THE OSEL SUMMER RESEARCH PROGRAM PROJECT CATALOG

Summer 2023

This catalog provides details for the current summer research opportunities offered in OSEL.

Office of Science Engineering Laboratories (OSEL)
Center for Devices and Radiological Health (CDRH)
U.S. Food and Drug Administration (FDA)

I. Division of Applied Mechanics (DAM)

DAM, within OSEL, identifies and uses applied mechanics to investigate interactions between the human body and medical devices or radiation-emitting products.

(Figure 1)

Projects within DAM

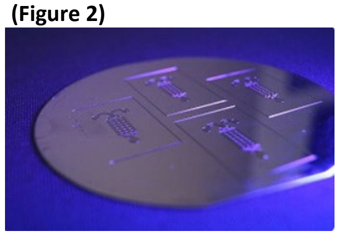
a. **Assessing Common Failure Mechanisms of Microfluidic Medical Devices**

Mentor: Rucha Natu, PhD

Project Description: The objective of this project is to investigate failure modes in microfluidic devices by conducting laboratory-based bench testing. The bench testing will aid FDA in developing simple test protocols for evaluating microfluidic devices. Issues related to bubble formation, fluid leakage, and clogging of microfluidic channels will be studied in this project. The intern will also study the effect of fabrication processes, materials, and surface wetting on microfluidic device quality and flow performance.

Specifically, the role of the intern will be to: This internship will introduce the student to basic laboratory safety procedures and provide them with hands-on laboratory experience. The student will be trained in the fabrication and testing of microfluidic devices. The intern will gain wet lab experience working with biological fluids and use precision pumps to carefully control the flow. The participant will collect pressure and flow data, analyze test results, and interpret their findings. The intern will also perform literature reviews to better understand common failure modes associated with microfluidic devices.

(Figure 2)



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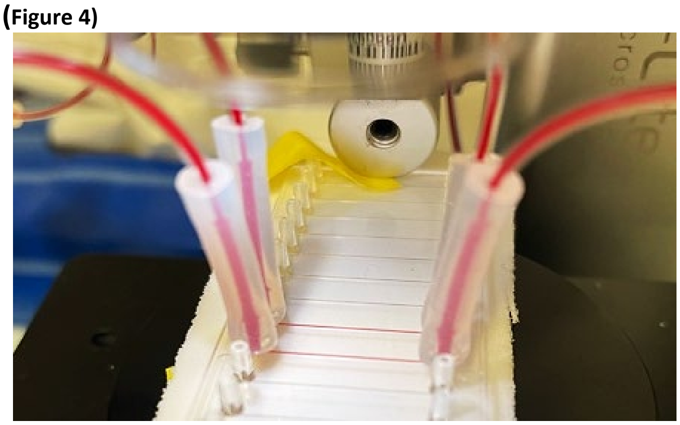


b. **Develop Methodologies for Evaluating Blood Compatibility of Medical Devices and Biomaterials.**

Mentor: Mehulkumar Patel

Project Description: Complications related to blood damage can occur in patients using blood-contacting medical devices such as catheters, ventricular assist devices, artificial heart valves, and extracorporeal circulation systems. The goal of this project is to develop bench test methods to better evaluate blood compatibility of blood-contacting medical devices and materials, with respective to potentials of platelet activation and blood clot formation.

Specifically, the role of the intern will be to: The intern will be involved in setting up and performing bench top experiments (blood flow loop system) using human and animal blood and characterize the extent of blood damage caused by different materials using various laboratory techniques such as spectrophotometry, microscopy, hematological analysis, and platelet activation assays. The intern will also involve in analyzing experimental results, perform statistical analyses, and summarize the test data. During this research project, the intern will receive broad biomedical research training in various aspects of engineering and biological testing.

(Figure 5)

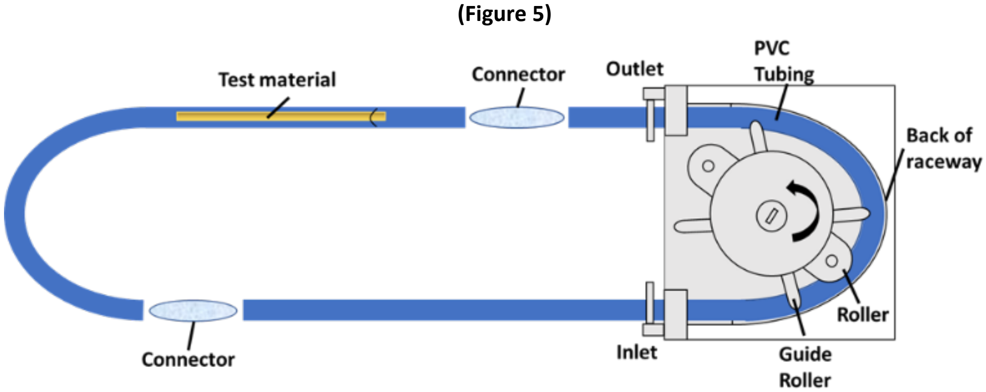


Figure 5: Experimental setup of a blood flow loop model. The dynamic flow loop is made of PVC tubing and contains a test material inside. Heparinized blood will be recirculated through the loop for 1 to 4 hrs. at room temperature, using a roller pump.

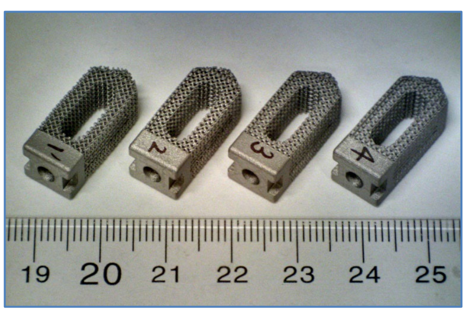
c. Evaluation of Additive Manufacturing Technology in Regulatory Science

Mentor: Additive Manufacturing Sub-Program

Project Description: The Additive Manufacturing (AM) sub-program in the Division of Applied Mechanics (DAM) is seeking up to three student interns to assist with researching AM technology. AM has become a major contributor to the production of medical devices. Many industry stakeholders leverage AM as a means of producing complex geometries that are beyond the capabilities of traditional wrought manufacturing methods. AM will continue to expand as a production method in the medical device space. Ensuring AM devices are as safe as their wrought counterparts will be critical to ensuring public health. This project will investigate the nuances of the AM process and assess the safety and effectiveness of AM products.

Specifically, the role of the intern will be to: The intern(s) will assist with the preparation, setup, running, and postprocessing of AM builds. Evaluate critical AM part features such as mechanical integrity, surface finish, chemical characterization, biocompatibility, and dimensional accuracy. Develop workflows and experiments for testing AM parts and processes. Design AM device coupons and measure variability. Interns will get exposure to several different AM build technologies including powder bed fusion, fused deposition modeling, and stereolithography.

(**Figure 6)**



(Figure 7)

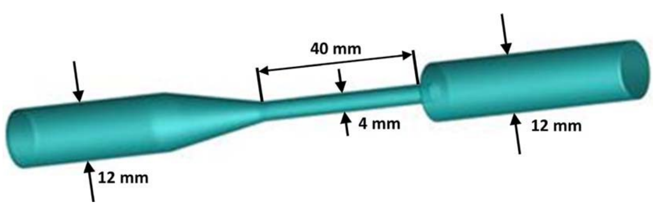
d. Evaluation of Damage to Red Blood Cells Caused by Medical Devices

Mentor: Richard Malinauskas, PhD

Project Description: Complications related to blood damage can occur in patients using blood-contacting medical devices such as catheters, ventricular assist devices, and artificial heart valves. The goal of this project is to improve bench test methods used to assess red blood cell damage in the evaluation of medical devices and blood-contacting materials. Improved test methods will lead to the development of safer medical devices.

Specifically, the role of the intern will be to: The intern will receive broad biomedical research training in various aspects of engineering and biological testing. The major tasks assigned to the intern will be to: 1) develop different engineering models for simulating physiologic blood flow through medical devices, 2) perform benchtop experiments using human and animal blood, 3) characterize the extent of blood damage using various laboratory techniques such as spectrophotometry, microscopy, and hematological analysis, and 4) analyze experimental results, perform statistical analyses, and summarize the test data in relation to what has been reported in the medical literature. A completed Hepatitis B vaccination record is required.

(Figure 8)



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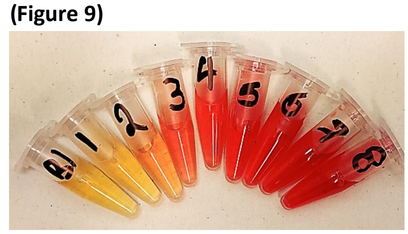


Figure 8: Example flow model used to assess red blood cell damage at different flow rates.
Figure 9: Hemoglobin, released from damaged red blood cells into the plasma as the flow rate increases, can be quantified using a spectrophotometer to assess the flow model.

e. **Using Mock Circulatory Loops to Evaluate Cardiovascular Devices**

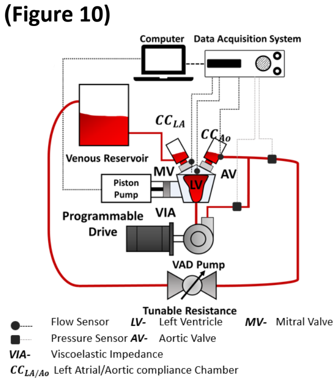
Mentor: Luke Herbertson, PhD

Project Description: Heart failure is a major cause of death in the United States. Cardiovascular devices can provide effective treatment options and help to improve patient outcomes. This project aims to better predict the flow performance of cardiovascular devices prior to clinical use by subjecting them to simulated critical disease conditions on the bench. A standard test protocol including data acquisition hardware and software, instrument calibrations, fluid properties, measured quantities of interest (i.e., cardiac and device pressures and flows), and data formatting techniques will be established using a mock circulatory loop. Key metrics for quantifying the flow performance of cardiovascular devices will be identified and characterized. The goal of this research is to improve cardiovascular device performance testing by developing well-defined, reproducible, bench test methods using mock circulatory loops to simulate different aspects of heart failure.

Specifically, the role of the intern will be to: We might need 1-2 interns to:

- Understand the different components of mock circulatory loops and their impact on system hemodynamics.
- Learn fabrication skills like CAD drawing, 3D printing, and silicone molding for making fluid-contacting parts.
- Apply basic fluid mechanics principles to understand cardiovascular flows.
- Gain wet lab experience by performing bench testing of cardiovascular medical devices.
- Use statistical analyses to characterize the reproducibility and sensitivity of the mock circulatory loop.
- Summarize real-world evidence from peer-reviewed literature to correlate bench test results to clinical outcomes.

(Figure 10)



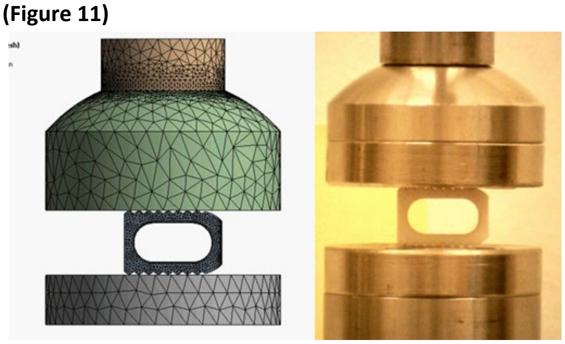
f. Orthopaedic Medical Device Research and Evaluation FDA/CDRH/OSEL/DAM

Mentor: Orthopaedic Sub-Program

Project Description: The Orthopaedics sub-program in the Division of Applied Mechanics (DAM) is seeking up to three student interns to assist with researching orthopaedic medical device technology. Orthopaedics is a broad medical space encompassing many different device types and technologies. The medical devices as well as the tools used to evaluate them are continually evolving as industry stakeholders develop new and innovative products. The Orthopaedics sub-program researches and develops ways to ensure medical devices are safe and effective for public use.

Specifically, the role of the intern will be to: The intern(s) may assist with many facets of orthopaedic device research. This can include designing test coupons, developing experimental workflows, setting up and running experiments, running simulations, analyzing data, reviewing literature, and troubleshooting processes. Orthopaedic devices being investigated may include bone screws, bone plates, spinal implants, as well as hip, knee, and shoulder arthroplasty devices. Interns may use load frames, imaging systems, high-performance computers, material testers, and other specialized equipment during their research experience.

(Figure 11)



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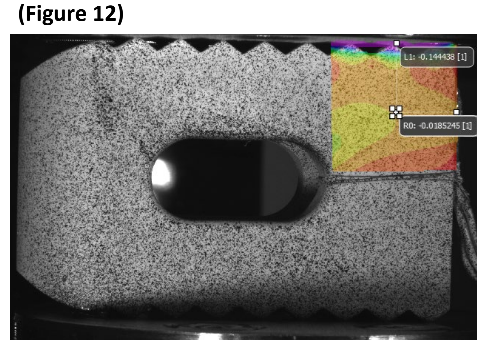


g. **Development of Regulatory Science Tools for Therapeutic Ultrasound Devices**

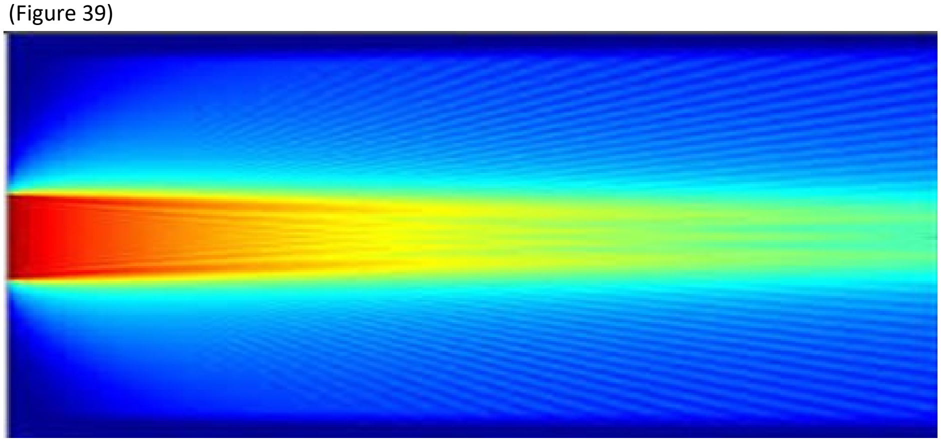
Mentor/Supervisor: Genevieve McRae, PhD

Project Description: We are working on various projects related to therapeutic ultrasound devices with a focus on the following regulatory science research areas:

- Techniques to understand the reliability and repeatability of hydrophone High-Intensity therapeutic ultrasound (HITU) characterization.
- Methods for correcting for the effects of spatial averaging in hydrophone measurements of HITU pressure fields and acoustic radiation force impulse.
- Measurement of ultrasound power accurately over all frequencies of regulatory interest.
- Ultrasound-compatible matrix materials and microfluidic design for growing cells capable of contrast injection and flow.
- Ultrasound-compatible, optically transparent, three-dimensional in vitro BBB "lab-on-a-chip."

Technical Needs: We are seeking 2-3 summer interns to assist with various projects. To best suit our needs, we are looking for students with education in mechanical, biomedical, or electrical engineering, acoustics, physics, or applied mathematics with biomedical-specific training or interest. In addition, students with coding skills using mathematical/scientific software (e.g., MATLAB) will be considered.

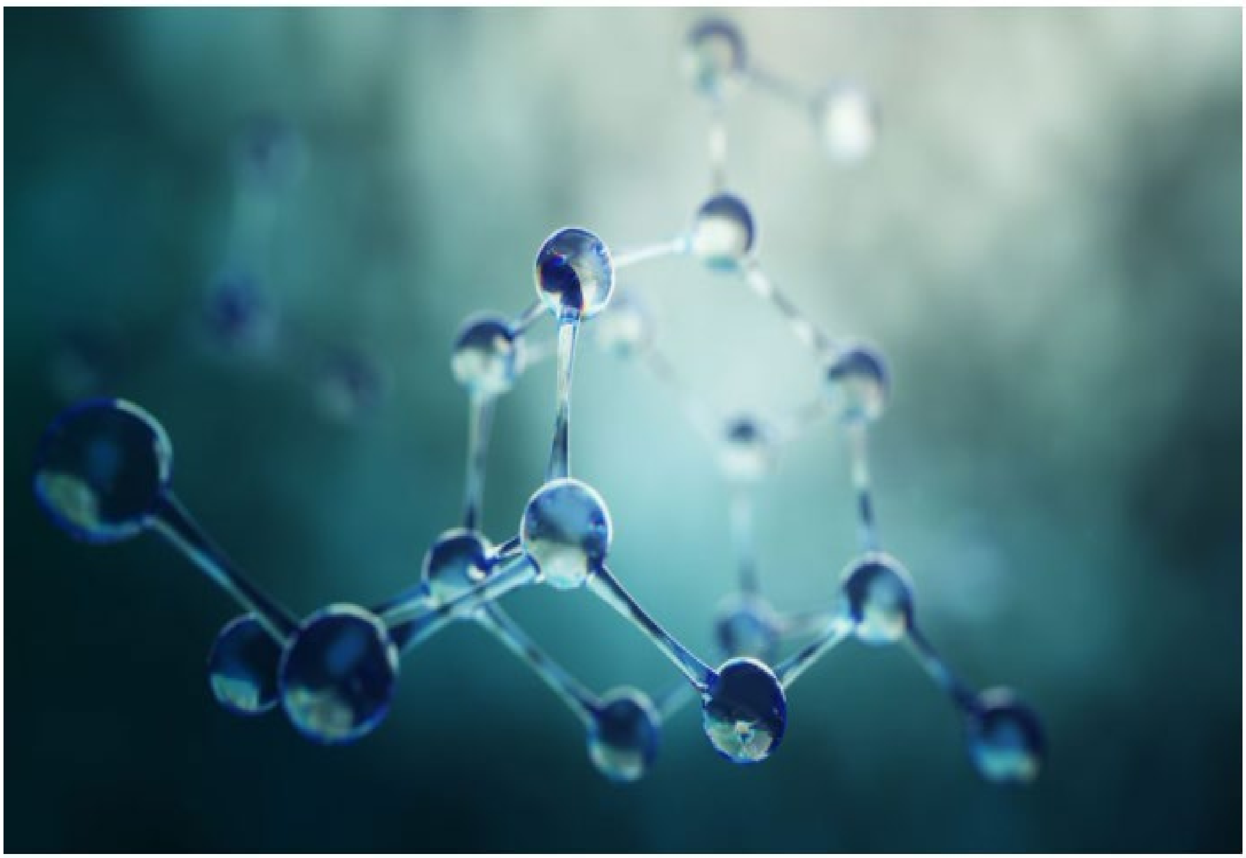
(Figure 39)



II. **The Division of Biology, Chemistry, and Materials Science (DBCMS)**

DBCMS, within OSEL, comprises wide-ranging expertise to address a host of issues stemming from molecular-level interactions between the human body and medical devices or radiation-emitting products.

(Figure 12)



Projects within DBCMS

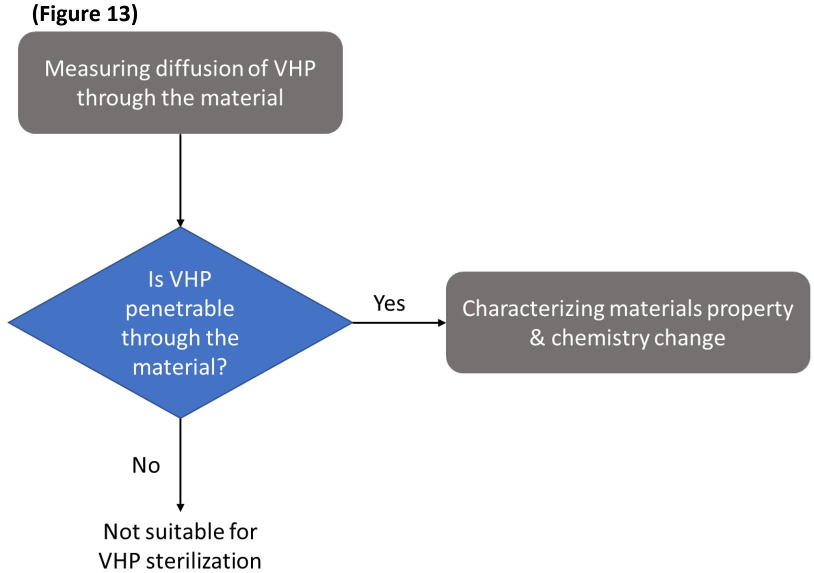
a. Advancing Alternative Sterilization Modalities for Medical Devices

Mentor: Yunzhi (Bonnie) Liu, Ph.D.

Project Description: This highly visible project is aimed to assist medical device manufacturers to transition their chemical sterilization approach away from ethylene oxide (EtO) to alternatives, as the increasing impact on medical device supply caused by increasing EtO sterilization facility closures.
This project is focused on one of the most promising alternative modalities: vaporized hydrogen peroxide (VHP). The project has two aims: first to evaluate if and how fast VHP can penetrate through the materials (process feasibility), and second to evaluate the change of materials and chemistry after VHP penetration (risk assessment).
The outputs from this project will be included in the CDRH tools catalog which will help to assess the safety and effectiveness of sterilants used to process medical devices

Specifically, the role of the intern will be to: A student with the background in materials science/engineering, chemistry, or chemical engineering is preferred.
The student will participate in the diffusion measurement and the materials characterization. They will gain hands-on learning on instrument operation, as well as the corresponding data processing and analysis.

(Figure 13)



b. Advancing Chemical Characterization of Medical Devices

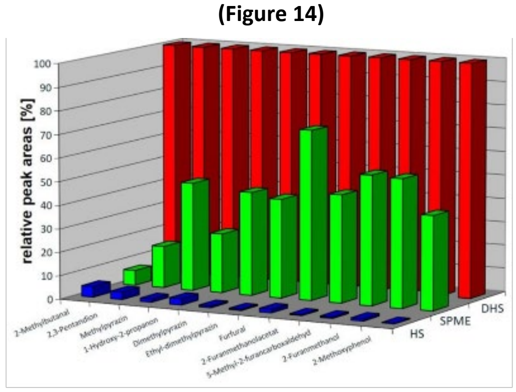
Mentor: Samanthi Wickramasekara

Project Description: Volatile extractables release from medical devices in use can possibly expose patients to the harmful levels of toxic compounds. These compounds need to be identified and quantified to support the toxicological risk assessment. Currently, static headspace gas chromatography -mass spectrometry (GC/MS) analysis is used as a supplementary technique for the analysis of volatiles from medical devices or material extracts. However, due to the large variation of chemical-to-chemical signal by static headspace, achieving the sensitivity necessary to support the toxicological risk assessment has become a substantial burden. We are exploring the possibility of using dynamic headspace GC/MS method as an alternative to detect these volatile from medical device extracts. Methods developed in this project will be included in CDRH tools catalog which will help to assess the safety and effectiveness of a medical device.

Specifically, the role of the intern will be to: A student with the background in analytical chemistry, biochemistry or chemical engineering is preferred. The student will gain hands-on experience in sample extraction, instrument operation, as well as the corresponding data processing and analysis. Student will have the opportunity to present their results at the FDA's summer student posted session at the end of their internship.

Goal of the Project: Development of standardized medical device sample processing methods to meet requirements of analytical thresholds in regulatory standards.

(Figure 14)



Relative quantification of commonly found volatiles using different analysis methods; HS-head space ; SPME-solid phase microextraction; DHS- dynamic head space

III. Division of Biomedical Physics (DBP)

DBP, within OSEL, participates in the Center's mission of protecting and promoting public health by identifying and investigating the biophysical interactions between medical devices and the human body.

(Figure 15)

Projects within DBP

a. **Developing a testing platform for assessing photoplethysmography (PPG)-based hemodynamic monitoring algorithms.**

OSEL Program: Patient Monitoring and Control

Mentor: : Masoud Farahmand, PhD Other OSEL staff involved: Christopher Scully, PhD

Goal of the Project: We are taking a regulatory science approach to develop complementary and alternative bench performance testing for PPG-based hemodynamic monitoring algorithms such PPG-based blood pressure and cardiac output monitoring algorithms. The student will help our team with bench testing, data collection and analysis.

Role of the Student:

- Perform a literature review on PPG phantom development and identify the requirements for developing this type of phantom
- Develop, design, prototype, and evaluate testing platforms including a mock flow loop (MCL) integrated with the PPG phantom
- Design test methods for evaluating PPG based hemodynamic algorithms using the MCL platform

Expectations with the Project:

- Participate in the development of regulatory science tools for testing PPG-based hemodynamic monitoring systems
- Contribute to peer-reviewed publication
- Gain experience with physiologic signal processing, instrumentation, and data acquisition.

Schematic diagram of the MCL platform for testing PPG-based hemodynamic monitoring algorithms

(Figure 16)

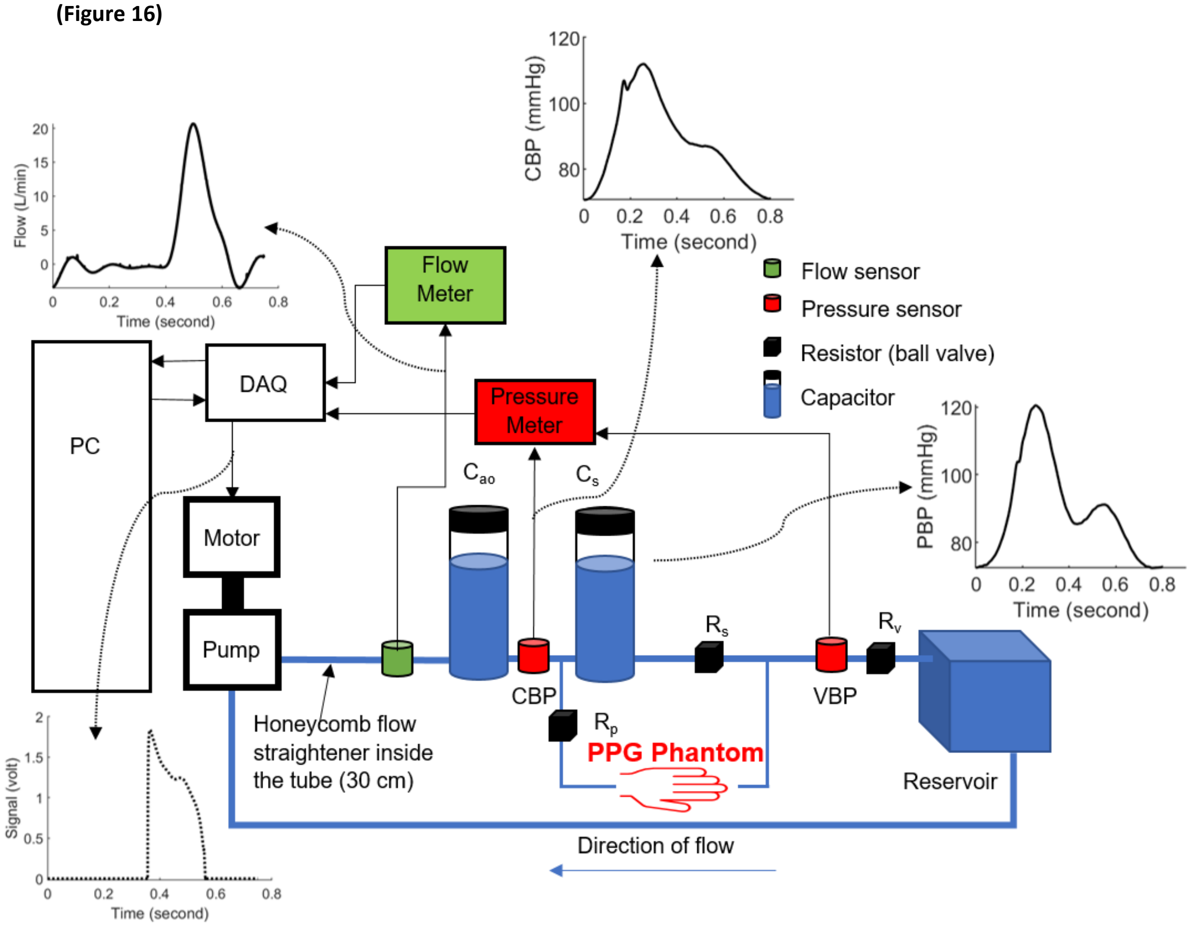


Figure 16: Schematic diagram of the mock circulation loop (MCL) integrated with a PPG phantom. CBP: Central blood pressure; PBP: Peripheral (radial) blood pressure; VBP: Venous blood pressure; Rs: Systemic resistance; Rp: peripheral radial resistance; Rv: Venous resistance; Cao: aortic compliance; Cs: Arterial compliance.

b. Evaluating the Impact of 5G Cellular Network Failure Modes on the Performance of 5G-enabled Medical Extended Reality (MXR) Applications .

OSEL Program: Electromagnetic and Electrical Safety Program

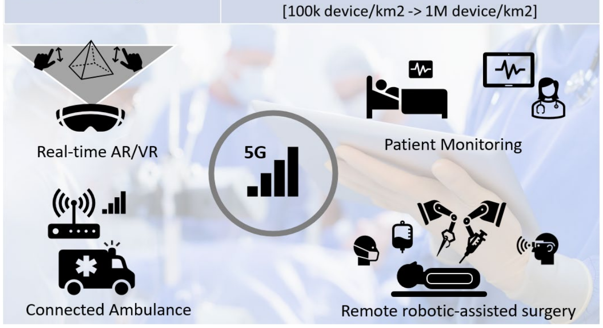
Mentor: Yongkang Liu, PhD

Project Description: The fifth generation (5G) mobile network enables novel use cases and applications in medical devices. At OSEL, our team has identified knowledge gaps in how 5G-enabled medical devices are implemented and evaluated. We are conducting regulatory science research to develop new testing tools and evaluation methods leveraging an in-house testing facility. Medical extended reality (MXR) applications are among the first to be reported in early deployments of 5G-enabled medical applications, which promises to extend MXR use to mobile and dense use-cases with high throughput and low latency 5G connectivity. In this project, we aim to measure and characterize the impact of 5G network disruptions on the quality of user experience in 5G-enabled MXR applications. We have characterized the traffic patterns of the MXR services and built an end-to-end, measurable 5G data path. We are looking for a student to help us investigate the MXR service performance degradation in representative 5G network failures using the collected data from our testbed.

Examples of 5G-enabled medical devices. (See Figure 17)

(Figure 17)

Key Performance Indicator	5G improves over 4G
Throughput (data rate)	10x increase [10 Mbps -> 100 Mbps]
Latency	10x reduction [10 ms -> 1 ms]
Connection Density	10x increase [100k device/km2 -> 1M device/km2]



5G testbed @ FDA

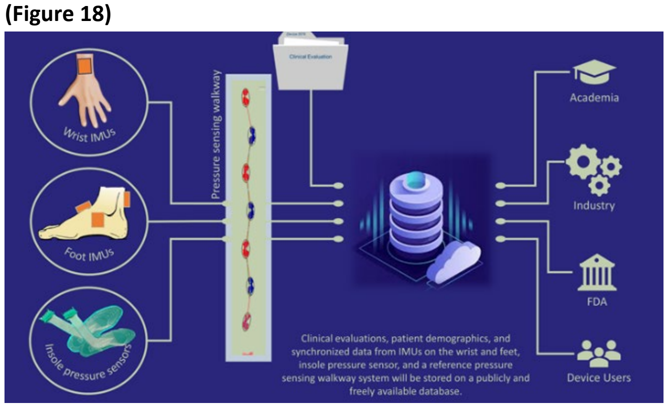
c. **Open-Access Database as a Tool for Development and Assessment of Novel Algorithms Deriving Gait Metrics through Wearables.**

Mentor: Kimberly Kontson, PhD, and Edward Nyman

Project Description: Interest in wearables as stand-alone medical devices to monitor changes in gait impairment and/or to assess the efficacy of therapeutic interventions is on the rise. HOWEVER, algorithms lack validation in large scale, independent studies. The main deliverable of this project is an open-access database of synchronized raw inertial measurement unit (IMUs), insole pressure sensor, and pressure sensing walkway data, and clinical information from individuals with Parkinson's Disease (PD) at various stages of the disease. This will benefit FDA and other stakeholders by providing a tool to independently validate algorithms used to support clinical endpoints and the means to identify novel digital biomarkers for PD.

Specifically, the role of the intern will be to: characterize wearable sensors for gait assessment and to curate a database of wearables data from individuals with Parkinson's Disease. Activities may include experimental design, experimental setup, data acquisition, writing MATLAB scripts for data analysis, and mastering the use of relevant lab instrumentation.
The learning objectives of this research appointment are to:
(1) learn about Parkinsonian gait and emerging technologies used to assess gait disorders,
(2) learn how to acquire and analyze data from various wearable sensor modalities,
(3) develop new or further develop skills related to human subject research protocol development and implementation, and
(4) develop communication, organizational, and other critical skills necessary for successful execution of a multi-site clinical study.

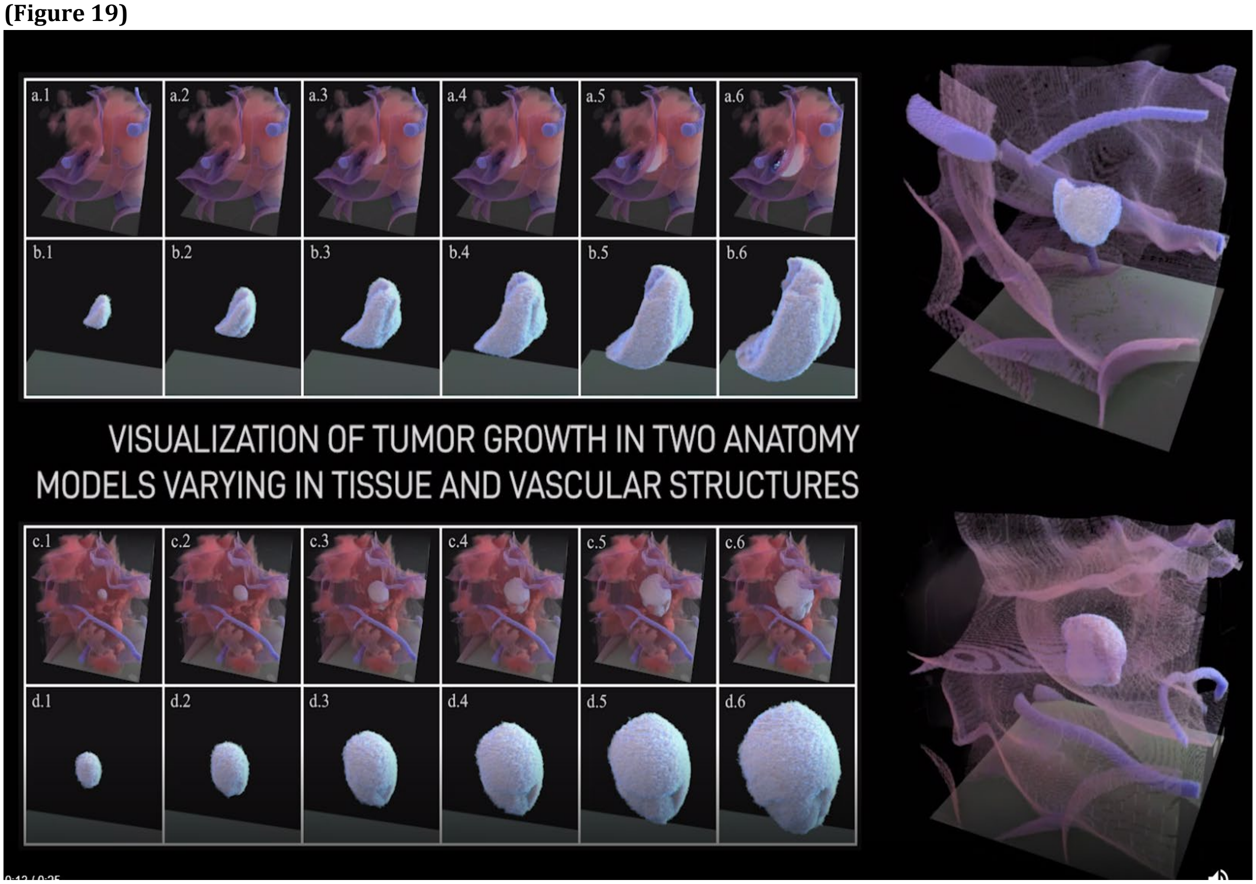
(Figure 18)



IV. The Division of Imaging, Diagnostics and Software Reliability (DIDSR)

DIDSR, within OSEL, develops methods for evaluating the image quality of emerging imaging systems; develops methods for characterizing new medical image display devices; evaluates the dose reduction potential of new image reconstruction methods and assesses the performance of Artificial Intelligence and Machine Learning algorithms. DIDSR also develops state-of-the-art methods for the design of clinical trials involving imaging devices and the evaluation of resulting trial data to enable more efficient and effective utilization of imaging data and more powerful clinical studies.

(Figure 19)



Projects within DIDSR

a. Confidence Interval for Balanced Accuracy

Artificial Intelligence and Machine Learning (AI/ML) Program

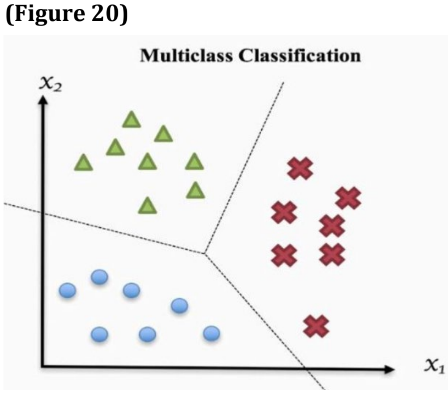
Mentor: Tingting Hu

Project Description: In this project, we will develop a statistical tool to measure the uncertainty associated with balanced accuracy, a performance evaluation metric for multi-class classification. Currently, for devices with multi-class classification functionalities, there is no widely acknowledged evaluation metric. Balanced accuracy is such a metric that may be used as a potential metric for comparing multi-class classifiers, while there is a gap in its interval estimate methodology.

Specifically, the role of the intern will be to:

- Perform literature review for candidate interval estimate methods for balanced accuracy.
- Assist in math derivation of score method or other method for balanced accuracy CI and verification.
- Assist in developing methods to quantify the uncertainty around balanced accuracy by simulation and real-data application (R, Python).
- Organize and present results

(Figure 20)



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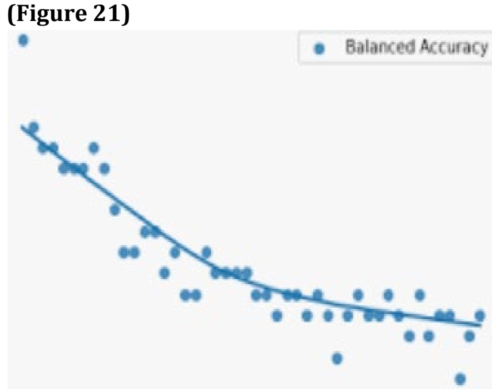


b. Assessment of Bone Health using Image Texture

Mentor: Qian Cao

Project Description: This project aims to assess bone quality using trabecular bone texture in computed tomography (CT) images. Currently, we have developed image processing pipelines for micro-CT images of trabecular bone, as well as finite element analysis and simulations of CT image quality. The participant will build upon these tools to evaluate the effectiveness of radiomics and deep learning-based texture features in predicting mechanical properties of bone in different acquisition conditions, with various noise texture and spatial resolution properties. The participant will contribute development of open-source software for bone texture analysis that will be submitted as RSTs.

The participant will be working with Qian Cao, Sriharsha Marupudi, Ravi Samala and Nicholas Petrick.

Specifically, the role of the intern will be to:

- The participant will review literature and learn about radiomics and deep learning models for medical image analysis.
- The participant will collect high-resolution images of trabecular bone core samples using micro-CT.
- The participant will perform finite element analysis to gain understanding of the structural mechanics of trabecular bone.
- The participant will develop machine learning models to predict the stiffness and other mechanical properties of trabecular bone samples in different simulated imaging conditions.
- The participant will contribute to open-source software tools developed as part of the project.

(Figure 22)

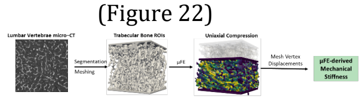


Figure 1 Mechanical analysis of trabecular bone

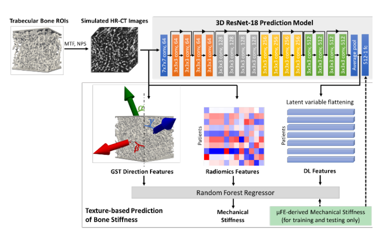


Figure 2 Texture features for the assessment of mechanical stiffness

c. **Develop methodology to evaluate wait-time-saving of a Computer-Aided Triage and Notification (CADt) device when used in conjunction with other CADt devices.**

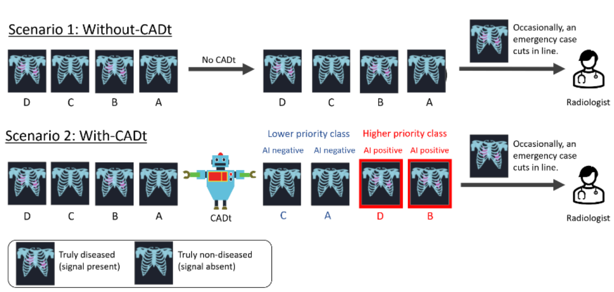
Mentor: Elim Thompson and Frank Samuelson

Project Description: The project goal is to extend current CADt software to evaluate wait-time-saving of a CADt device when used in conjunction with other CADt devices that triage different disease conditions in the same radiologist's reading queue. This work involves both simulation and theoretical computation based on queueing theory. The software will be publicly available in GitHub and be submitted as RST. The participant will be co-mentored by Elim and Frank.

Specifically, the role of the intern will be to:

- The participant will review existing literature in Operations Research and apply/modify existing techniques to calculate waiting time in a multi-AI scenario.
- The participant will learn Markov Chain-based queueing theory and the mathematical framework to calculate patient waiting time.
- The participant will gain understanding of Receiver Operating Characteristic (ROC) curve analysis.
- The participant will become proficient in python, especially in performing matrix manipulation and in using the queue packages.
- The participant will gain experience in using distributed processing with our OpenHPC cluster.

(Figure 23)



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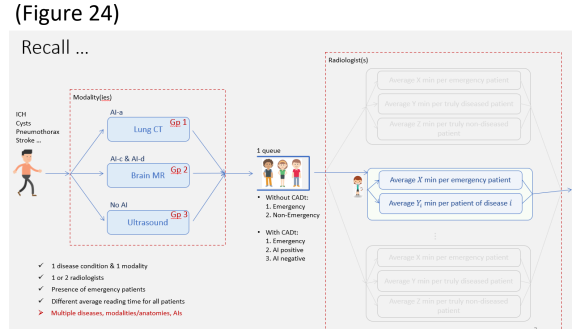


d. Develop interactive data visualizations and user interface to facilitate administrative tasks and consult reviews within the division.

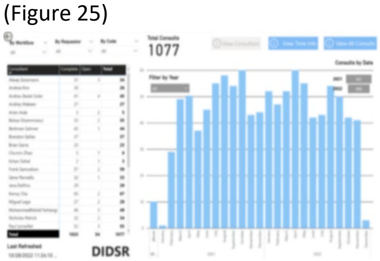
Mentor: Miguel Lago and Elim Thompson

Project Description: The project goal is to summarize and visualize data to support, automate, and facilitate administrative tasks and consult reviews within the division. This includes data mining from external and internal sources, enhancing existing visual reports and/or building new reports, and integrating/streamlining the reports within the division. The participant will be co-mentored by Miguel and Elim who will communicate with the management team for feedback and big picture ideas.

Specifically, the role of the intern will be to:

- The participant will become proficient in extracting data via web scrapping and from different formats such as APIs and PDF files. The participant will be encouraged to use python packages such as pandas, beautifulsoup, nltk, selenium, pdfminer, etc.
- The participant will gain experience in data mining from FDA public domains e.g. FDA releasable databases, openFDA API, and other publicly available documents (example).
- The participant will learn to design effective visual reports using MS PowerBI and gain experience in Python/R scripting, DAX syntax, and other PowerBI features.
- The participant will acquire skills in using other Microsoft 365 integrated tools such as PowerAutomate, SharePoint, etc.
- The participant will acquire a knowledge of how the FDA manages reviews of medical devices, including submission types, product codes, etc.

(Figure 25)



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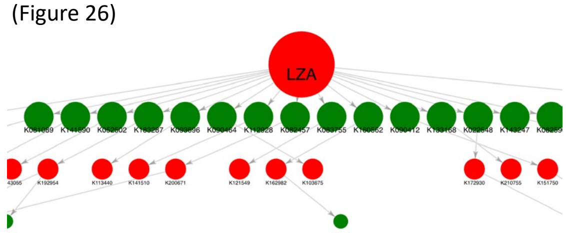


e. **Tool development for improvement and assessment of AI/ML generalizability in digital pathology**

Mentor: Seyed Kahaki, Arian Arab, Weijie Chen

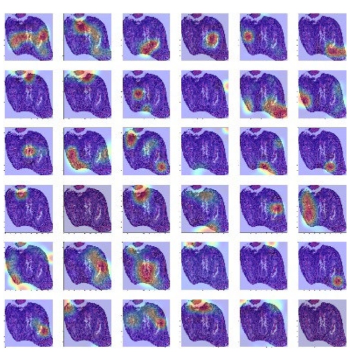
Project Description: This project aims to develop tools for the improvement and assessment of AI/ML generalizability in digital pathology applications. Specifically, we are developing tools to characterize and mitigate variations of whole slide imaging (WSI) data (color, resolution, etc.) across scanners and clinical sites and investigate how the mitigation of such variations impacts the performance of AI/ML algorithms in certain clinical tasks such as segmentation, classification, biomarker quantification, prediction of response to treatment.

Specifically, the role of the intern will be to:

- **Learn how to use software tools for image registration, color normalization, and explainable AI (xAI);**
- **Participate in development of tools for WSI data processing and xAI;**
- **Communicate with a collaborative team of subject matter experts**

Programming skills (Python/MATLAB) are required, Two positions available

(Figure 27)



(Figure 28)

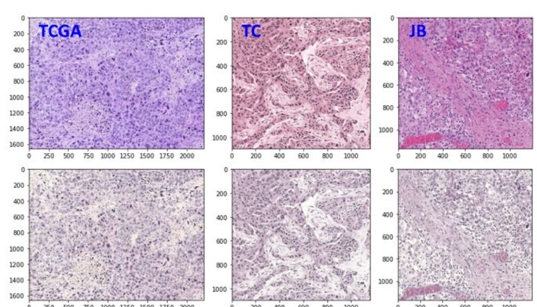


Figure 27: Saliency map of a convolutional neural network in which pixels are colored by their contribution to a classification task. This approach has the potential to check shortcut learning and avoid generalizability failure in ML models and advance explainable AI.

Figure 28: Top row shows color variation between selected ROIs from the three sources of TCGA, TC, JB of the TiGER challenge. Bottom row are the same ROIs after normalizing the color using Reinhard method.

f. Development of novel machine learning methods and evaluation approaches to identify and mitigate bias

Artificial Intelligence and Machine Learning (AI/ML) Program

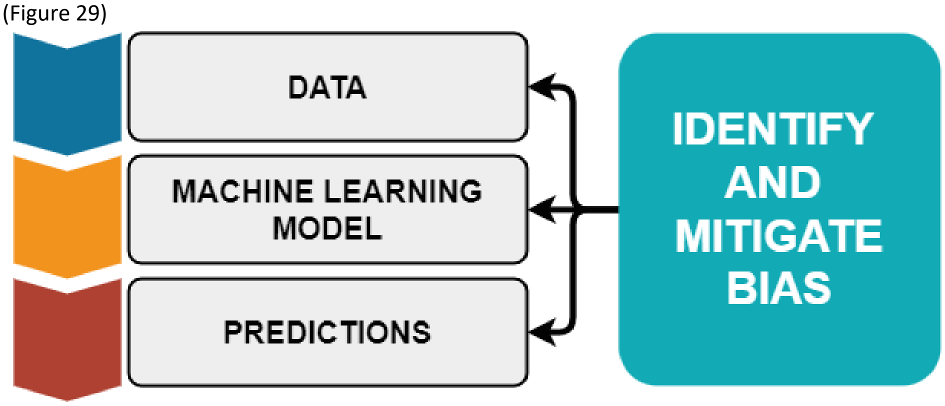
Mentor: Ravi Samala

Project Description: In this project, the AI/ML program at the Division of Imaging, Diagnostics, and Software Reliability (DIDSR) is developing novel methods to identify and measure the representation and diversity of the data, its influence on the complex learning processes of ML-enabled devices and to mitigate any possible disparities with particular emphasis on sex related disparities.

Specifically, the role of the intern will be to:

- Perform medical imaging data preparation, pre-processing, and harmonization from multiple sources to be used as predictors variables into a machine learning (ML) algorithm
- Assist in developing methods to quantify ML model-dependent diversity in the data and the effects on the machine learning models
- Organize and summarize results
- Opportunities to learn to develop code for traditional and deep-learning-based ML methods (CNN, RNN, GAN, etc.)
- Opportunities to learn to develop code in Python (including scientific stack: NumPy, SciPy, scikit-learn, etc.), and deep learning frameworks (PyTorch)

(Figure 29)



g. Performance evaluation of deep learning image reconstruction for accelerated MRI

Mentor: Rongping Zeng

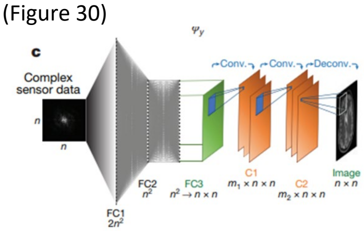
Project Description: Deep learning algorithm is being explored to reconstruct medical MRI images with fast data acquisition through short acquisition time or sparse k-space sampling trajectories. The goal of this project is to develop phantom and hybrid clinical images and investigate their utilities in training and testing deep learning image reconstruction (DLIR) methods for accelerated MRI.

Specifically, the role of the intern will be to:

1. Learn the MRI imaging physics and expand our in-house MRI simulation codes to contain the function of simulating data under accelerated acquisition mode.
2. Modify the AUTOMAP DLIR network to be more effective in image denoising and build an additional type of DLIR model for MRI named KIKI.
3. Study the generalizability performance of DLIR in phantom-based testing and patient-based testing across different data acquisition acceleration rate.
4. Gain research experience in regulatory science particularly related to radiological imaging devices.

The candidate is expected to be a graduate student with medical imaging background and programming skills.

(Figure 30)



(Figure 31)

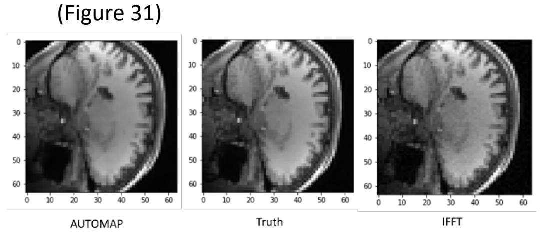


Figure 30: AUTOMAP reconstruction network structure (from Zhu et. al, Nature 2017).

Figure 31: AUTOMAP reconstruction compared to the truth, and IFFT reconstruction of a patient brain image.

(Figure 32)

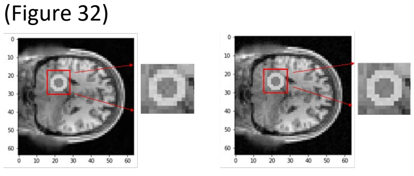


Figure 32: AUTOMAP reconstruction compared to IFFT reconstruction of a patient brain image containing an artificial ring-like lesion-mimicking feature.

h. Develop Tools for High Throughput Truthing (HTT) of pathologist annotations as a reference standard for validating artificial intelligence in digital pathology

Mentor: Brandon Gallas, PhD

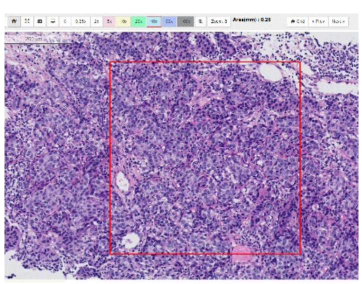
Project Description: In collaboration with internal and external subject matter experts, this project will develop tools and analysis methods for data-collection in digital pathology. Data from this project will be submitted for qualification as a Medical Device Development Tool (MDDT). Once qualified, this MDDT would be available to any artificial intelligence model developer to validate their model performance in a submission to the FDA/CDRH.

Specifically, the role of the intern will be to:

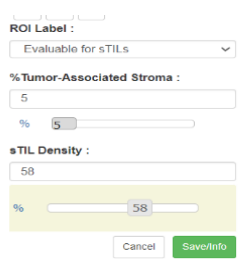
- The participant will learn how to use and apply statistical and data science tools, such as git and R, for pre-processing of data and data-analysis.
- The participant will have the opportunity to learn how to work with web applications, container programming, and application programming interfaces, to modularize code for data collection.
- The participant will learn how to communicate professionally and effectively with an interdisciplinary collaborative team of subject matter experts.

Programming skills are required

(Figure 33)



(Figure 34)



(Figure 35)

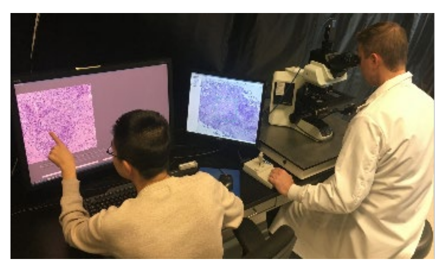


Figure 33: Example of a custom web-application data-collection tool.
Figure 34: Example of in-person data-collection.

i. **Analysis of the effect of Synthetic Data on Neural Network Model Evaluation**

Artificial Intelligence and Machine Learning (AI/ML) Program

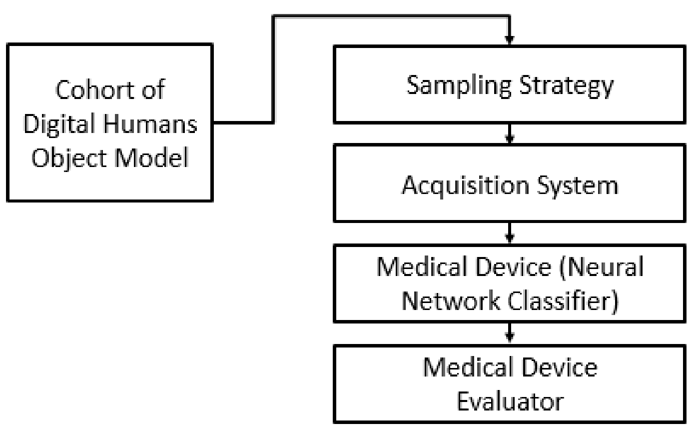
Mentor: Elena Sizikova

Project Description: In this project, we are evaluating how synthetically generated data from phantoms of the human body can address existing limitations of neural network models in medical imaging. We hypothesize that synthetic data can both improve performance in underrepresented groups, as compared to only using limited real patient data, and identify limitations of existing models.

Specifically, the role of the intern will be to:

- **Participate in research discussions to design novel workflows of using synthetic data in medical imaging/computer vision**
- **Implement code in Python/Pytorch/Keras/CUDA/C++ to train and test neural network architectures**
- **Design and deploy large-scale experiments in a high-performance computing (HPC) environment**

(Figure 36)



Overview of synthetic data evaluation pipeline for medical device assessment

j. First stab at a quantitative evaluation for rule-out devices using simulation.

Mentor: Elim Thompson, Frank Samuelson, Weijie Chen

Project Description: The project goal is to extend current CADt simulation software to understand the risks and benefits of rule-out devices by considering in simulation the radiologist performance and correlation between radiologist's diagnosis and AI outputs. Time-dependent factors (such as reader fatigue) can be parameterized and studied. We will examine the correlations between humans and AI in real world mammography data for patients with different characteristics such as breast density and malignancy to better inform our model.

This research will facilitate the development of a regulatory science tool for the evaluation of rule-out AI devices. The software can also be publicly available in GitHub and be submitted as RST. The participant will be mentored by Elim, Frank, and Weijie.

Specifically, the role of the intern will be to:

- **The participant will gain understanding of Receiver Operating Characteristic (ROC) curve analysis, and other advanced diagnostic statistical methods.**
- **The participant will become proficient in python, especially in using the queue package.**
- **The participant will learn about utility theory applied in a radiology department.**
- **The participant will gain experience in using distributed processing with our OpenHPC cluster.**

(Figure 37)

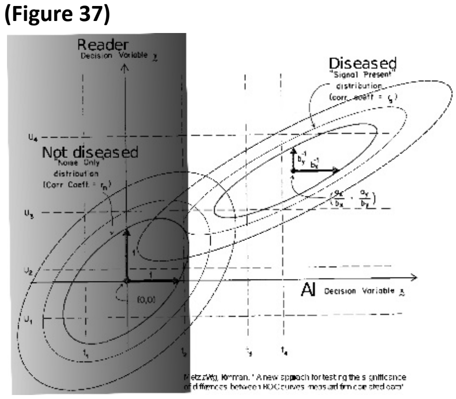


Figure 37: A model for AI and human image ratings. The abscissa is the AI ratings, the ordinate is the human ratings. One 2D normal distribution represents the distribution of ratings of images with disease, and the other represents images without disease. The AI removes all images in the shaded area from the radiologists reading queue.

(Figure 38)

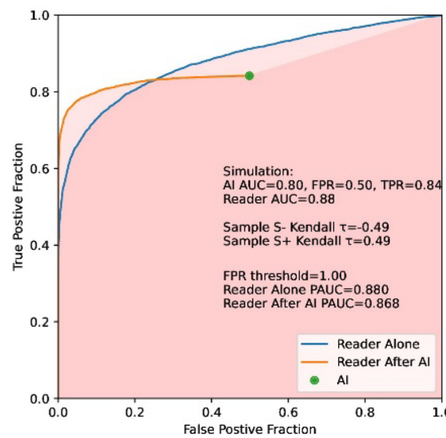


Figure 38: An example of ROC curves of reader without the rule-out AI (blue) and with the rule-out (orange). In this example the correlation between reader and AI are significantly different for the diseased and nondiseased images, leading to very different ROC curve shapes, and different AUC values (pink area).