

REMOTELY TOGETHER



**RESEARCH
INTERNSHIP
PROGRAM**

**POLYTECHNIQUE
MONTREAL**

TECHNOLOGICAL
UNIVERSITY



SUMMER 2021

Founded in 1873, **Polytechnique Montréal** is a leading Canadian university for the scope and intensity of its engineering research and industrial partnerships. It is highly ranked for the number of Canada Research Chairs in Engineering, the most prestigious research funding in the country, and is also first in Québec for the size of its student body and the scope of its research activities. Polytechnique Montréal has laboratories at the cutting edge of technology thanks to funding of nearly a quarter of a billion dollars from the Canada Foundation for Innovation over the past 10 years. More than ever, society needs creative and innovative engineers, and that is where Polytechnique and its community truly shine, especially through its active research activities on campus or remotely!

REMOTE RESEARCH INTERNSHIP PROGRAM

A research internship is a research activity that is an integral part of an international student's academic program at the home institution. The research is conducted remotely, supervised by a professor of Polytechnique and is always related to needs expressed by society or companies, and is made remotely.

DURATION

The recommended duration of the internship is a minimum of 4 months, usually taking place between May and August. Once the admission to the program has been confirmed, no change in the duration and the dates can be made. Please confirm the research duration with your home institution supervisor before applying.

FINANCIAL ARRANGEMENT

- Tuition fees waiver for the duration of the internship.

Outstanding candidates may receive one of the 20 scholarships available! Maximum amount of the scholarship: \$4000 CAD (calculated according to the duration of your stay).



ELIGIBILITY CRITERIA

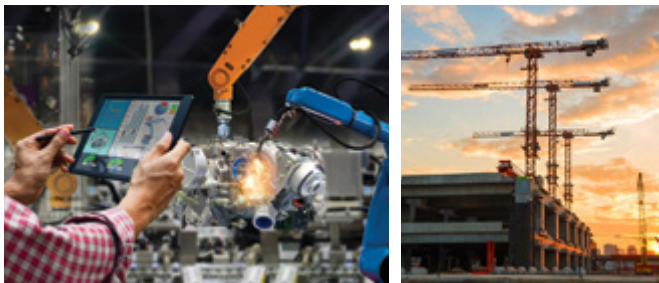
- Being enrolled in one of Polytechnique Montréal's partner universities
- Having completed at least two years of an engineering undergraduate program or at least one year of a graduate program (Master or Ph.D.) according to projects' requirements as described in the following pages
- Having a minimum GPA of 2.75 out of 4
- Meet the specific skills required by the supervisor if any
- Being fluent in French or in English (no language proficiency test is required)

REQUIRED DOCUMENTS FOR APPLICATION

(in French or in English)

- Application Form;
- Letter of motivation including the following information (if you have selected 2 research projects, provide a letter of motivation for each project):
 - your interest in working in the selected project
 - your skills in respect to the project
- Curriculum vitae (CV);
- Copy of your passport;
- Copy of your most recent academic transcript;
- Proof of a full-time enrollment from your home institution (the letter must confirm that you are currently enrolled in a full-time program and will continue to be enrolled upon your return);
- If possible, a copy of an internship report made in the past.

To enhance your chances to be selected, choose 2 research projects. It can be 2 research projects from the list or 1 research project from the list and 1 supervisor from the Directory of Expertises!



APPLICATION DEADLINE

All documents must be sent electronically by **February 1, 2021** to Polytechnique Montréal International: point@polymtl.ca. Please specify in the subject "2021 Summer Research Internship Program". Note that a conference call via Skype may be organized if needed for final selection.

ANNOUNCEMENT

The results will be announced in February 2021 to each candidate. Selected candidates will receive a Letter of Invitation from the host department to officialize the remote internship.

LIST OF RESEARCH PROJECTS

Click on numbers to access project description

AEROSPACE ENGINEERING

- [1](#) Open-source clearance consumption calculation for aircraft engine blade optimization
- [2](#) Efficient reduced order modelling of aircraft engine bladed disks with Code Aster
- [3](#) Digital twins for dynamics and fluid structure interaction systems

BIOMEDICAL ENGINEERING

- [4](#) Simulation and control of a 3D-printed Exoskeleton of the Upper Limb
- [5](#) Real-time Quantification of Muscle Forces
- [6](#) Control of a Robotic Arm for Assisting Patients with Musculoskeletal Disorders

CHEMICAL ENGINEERING

- [7](#) Development of numerical models to simulate granular flows
- [8](#) Modeling of water use impacts on ecosystems
- [9](#) Gas to liquid technology, process control and optimization
- [10](#) Recycling Technologies for Polymer Automotive Components

CIVIL, GEOLOGICAL AND/OR MINING ENGINEERING

- [11](#) Reclamation of abandoned acid generating tailings storage facilities

COMPUTER AND SOFTWARE ENGINEERING

- [12](#) Multi-Robot Planetary Exploration System
- [13](#) High Fidelity Data Collection for Precision Agriculture with Drone Swarms
- [14](#) Failure-Tolerant Connectivity Maintenance for Robot Swarms
- [15](#) Merging semantic and feature maps
- [16](#) Intelligent image mining for user interaction design
- [17](#) Natural language processing for mining open source issue discussions

MATHEMATICS AND INDUSTRIAL ENGINEERING

- [18](#) Artificial Intelligence (AI) for adaptive pilot training in flight simulator
- [19](#) Topological and functional optimization of lattice structures using adaptive approaches

MECHANICAL ENGINEERING

- [20](#) Development of simulation tools for geothermal heat pump systems



ADDITIONAL AREAS OF EXPERTISE

YOU DIDN'T FIND WHAT YOU WERE LOOKING FOR?

- Browse our professors' directory by area of expertise: **www.polymtl.ca/recherche/rc/en/expertises**
- Submit the area of expertise you would like to work on and provide the names of 2-3 professors working in this field.
- Explain in your letter of motivation why you would like to do a research internship in this area.
- Polytechnique Montréal International will try to find the appropriate match for you!
- Polytechnique Montréal's professors must agree to offer the research project remotely.

HERE ARE SOME IDEAS:

- Aerospace Engineering
- Applied Mathematics
- Artificial Intelligence
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering
- Computer and Software Engineering
- Design and Manufacturing
- Electric and Electronic Engineering
- Environmental Engineering
- Fluid Mechanics
- Fuel and Energy Technology
- Hydrology
- Industrial Engineering
- Information Technology
- Materials Science and Technology
- Mechanical Engineering
- Mining and Mineral Processing
- Nuclear Engineering
- Physics Engineering
- Robotics
- Structural Engineering

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☒ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☒ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Open-source clearance consumption calculation for aircraft engine blade optimization
University Cycle :	☒ 1 st cycle (Undergraduate) ☐ 2 nd cycle (Master) ☐ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	In aircraft engines, the blades are designed based on aerodynamic considerations to decrease the fuel consumption to reach environmental and economical constraints. The blade mechanical resistance to contact events is verified at the end of design process. In order to take structural consideration as soon as the design stage, the LAVA (Laboratory of Acoustics and Vibration Analysis) is developing an in-house code to optimize the blade geometry with respect to structural criteria. However, this tool has the drawback to rely on a commercial finite element software. The aim of this internship is to replace the portion of the code that calls for the commercial software by an open-source software.
Tasks during the Internship: (max. 50 words)	(1) export of .med file from the CAD software Salomé, (2) import of .med file in the finite element software Code Aster, (3) translation of an existing code in a compatible script for Code Aster and launch simulations, and (4) extraction of key output quantities.
Required Skills for the Internship: (max. 50 words)	The intern should have an advanced knowledge of the finite element method. Also, the intern should have good programming skills. The code will be developed in Python. The prior knowledge of this programming language is a strong asset for the internship.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Alain Batailly Title: Associate Professor Department: Département de génie mécanique Website: http://lava.polymtl.ca

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Area of Expertise :	☒ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☒ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Efficient reduced order modelling of aircraft engine bladed disks with Code Aster
University Cycle :	☐ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☐ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Finite element models can contain millions of degrees of freedom. Their large size makes them not suitable for nonlinear analyses. Therefore, reduction techniques have been developed. The aim of this internship is to be able to build these reduced order models using an open access finite element software package Code Aster through an automated procedure. Centrifugal effects will also be considered in the reduced model. An extensive validation of the code will be carried out using existing models. These reduced order model will be used as an input of an in-house code developed at the LAVA (Laboratory of Acoustics and Vibration Analyses) dedicated to the study of contact nonlinearities in aircraft engines.
Tasks during the Internship: (max. 50 words)	The tasks of the internship are: (1) import of .med file in Code Aster, (2) automated extraction of nodes lists from the .med file, (3) translation and adaptation of the reduction procedure, (4) addition of centrifugal effects in the reduction, (5) validation of the obtained reduced model.
Required Skills for the Internship: (max. 50 words)	The intern should have an advanced knowledge of the finite element method. Also, the intern should have good programming skills. The code will be developed in Python. The prior knowledge of this programming language is a strong asset for the internship.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Alain Batailly Title: Associate Professor Department: Département de génie mécanique Website: http://lava.polymtl.ca

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Research Project Title : (max. 10 words)	Digital twins for dynamics and fluid structure interaction systems
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	We are developing the Digital twin of academic model systems exhibiting some of the same physics as hydroelectric power generating equipment. It will combine physics-based numerical simulation with live data collected from sensors through the use of artificial intelligence and machine learning to achieve real-time simulation. We will generate reduced-order academic models which exhibits some of the physics of real power generating equipment using Physics-Informed Neural Networks and based on Proper Generalized Decomposition expansion. Simultaneously, we are designing, building and instrumenting experimental setups for the academic models to validate the models.
Tasks during the Internship: (max. 50 words)	You will join a team to work on modelling and/or experimenting according to your interests and strength. Your tasks will include deriving equations, coding models (Python/ Matlab), training neural networks, running simulations, help in designing, sizing, manufacturing, assembling, and testing the experimental setup.
Required Skills for the Internship: (max. 50 words)	Self-motivated, eager and curious to try new and different approaches. Modeling: Strong programming skills (Python, Matlab), Finite Element Analysis, Neural Networks, Reduced-order Modeling. Technical: CAD (Siemens NX, Catia, Solidworks), designing, machining, instrumentation.
Confidentiality and Intellectual Property *	Will the signature of a “Confidentiality Agreement” be required? ☒ Yes ☐ No Will the signature of an “Assignment of Intellectual Property” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Frederick P. Gosselin Title: Professor Department: Mechanical Engineering Website: www.fgosselin.com

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Research Project Title : (max. 10 words)	Simulation and control of a 3D-printed Exoskeleton of the Upper Limb
University Cycle :	☒ 1 st cycle (Undergraduate) ☐ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	According to https://magicarms.org/, for the millions of children with neuromuscular disorders, debilitating weakness in the arms and shoulders makes everyday tasks nearly impossible. And no satisfying commercial solution has ever existed for them. But with the emerging innovative 3D-printed exoskeletons, the impossible becomes possible. We have developed an innovative gravity-balancing actuated upper limb exoskeleton, available to children who need it, thanks to 3D-printing (rapid prototyping). The objective of this project is to simulate and control this innovative exoskeleton of the upper limb, based on our expertise and infrastructure on rapid prototyping, robotics, and upper limb musculoskeletal modeling.
Tasks during the Internship: (max. 50 words)	Get familiarized with our upper limb exoskeleton model (and v-rep with C++, CAD) ; Simulate and control this innovative exoskeleton of the upper limb, for new populations, and analyze it; Prepare a demo video showing the ability of the exoskeleton; Technical Report.
Required Skills for the Internship: (max. 50 words)	Knowledge in robotics, C++ and CAD Software, ideally Solidworks; Interest in musculoskeletal modeling (biomechanics); Knowledge of musculoskeletal modeling (biomechanics) is a plus; Priority will be given to candidates enrolled in a mechanical engineering prog., a biomedical engineering prog. or an electrical engineering prog.
Confidentiality and Intellectual Property *	Will the signature of a “Confidentiality Agreement” be required? ☒ Yes ☐ No Will the signature of an “Assignment of Intellectual Property” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Maxime RAISON / Sofiane ACHICHE Title: Full Professors Department: Mechanical Engineering Website: polymtl.ca/expertises/en/achiche-sofiane polymtl.ca/expertises/en/raison-maxime

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Research Project Title : (max. 10 words)	Real-time Quantification of Muscle Forces
University Cycle :	☒ 1 st cycle (Undergraduate) ☐ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	The major problem to assess individual muscle forces is to solve the muscle force redundancy problem, as several muscles overactuate each human body joint. To solve this problem, a novel non-invasive method was proposed by the lab by using musculoskeletal modeling and electromyographic (EMG) data. The objective is to contribute to the development of a novel tool for real-time quantification of muscle forces based on musculoskeletal modeling and electromyography, by either extending the musculoskeletal model or transforming the process in real-time, or both.
Tasks during the Internship: (max. 50 words)	Get familiarized with our musculoskeletal modeling in MATLAB and ROBOTRAN (www.robotran.be), efficient multibody dynamics software; Contribute to the development of a novel tool for real-time quantification of muscle forces based on musculoskeletal; Extend the musculoskeletal modeling; Technical Report.
Required Skills for the Internship: (max. 50 words)	Basic knowledge of coding in MATLAB but C++ is a plus; Basic knowledge about musculoskeletal modeling (biomechanics); Knowledge of optimization and ordinary differential equations is a must; Priority will be given to candidates enrolled in a computer science program or an electrical engineering program.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Sofiane ACHICHE / Maxime RAISON Title: Full Professors Department: Mechanical Engineering Website: polymtl.ca/expertises/en/achiche-sofiane polymtl.ca/expertises/en/raison-maxime

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Research Project Title : (max. 10 words)	Control of a Robotic Arm for Assisting Patients with Musculoskeletal Disorders
University Cycle :	☒ 1 st cycle (Undergraduate) ☐ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Robotic arms for assistance, such as JACO(TM) developed by the Canadian company Kinova. The time to reach certain objects with the arm can be long and complex, causing fatigue and frustrations. It is therefore necessary to consider simplifications of the command. To achieve this, we propose the use gaze supported robotic control. A robotic arm is available in our research laboratory as well as a low-cost eye-tracker. The objective of this project is to semi-automate the control of the robotic arm through the control of the orientation of the effector with respect to the user, in order to reduce the time of completion of everyday tasks. We expect to reduce the time to reach objects by over 50 %.
Tasks during the Internship: (max. 50 words)	Identify and categorize the most common / useful trajectories among users of the robotic arm; Determine optimal usage of a low cost eye-tracker; Develop a code to direct the end-effector in real time using the eyetracker information; Technical Report.
Required Skills for the Internship: (max. 50 words)	Basic knowledge of coding in MATLAB but C++ is a plus; Basic knowledge about design; Knowledge of robotics and/or image processing is a must; Priority will be given to candidates enrolled in a mechatronics program or an electrical engineering program.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Sofiane ACHICHE / Maxime RAISON Title: Full Professors Department: Mechanical Engineering Website: polymtl.ca/expertises/en/achiche-sofiane polymtl.ca/expertises/en/raison-maxime

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Research Project Title : (max. 10 words)	Development of numerical models to simulate granular flows
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Metal additive manufacturing (AM) is growing fast, progressively moving from prototyping and R&D to part production. Most metal AM processes use metal powder as their base feedstock and several flowability challenges remain to be solved to facilitate this transition toward high-end applications. Poor understanding of powder flowability lead to severe problems for manufacturers which can lead to failure of the printed part due to the presence of porous zones or high residual stresses. This project aims at better characterising and predicting the flow behaviour of AM powders, and improving powder flow simulation.
Tasks during the Internship: (max. 50 words)	- Design and carry out Discrete Element Method (DEM) simulations; - Develop in C++ without our high-performance DEM code; - Develop tools to post-process DEM simulation results.
Required Skills for the Internship: (max. 50 words)	The applicant should be curious, autonomous and should have a keen interest for simulation and modelling. Basic knowledge of the Linux command shell (bash) and some programming experience (C++, Python) will be considered as significant advantage when applying to this internship.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Bruno Blais Title: Assistant Professor Department: Chemical engineering Website: https://www.polymtl.ca/expertises/en/blais-bruno

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Research Project Title : (max. 10 words)	Modeling of water use impacts on ecosystems
University Cycle :	☐ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Life Cycle Assessment is a methodology that quantifies potential environmental impacts associated with the life cycle of a product. It translate an intervention, such as water consumption, into a potential impact on the environment, such as the change of quality of the ecosystem via species richness for example. The present project is developing the model describing that impact pathway precisely: converting a water consumption into a potential effect on the quality of the ecosystem caused by a reduction of the water flow.
Tasks during the Internship: (max. 50 words)	The intern will join a group working on the development of the model and assist with tasks such as data research, GIS mapping, calculations, application to a case study, comparison with another model.
Required Skills for the Internship: (max. 50 words)	Knowledge of Excel and QGIS is an asset.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Anne-Marie Boulay Title: Assistant Professor Department: Chemical Engineering Website: www.ciraig.org

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Area of Expertise :	☐ Aerospace ☐ Biomedical ☒ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Gas to liquid technology, process control and optimization
University Cycle :	☐ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☐ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Being familiar with thermodynamics and the kinetics of catalytic reactions, Expert enough in chemical process simulators especially ASPEN PLUS, and ASPEN HYSYS. Being familiar with basics of design of experiment. Has enough knowledge on coding in MATLAB and Python
Tasks during the Internship: (max. 50 words)	Working on micro-refinery unit pilot setup, Simulation by ASPEN software, Programming by MATLAB and perhaps Python
Required Skills for the Internship: (max. 50 words)	Softwares such as Pro II, Aspen package, MATLAB, Python, Engineering standards such as API
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Gregory Patience Title: Professor Department: Chemical Engineering Website: https://www.polymtl.ca/gch/en

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Area of Expertise :	☐ Aerospace ☐ Biomedical ☒ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Recycling Technologies for Polymer Automotive Components
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Automotive polymers are currently not recycled in Canada. It is estimated 350 kt /year of plastics from end-of-life vehicles are landfilled. However, the use of plastics and plastic composites in vehicles is expected to increase, since they allow for significant weight reduction, and hence fuel consumption reduction, compared to conventional materials such as metals or glass. This project will develop economically viable and environmentally acceptable technologies for recycling polymer automotive components, with emphasis on PMMA (poly methyl methacrylate) and PC (polycarbonate), two transparent polymers envisioned for developing lightweight polymer glazings and other advanced components.
Tasks during the Internship: (max. 50 words)	1- Literature review 2- Analysis of data 3- Visualization of data 4- Documentation and writing of reports
Required Skills for the Internship: (max. 50 words)	1- Write and speak professionally and communicate and relate well to others 2- Problem solving: ability to analyze and evaluate a situation 3- Basic knowledge of chemical processes
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Gregory S. Patience Title: Professor, Canada Research Chair Department: Chemical Engineering Website: https://www.polymtl.ca/expertises/en/patience-gregory-scott

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Area of Expertise :	☐ Aerospace ☐ Biomedical ☒ Chemical ☒ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Reclamation of abandoned acid generating tailings storage facilities
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Mine wastes (tailings and waste rocks) often contain sulfides which can oxidize upon contact with oxygen and water, and produce acid mine drainage (AMD) characterized by high concentrations of sulfates and heavy metals. Nowadays, reclamation at mine closure is mandatory to prevent contamination, but many mine sites were abandoned in the past and have been producing AMD for years, with severe environmental consequences. Their reclamation is, however, complex because of the contaminated pore water and unstable secondary precipitates. The objective of this project is therefore to evaluate the performance of several reclamation options to prevent further contamination.
Tasks during the Internship: (max. 50 words)	Guided literature review. Calibration and validation of numerical simulations (PHREEQC and/or MIN3P) based on laboratory experiment results. Quantitative evaluation and comparison of the performance of various reclamation techniques.
Required Skills for the Internship: (max. 50 words)	Basic knowledge in geochemistry and hydrogeology. Good autonomy. Experience with numerical simulations would be beneficial but is not mandatory. A relatively recent PC is required for the project.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Thomas Pabst Title: Professor, Scientific Director of RIME Polytechnique Department: Civil, Geological and Mining Engineering Department Website: http://www.irme.ca/en/

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Research Project Title : (max. 10 words)	Multi-Robot Planetary Exploration System
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	The aim of this project is to develop the software infrastructure needed for one (or more) human(s) and a swarm of robots to collaborate in the exploration of hardly accessible planetary environments. We are currently working with NASA and ESA to develop a multi-robot mission to explore a lava tube on the moon. As the robots advance, they shall map the environment, place themselves so that network connectivity is guaranteed, and relay data. The overall goal is to increase the performance as well as the safety of the humans involved in the exploration.
Tasks during the Internship: (max. 50 words)	Help in the preparation of a field mission for the exploration of a lava tube on the island of Lanzarote: write code, perform experiment with rovers and flying robots.
Required Skills for the Internship: (max. 50 words)	Python and/or C/C++ skills are preferable. If you are new to programming, don't worry you can learn to code with robots at MIST lab.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Giovanni Beltrame Title: Professor Department: Computer and Software Engineering Website: https://mistlab.ca

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Research Project Title : (max. 10 words)	High Fidelity Data Collection for Precision Agriculture with Drone Swarms
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	The world needs more food. What can we do to improve the way food is produced? This project proposes to improve productivity and sustainability by increasing the precision of the data collected with the use of Artificial Intelligence (Deep Convolutional Neural Networks) powered autonomous drone swarms capable to fly among crops. There are many exciting challenges to be overcome here: SLAM, Visual Inertial Odometry, Image Segmentation (and Classification), Sensor Fusion and drone design/optimization. Much of the work developed here will be useful for other cool research fields like self-driving cars, industrial robots, search and rescue, and even space exploration!
Tasks during the Internship: (max. 50 words)	We will have many cool and exciting possible tasks where the intern will be able to learn more about: TensorFlow (deep learning/machine learning), dataset creation and augmentation, operating/building drones (UAVs), ROS/Robotics and electronics in general, Buzz (robot swarms), Computer Vision and Motion Tracking.
Required Skills for the Internship: (max. 50 words)	The skills will depend on the task, but in general terms the minimum skills are: Python (the deeper the better), C/C++ (basic knowledge is fine), sh/bash, Linux (Ubuntu/Debian), linear algebra (for computer vision and machine learning) and basic knowledge on electronics (for operating/building drones).
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Giovanni Beltrame Title: Professor Department: Computer Engineering Website: http://mistlab.ca

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☒ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☒ Computer/Software ☒ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Failure-Tolerant Connectivity Maintenance for Robot Swarms
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	In many real-world applications, robots need communication between each other to coordinate. For the information to propagate, robots need to be connected, i.e. there has to be a communication path between all the robots in a team. We have designed a decentralized connectivity-preserving algorithm and validated using the ARGOS multi-robot simulator. The connectivity-preserving algorithm has to be ported on to a fleet of Khepera IV (ground robots) and CrazyFlies (small indoor drones).
Tasks during the Internship: (max. 50 words)	Develop software for a group of ground robots and small indoor drones, and port the connectivity maintenance algorithm from simulation to reality.
Required Skills for the Internship: (max. 50 words)	Python and/or C/C++ skills are preferable. If you are new to programming, don't worry you can learn to code with robots at MIST lab.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Giovanni Beltrame Title: Professor Department: Computer and Software Engineering Website: http://mistlab.ca

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☒ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☒ Computer/Software ☒ Electrical ☐ Mathematics/Industrial ☒ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Merging semantic and feature maps
University Cycle :	☐ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Mapping is the fundamental requirement for autonomous robot navigation, which is also important for operators to visualize and understand the environment. With the help from machine learning, semantic meaning can enhance a map with high-level knowledge of the world. In this project, we want to merge the semantic meaning into a point cloud map to build a 3D semantic map. In other words, combine the objects recognized with a given point cloud, i.e. some points stand for a chair and some other points stand for a table. Given this high-level map, robots can navigate based on the compact path planning commands, i.e. go to the table.
Tasks during the Internship: (max. 50 words)	Use the robots in the lab to get semantic meaning and 3D point maps. Explore the way to fuse these information together.
Required Skills for the Internship: (max. 50 words)	Python and/or C/C++ skills are preferable. Knowledge about robots navigation and/or mapping will help a lot. If you are new about these, don't worry you can learn to code with robots at MIST lab.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Giovanni Beltrame Title: Full Professor Department: Department of Computer and Software Engineering Website: https://mistlab.ca/

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☐ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☒ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Intelligent image mining for user interaction design
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	User-centered design (UCD) is widely adopted to create interactive systems that satisfy user needs and characteristics. During this process, designers create and access a large number of design artifacts, including sketches, design examples, and mockups. With little tool support, however, designers are usually frustrated when managing a huge collection of artifacts. This project aims at addressing this challenge by using computer vision techniques to identify patterns and relationships among design artifacts. This knowledge will enable new technologies that help interaction designers organize, reuse, and retrieve design knowledge from these artifacts.
Tasks during the Internship: (max. 50 words)	We will explore (1) automated methods for identifying interactive elements in the design artifacts (images of UI design), (2) automated matching of the interactive elements and their relationships to established interaction design patterns (e.g. those in Tidwell's patterns), (3) design of tools that leverage these methods.
Required Skills for the Internship: (max. 50 words)	- Motivated learner, critical thinker, and team contributor - Experience and/or skills in machine learning and computer vision techniques - Programming skill in python - Knowledge and/or interests in user-centered interaction design
Confidentiality and Intellectual Property *	Will the signature of a "Confidentiality Agreement" be required? ☐ Yes ☒ No Will the signature of an "Assignment of Intellectual Property" be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Jinghui Cheng Title: Assistant Professor Department: Computer and Software Engineering Website: http://jhcheng.me

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☐ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☒ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Natural language processing for mining open source issue discussions
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Open source software (OSS) development teams often use Issue Tracking Systems (ITSs) to manage bug reports, new feature requests, tasks to be completed, and other affairs or cases during the development process. Most modern ITSs for OSS projects allow users to add comments to issues. Over time, these comments accumulate into discussion threads embedded with rich information about the software project, which can potentially satisfy the diverse needs of OSS stakeholders. However, discovering and retrieving relevant information from the discussion threads is a challenging task, especially when the discussions are lengthy and the number of issues in ITSs are vast.
Tasks during the Internship: (max. 50 words)	We will explore natural language processing (NLP)-based argumentation mining techniques to support diverse OSS stakeholders in discovering and contributing information to the ITSs. We will design and implement both the back-end algorithms and the user interaction of the tool.
Required Skills for the Internship: (max. 50 words)	- Motivated learner, critical thinker, and team contributor - Knowledge and/or experience in open source development - Experience and/or skills in machine learning and natural language processing - Back-end (python) or front-end (HTML, CSS, Angular) programming skill - Experience and/or interests in user-centered interaction design techniques
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Jinghui Cheng Title: Assistant Professor Department: Computer and Software Engineering Website: http://jhcheng.me

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☒ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☒ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Artificial Intelligence (AI) for adaptive pilot training in flight simulator.
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☐ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Current airline pilot training methods consist of training pilots on the repetitive execution of maneuvers. In this developing and dynamic industry, this approach is no longer meeting the requirements for real-life operations. Pilot training methods need to focus on the development of pilot competencies in order to foster resilience, which is the ability of the crew to deal calmly and efficiently with unexpected situations. In this study, the research team aims at creating an AI which will be able to: 1. identify pilot weaknesses and 2. provide real-time adaptive training to improve these weaknesses. This study will be done using a virtual flight simulator.
Tasks during the Internship: (max. 50 words)	The intern will work with a POLY-MTL Ph.D. student, a Canadian manufacturer of simulation technologies, & a Montreal-based human-AI collaboration startup. 1. Familiarization with airline pilot training & flight operations, 2. Perform data analysis & data mining activities, 3. Participate in the development & testing of the AI.
Required Skills for the Internship: (max. 50 words)	Interpersonal skills, autonomous, great communication skills, works wells in a team, organized and meticulous, and have interest in the domain! Having experience with data manipulation and AI is a major plus.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☒ Yes ☐ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☒ Yes ☐ No
Location:	☒ Remotely
Supervisor:	Name: Philippe Doyon-Poulin Title: Professor Department: Industrial Engineering Website: https://www.polymtl.ca/expertises/en/doyon-poulin-philippe

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☐ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☒ Mathematics/Industrial ☐ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Topological and functional optimization of lattice structures using adaptive approaches
University Cycle :	☒ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☐ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Additive manufacturing provides sufficient flexibility to produce lattice structures with complex geometries that can replace solid structures in order to reduce their mass while retaining their mechanical and thermal properties. One can utilize numerical methods to optimize the design of lattices with respect to their functionality. This leads to the solution of large optimization problems with geometrical constraints. In order to reduce computational costs, the overall objective of the project is to develop adaptive methods in which coarse lattices are iteratively populated with new cells where necessary. Specific goals are to develop and test new adaptation criteria and adaptive algorithms for two and three dimensional lattices.
Tasks during the Internship: (max. 50 words)	Development and analysis of adaptation criteria for 2D and 3D lattices. Analysis of optimization methods. Implementation of new algorithms in Matlab. Implementation of numerical examples and analysis of the results.
Required Skills for the Internship: (max. 50 words)	Background in numerical analysis and scientific computing. Some knowledge of the Finite Element Method. Excellent programming skills. Some knowledge of Solid Mechanics.
Confidentiality and Intellectual Property *	Will the signature of a “ Confidentiality Agreement ” be required? ☐ Yes ☒ No Will the signature of an “ Assignment of Intellectual Property ” be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Serge Prudhomme Title: Professor Department: Department of Mathematics and Industrial Engineering Website: https://www.polymtl.ca/expertises/en/prudhomme-serge

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PROJECT DESCRIPTION

2021 Summer Research Internship Scholarship Program

Area of Expertise :	☐ Aerospace ☐ Biomedical ☐ Chemical ☐ Civil, Geological, Mining ☐ Computer/Software ☐ Electrical ☐ Mathematics/Industrial ☒ Mechanical ☐ Physics
Research Project Title : (max. 10 words)	Development of simulation tools for geothermal heat pump systems
University Cycle :	☐ 1 st cycle (Undergraduate) ☒ 2 nd cycle (Master) ☒ 3 rd cycle (Ph.D.)
Background Information: (max. 100 words)	Design and simulation of geothermal systems rely on accurate predictions of soil and fluid temperature variations due to the operation of the heat pump over the system's life-span. Typically, temperatures are calculated from the spatial and temporal superposition of analytical thermal response functions, considering the heat extraction and rejection history of the system since the start of operation. The temporal superposition method is critical to the accuracy of temperature predictions and computational efficiency of the simulation. The objective of this project is to implement and assess the accuracy and efficiency of higher order temporal superposition techniques.
Tasks during the Internship: (max. 50 words)	1. Identify and implement higher order temporal superposition techniques for the simulation of geothermal systems 2. Assess the accuracy and computational efficiency of the implemented methods, and recommend parameters for practical simulations
Required Skills for the Internship: (max. 50 words)	1. Knowledge of Object-Oriented Programming (Python) 2. Experience or relevant courses in : Heat transfer, Numerical methods in engineering, Partial differential equations
Confidentiality and Intellectual Property *	Will the signature of a "Confidentiality Agreement" be required? ☐ Yes ☒ No Will the signature of an "Assignment of Intellectual Property" be required? ☐ Yes ☒ No
Location:	☒ Remotely
Supervisor:	Name: Massimo Cimmino Title: Assistant Professor Department: Mechanical Engineering Website: https://www.polymtl.ca/expertises/en/cimmino-massimo

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