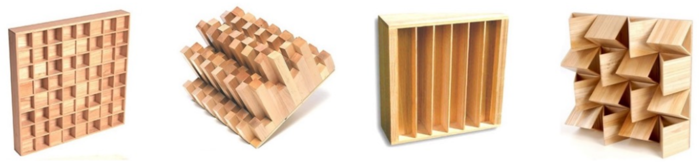
Sound Diffusers

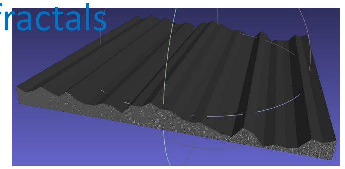
Diffusers are a type of acoustic treatment installed in acoustically sensitive environments such as performing arts spaces, concert halls, and classrooms.



Examples of different types of geometric diffusers.

Examples of fractals in nature

RMD stochastic fractals



Fractal surfaces are virtually generated with a different roughness parameter

MOTIVATION:

Design of geometric sound diffusers

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

Design of volume sound diffusers

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

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

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Projects from Jabil

https://www.jabil.com/

Project Topic: Acoustic Wave Propagation Manipulation

Summary: This project explores using acoustic metamaterials to manipulate sound wave propagation for noise reduction applications.

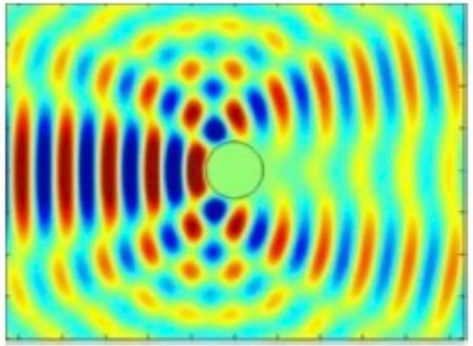
Acoustic metamaterials are artificially fabricated materials designed to manipulate sound wave propagation resulting in wave transformation behavior's that are not normally observed in naturally occurring materials.

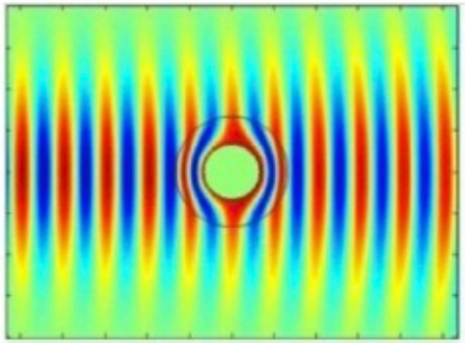
A metamaterial is constructed using periodic (or non-periodic) structural objects called "unit cells" that are embedded within the metamaterial itself.

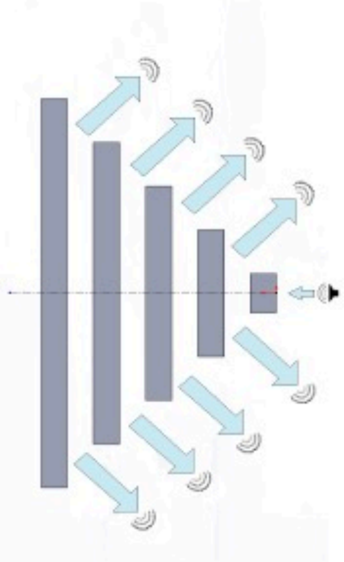
The individual unit cells have mass density and bulk modulus material parameters. These parameters can be manipulated through different unit cell construction characteristics.

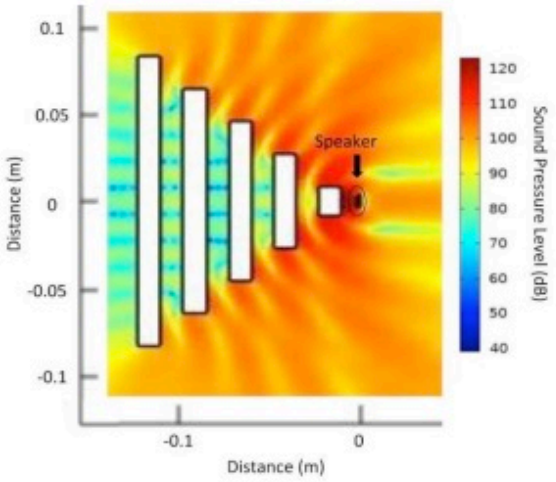
FEA modeling in COMSOL will be used to explore these construction characteristics resulting in unique sound wave propagation. The construction characteristics are:

- unit cell materials
- unit cell geometry
- unit cell orientation or structures









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Projects from Jabil

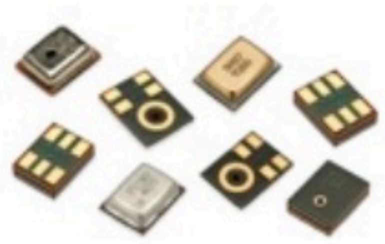
https://www.jabil.com/

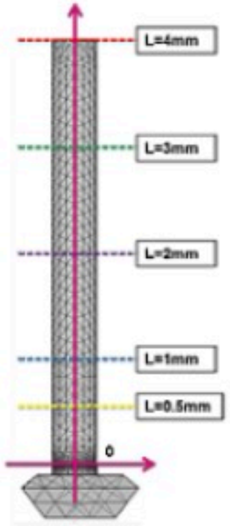
Project Topic: Microphone integration into Smart Products

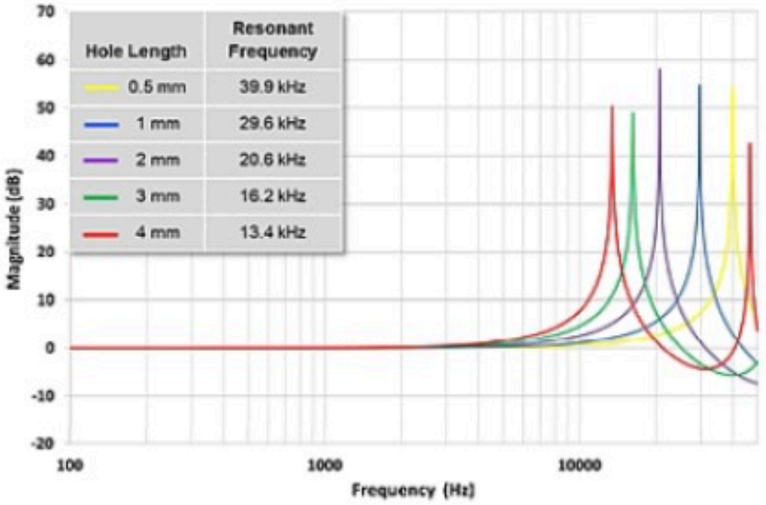
Summary: This project explores the effect of mounting (or integrating) a MEM's type microphone (or microphone array) into a mechanical enclosure (or structure) such as those used in smart speakers and wearables. The different materials and geometries used for this integration process shifts the inherent Helmholtz resonance of the overall system. This shift in resonant frequency effects the perceived sound quality and voice control algorithm performance.

FEA modeling in COMSOL will be used to explore the following integration characteristics on system performance:

- Port hole dimensions
  - Shape
  - length and diameter
- Gasket materials
  - Air leaks
  - Permeability (open cell vs. closed cell)
  - Compression
- Mesh material
  - Ingress ratings
  - Acoustic impedance







feruza.amirkulova@sjsu.edu

Proposed topics by F. Amirkulova

1. Acoustic wave propagation manipulation
2. Microphone integration into smart products
3. Active and passive control of waves

3. Inverse design of Metamaterials and Meta-devices using Optimization, Deep Learning and Reinforcement Learning

- Inverse Design of Acoustic lens using Generative Neural Networks (WGAN, VAE, and GAN-VAE)

  Design of Metamaterials Using Gradient Based Optimization Algorithms, Deep Learning (DL), and Reinforcement Learning(RL)

  - Design of Metaclusters for Passive Control Of Acoustic and Waves (sound/vibration control) (DL,RL)
  - Design of Multipole Clusters for Active Control Of Acoustic, Elastic, and Flexural Waves (DL,RL)
  - Inverse design of 3D Volume Sound Diffusers using neural networks (DL,RL)
  - Inverse design of 3D multilayered metamaterials using Deep Learning (DL) (DL,RL, recurrent neural networks)
  - Inverse design of 2D multilayered metamaterials using Deep Learning (DL)(DL,RL, recurrent neural networks)
  - Inverse design of 3D multilayered metamaterials using gradient based optimization

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

5. Manufacturing of Metamaterials and Metaclusters using selective laser melting (SLM) metal additive manufacturing system and testing performance of metastructures.

6. Investigation of human directional hearing in a semi-anechoic environment

7. Develop novel innovative techniques for design of hearing aids using optimization, and artificial intelligence algorithms, including deep learning, reinforcement learning, and generative modeling

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Potential MS Projects for 2021-2022

Burford Furman

burford.furman@sjsu.edu

Potential MS Projects for 2021-2022

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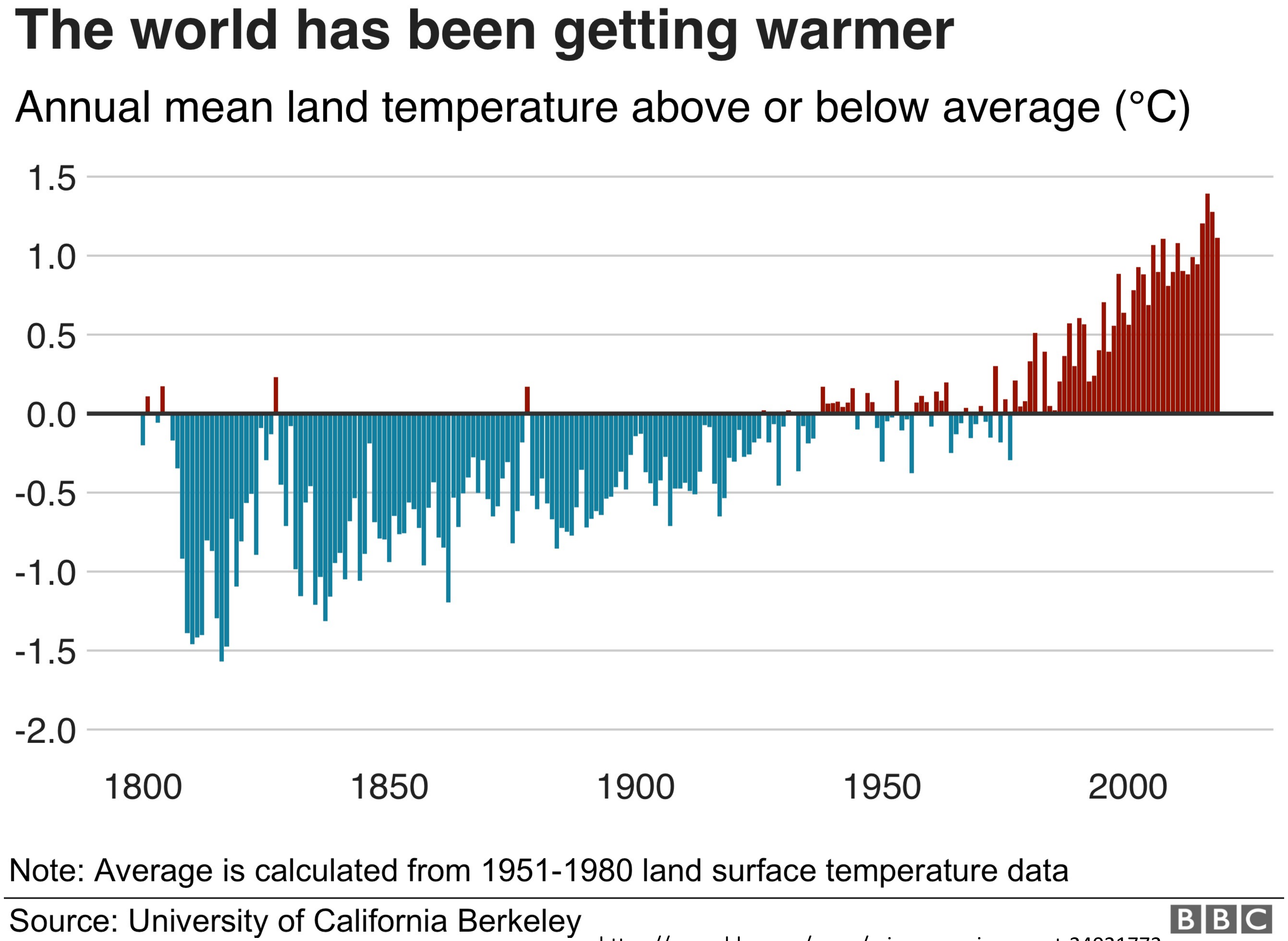
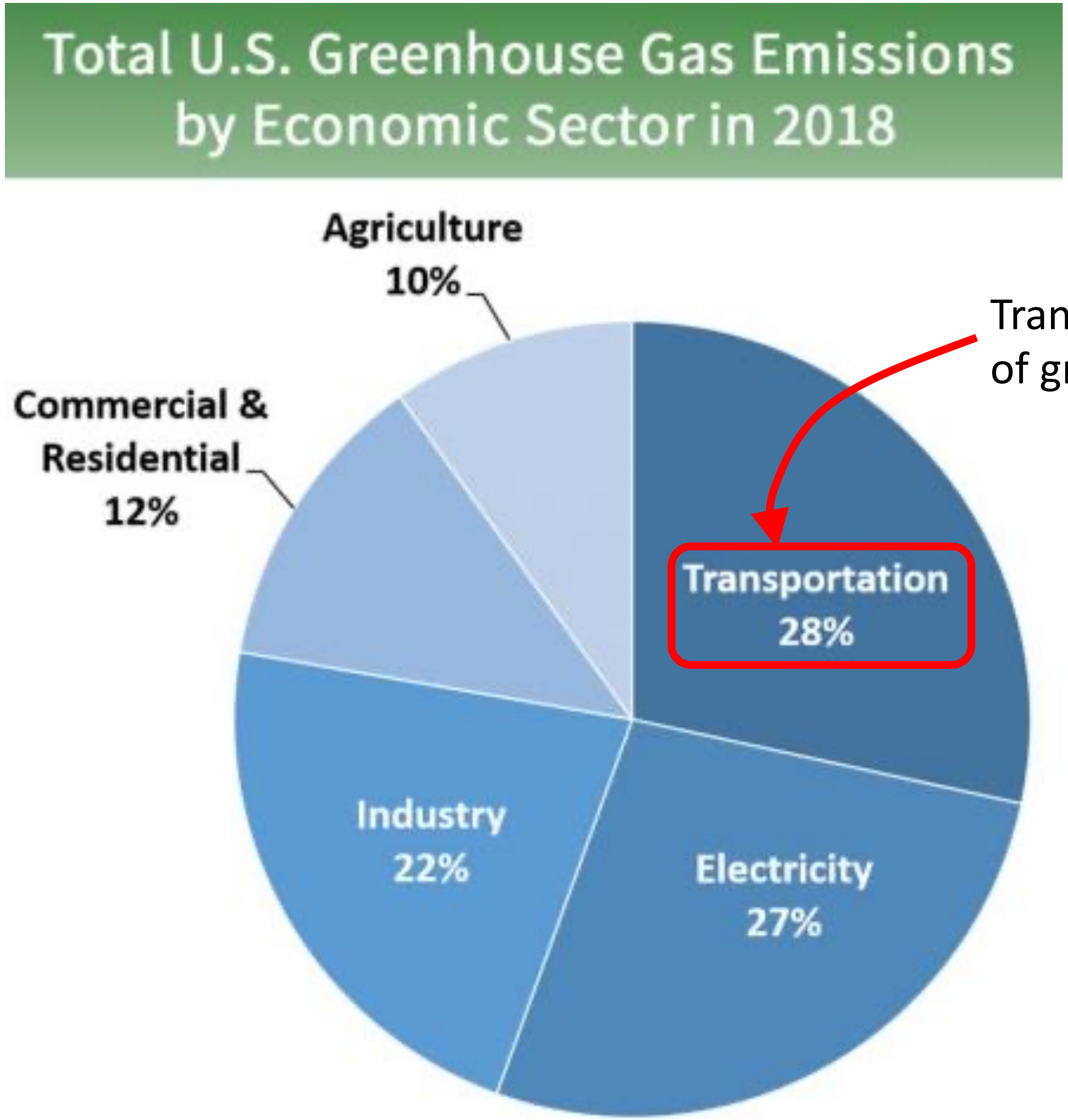
We are focused on major problems with the current mobility paradigm



https://www.bbc.com/news/science-environment-24021772

We are focused on major problems with the current mobility paradigm



Transportation is the largest source of greenhouse gas emissions

https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

We are focused on major problems with the current mobility paradigm

Our transportation system is harmful to human life

http://bit.ly/3oA2swl

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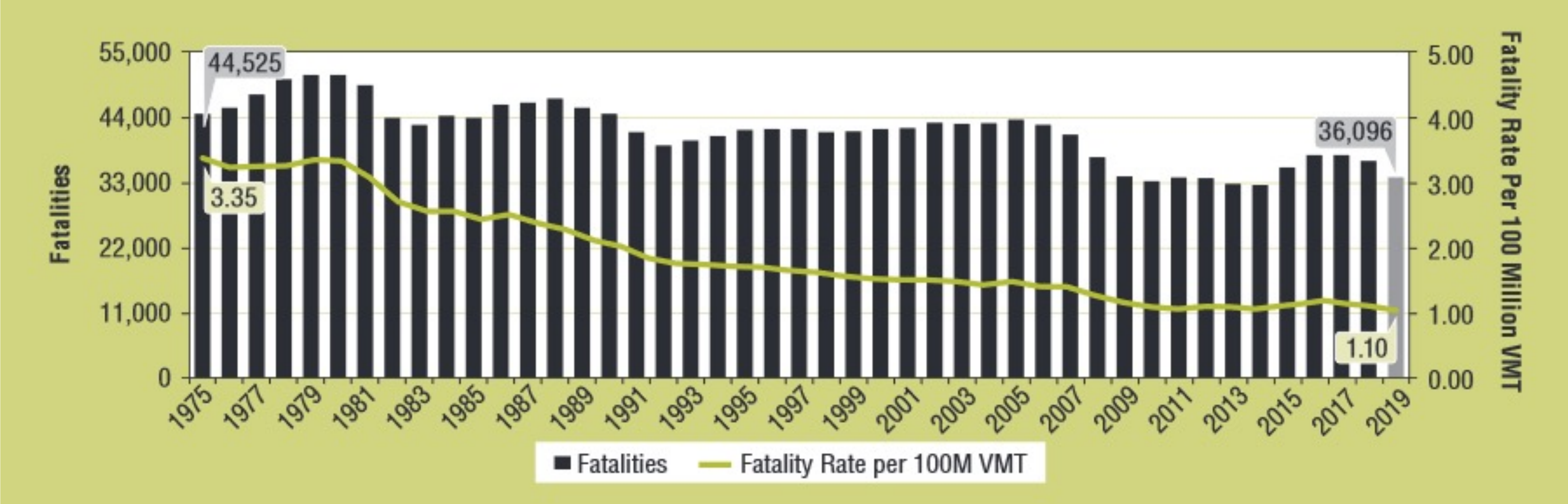
Our transportation system is harmful to human life



https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813060

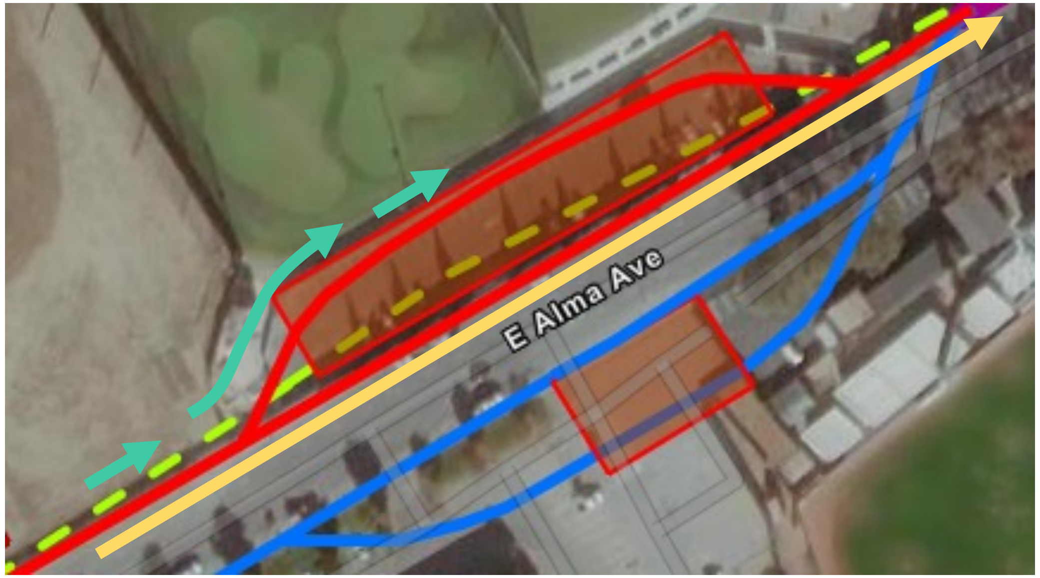
We are focused on major problems with the current mobility paradigm

Our transportation system does not lead to human flourshing

http://lat.ms/3j7geWh

The SPARTAN Superway is a new paradigm for truly *sustainable* urban mobility

- Grade-separated guideway with solar PV panels
- Utilizes existing vehicular rights-of-ways (ROWs)
- Suspended driverless vehicles
- Off-line stations
- On-demand scheduling



Source: Jpods.com

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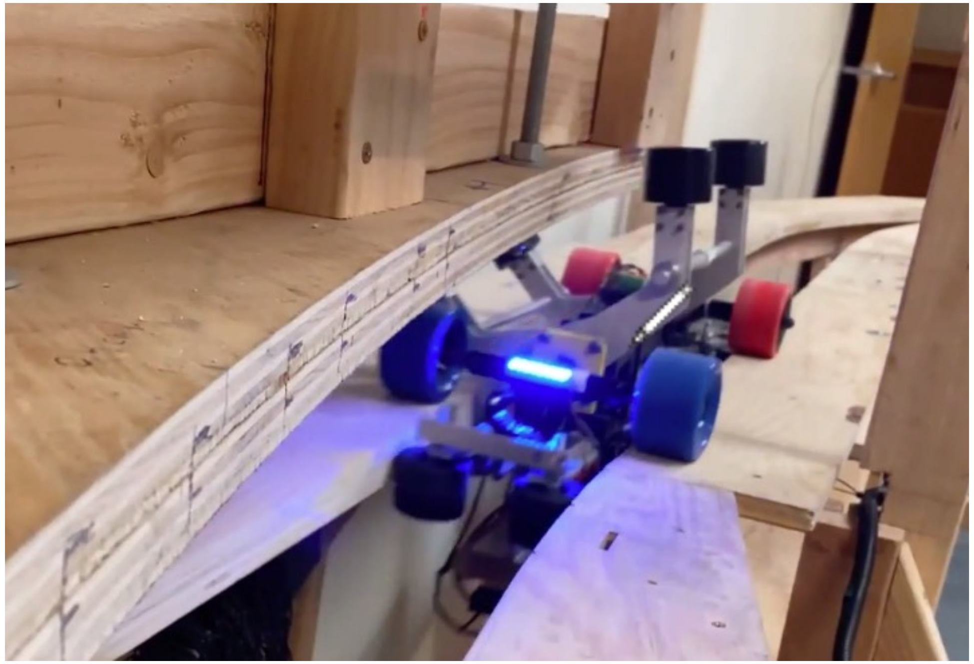
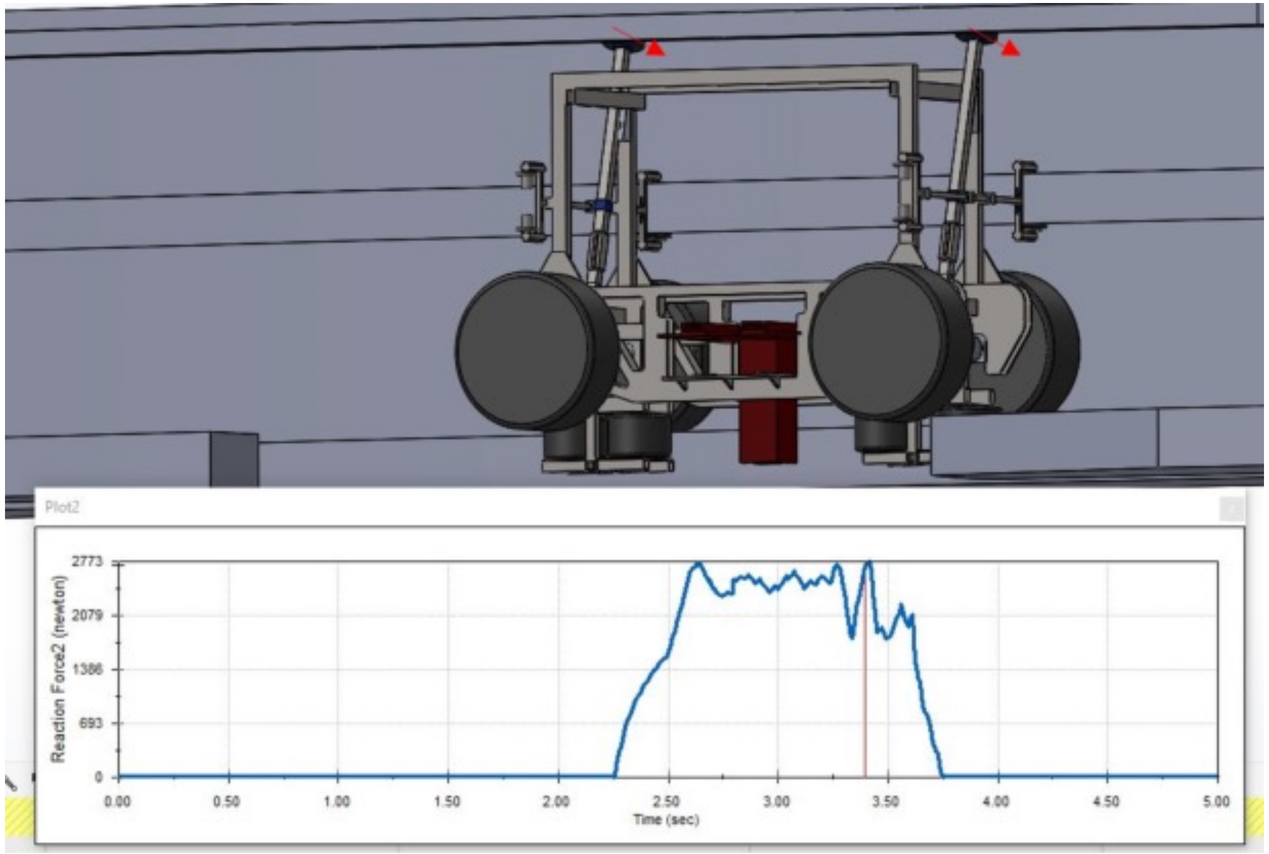
- Bogie switching mechanism design and analysis





Mohammed Owais Saiyed, MSME December 2020

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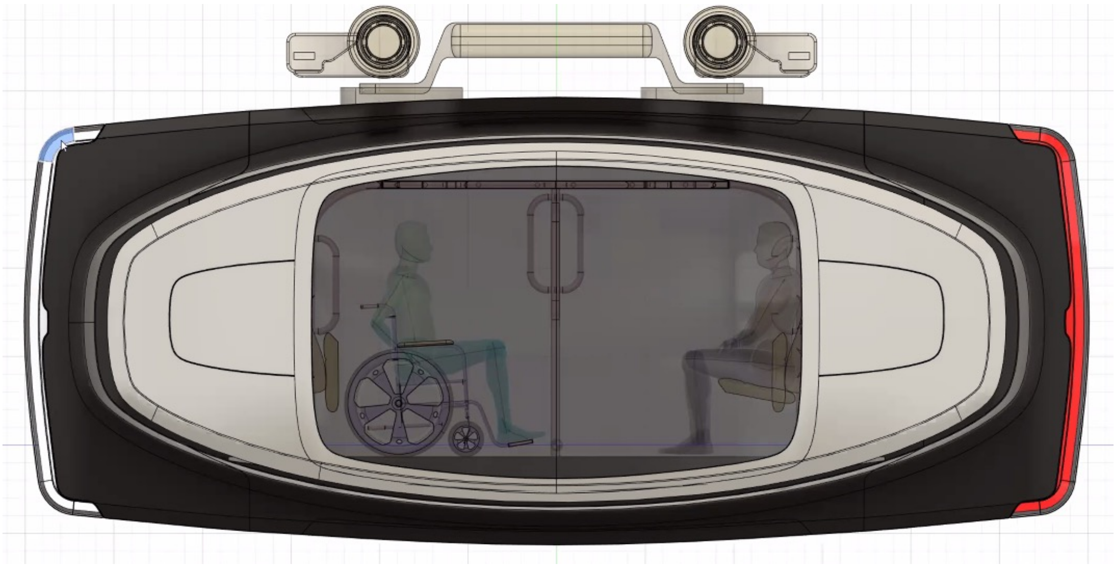

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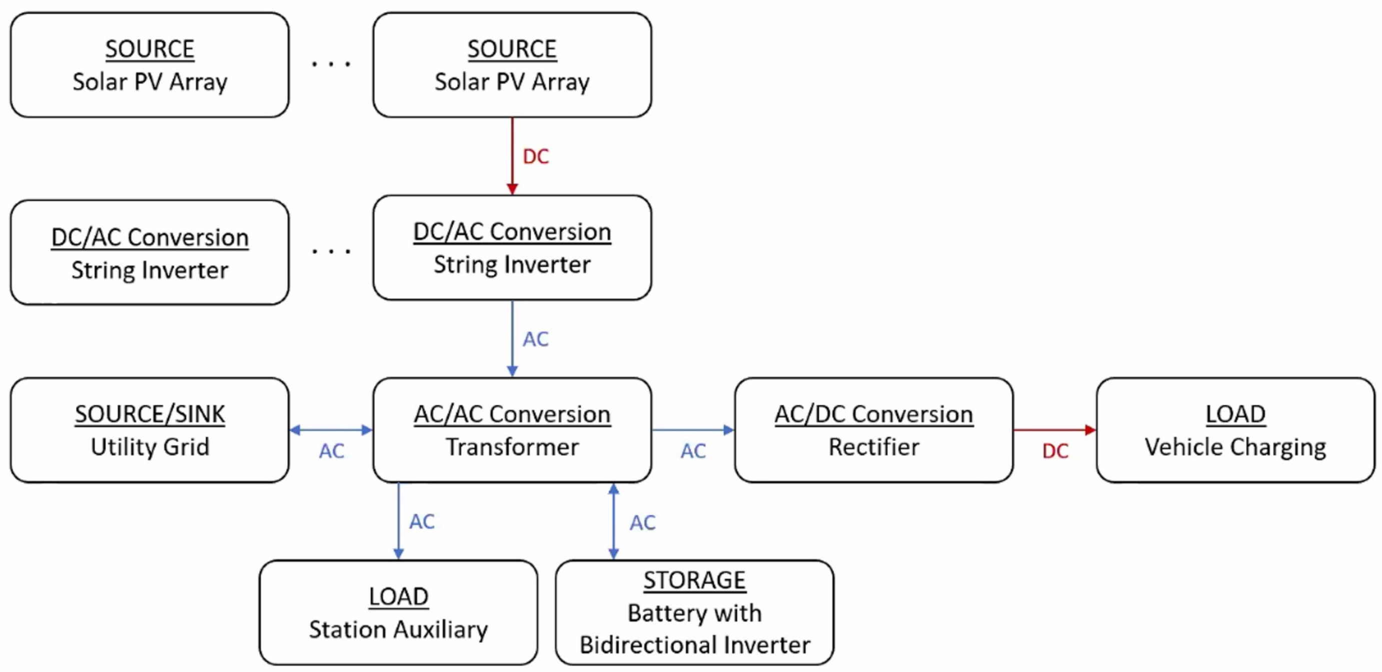

Jack Fogelquist, UC Davis, 2021

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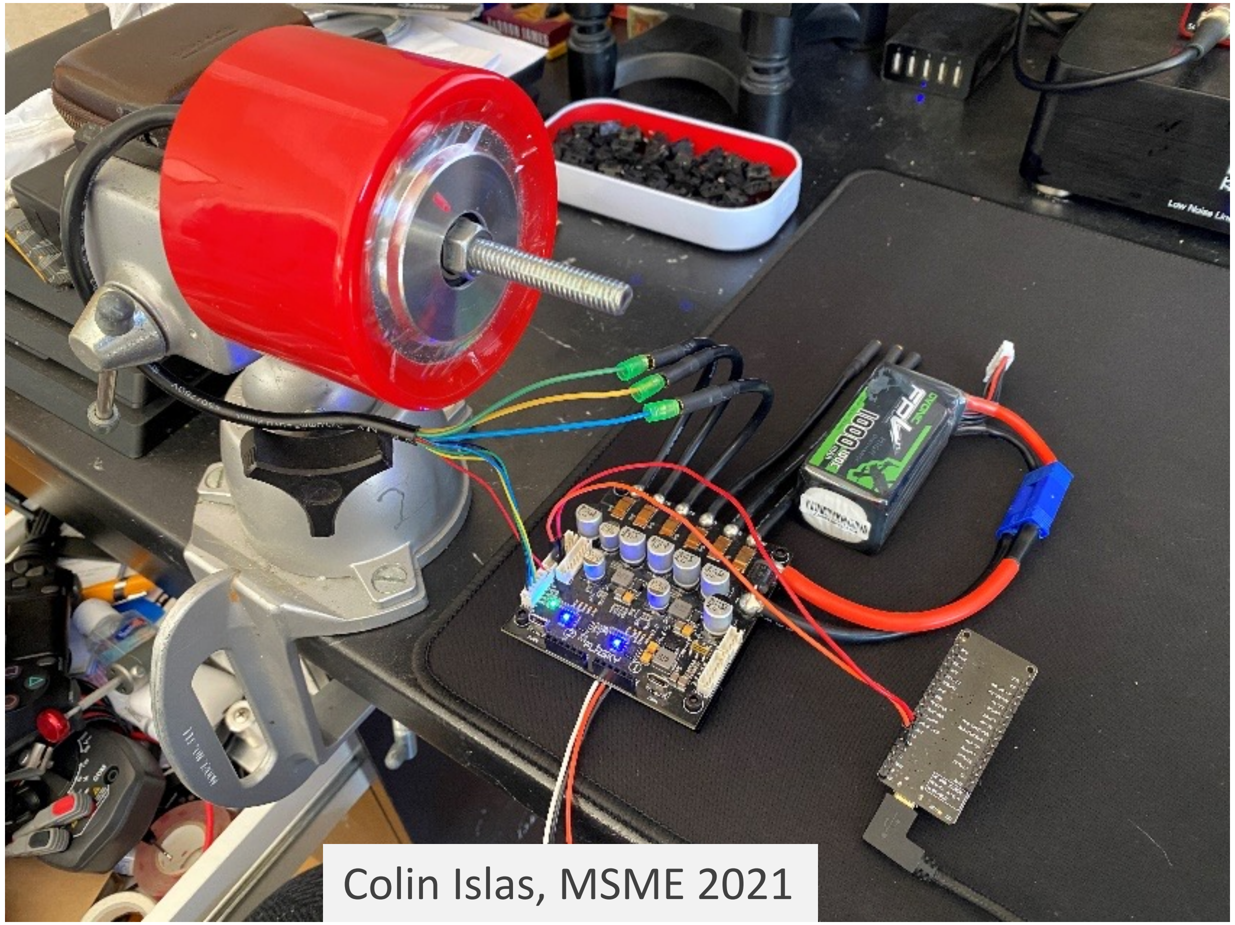
Colin Islas, MSME 2021

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- Automated wheelchair restraint system

Olivares, Sanchez, Turcios, 2017

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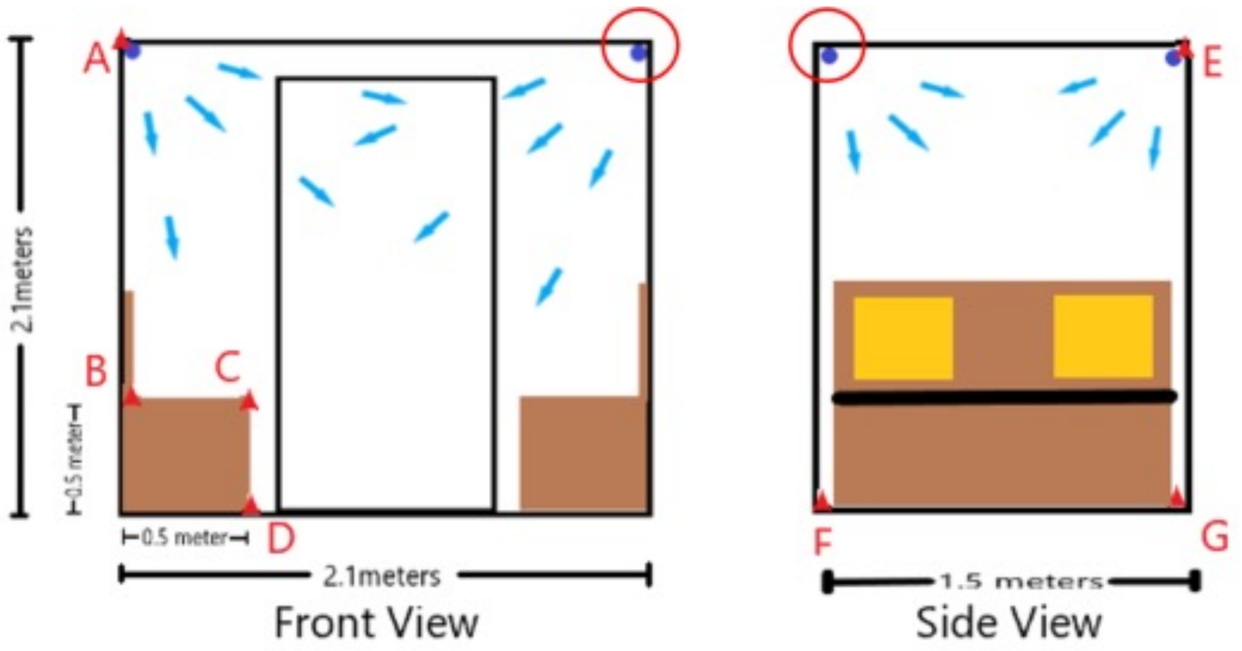

Fernando NgChie, MSME 2021

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Liwei Lu, MSME 2020

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- Rapid automated vehicle disinfection method
- Guideway fabrication and manufacturing automation
- N-S SJSU campus guideway design

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burford.furman@sjsu.edu

Available Project/Thesis Topics for Fall 2021

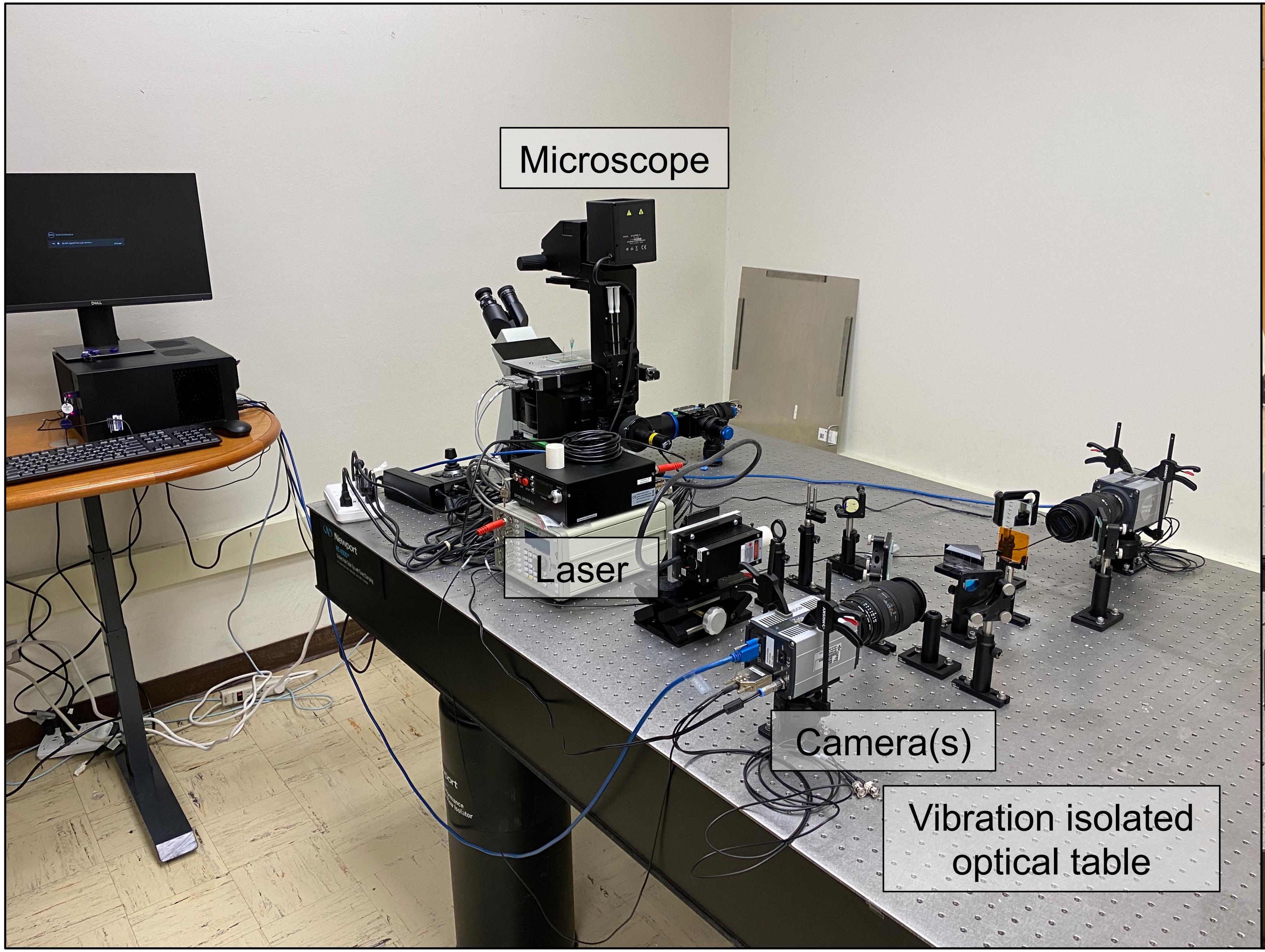
Farzan Kazemifar
Department of Mechanical Engineering
San José State University

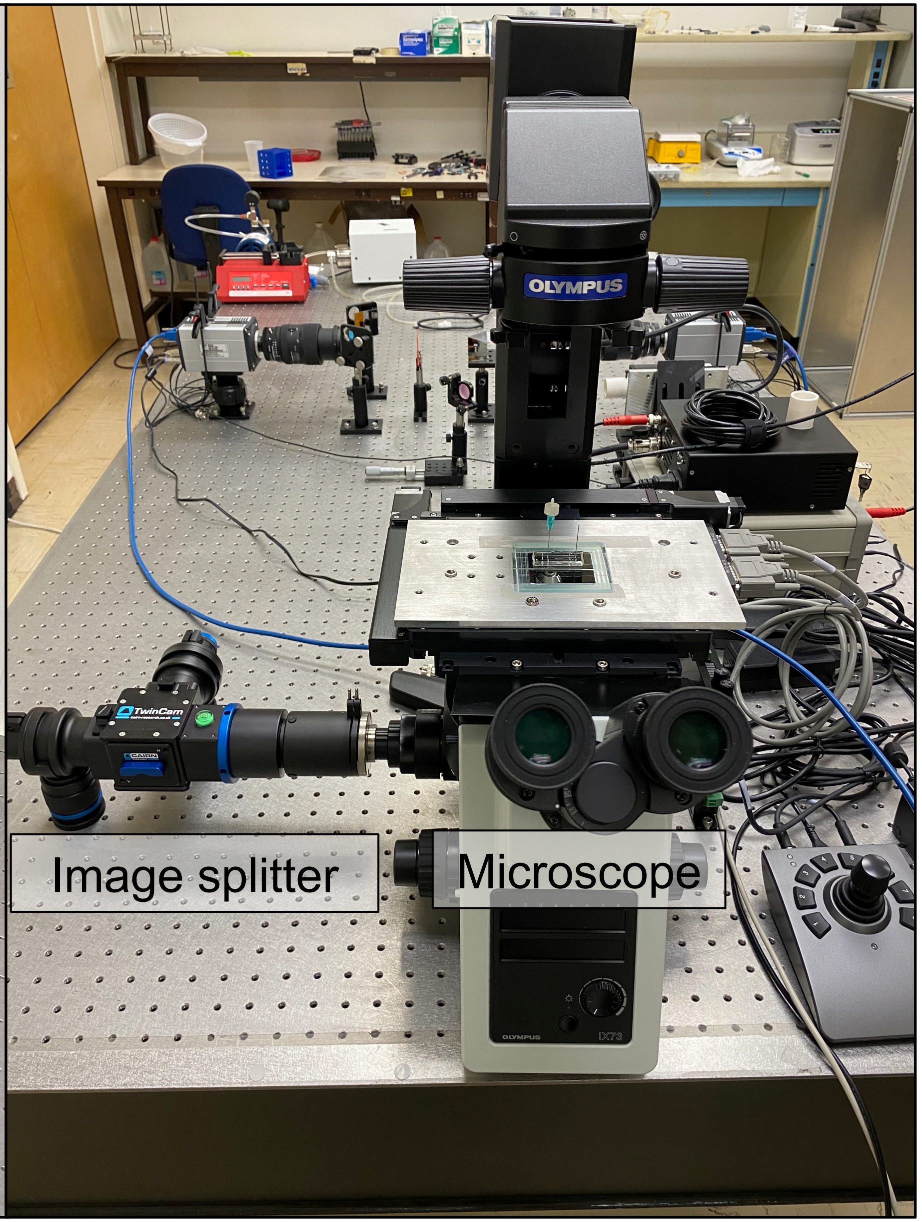
Project Initiation Meeting – April 2021

Energy, Environment and Multiphase Flow (EEMF)

- Lab website: https://sites.google.com/sjsu.edu/eemf
- Experiments & Simulations
- Optical and laser-based techniques to visualize flow and measure velocity, temperature, concentration, etc. in fluids
- Multi-phase flow and flow in porous media.
- Applications for energy and environment
  - Geothermal energy
  - CO_2 sequestration
  - Thermal energy storage
  - Thermal management

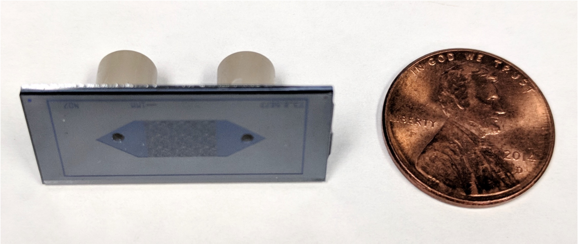
Energy, Environment and Multiphase Flow (EEMF)

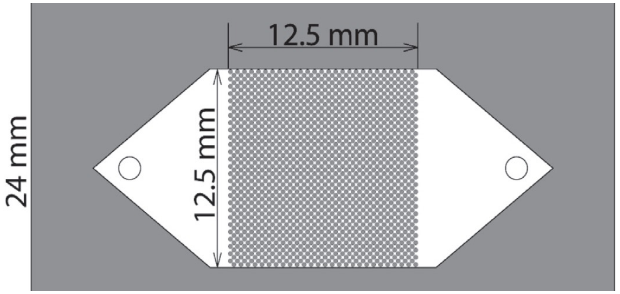


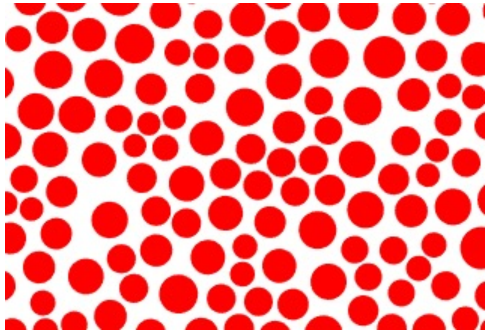


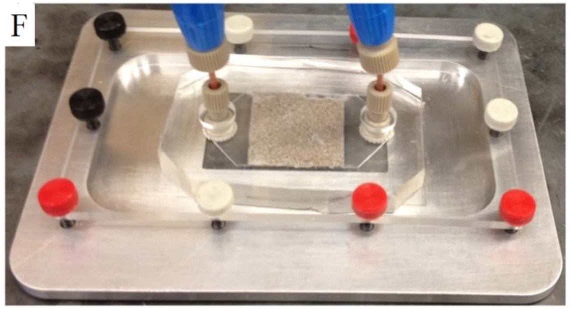
2D Idealized Porous Models with Optical Access

- Examples of Microfabricated devices called **micromodels**

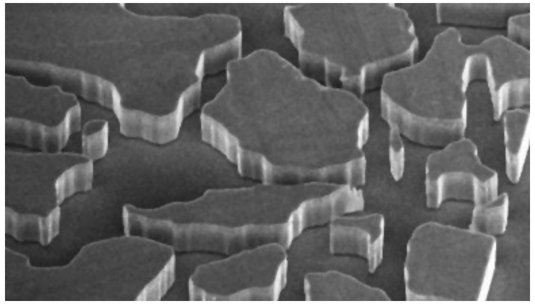








Singh et al.

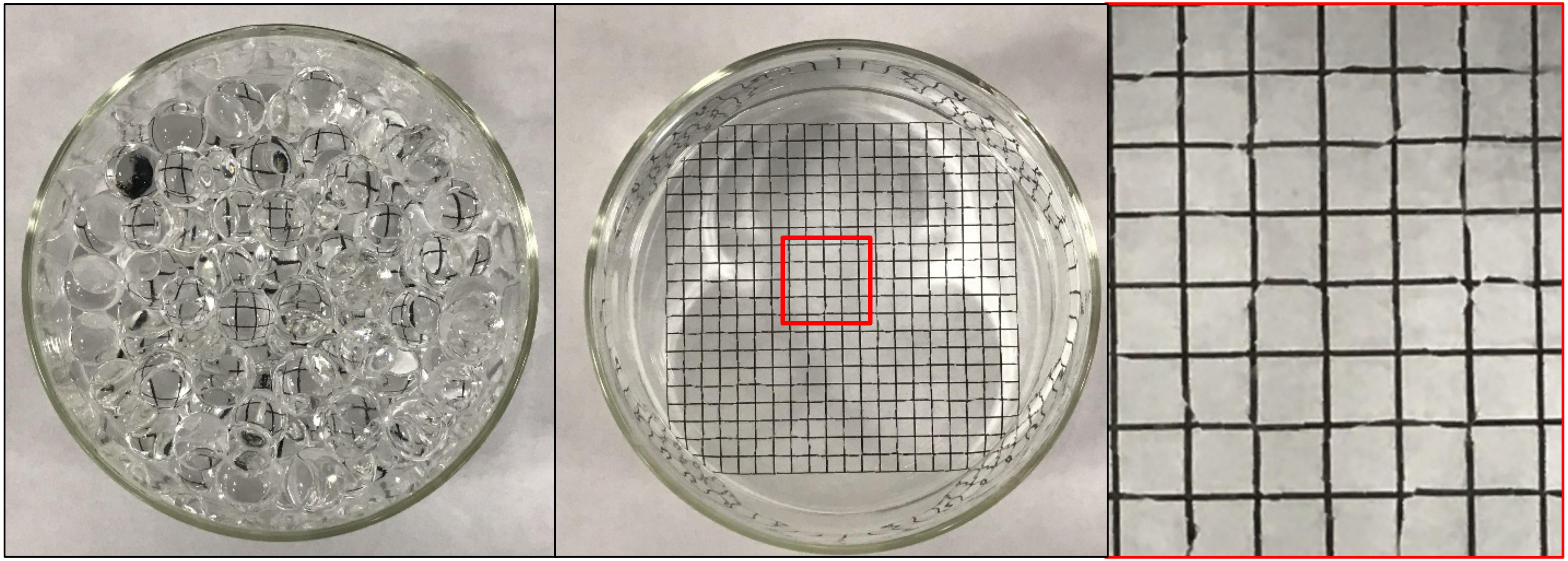


Li, Kazemifar, et al.

3D Transparent Porous Media

- Transparent beads/spheres submerged in a liquid with the same refractive index.

Example: Hydrogel Beads

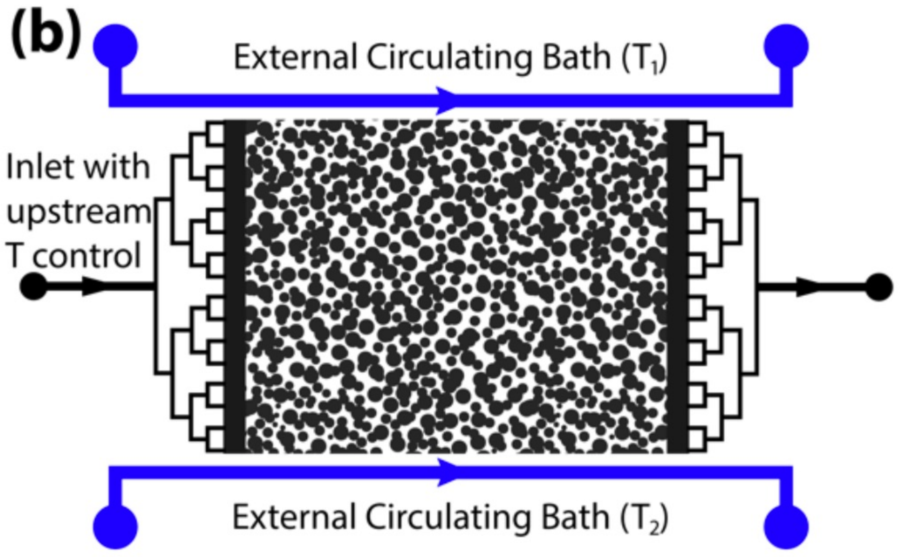


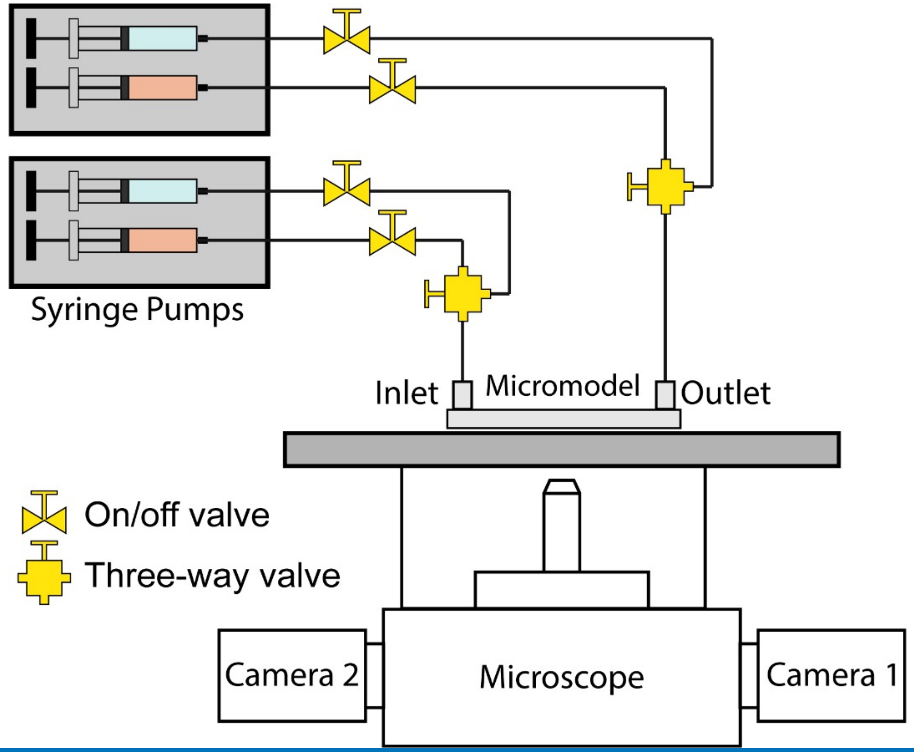
Hydrogel beads in air	Hydrogel beads in water	Zoomed in view

Available Projects

Flow and heat transfer in microchannels and porous media

1. Microscale temperature measurement using laser induced fluorescence
2. Velocity field measurement in microchannels using microscopic particle image velocimetry (micro-PIV)
3. Effect of surface roughness on flow and heat transfer in single and multi-phase porous media
4. Application of temperature sensitive paint (TSP) for temperature measurements



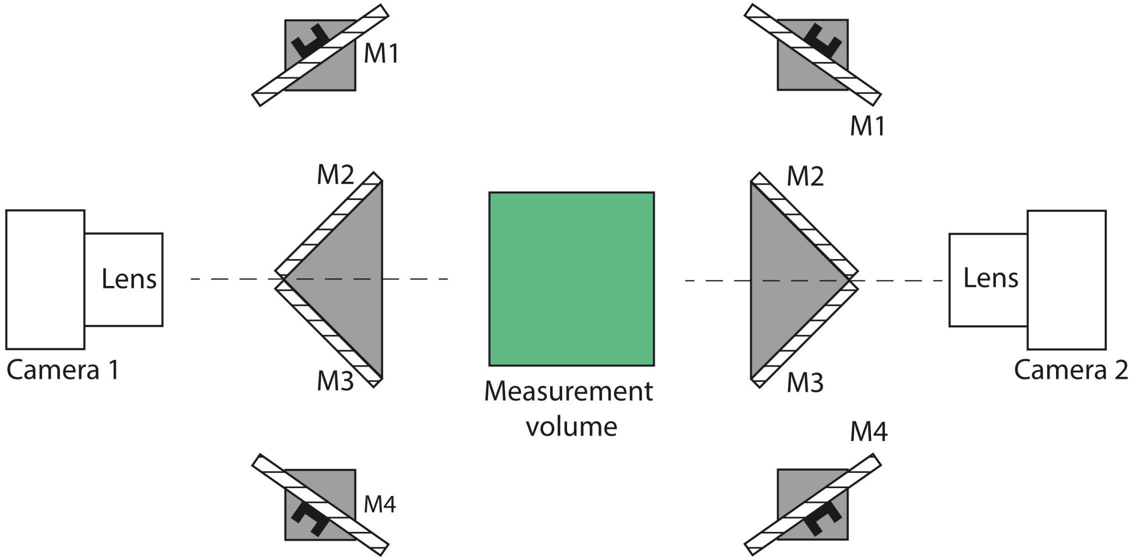


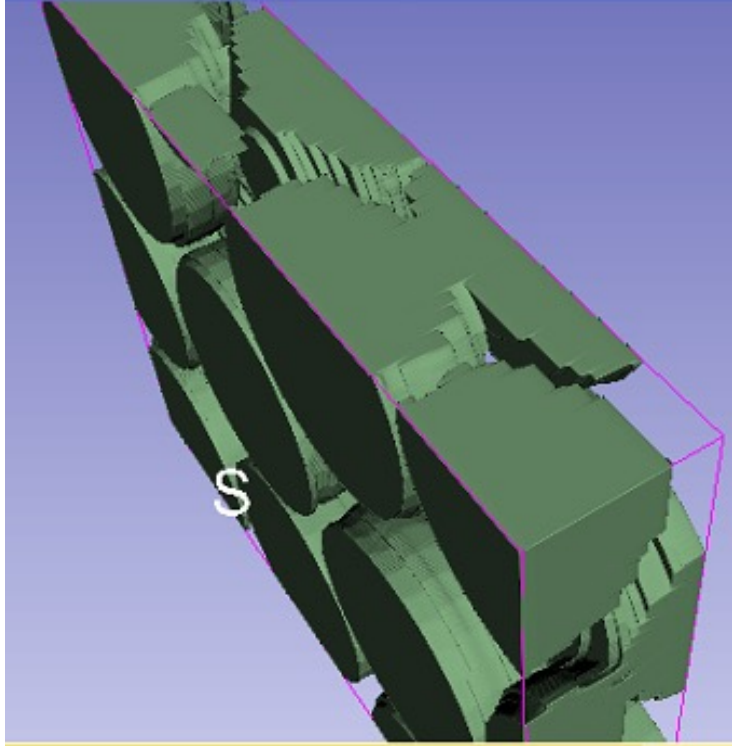
3D Particle Image Velocimetry in Porous Media

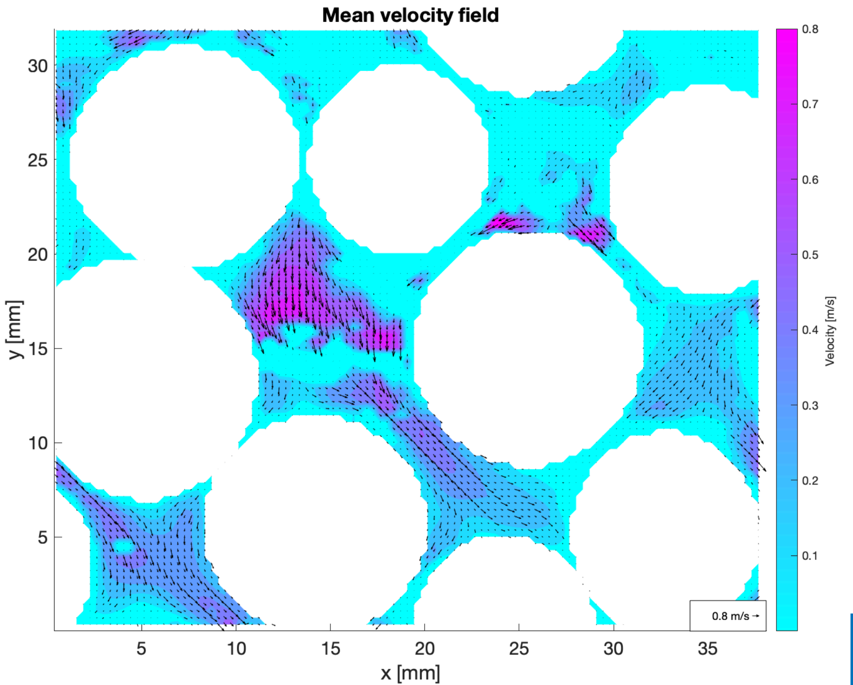
- Activities Involved
  - Image/data acquisition and analysis

Preferred experience and interest:

- Interest in fluid mechanics and/or heat transfer
- Hands-on lab/shop experience/interest.
- Programming: MATLAB and/or Python.







Joint Projects with Prof. Lee

- Design and fabrication of microfluidic device with an array of integrated pressure and temperature sensors.
  - Simulation (COMSOL), microfabrication, experiment.
  - Optical techniques, Pressure/Temperature sensitive paint (PSP/TSP), etc.

Other Projects

- Feel free to contact me if you have any project ideas related to energy systems that involve heat transfer and/or fluid flow.
- Phase change material for thermal management
- Thermal energy storage systems
- Hybrid renewable energy systems

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https://sites.google.com/sjsu.edu/eemf/