Frugal Biomedical Innovation Summer Studentships
Summer 2022

Nations comprising 13% of the world's population account for 76% of global medical device use, while more than half of the world's population lacks access to essential healthcare services or lifesaving technologies that are taken for granted in North America, such as infant incubators and simple laboratory diagnostics [1,2]. Similarly, within Canada, the average life expectancy for residents of remote communities is 5.2 years shorter than the life expectancy in Canada's largest, wealthiest cities [3]. This unjust, inequitable access to healthcare can be remediated by developing and deploying frugal medical devices designed to address the unmet needs of patients in remote and low-resource communities. Frugal medical devices are a specialized application of "frugal innovation", an emerging philosophy that emphasizes sustainability and equity within all disciplines of engineering [4]. Design and fabrication of frugal medical devices arguably poses greater engineering challenges than devices intended for hospitals in high-resource urban locations because frugal devices must meet the same technical performance benchmarks as a conventional medical device while operating under adverse environmental conditions, shortages of replacement parts, consumables, and specialist healthcare providers, and unreliable access to power, clean water, and medical air [1].

The School of Biomedical Engineering recently launched a Program in Frugal Biomedical Innovations with our partners, the Africa Institute and Robarts Research Institute. The objectives of the program are to (1) support technology development under conditions compliant with international quality management and medical device regulatory standards, (2) establish partnerships in Africa and in Canadian Indigenous communities to facilitate deployment and testing of frugal devices in remote and low-resource settings, and (3) provide education in the principles of frugal design and open-source hardware to Western trainees and students at partner institutions. As a component of this initiative, we are pleased to announce a summer student program intended for Western undergraduates in engineering, the physical sciences, or the biomedical and health sciences. Participants in the 2022 edition of the summer student program will carry out fabrication and laboratory performance testing of frugal medical devices in a Western laboratory with the goal of advancing prototype devices to a state where they are suitable for future testing with human subjects. These placements are 16-week, full-time positions modeled on the NSERC Undergraduate Student Research Awards and Western's Undergraduate Summer Research Internships for which students will receive a stipend of at least $7,500.

How to apply:

1. Review the project descriptions on the following pages to find positions that match your interests.
2. Apply via the link on the page for the project that interests you. The online application form will ask you to upload a cover letter, a resume, and a copy of your Western academic record from your Student Center account (an official transcript is not necessary).
3. You may apply for multiple projects by submitting separate applications for each project.
4. Applications will be reviewed by the project supervisor. The supervisor may contact selected applicants to request an interview or additional information at their discretion.
5. Applications received by **11:55 pm** on **Thursday, March 24** will receive first consideration.

References

[1] D. Piaggio, R. Castaldo, *et al.*, "A framework for designing medical devices resilient to low-resource settings," *Globalization and Health* 17:64, 2021.

[2] R. Richards-Kortum and M. Oden, "Devices for low-resource health care," *Science* 342:1055-1057, 2013.

[3] Public Health Agency of Canada, *Key Health Inequalities in Canada: A National Portrait*, 2018.

[4] J. Prabhu, "Frugal innovation: Doing more with less for more," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 375:2016.0372, 2017.

Project Title:
Building a free and open-source digital algometer for clinical evaluation of pain sensitivity

Supervisors:
Dr. Ana Luisa Trejos, Electrical & Computer Engineering and Biomedical Engineering
Dr. Dave Walton, Physical Therapy

Project Description
Assessment and evaluation of a patient in pain is most commonly done through direct questioning in the healthcare clinic environment. While patient reports are important, there are many reasons to supplement those with more quantifiable metrics of pain sensitivity. This can help with pain classification, treatment, prognosis, and evaluating effectiveness of intervention. To date, however, "algometry" (pain measurement) has not been routinely implemented in clinic, owing partly to the cost of the very few digital algometers currently on the market. Over the past year, we have been engaging with undergraduate students to develop a hardware/software solution that is a new digital algometer that can be assembled through 3D printing and simple Arduino-based components, paired with a PC-based software interface. The software interface and hardware prototype have both been completed, but now require further refinement and functionality before they can be endorsed for clinical use. This project will invite an undergraduate engineering student to continue the development of the hardware algometer, and facilitate wireless communication between it and the software interface.

Student Qualifications
A student having completed second or third year in Mechatronic Systems Engineering, Electrical Engineering, or Computer Engineering will be hired. The student must have strong design skills, and must have had completed courses in electric circuits and programming.

Apply for this project

Project Title:
Open-source bioreactors

Supervisor:
Dr. Joshua Pearce, Electrical & Computer Engineering, Thompson Centre for Engineering Leadership and Innovation, and Ivey School of Business

Project Description
A bioreactor provides a controlled environment to ensure ideal growing conditions for organisms like bacteria and yeast. Enzymes, plant or animal cells, and microorganisms need specific environmental conditions within bioreactors to produce the desired output of organic material. The pharmaceutical industry uses bioreactors to create medicines, vaccines, produce antibodies and even food. Proprietary bioreactors are extremely expensive and rigid in what they allow users to do with them. This makes the innovation cycle slow and inequitable as those without financial resources simply do not have access to them. To overcome these challenges, this project will design, build and test an open source bioreactor. Having a low-cost, medium-scale (1 L), free and open-source vetted bioreactor design will enable a future of increasing use of bioreactors in medical treatments throughout the world.

Student Qualifications
1-2 qualified students will have either a Biomedical Engineering, Chemical Engineering, or Electrical or Computer Engineering and control systems background, be a persistent problem solver and an enthusiastic team player (joining the Free Appropriate Sustainability Technology (FAST) Research Group). The ideal candidate(s) would have previous experience with bioreactors.

Apply for this project

Project Title:
Biomedical Signal and Image Processing

Supervisor:
Dr. Michael Rieder, Medicine, Physiology & Pharmacology, and Robarts Research Institute
Industry Partner: CELLSEES Inc.

Project Description
We are looking for a candidate with background in signal processing algorithms applied to physiologic signals. Ideal candidate has a strong background in algorithm development and MATLAB, good work ethics and interpersonal skills. The candidate must be detail-oriented, systematic, persistent, driven, and willing to work hard. Candidate will contribute on developing novel systems for multi-modal vital-signs analysis and will become part of a multidisciplinary team of engineers and physicians exploring new concepts through design and fast iterative prototyping. The candidate will actively contribute to conception, development and execution of innovative R&D projects involving new medical devices via signal processing and algorithm development. The tasks include:

- Develop and implement novel signal processing/algorithms for patient/subject monitoring and aid in diagnosis/therapy based on physiological signals.
- Conception and implementation of innovative algorithms for extraction of relevant information/features from signals/data.
- Assist with the design and implementation of clinical studies to acquire bio/physiological signals from human subjects for algorithm development and validation.
- Perform statistical analysis of acquired and processed data.
- Develop and maintain regulatory documentation for related clinical studies.
- Participate as needed in training, monitoring, and audits of clinical sites.
- Prepare scientific reports and publications.

Student Qualifications

- Theoretical knowledge and practical experience in biomedical research, particularly in advanced signal processing/analysis.
- Experience with analysis of bio/physiological signals.
- Adequate knowledge of reading schematics and data sheets for components.
- Excellent oral/verbal/written communication skills in English and experience with writing scientific reports.
- Friendly, articulate, and interested in working in a fun, small team environment.
- A keen interest in innovating medical technologies for clinical translation and commercialization.
- Strong programming expertise (Python, C, Assembly, MATLAB) is an asset.

Apply for this project

Project Title:
Photosensors and Photomedicine

Supervisor:
Dr. Michael Rieder, Medicine, Physiology & Pharmacology, and Robarts Research Institute
Industry Partner: CELLSEES Inc.

Project Description
The Bio-optics and Photomedicine Laboratories at CELLSEES Inc. are focused on the development, clinical validation, and commercialization of medical-grade non-invasive, continuous, contact-less, high-resolution optical imaging methods for disease diagnosis, with a number of these technologies currently involved in clinical trials. Representative imaging technologies include mm-wave, THz, photoacoustic, optical coherence tomography, autofluorescence, near-infrared and Raman spectroscopy. These imaging technologies are used to investigate a range of diseases and biomarkers.

You will actively contribute to conception, development and execution of innovative R&D projects involving new medical devices via signal processing and algorithm development. You will focus on developing optical imaging and sensing systems for multi-modal vital-signs and blood analysis and will become part of a team exploring new concepts through design and fast iterative prototyping.

Student Qualifications
Ideal candidates have a basic background or interest in biomedical engineering, biosensors, wearables, bio-optics, photomedicine, algorithm development, medical device design and commercialization and a productive mindset who can apply their expertise to solve problems in creative, insightful ways.

Apply for this project

Project Title:
Computational Optics Design of an Optical Microscope for Malaria Diagnoses

Supervisor:
Dr. Ian Cunningham, Medical Biophysics and Robarts Research Institute

Project Description
Malaria is one of the four most life-threatening infectious diseases worldwide. While treatments are often available, they must be delivered as quickly as possible after onset of symptoms. Malaria is a parasite carried by mosquitos and can be diagnosed with a microscope and blood smear. However, most infections occur in rural areas where these facilities are not available due to limited resources. We are developing a low-cost microscope that is based on recent discoveries in the field of computational optics that have the potential to change the world of microscopy imaging. Using a simple 3-D printed microscope design and Raspberry Pi camera, we use optics to capture the image as a Fourier transform and take the inverse Fourier transform to create the image. With this approach, ultra-high resolution (1 µm) images with large field of view (10 mm) can be acquired at the same time, which is ideal for microscopy. Our goal is to be the first team in the world to use this approach for malaria diagnoses.

Student Qualifications
We are looking for a student with good computer programming skills, in particular Python and Matlab, an interest in physics, and a willingness to learn about optics and Fourier transforms.

Apply for this project

Additional Projects Available Soon

Project Title:
Miniature spectrometer for tissue blood oxygen monitoring in low-resource settings
Supervisor:
Dr. Mamadou Diop, Medical Biophysics and Lawson Health Research Institute

Project Title:
Optimization of spectral resolution and light throughput for *in vivo* tissue spectroscopy in low-resource settings
Supervisor:
Dr. Mamadou Diop, Medical Biophysics and Lawson Health Research Institute

Project Title:
Low-cost emergency ventilator
Supervisor:
Dr. David Holdsworth, Medical Biophysics and Robarts Research Institute