Cerebral aneurysm hemodynamic factors

Laboratory Name: Industrial and Biological Multiphysics Laboratory
Faculty Supervisor: Prof. Dana Grecov
Graduate Student Mentor: Dr. Mehdi Jahandardoost

Appointment Details:

Summer Term:

X Summer, 27 hours/week for research -> $6000 stipend

Fall Term:

X Willing to extend into a Mech 493 project in fall (unpaid)

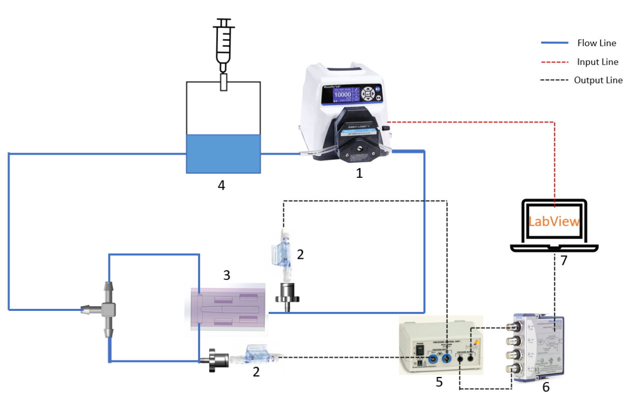
General Area of Research:

Fluid Mechanics

The Project:

Cerebral aneurysms (CAs) have a great chance of causing mortality and permanent disability, and it is one of the leading causes of death across the world. Bifurcated CAs are one type of lesions located at the major bifurcations in the cerebral vessels, and they have rupture risk and are harder to manage and treat. This project aims to use an *in vitro* experiment to assess the hemodynamic factors of bifurcated CAs to assist their treatment and management.

The proposed method uses pressure transducers and particle image velocimetry (PIV) to measure the pressure gradients and velocity profile of bifurcated CAs in an *in vitro* environment. The experiment setup mimics the cerebral circulation for a PDMS cast phantom of a bifurcated CA to develop image and pressure measurement. Both Newtonian and non-Newtonian working fluids will be used to match the rheology of the blood and the reflective index of the PDMS. A peristaltic pump will be used to produce a pulsatile flow that mimics the inlet boundary condition for the CAs.



What You Will Do:

- Design and 3D print the aneurysm phantoms.
- Test Newtonian and non-Newtonian working fluids using different hemodynamic factors.
- Analyze and process the data and interpret results.

Supervision Received:

The experiments will be conducted in PPC (Pulp and Paper Center) 108. The student will work closely with Dr. Mehdi Jahandardoost, postdoctoral fellow in the Industrial and Biological Multiphysics Laboratory (email: mehdi.jahandardoost@ubc.ca).
The student will be assisted on a regular basis by the mentor, and will receive guidance from Prof. Grecov.

Skills for Success:

- Fluid Mechanics background
- Ability to conduct experiments
- Python or LabView programming

Characterization of piezoelectric paper composite for sensing applications

Laboratory Name: Stoeber Lab
Faculty Supervisor: Prof. Boris Stoeber
Postdoctoral Mentor: Kanagasubbulakshmi Sankaralingam

Appointment Details:

Summer Term:

☒ Summer, 35 hours/week for research -> $7660.80 stipend

Fall Term:

☒ Appointment can be extended in fall if applicant secures an Undergraduate Student Research Award or a Work Learn International Research Award (paid)

General Area of Research:

Piezoelectric sensors, Micro\Nanomaterials, Material fabrication, Material characterization

Background of Research:

Piezoelectric materials are characterized by a coupling of mechanical and electric quantities, which makes them useful components of sensors, energy harvesters and actuators. Significant research efforts have been recently devoted to developing flexible piezoelectric material using paper as a substrate. Piezoelectric materials such as BaTiO3 (BTO), ZnO, ZnSnO3, Pb (Zr, Ti) O3 – PZT, were demonstrated for their significant performance in various technological applications, such as remote/wireless data transmission, battery charging, the powering of electronic devices and sensing applications.

Among the other materials, BTO has been regarded as one of the most technologically promising materials because of its strong piezoelectric properties and the environmental advantages that it offers over lead-based ceramics such as PZT. However, little experimental consensus exists regarding the influence of BTO micro/nanoparticle size on the properties of flexible piezoelectric composites. Hereby, we are developing a piezoelectric-based sensing device by optimizing various fabrication approaches to maximize the composites' piezoelectric response.

The Project:

In addition to optimizing the process to incorporate BaTiO3 in the matrix of paper, it is important to select particles of appropriate size and microstructures to maximize the piezoelectric performance of the material. Recently, some researchers have reported on the particle size dependent piezoelectric performance of BaTiO3 ceramics, in which the piezoelectric performance is improved with decreasing particle size. For the development of next-generation lead-free piezoelectric materials, it is necessary to understand the particle size effect on the piezoelectric properties of BaTiO3.

This project will be focused on the fabrication of piezoelectric paper composites and the evaluation of their electro-mechanical properties using the so-called “resonance–antiresonance method” according to IEEE standards using an impedance analyzer for flexible sensor applications.

What You Will Do:

- To characterize the electro-mechanical properties of piezoelectric composites via an impedance analyzer
- To relate the electro-mechanical properties to the composition and fabrication method of the piezoelectric composites

Facilities and Team

The student will have access to an office space in the Fred Kaiser building and working space at AMPEL-146 for the experimental works. The student will work closely with Prof. Boris Stoeber’s post-doctoral fellow, Kanagasubbulakshmi Sankaralingam (email: ksankara@mail.ubc.ca).

Supervision Received:

The student will be assisted on a regular basis by the postdoctoral mentor and will receive guidance from Prof. Stoeber. The student will be provided with initial references for literature review, and will be trained on the paper fabrication process and the electromechanical characterization techniques. The student will attend group meetings for the Stoeber Lab, which occur approximately once every week.

Skills for Success:

- Literature comprehension: read scientific journal papers, and understand the goals and conclusions
- Interest in working in a laboratory setting
- Ability to work under minimal supervision
- Curiosity to learn new concepts/techniques

Classification of blood films using machine learning for detecting sickle cell disease

Laboratory Name: Stoeber Lab
Faculty Supervisor: Prof. Boris Stoeber
Graduate Student Mentor: Pranav Shrestha

Appointment Details

Summer Term:

- Summer, 35 hours/week for research -> $7660.80 stipend
- OR Summer, between 27 to 35 hours/week, proportional stipend (between $6000 to $7660.80)

General Area of Research

Machine learning, Global health, sickle cell disease

The Project

Sickle cell disease (SCD) is an inherited blood disorder where red blood cells become crescent or sickle shaped, often resulting in blockage of narrow blood vessels and progressive organ damage. In low-income countries, the mortality rate for children born with SCD is high (50-90%), mainly due to the lack of screening and treatment options. There is a need for low-cost screening techniques to detect SCD in remote/rural settings. The sickling test is a screening technique, where blood is placed on a glass slide, mixed with a reducing agent, and observed under a microscope. In the sickling test, red blood cells with high concentration of hemoglobin S (as in cases of SCD) become sickled, while normal red blood cells do not. Traditionally, these microscopic observations (Fig. 1) are performed manually, but the sickling test could potentially be performed automatically using machine learning. Using blood samples from patients with SCD (from BC Children's hospital and St. Paul's hospital) and normal participants, this project aims to use machine learning to classify SCD participants from normal participants.

Tasks to be performed by the student

- Test the performance of multiple machine learning algorithms to classify SCD participants from normal participants
- Characterize accuracy of different classification algorithms
- Use existing image datasets, and datasets generated in Vancouver to train/test classification algorithms
- Test other image processing methods to detect sickle cell disease from blood film images

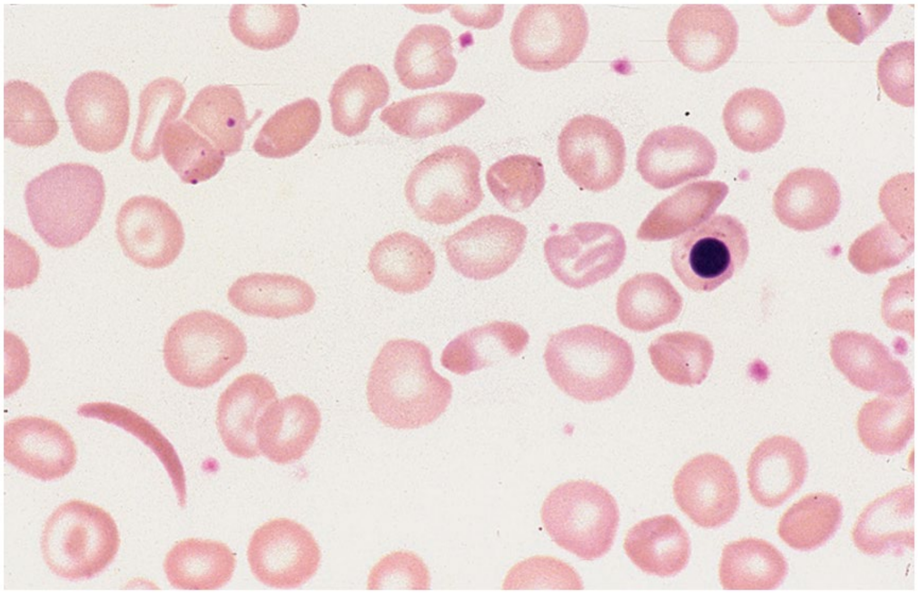


Figure 1 | Photomicrograph of blood film (without induced sickling) showing red blood cells, with one sickled cell and a few boat shaped cells [1]

Facilities and team

The student will have access to an office space in the Fred Kaiser building for the analyses. The student will work closely with Prof. Boris Stoeber's graduate student, Pranav Shrestha (email: pranavsh@mail.ubc.ca).

Supervision Received

The student will be assisted on a regular basis by the graduate student mentor, and will receive guidance from Prof. Stoeber. The student will be provided with initial references for literature review, and background related to the overall project. The student will get access to a student office space in Kaiser, which is shared by members of the Stoeber Lab and other research groups.

Skills for Success

- Interest in machine learning, image processing or programming (e.g. Python)
- Ability to work under minimal supervision
- Curiosity to learn new concepts/techniques

Reference

[1] B. J. Bain, "Blood Cell Morphology in Health and Disease," in *Dacie and Lewis Practical Haematology*, Twelfth Ed., Elsevier, 2017, pp. 61–92.

Experiments with hollow microneedles – insertion or fluid extraction

Laboratory Name: Stoeber Lab
Faculty Supervisor: Prof. Boris Stoeber
Graduate Student Mentor: Pranav Shrestha

Appointment Details

Summer Term:

- Summer, 35 hours/week for research -> $7660.80 stipend
- OR Summer, between 27 to 35 hours/week, proportional stipend (between $6000 to $7660.80)

General Area of Research

Tissue biomechanics, microfluidics, biomedical imaging, fluid/solid mechanics

The Project

Microneedles are small needle structure (Fig. 1) that allow accessing the skin for medical applications as opposed to conventional needles that are mostly used for accessing the muscle tissue. The mechanics of dynamic microneedle insertion into skin needs to be investigated for optimizing the use of microneedles for injection of drugs (such as vaccines) and for extraction of blood or interstitial fluid from the skin. This study aims to experimentally investigate 1) the insertion mechanics of hollow microneedles into artificial skin models; and 2) fluid extraction through hollow microneedles for bio-sensing applications. The findings from such a study can help improve or create new minimally-invasive techniques for drug delivery and bio-sensing.

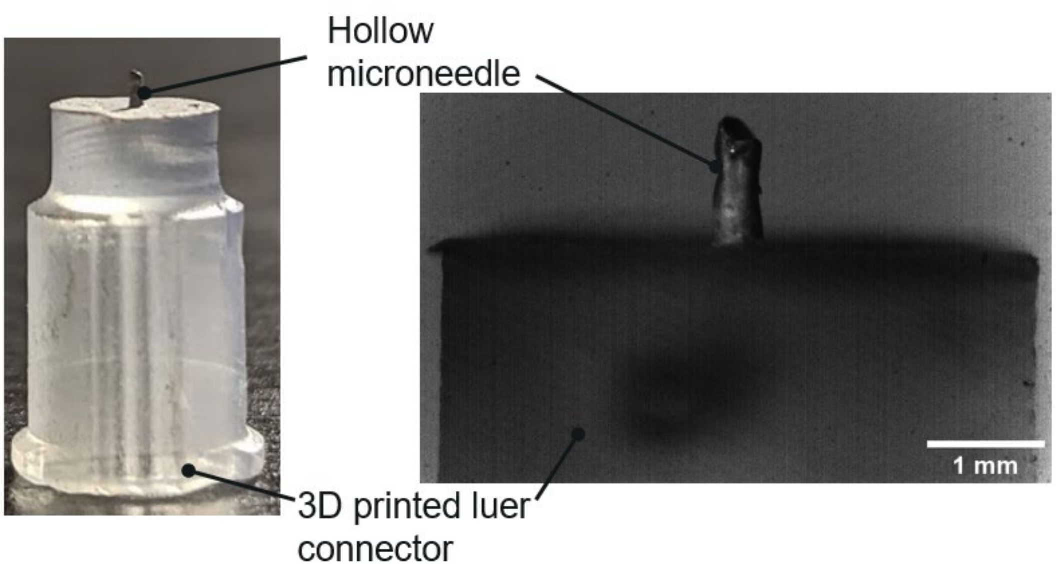


Figure 1 | Hollow microneedle connected to a 3D printed Luer adapter

Potential tasks to be performed by the student

- Conduct experiments with hollow microneedles using existing experimental setup (Fig. 2) for insertion/ /extraction
- Analyze and process sensor/actuator data
- Design and 3D print (or machine) any required modifications to the experimental setup for testing new samples
- Conduct literature review to relate experimental findings to theoretical models

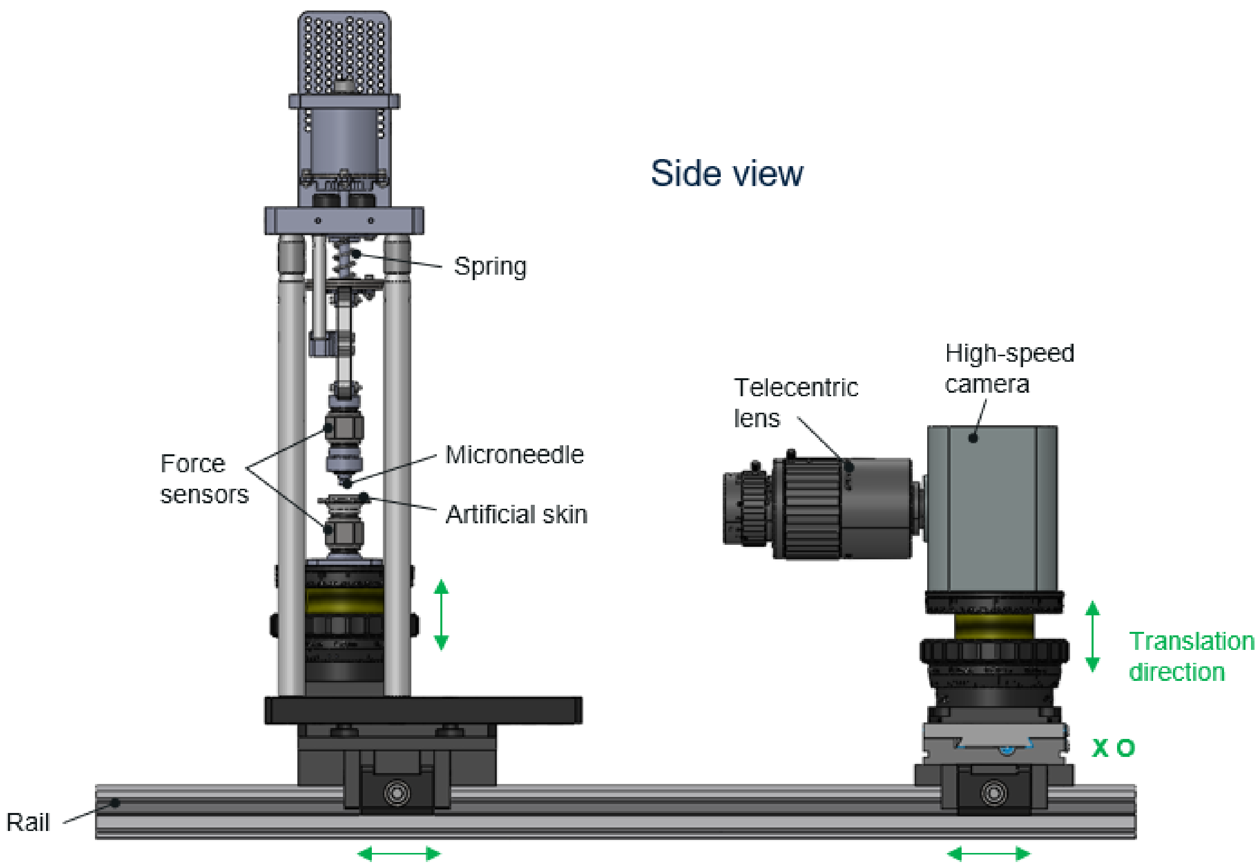


Figure 2 | Experimental setup used for controlled dynamic insertion of hollow microneedles

Facilities and team

The experiments will be conducted in AMPEL 146, Advanced Materials Process Engineering Laboratory. The student will work closely with Prof. Boris Stoeber's graduate student, Pranav Shrestha (email: pranavsh@mail.ubc.ca).

Supervision Received

The regular supervision of the student will be performed by the graduate student mentor. The student will be provided with initial references for literature review, and will be trained on using the experimental setup, the imaging modality (e.g. high-speed imaging), and sensors (e.g. force, flow). The student will get access to the lab and a student office space in the Fred Kaiser building, which is shared by members of the Stoeber Lab and other research groups. The student will attend group meetings for the Stoeber Lab, which occur approximately once every week.

Skills for Success

- Interest in biomechanics and/or fluid mechanics
- Interest in working in a laboratory setting or data analysis
- Ability to work under minimal supervision
- Curiosity to learn new concepts/techniques

Understanding the fluid dynamics in wellbore cementing to prevent migration of methane

Laboratory Name: Complex Fluids
Faculty Supervisor: Ian Frigaard
Graduate Student Mentor: Ruizi Zhang/ Alondra Renteria

Appointment Details:

Summer Term:

- Summer, 35 hours/week for research -> $7660.80 stipend

Fall Term:

- Willing to extend into a Mech 493 project in fall (unpaid)
- Appointment can be extended in fall regardless of whether a second research award is won (you are still expected to apply for the award) (paid)

General Area of Research:

Experimental and Computational Fluid Dynamics

The Project:

It is estimated that about 28.5% of wells drilled from 2010-2018 in BC have reported Surface Casing Vent Flow, a source of greenhouse gas emission attributed to wellbore leakage. These emissions have serious health and safety consequences as well as environmental impact, such as increasing the amount of methane in our atmosphere and the potential pollution of our water bodies. This project studies cementing of wellbores from a fluid dynamics perspective with the main objective of preventing methane and other greenhouse gas emissions in our environment.

Primary cementing is the operation that seals the annular section between a steel pipe that stabilizes the well (the *casing*), and the rock formation; see Figure 1. After a well is drilled, a casing is lowered inside it. In this point, the space inside and outside the casing is occupied by the drilling mud that keeps the hydrostatic balance between the hole and the formation. Then, cement slurry is pumped downwards inside the casing until it reaches the bottom and flows up into the annular section displacing the drilling mud upwards. A good seal will not leave residual mud anywhere preventing subsurface fluids from percolating to surface.

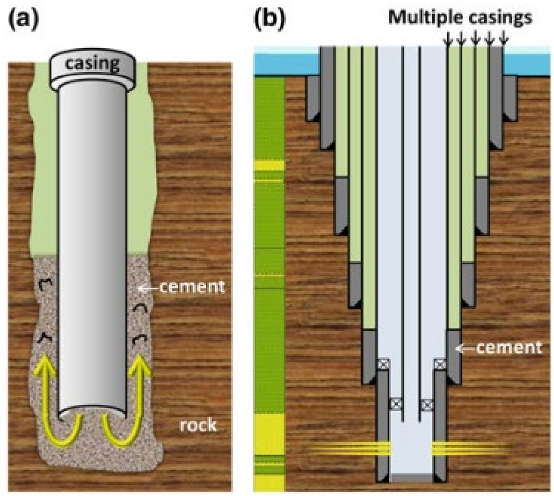


Figure 1. Primary Cementing schematic illustration of a) placing cement in the annular space between casing and rock, and b) multiple casings cemented in place. Taken from A. Lavrov and M. Torsaeter.

Our lab has two sophisticated flow loops to simulate the field process. We have carefully designed and built the loops to achieve dynamic similarity. We can control the key parameters of the process, such as flow rate, eccentricity, rheology, and fluid's densities. The data acquisition is through imaging with high sensitivity cameras and automated instrumentation. The objective is to capture experimental data relevant to fluid-fluid displacement flows under a wide variety of scenarios. We typically complement our experiments with simulations using either our two-dimensional gap-averaged model, which is the standard of industrial practice; or with three-dimensional computations using OpenFOAM opensource CFD toolbox.

What You Will Do:

The student will perform some combination of mainly experimental work and associated computations, depending partly on interest and partly on needs of the team. Experimentally, the student will assist in all operations related with the experiment: fluid preparation (Newtonian and non-Newtonian), running experiments, image processing of the data, rheometry measurements of the fluids and data analysis. The student will learn the physical background of the experiments and may help to design new components, undertake bits of machining/manufacturing, and implement changes to the current apparatus. Computationally, the student will learn to run some 2D and 3D simulations, which can be then compared with the experimental results.

Supervision Received:

Ruizi Zhang, a senior PhD student, will support the student daily as will Dr Alondra Renteria who is also involved in the project. Professor Ian Frigaard will facilitate several group meetings.

Skills for Success:

Hands-on skills, problem solving, creative thinking, critical thinking, collaboration skills. Basic programming and machining skills. Interest in fluid mechanics.

Mechanics of bubbles in yield stress fluids

Laboratory Name: Complex Fluids Lab
Faculty Supervisor: Ian Frigaard
Graduate Student Mentor: Dr Masoud Daneshi

Appointment Details:

Summer Term:

- Summer, 35 hours/week for research -> $7660.80 stipend

Fall Term:

- Please only rank if you want to do extend into a Mech 493 project in fall (unpaid)
- Please only rank if you are willing to extend into the fall, regardless of whether a second research award is won (you are still expected to apply for the award) (paid)

General Area of Research:

Fluid Dynamics

The Project:

Canada has the third-largest crude oil reserve in the world. Canadian oil reserve is believed to include approximately 170 billion barrels of oil or 11% of total global oil reserves. The oil sands industry is both a significant contributor to the Canadian economy and is widely regarded as a cause of adverse environmental effects, e.g. it has been estimated to account for 10% of GHG emission in Canada.

Recent studies show that anaerobic microorganisms contribute to the degradation of Naphtha hydrocarbons and naphthenic acids in the FFT and MFT layers of oil sands tailings ponds, producing methane and CO2, both potential causes of GHG emissions. The FFT and MFT layers are colloidal suspensions, which behave like viscoplastic fluids with time-dependent rheology: changing both with age and depth in the pond. The key feature of a viscoplastic fluid is its yield stress: the material flows only if the imposed stress exceeds the yield stress. This raises questions regarding the stability of bubbles, which are trapped in a yield stress fluid. Previously, we have performed a series of experiments with a model yield stress fluid, Carbopol gel, to study the onset of motion of bubbles. We would like to continue this project with some other laboratory yield stress fluids, i.e. Laponite and Kaolinite suspension, which are considered as better models for tailings material. Besides, we'd like to extend our study to the bubbles migration in a yield stress fluid including networks of angled 'damaged' layers within which the yield stress is destroyed. This might model the effect of non-uniform rheology of the tailings material or/and the presence of water chimneys on the stability and migration of bubbles in the tailing ponds.

We are seeking a student to work on two subprojects: (i) the growth and stability of bubbles in several different viscoplastic fluids; (ii) bubbles migration towards and along damaged networks in a yield stress fluid. This might lead to fundamental understanding of how the rheology of the fluid, shear history of the *fluid, and interaction between the stress field around the bubbles affect the onset of motion and bubbles propagation.*

What You Will Do:

The students will assist in all operations related with the experiment: fluid preparation, rheometry measurements of the fluids, running experiments and image processing. The students will learn the physical background to the experiments and may help in design of new components and implement changes to the current apparatus.

Supervision Received:

The student will work under the day-to-day supervision of Dr. Masoud Daneshi in the complex fluids lab, in LSK, UBC, where the experiments are set up.

Skills for Success:

Ideally the candidate would have lab experience e.g. in an engineering discipline or physics. We prefer those who have experience in instrumentation, Labview programming and imaging and are familiar with Matlab and SolidWorks.

New Soft Robotics Actuators for Surgical Applications

Microelectromechanical Systems Laboratory
Faculty Supervisor: Dr. Mu Chiao
Graduate Student Mentor: Hiroshan Gunawardane

Appointment Details:

Summer Term:

- X Summer, 35 hours/week for research -> $7660.80 stipend

Fall Term:

- X Willing to extend into a Mech 493 project in fall (unpaid)
- X Please only rank if you want to do extend into a Mech 493 project in fall (unpaid)
- X Appointment can be extended in fall if applicant secures an Undergraduate Student Research Award or a Work Learn International Research Award (paid)

General Area of Research:

Soft Robotics, Robotics

The Project:

This project is focused on developing new Soft Pneumatic Actuators (SPAs) for surgical applications based on Soft Robotics principles. Our new designs have the ability to actuate in multi-degree-of-freedom (MDoF) with the minimum energy footprint and control its path on demand. These actuators use a pneumatic input to control its position and a current (i.e., to generate Joule heating) input to control its path on demand. The actuators are composed of elastomers and thermo-elastic materials.

Two recent updates of this project can be found as follows (these are two recent papers we submitted to IEEE RoboSoft 2022 and both works have previous selectees for the CREATE-U program):

1. ***A PneuNet-based Multi-Degree-of-Freedom Soft Pneumatic Actuator with Multiple Chambers***

   https://www.youtube.com/watch?v=LlptihTL8nE&list=PLZax7I98VoXsHtUes3d6d9zVysfVpFVNJ&index=2

2. ***Thermoelastic Strain-limiting Layers to Actively-control Soft Actuator Trajectories***

   https://www.youtube.com/watch?v=0akdS27jrTk&list=PLZax7I98VoXsHtUes3d6d9zVysfVpFVNJ&index=1

We are currently working on designing, fabricating, and optimizing this actuator and actively seeking avenues of clinical collaborations.

What You Will Do:

Our team is working on multiple phases of this project, and you will be engaged in executing several tasks at different design levels. You will be mainly working on fabricating new SPAs (3D printing, molding, and casing) and characterizing them in our test rigs. Besides that, we will be developing a new robotics gripper using these SPAs and you will be helping us in developing and testing them in a robotics manipulator (using Kinova robotics platform) at MEMS Lab UBC.

Supervision Received:

The day-to-day mentoring will be carried out by the graduate student at the MEMS laboratory and the student will be meeting the faculty supervisor weekly basis to deliver the progress. In case of unavailability, the zoom meetings will be arranged to deliver the progress and clarify any issues related to the project. Moreover, WhatsApp will be used as a communication platform to stay connected during the day and connect with other members of the team.

Skills for Success:

It is preferred for the student to have some experience in Mechatronics related projects. Intermediate skills in programing and some experience in electronics would be advantageous. The student required to finish his/her chem safety prior to the beginning of the CRETE-U program. You can further discuss the details related to this at the first meeting.

Seawater Atomization for Marine Cloud Brightening

Laboratory Name: Aerosols and Energy
Faculty Supervisor: Steven Rogak
Graduate Student Mentor: Hamed Nikookar

Appointment Details:

Summer Term:

- ☐ **Summer, 27 hours/week for research -> $6000 stipend**

Fall Term:

- ☐ Willing to extend into a Mech 493 project in fall (unpaid)

General Area of Research:

Energy and Environment

The Project:

The climate crisis is the result of a century of humans emitting climate-forcing pollution (carbon dioxide, methane, soot) and cutting down trees unsustainably. The real solution must be to stop these practices. However, even if we stopped these today the climate would warm for many decades, resulting in the loss of reflective ice sheets and the release of frozen methane – accelerating the warming. We will need emergency cooling strategies for the planet in the coming decades- and this is where "Geoengineering" or "Climate Engineering" comes in. Wikipedia has a good, general discussion of the issue, including the controversies, which are really important! The major national research academies of the US and Britain have looked at this and concluded: it is risky but we need to do research on this **now**.

Marine Cloud Brightening may be among the least dangerous forms of climate engineering because the effects of atomized seawater are not long lasting and they are relatively local. This makes it a good place to start, slowly, to apply local cooling at the most at-risk marine environments. Possibly the first place this can make a difference is in reducing damage to the Great Barrier Reef of Australia. There are many cloud and climate science questions to be addressed, but there is also a big mechanical engineering challenge: **producing aerosol particles of the correct size distribution with a technology that requires relatively little energy and can be scaled massively.** This is the challenge we are taking on to help the Australian team. We will continue the work of Cooper et al, bringing some new atomization techniques to the mix and supporting atomizer design using computational fluid dynamics.

What You Will Do:

You will design and fabricate 2-3 new nozzle designs and determine the aerosol size distribution that results from them, and the energy consumption required. The two major classes of atomizers likely to be tested are pressure-swirl atomizers and ultrasonic atomizers. The experiments will require using nanoparticle measurement systems in the UBC Aerosol Lab.

Supervision Received:

You will receive weekly feedback from Prof. Rogak and possibility of daily assistance from a PhD student in the lab.

Skills for Success:

Should be comfortable analyzing data in matlab or excel. Must be interested in experimental work and making things. Must have a demonstrated interest in learning new things.

Single Cell Image Analysis using Machine Learning

Laboratory Name: Multi-scale Design Laboratory
Faculty Supervisor: Hong Ma
Graduate Student Mentor: Erik Lamoureux

Appointment Details:

Summer Term:

- X Summer, 35 hours/week for research -> $7660.80 stipend

Fall Term:

- X Willing to extend into a Mech 493 project in fall (unpaid)

- X Appointment can be extended in fall regardless of whether a second research award is won (you are still expected to apply for the award) (paid)

General Area of Research:

Biomedical engineering

The Project:

There are two main projects where we use machine learning to assess individual biological cells. The first project involves using software and biological experiments to assess sperm cells. We will use a type of machine learning called deep learning U-Nets to segment microscope images of biological cells taken from testis samples (**Figure 1**). The aim is to identify rare sperm cells in people with low sperm counts. Further, we predict that we can quantify sperm DNA fragmentation from microscope images using machine learning. The machine learning model will use data acquired from a biological test used to assess the level of DNA fragmentation, called a comet assay. In this manner, we expect to improve the selection of viable sperm for *in vitro* fertilization (where fertilization of the egg and sperm occur in a laboratory glass dish).

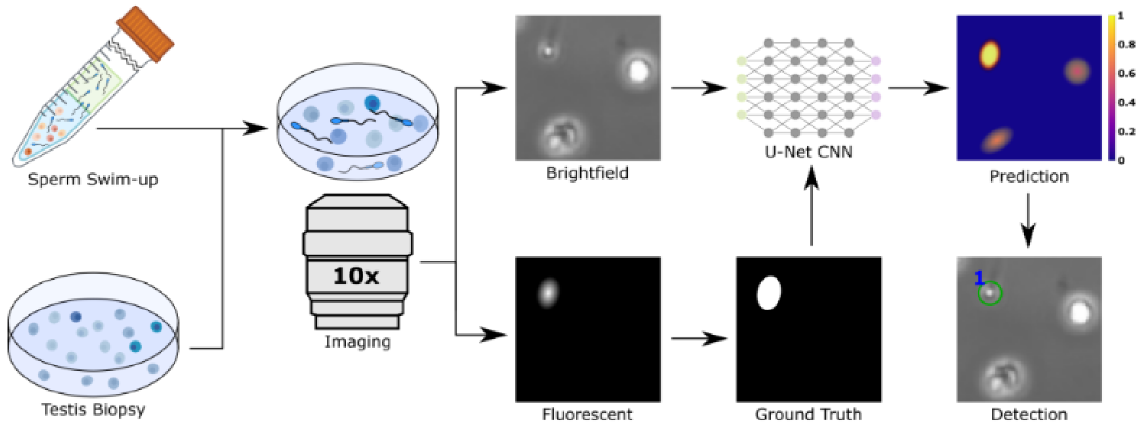


Figure 1: Approach for AI-based rare sperm detection [1].

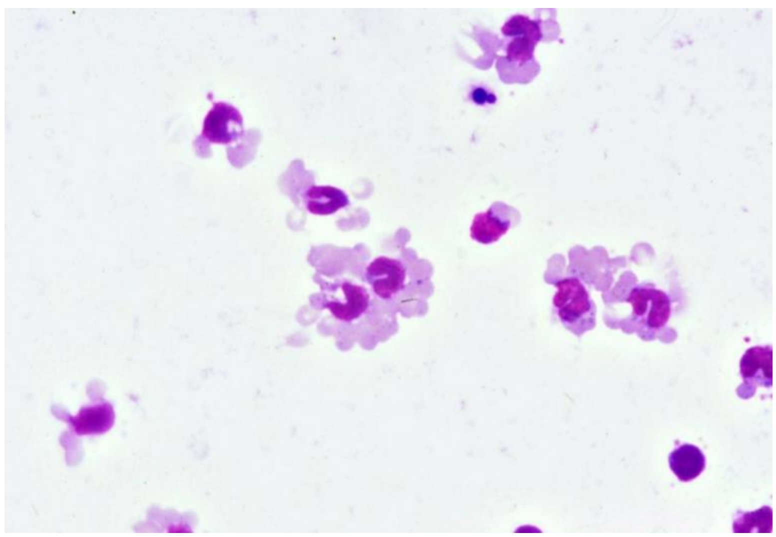


Figure 2: Red blood cells (light) bound to monocytes (dark) in the monocyte monolayer assay [2].

The second project comprises of using software to speed the quantification of a biological test, the monocyte monolayer assay. This assay is used clinically to determine the compatibility of a donor's red blood cells with the immune cells of the recipient. Currently, quantification of this assay is done manually and is time-consuming. By developing a computer vision algorithm, we expect to be able to more rapidly assess the outcome of this assay.

This project is important because we are developing technologies to assess cell properties in a manner faster and more accessible than current methods. Specifically, further validation on identifying rare sperm cells and quantifying sperm DNA fragmentation non-invasively using software will make these methods more straightforward for other research groups or clinics to implement. This work will increase the success rate of *in vitro* fertilization. Automating the quantification process of the monocyte monolayer assay will increase the speed of data collection and will make the procedure more common in blood banks. Currently, the length of time needed to perform and analyze this assay has prevented it from being widely used.

What You Will Do:

We expect the student to contribute towards both projects, which will be, for the most part, running in parallel. We expect the monocyte monolayer assay project will finish first, and the focus will shift towards the sperm project. The student will assist and conduct biological experiments, data analysis, software use and programming, and research presentations. We expect the bulk of the work to consist of the biological experimentation, but the other aspects will be present throughout.

Supervision Received:

The student's graduate student mentor will be Erik Lamoureux, a PhD student (Mechanical Engineering, Biomedical Engineering Research Group) in Dr. Ma's Multi-Scale Design Laboratory. He is on campus daily for courses and wet (experimental) lab work. He will do the day-to-day supervision of the student, including experimental, data analysis, and research methods mentorship. Additionally, usually there is at least one graduate student, post-doctoral researcher, or lab manager in the experimental lab space or nearby offices during working hours. All lab members are friendly and accommodating. All members are willing to assist the student and give advice. Erik has weekly or biweekly meetings with Dr. Ma – the student will attend these meetings and provide progress updates.

Skills for Success:

- Enjoy experimentation and troubleshooting experimental problems.
- Willingness to learn bioengineering research techniques including experimental protocol development, data analysis, and data presentation.
- Willingness to learn and conduct biological experiments involving human blood, semen, and testis samples.
- Familiarity with general purpose programming languages (some examples include C, MATLAB, Python).

References

[1] R. Lee *et al.*, "Deep Learning-based Automated Rare Sperm Identification from Testes Biopsies," Bioengineering, preprint, Nov. 2021. doi: 10.1101/2021.11.14.468543.

[2] G. Walsh., "Through the Microscope: monocyte monolayer assays," Canadian Blood Services, Aug. 2016. https://www.blood.ca/en/research/our-research-stories/research-education-discovery/through-microscope-monocyte-monolayer#whatis

Understanding Air Quality in Rural India

Laboratory Name: iREACH (Integrated Research in Energy, Air, Climate and Health)
Faculty Supervisor: Naomi Zimmerman
Graduate Student Mentor: Sakshi Jain

Appointment Details:

Summer Term:

- ✔ Summer, 27 hours/week for research -> $6000 stipend

Fall Term:

- ✔ Willing to extend into a Mech 493 project in fall (unpaid)

- ✔ Appointment can be extended in fall if applicant secures an Undergraduate Student Research Award or a Work Learn International Research Award (paid)

General Area of Research:

Air pollution, energy access

The Project:

Recent advancement in low-cost sensor (LCS) technology has presented a new and affordable opportunity to understand and subsequently improve air quality. One area that could benefit substantially from LCS networks is rural areas in Low-to-Middle Income Countries (LMICs) where biomass cooking emissions have a large disease burden, but real-time understanding of concentrations or detailed exposure estimates are lacking (Figure 1). To explore this question, the iREACH lab (headed by Prof. Naomi Zimmerman) deployed 16 LCS in rural India (outside Unnao, Uttar Pradesh) for 6 weeks in winter 2019 to measure air pollutant concentrations ($PM_{2.5}$, NO_x, O_3 and CO) at 15-second resolution and simultaneously surveyed 27 households to understand behaviours, ventilation characteristics, and satisfaction with air quality. This research project will focus on analyzing the data collected to quantify the effects of biomass cooking on indoor and ambient air quality (picture of deployed equipment in Figure 2).

This work will contribute to a more holistic understanding of cooking emissions in LMICs and will assist in improving our understanding of health and environmental impacts of biomass cooking activities. As such, air quality data collected in LMICs has the potential to have significant impact on our understanding of global mortality due to exposure to air pollutants, and the role of indoor-outdoor pollutant fluxes and natural ventilation.

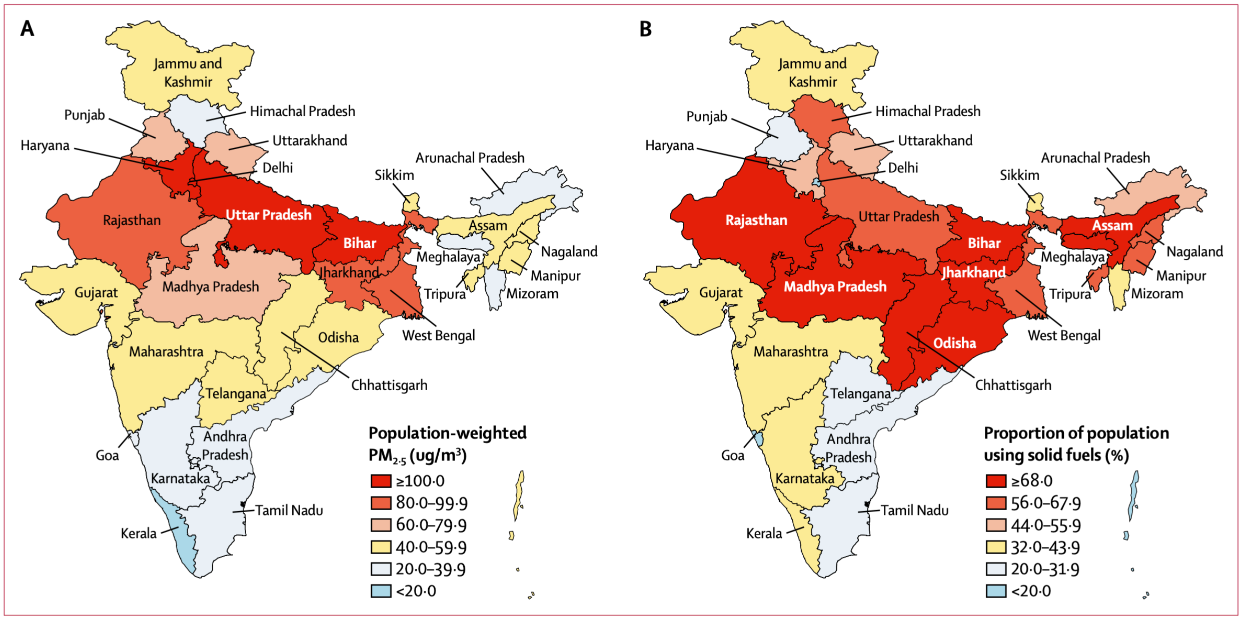


Fig. 1 $PM_{2\cdot5}$ concentration and use of solid fuels in the states of India, 2017. (A) Population weighted mean ambient air $PM_{2.5}$, (B) Proportion of population using solid fuels. The iREACH lab conducted field work in the northern state of Uttar Pradesh.

Fig. 2 *(Left)* The instrument package deployed in a household in Unnao, Uttar Pradesh. *(Right)* The buildup of pollution on the sensors by the end of the 6-week deployment.

What You Will Do:

The student will work under the supervision of Dr. Naomi Zimmerman and PhD candidate Sakshi Jain and their duties and responsibilities will include:

- Literature review: review relevant literature on specific areas (e.g., biomass cooking, indoor air pollution, calibration of low-cost air quality sensors).
- Apply statistical data analysis techniques to clean/prepare air pollutant datasets.
- Participate in calibrating air quality data collected in rural India by modifying existing calibration models and assessing the suitability of existing calibration models in an India context
- Create databases (timeseries) using calibrated air quality data and household characteristics.
- Develop and run logistic regression models and/or advanced machine learning statistical models to link relationships between observed indoor and outdoor air pollutant concentrations and parameters measured and collected in surveys.

Supervision Received:

The student will report directly to the faculty member and senior graduate student (Sakshi Jain) at iREACH. Day-to-day supervision will be provided by PhD candidate Sakshi Jain, and the student will meet with Sakshi and Prof. Zimmerman in weekly or bi-weekly meetings. The student will also attend and participate in weekly research group meetings and the Mechanical Engineering Energy and Environment Talks (MEEET) seminar series to learn about energy and environment graduate research in the department. These individual and group meetings will provide regular opportunities for questions, and two-way feedback. Additional informal feedback and support will be provided through the vibrant iREACH Slack Channel, as necessary.

Skills for Success:

- Interest in environmental applications of mechanical engineering (clean energy, air pollution, climate change, ventilation)
- Comfortable and/or excited to learn about coding techniques to analyze complex and large datasets. (Note: Knowledge of a specific coding language is not required, but some experience with a coding language such as MATLAB, Python or R is an asset.)
- Familiarity with simple logistic regression, statistical analysis and/or machine learning is considered an asset
- Critical thinking and reflection skills
- Time management skills
- Strong written and oral communication skills
- Knowledge or interest in learning about research ethics and protocols
- Willingness to employ an interdisciplinary approach to research
- Ability to work both in a team and individually