2017 POLYTECHNIQUE MONTRÉAL WINTER RESEARCH INTERNSHIP

POLYTECHNIQUE MONTRÉAL

LE GÉNIE EN PREMIÈRE CLASSE

Polytechnique Montréal

Founded in 1873, Polytechnique Montréal is a leading Canadian university for the scope and intensity of its engineering research and industrial partnerships. It is ranked #1 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.

Research Internship Program

A research internship is a research activity that is an integral part of a visiting student's academic program at the home institution. Each year, Polytechnique's research units welcome more than 250 students from other universities wishing to put into practice the technical and scientific knowledge acquired in their studies. The research conducted is supervised by a professor of Polytechnique and is always related to needs expressed by society or companies, and can be made in laboratories or *in situ*.

Duration

The recommended duration of the internship is a minimum of 4 months, usually taking place between January and May 2017. Other duration or period can be negotiated to suit your university schedule.

Financial Arrangement

- Tuition fee waiver for the duration of the internship;
- Free transportation from the airport to your place of residence upon your arrival;
- Employer Compliance Fee of $230 CAD covered by Polytechnique Montréal (once the internship is confirmed, the work permit applicant must pay the requested immigration fee).

Outstanding candidates may receive one of the 15 scholarships available! Amount of the scholarship: $1000 CAD per month for a maximum of 4 months.

Eligibility Criteria

- Being enrolled in one of Polytechnique Montréal's partner universities;
- Having completed at least two years of an engineering undergraduate program or one year of a Ph.D. program according to projects' requirements as described in the following pages;
- 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):
  - explanations of your interest in working in the selected project
  - your skills in respect to the project
- Curriculum vitae (CV);
- 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 **July 29, 2016** to the International Relations Office of Polytechnique Montréal: *brin@polymtl.ca*. Please specify in the subject "2017 Winter 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 September 2016 to each candidate. Selected candidates will receive an "Offer of Employment to a Foreign National Exempt from a Labour Market Impact Assessment (LMIA)" and will have to apply for a Work Permit at the Canadian Visa office that serves the area they live in.

For any questions regarding your application, please contact:
International Relations Office ■ *brin@polymtl.ca*

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LIST OF RESEARCH PROJECTS

Click on numbers to access project description

Aerospace Engineering

1 Biomimetic Design of a Passively Adaptable Flexible Wing (undergraduate or Ph.D.)

Biomedical Engineering

2 Biomimetic Design of a Prosthetic Hand (undergraduate or Ph.D.)

3 Control of a Robotic Arm for Assisting Patients with Musculoskeletal Disorders using Low-Cost Eye-Tracking Device (undergraduate or Ph.D.)

4 Design and Fabrication of an Orthosis Prototype (undergraduate)

5 Design of Compliant Mechanisms for a Walking Application (Ph.D.)

6 Twisting Wire Actuation in Self-adaptive Fingers (Ph.D.)

7 Real-time Quantification of Muscle Forces based on Musculoskeletal Modeling and Electromyography (undergraduate or Ph.D.)

8 Development of a 3D-printed Exoskeleton of the Upper Limb (undergraduate or Ph.D.)

Chemical Engineering

9 Conducting Polymer Films for High-performance Bioelectronic Devices (undergraduate)

10 Processing of Conducting Polymer Films for Biological Applications (undergraduate)

11 Modeling Municipal Solid Waste (MSW) Streams using a Material Flux Analysis Approach (MFA) (undergraduate)

12 To develop a Biodryer Adapted for Sorted Solid Waste Stream Destined for RDF Production (Ph.D.)

13 Design a RDF Production Process Suitable for the Treatment of Household Waste for the City of Montreal (Ph.D.)

14 Photochemical Surface Engineering of Nanomaterials (undergraduate or Ph.D.)

Civil, Geological and/or Mining Engineering

15 Development of Ultra-high Performances Fiber Reinforced Concretes and Characterization of their Mechanical Properties (undergraduate)

16 Evaluation of the Durability of Fiber Reinforced Concretes in Realistic Conditions Found in Structures (undergraduate)

17 Development of an Algorithm in Matlab to Determine the Entrapped Air Propagation in a Stormwater Pipe (undergraduate or Ph.D.)

18 Framework for the Systematic Validation of Tracking Improvements (undergraduate or Ph.D.)

19 Video-based Analysis of Road User Behaviour (Ph.D.)

Computer and Software Engineering

20 Identifying Bottlenecks in Build System Performance (undergraduate or Ph.D.)

21 Swarm Robotics Playground Development (undergraduate)

22 Wireless Robot Localization (undergraduate)

23 A Library of Swarm Behaviors (undergraduate)

24 Probabilistic Real-Time Systems (Ph.D.)

25 Primitives for Dynamic Task Allocation in Robot Swarms (Ph.D.)

26 Software Designs Analyses (undergraduate)

27 On-line Software Quality Analyser (undergraduate)

28 Low Foot-print Meta-model for Ultra-large Scale Systems (undergraduate)

29 Multi-language Parsers (undergraduate or Ph.D.)

30 P-MARt (undergraduate or Ph.D.)

31 Improving Developers' IDEs (undergraduate or Ph.D.)

Electrical Engineering

32 Distributed Robotics (undergraduate)

33 Analysis and Design of Emerging Monitoring and Control Networks or Mobile Robotics (Ph.D.)

34 Sensors Comparison for the Detection of Movement Intent of the Upper Limb for the Control of Dynamic Systems (undergraduate or Ph.D.)

35 Evolving Mathematical Expressions Using Genetic Algorithms for V02 Max Kinematics Modelling (undergraduate or Ph.D.)

36 Designing and Prototyping a Self-Adaptive Gripper for a Baxter Robot (undergraduate)

37 Designing and Prototyping a Planar Differentially Driven Cable Robot (Ph.D.)

Mechanical Engineering

38 3D Printing of Mechanical Microsystems (undergraduate)

39 3D Printing of Advanced Materials for Mechanical Microsystems (Ph.D.)

Physics Engineering and/or Materials Science

40 Biomimetic of Spider Silk: Instability-assisted Microfabrication of Tough Fibers (undergraduate or Ph.D.)

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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.
- The International Relations Office will try to find the appropriate match for you!

Here are some ideas:

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

#1 Area of Expertise: Aerospace Engineering

Research Project Title
Biomimetic Design of a Passively Adaptable Flexible Wing

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
In most engineering applications, structures are designed to be stiff so that the loads they carry do not deform them significantly. In nature, structures are usually compliant; that is especially true for terrestrial and aquatic plants. Because they seek to maximise their surface and height in order to capture the most sunlight, plants rely on their flexibility to change form and reduce their drag when subjected to fluid flow, whether water current or wind. We say that they reconfigure. By studying how flexible structures reconfigure when subjected to flow, we can learn more about the adaptation of plants to their environment and also inspire biomimetic applications of passive reconfiguration to aerodynamic loads. With wind tunnel tests and fluid-structure interaction models, we seek to understand how flexible structures deform with great amplitude and how this affects their drag and lift. Because they seek to maximise their surface and height in order to capture the most sunlight, plants must rely on their flexibility to change form and reduce their drag when subjected to wind. We say that they reconfigure. This behavior is highly interesting for biomimetics because plants rely on passive reconfiguration and lack complex control systems. From what we have learned from studying plant reconfiguration, we seek to apply this bioinspiration to design a passively morphing wing.

The goal of the project will be to design, fabricate and test a wing that will reconfigure passively when subjected to flow. This will allow the wing to maximize its lift at low flow velocity and minimize its drag at high flow velocity. This morphing wing could have applications in miniature unmanned aerial vehicles, wind turbines or even Formula 1 racing.

Main Tasks during the Internship
To do this the student will design the wing structure, perform calculations to evaluate its reconfiguration when subjected to flow, fabricate the wing with soft polymers and test the wing in a closed loop wind tunnel we have at Polytechnique. The student will be involved in all stages of the project: design, calculations, fabrication and testing. He can expect to spend some time in front of a computer to design the wing and simulate its deformation. He will have to mold his flexible wing from soft polymers and test it in the wind tunnel. He will be supervised by a professor and a PhD student.

Required Skills for the Internship
The interested student should have basic knowledge of aerodynamics, solid mechanics, numerical methods and strain gauge measurements. He should be at ease with Matlab and some CAD software. Knowledge of finite elements is a plus.

[1]M. Hassani, N. W. Mureithi, and F. P. Gosselin, “Large coupled bending and torsional deformation of an elastic rod subjected to fluid flow,” Journal of Fluids and Structures, vol. 62, pp. 367–383, 2016.

Supervisor
Mr Frederick GOSSELIN, Assistant Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=542&Langue=A
Website: http://www.fgosselin.com

#2 Area of Expertise: Biomedical Engineering

Research Project Title
Biomimetic Design of a Prosthetic Hand

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
In most prosthetic hands the human hand is copied and modified in terms of its Degrees of Freedom or number of actuated fingers. In nature, one can observe several different topologies of "hands" for example an octopus uses its tentacles to grasp objects and monkeys have similar hands to humans but with a different position of the thumb and much higher grasping force.

If we simplify the task of the hand to grasping objects with a strong enough force, one can argue that the human hand isn't necessarily the most optimal model.

We therefore seek to apply bioinspired designs (biomimetic design) to a prosthetic hand to achieve a strong grasping of objects using the lowest energy possible and the least parts possible.

The goal of the project is to design, fabricate by rapid prototyping and if time allows test a newly designed prosthetic hand inspired by nature. The performances of the new hand will be compared to the one available at our lab in terms of grasping force and ease to use (simple metrics need to be defined).

Main Tasks during the Internship
- Get familiarized with Biomimetic Design Methods and available tools.
- Organize a small design workshop with our students to provide a group view on the design to be made, guided by biomimetic design.
- Propose a new design and analyses it.
- Write a technical report on the results.

Required Skills for the Internship
- The interested student should have basic knowledge of CAD Software ideally CATIA.
- The interested student should have basic knowledge about design methods.
- Knowledge of finite elements is a plus.
- Priority will be given to candidates enrolled in a biomedical engineering program or a mechanical engineering program.

Supervisor
Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=434&Langue=A

#3 Area of Expertise: Biomedical Engineering

Research Project Title
Control of a Robotic Arm for Assisting Patients with Musculoskeletal Disorders using Low-Cost Eye-Tracking Device

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
JACOTM is a robotic arm for assistance developed by the Canadian company Kinova. This robot has six degrees of freedom and has a three fingers gripper fixed to its end. Placed on the wheelchair of people with muscle weaknesses, this robotic arm allows them to regain some autonomy in their daily activities. Users control the arm via a joystick attached to the armrest of the powered chair, its use requires great concentration and a lot of energy for some users. Thus, 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. The arm JACOTM 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 JACOTM 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 %.

Main Tasks during the Internship
- 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 eytracker information
- Write a technical report on the results.

Required Skills for the Internship
- The interested student should have basic knowledge of coding in MATLAB but C++ is a plus
- The interested student should have 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.

Supervisor
Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=434&Langue=A

#4 Area of Expertise: Biomedical Engineering

Research Project Title
Design and Fabrication of an Orthosis Prototype

University Cycle
1st cycle (undergraduate)

Background Information
Various conditions, such as hemiparalysis, can affect walking gait due to muscular weakness or impaired motor control. In particular, stroke victims often exhibit a pattern known as "foot drop", where insufficient flexion of the ankle at the beginning of the swing phase causes dragging or slapping of the foot, and often results in the patient falling.

Various active (i.e. actuated) or passive orthoses have been developed to correct or prevent gait anomalies for rehabilitation purposes. A new research direction is currently explored at the robotics laboratory of Polytechnique Montréal to design a mechanical system considerably simplifying competing devices through the innovating use of particular mechanisms, linkages, and energy producing elements.

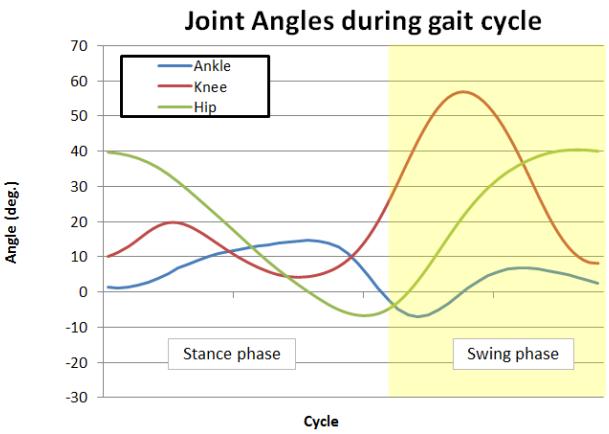

Figure 1: Walking gait cycle

(source : CGA Normative Gait Database, data from Stansfield BW)

Main Tasks during the Internship
In collaboration with the graduate student leading the project, it is required to design and build an engineering prototype implementing the developed mechanism for concept validation and performance analysis purpose. At this stage, the main issue is linking the different body joints to generate the functions illustrated in Fig. 1. The prototype would therefore include a test bench simulating a human leg with either nominal or abnormal gait.

Orthosis prototype:
- Model the mechanism according to the existing design parameters.
- Provide the drawings for the manufacturing of the components of the prototype.
- Manufacture and assemble the parts of the prototype.

Bench test:
- Modelling, manufacturing and assembly.
- Select and assemble the electronic drives.
- Implement a simple controller on an onboard microcontroller
- Proceed with experimental validation of the concept.

Required Skills for the Internship
Experience with the following techniques is desirable:
- 3D modeling and design
- Rapid prototyping (3D printing & laser cutting)
- Electronic circuit design
- Basic programming skills
- Excellent writing and speaking communication are mandatory

Supervisor
Mr Lionel BIRGLEN, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=341&Langue=A

#5 Area of Expertise: Biomedical Engineering

Research Project Title
Design of Compliant Mechanisms for a Walking Application

University Cycle
3rd cycle (Ph.D.)

Background Information
Compared to a fully actuated serial mechanism mimicking a human or animal leg, a parallel mechanism (such as a Hoeckens, Klann or Jansen linkage) may use as few as a single degree of freedom to generate the desired leg endpoint trajectory at the expense of having a fixed gait. Generally, a suitable leg endpoint trajectory is made of an approximatively straight line with respect to the body during the supporting phase and a more arbitrary curve when the leg is raised and brought back during the flight phase.

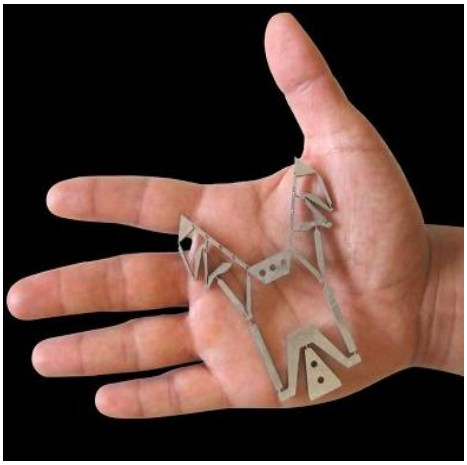

Figure 2 : Compliant gripper developed at Polytechnique Montréal

Compliant mechanisms use mechanical deformations to generate displacement or transmit forces and have mainly been developed because of their specific advantages such as an ease of manufacturing, reduced cost/weight, and absence of maintenance. The robotics laboratory at Polytechnique Montréal has over the years developed an expertise in compliant finger and gripper design. In complement of this, new research directions are currently led to develop compliant leg mechanisms, for which an initial exploration of possible designs has been undertaken.

Conceptually, the mechanism would use the rotation of an actuated crank as a main input and the position of the leg endpoint as output. A second input would be used to alter the shape of the trajectory or adjust the equivalent stiffness at the endpoint. In comparison to rigid designs, using compliant hinges in the mechanical design of the leg could provide the following advantages for a walking application: 1) Use of the deformation to store energy during the flight phase and restitute it during the support phase for more efficient motor usage; 2) Control over ground reaction forces, allowing for shock absorption and suspension.

Objectives
- Exploration of the advantages and drawbacks of multi-input compliant mechanisms for walking applications.
- Mechanical design of practical prototypes.
- Manufacturing of prototypes for performance analysis.

Main Tasks during the Internship
- Develop a model for the behavior of a compliant mechanism in the flight phase (free-state trajectory), and after contact with the ground.
- Iterate through rigid-body, lumped compliance, and distributed compliance versions of promising designs.
- Optimize the designs based on relevant performance indices.
- Evaluate the designs and general models based on experimental results.

Required Skills for the Internship
Experience with the following techniques is desirable:
- Compliant mechanism analysis and design
- Planar linkage synthesis
- Stress Analysis
- Excellent writing and speaking communication are mandatory

Supervisor
Mr Lionel BIRGLEN, Associate Professor, Department of Mechanical Engineering:
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=341&Langue=A

#6 Area of Expertise: Biomedical Engineering

Research Project Title
Twisting Wire Actuation in Self-adaptive Fingers

University Cycle
3rd cycle (Ph.D.)

Background Information
Mechatronic fingers and hands are used in a wide range of applications, ranging from spatial teleoperation to medical devices. These hands are made of multiple systems, including the actuation, the transmission, the control scheme, and the sensors. To enhance these electromechanical systems and to simplify grasping and manipulation, underactuated mechanisms have been used in the recent years. With a minimized number of actuators and some compliant elements, an underactuated hand is capable of mechanically self-adapting itself to numerous objects during grasping without any complex control law. Thus, a low-cost versatile artificial hand can be designed and manufactured. To provide actuation, DC motors, cables and pulleys are commonly used. However, a new trend in robotics consists of twisting wire actuators. Instead of having a single cable winding around a pulley, at least two wires are twist around each other, modifying their overall length. This can be advantageous in terms of space, transmission and efficiency.

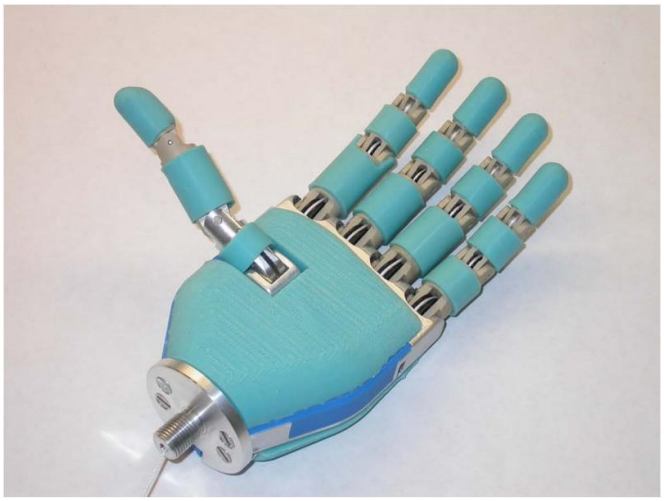

Figure 3: Example of a prostethic hand [Baril, M. *et al*. 2012, *On the design of mechanically programmable underactuated anthropomorphic robotic and prosthetic grippers*, Proc. of ASME Mechanisms and Robotics Conference, Chicago, USA, August, DETC2012-70705.]

Objectives
The objective of this internship is to assess the possibility of using twisting wire actuation in existing and future underactuated robotic fingers. The intern will have to mathematically model the relationship between the twisted wires length and the torque produced by the actuator. He/she will then have to replace the actuation mechanism of an existing underactuated robotic hand prototype and replaced it by the twisting wire actuation mechanism proposed.

Main Tasks during the Internship
- Create a theoretical model of the twisting wire actuator;
- Perform numerical simulations of the system;
- Provide the drawings to manufacture the components of the prototype;
- Choose the standard parts needed;
- Assemble the parts of the prototype and test it.

Required Skills for the Internship
- Good skills in computer-assisted design (CAD), CATIA preferably
- Excellent mathematical skills
- Comfortable with machine design and statics
- Prior experience in robotics and mechatronics;
- Having a bachelor degree in mechanical engineering, electrical engineering or equivalent.
- Excellent writing and speaking communication are mandatory

Supervisor
Mr Lionel BIRGLEN, Associate Professor, Department of Mechanical Engineering
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#7 Area of Expertise: Biomedical Engineering

Research Project Title
Real-time Quantification of Muscle Forces based on Musculoskeletal Modeling and Electromyography

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
The need for the quantification of individual muscle forces has been recognized for many years, since 1836! Its application concerns rehabilitation, ergonomics, prevention, sports, and today the design of efficient exoskeletons. 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.

Based on this method, the main challenges today are:
1. to extend the musculoskeletal model (MATLAB) to include various muscles by realistically respecting their insertions into the right bones.
2. to transform this process in real-time to ease the clinical and industrial transfer of this tool, e.g. to integrate it in exoskeletons to enhance their predictive reactions, as muscle forces appear before movement initiation. This requires transforming the process from MATLAB to C++.

The objective of this project 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.

Main Tasks during the Internship
- 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 modeling and electromyography, by performing at least one of these tasks:
- Extend the musculoskeletal modeling.
- Transform this process in real-time, i.e. from MATLAB to C++.
- Write a technical report on the results.

Required Skills for the Internship
- The interested student should have basic knowledge of coding in MATLAB but C++ is a plus
- The interested student should have 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.

Supervisor
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
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Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A

#8 Area of Expertise: Biomedical Engineering

Research Project Title
Development of a 3D-printed Exoskeleton of the Upper Limb

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
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 such as the Magic Arms, the impossible becomes possible. Magic Arms are gravity-balancing, exoskeletal devices, which become available to every child who needs it thanks to the 3D-printing (rapid prototyping).

The objective of this project is to develop a 3D-printed gravity-balancing exoskeleton of the upper limb, based on our expertise and infrastructure on rapid prototyping and upper limb musculoskeletal modeling.

Main Tasks during the Internship
- Get familiarized with our 3D-printer and our upper limb musculoskeletal model (MATLAB), which is the most accurate one in the literature.
- Develop a 3D-printed gravity-balancing exoskeleton of the upper limb. For convenience, the prototype could be developed for an adult, even if our incentive is for children from our collaborating clinical research center.
- Propose a new design and analyze it.
- Prepare a demo video showing the ability of the exoskeleton.
- Write a technical report on the results.

Required Skills for the Internship
- The interested student should have basic knowledge of CAD Software ideally CATIA.
- The interested student should have interest in musculoskeletal modeling (biomechanics).
- Knowledge of musculoskeletal modeling (biomechanics) is a plus.
- Priority will be given to candidates enrolled in a mechanical engineering program, a biomedical engineering program or an electrical engineering program.

Supervisor
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=434&Langue=A
Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
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#9 Area of Expertise: Chemical Engineering

Research Project Title
Conducting Polymer Films for High-performance Bioelectronic Devices

University Cycle
1st cycle (undergraduate)

Background Information
Organic electronic materials exhibit mixed conduction: they can transport not only electronic charge carriers (holes or electrons) but also ions. As such, they offer a suitable interface between the worlds of solid-state electronics, which use electronic charge carriers, and biology, where signals generally consist of ionic currents. Indeed, the application of conducting polymers at the interface with biology is an exciting new trend of organic electronics. The term organic bioelectronics refers to the coupling of devices based on conducting polymers with biological systems. Organic bioelectronics is the underpinning of new technologies, which bring unique capabilities at the interface between electronics and biology, such as implantable electrodes, biosensors and drug delivery systems. As an example, organic electrochemical transistors (OECTs, Figure 1a) are being used as sensors for biologically relevant species, such as hydrogen peroxide, glucose, dopamine and chloride ions. The specific objective of this project is to develop OECTs where the chemical composition and the morphology of the conducting polymer channel is tailored to achieve: i) high current modulation at low operating voltage (ideally 2-3 current decades below 100 mV), and ii) reversibility of the doping/dedoping process taking place upon application of an electrical bias. Such characteristics will improve the ability of OECTs to respond to external stimuli and to reversibly incorporate specific molecules (e.g. drugs), for possible applications of OECTs in sensing and drug delivery and for their interface with living systems. To achieve this objective we will explore a novel approach based on a combination of electrospinning and vapor phase polymerization, which is expected to lead to porous films that facilitate ionic transport between the polymer film and the electrolyte solution, with positive effects on the reversibility of the doping/dedoping process.

Main Tasks during the Internship
- Processsing of conducting polymer films
- Measurement of electrical properties
- Microfabrication

Required Skills for the Internship
- Basic knowledge of chemistry/physics
- Ability to communicate in English
- Motivation to work on multidisciplinary projects

Supervisor
Mr Fabio CICOIRA, Assistant Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=510&Langue=A
http://www.polymtl.ca/iontronics/en

#10 Area of Expertise: Chemical Engineering

Research Project Title
Processing of Conducting Polymer Films for Biological Applications

University Cycle
1st cycle (undergraduate)

Background Information
Organic electroactive materials are used to produce flexible and easily processable electronic devices, such as organic light-emitting diodes, transistors and photovoltaic cells. Alongside these well-established applications, organic electroactive materials have been introduced in bioelectronics, where electronic signals are translated into ionic bio signals and vice versa. Examples of bioelectronic devices are sensors based on organic electrochemical transistors (OECTs). The objective of this project is to provide a deeper understanding of the working mechanism of OECTs by exploring how the device electrical characteristics depend on the processing of the conducting polymer film. Conducting polymer films will be deposited by different techniques, to explore how film processing affects the doping/dedoping processes. We will use spin coating and vapor phase polymerization. We expect to obtain films with different doping/dedoping characteristics, which will shed light on the role of film processing on the ability of the conducting film to accommodate ions. The conducting polymer of choice for films to be processed by spin coating is PEDOT:PSS. PEDOT:PSS is used because of its high conductivity, biocompatibility, and chemical stability. VPP will yield films of PEDOT doped with p-toluenesulfonate (or tosylate, TOS). PEDOT:PSS and PEDOT:TOS are expected to lead to different operation mechanisms of operation in OECTs. In PEDOT:PSS the dopant anions (PSS-) are essentially immobile, since they are part of a polymer chain. Therefore the OECT current modulation is controlled mainly by incorporation of electrolyte cations. In PEDOT:TOS the dopant ions (TOS-) can be released during dedoping, therefore the dedoping process is a result of both cation incorporation and anion release. Spin-coated PEDOT:PSS films will be obtained from commercial aqueous suspensions, which need to be mixed with an organic compound (secondary dopant) to increase film conductivity. After spin coating, the films will be annealed to temperatures higher than 100°C to remove the excess of water and solvents.

Main Tasks during the Internship
- Processsing of conducting polymer films
- Measurement of electrical properties
- Microfabrication

Required Skills for the Internship
- Basic knowledge of chemistry/physics
- Ability to communicate in English
- Motivation to work on multidisciplinary projects

Supervisor
Mr Fabio CICOIRA, Assistant Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=510&Langue=A
http://www.polymtl.ca/iontronics/en

#11 Area of Expertise: Chemical Engineering

Research Project Title
Modeling Municipal Solid Waste (MSW) Streams using a Material Flux Analysis Approach (MFA)

University Cycle
1st cycle (undergraduate)

Background Information
The "Loi sur la qualité de l'environnement (LQE) states that municipalities must adopt a waste management master plan which should be based on the principle of hierarchy of 3RV-E, thus favoring, in order of priorities: reduction at source; reuse; recycling, including biological treatment or soil covering; recovery of materials and energy; ultimate disposal. In this context, in Quebec, and particularly in Montreal, the three measures for the reduction, reuse and recycling have already or will soon be established through awareness campaigns, regulations, selective collection of developments for recyclables as well as organic matter. The next big step, which is to valorize the content of household waste, is required to achieve the primary goal of the Québec Policy that is to eliminate only one residue in Quebec: the ultimate residue. It is generally accepted that over 75% of the content of household waste destined for landfill has significant recovery potential.

Several technologies already exist to recover the energy from waste, but others remain to be developed. In all cases, their application is very context-specific, particularly in terms of material flows and market availability for processed goods. A first option to investigate is the mechanical-biological treatment (MBT) of municipal waste to produce a refuse derived fuel (RDF). Indeed, in such a process, waste materials are mechanically separated prior to further treatments. Recyclable materials are recovered and recycled where possible or valued as RDF. The organic materials are biologically degraded by bio-drying, composting or anaerobic digestion. Non-recyclable inorganic materials are headed to the landfill as inert. This technique allows to reduce the amount of landfilling while recovering what can be recycled as material and energy. The ultimate residue is stabilized and thus does not contribute to the release of greenhouse gases in landfills. In practice, several problems remain to be solved to enable the production of RDF of sufficient quality to be efficiently burned (higher heating value, water content and composition). Thus, the influence of the intrinsic heterogeneity of the physical properties of solid wastes, together with the type of process selected to produce the RDF, on its properties must be characterized and modeled.

Research Objectives
The main objective of the research program is to design MBT processes for the production of RDF. To achieve this goal, several projects are defined such as the project entitled **Modeling municipal solid waste (MSW) streams using a material flux analysis approach (MFA).**

Main Tasks during the Internship
In this project, a detailed model of the MSW generation and treatment map will be developed. MFA will include all the treatment options available to process the various waste streams. A Three-way collection system will be implemented at the generator level, to help ascertain the effect of this type of waste segregation systems on the "quality" of the different waste streams. The overall MFA model will be used; 1. to evaluate current treatment strategies and 2. to optimize future MSW management plans. The main tasks during a 6 month internship are:

- Collect MSW data from the City of Montreal
- Analyze MSW data and produce a databank compatible with MFA software platform
- Develop a MFA model of the different MSW streams and treatments based on the City of Montreal's waste management plan
- Develop a user-friendly interface for data input and for presentation of results
- Carry out simulations of different waste management strategies using the MFA model
- Present and analyze results from simulation

Required Skills for the Internship

The candidate must be enrolled in final year of a Chemical Engineering program and should have:

- Solid knowledge of Chemical Engineering principles (mass and energy balances, waste treatment processes, process simulation)
- Proficient in calculation and simulation software (Matlab, Simulink, Aspen plus) and presentation interface
- Excellent communication skills (oral and written)

Supervisor

Mr Robert LEGROS, Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=36&Langue=A

#12 Area of Expertise: Chemical Engineering

Research Project Title
To develop a Biodryer Adapted for Sorted Solid Waste Stream Destined for RDF Production

University Cycle
3rd cycle (Ph.D.)

Background Information
The "Loi sur la qualité de l'environnement (LQE) states that municipalities must adopt a waste management master plan which should be based on the principle of hierarchy of 3RV-E, thus favoring, in order of priorities: reduction at source; reuse; recycling, including biological treatment or soil covering; recovery of materials and energy; ultimate disposal. In this context, in Quebec, and particularly in Montreal, the three measures for the reduction, reuse and recycling have already or will soon be established through awareness campaigns, regulations, selective collection of developments for recyclables as well as organic matter. The next big step, which is to valorize the content of household waste, is required to achieve the primary goal of the Québec Policy that is to eliminate only one residue in Quebec: the ultimate residue. It is generally accepted that over 75% of the content of household waste destined for landfill has significant recovery potential.

Several technologies already exist to recover the energy from waste, but others remain to be developed. In all cases, their application is very context-specific, particularly in terms of material flows and market availability for processed goods. A first option to investigate is the mechanical-biological treatment (MBT) of municipal waste to produce a refuse derived fuel (RDF). Indeed, in such a process, waste materials are mechanically separated prior to further treatments. Recyclable materials are recovered and recycled where possible or valued as RDF. The organic materials are biologically degraded by bio-drying, composting or anaerobic digestion. Non-recyclable inorganic materials are headed to the landfill as inert. This technique allows to reduce the amount of landfilling while recovering what can be recycled as material and energy. The ultimate residue is stabilized and thus does not contribute to the release of greenhouse gases in landfills. In practice, several problems remain to be solved to enable the production of RDF of sufficient quality to be efficiently burned (higher heating value, water content and composition). Thus, the influence of the intrinsic heterogeneity of the physical properties of solid wastes, together with the type of process selected to produce the RDF, on its properties must be characterized and modeled.

The main objective of the research program is to design MBT processes for the production of RDF. To achieve this goal, several projects are defined such as the project entitled **To develop a biodryer adapted for sorted solid waste stream destined for RDF production.**

Main tasks during the internship:
In this project, the sorted solid waste stream identified as feed for RDF production will be characterized in terms of potential candidate for biodrying. This will entail modeling the influence of the properties of the constituent materials on their biodrying behaviour (process yield and properties of the resulting RDF). In order to predict the influence of conditioning on the properties of biodried materials, a mathematical model will be developed and validated by comparison with collected actual data. Subsequently, biodrying tests will be carried out in the laboratory prototype available at the Department of Chemical Engineering at Polytechnique Montreal and will characterize the influence of the material properties and the operating conditions of the biodrying process, on the properties of fuels and products. The characterization of these properties will be carried out using conventional analytical methods, for which the equipment is also available at the Department of Chemical Engineering. In order to predict and optimize solid waste biodrying, a mathematical model will be developed and validated.

Requirement for project:
The candidate must have completed a Chemical Engineering undergraduate program and be enrolled in a graduate study program.

Supervisor
Mr Robert LEGROS, Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=36&Langue=A

#13 Area of Expertise: Chemical Engineering

Research Project Title
Design a RDF Production Process Suitable for the Treatment of Household Waste for the City of Montreal

University Cycle
3rd cycle (Ph.D.)

Background Information
The "Loi sur la qualité de l'environnement (LQE) states that municipalities must adopt a waste management master plan which should be based on the principle of hierarchy of 3RV-E, thus favoring, in order of priorities: reduction at source; reuse; recycling, including biological treatment or soil covering; recovery of materials and energy; ultimate disposal. In this context, in Quebec, and particularly in Montreal, the three measures for the reduction, reuse and recycling have already or will soon be established through awareness campaigns, regulations, selective collection of developments for recyclables as well as organic matter. The next big step, which is to valorize the content of household waste, is required to achieve the primary goal of the Québec Policy that is to eliminate only one residue in Quebec: the ultimate residue. It is generally accepted that over 75% of the content of household waste destined for landfill has significant recovery potential.

Several technologies already exist to recover the energy from waste, but others remain to be developed. In all cases, their application is very context-specific, particularly in terms of material flows and market availability for processed goods. A first option to investigate is the mechanical-biological treatment (MBT) of municipal waste to produce a refuse derived fuel (RDF). Indeed, in such a process, waste materials are mechanically separated prior to further treatments. Recyclable materials are recovered and recycled where possible or valued as RDF. The organic materials are biologically degraded by bio-drying, composting or anaerobic digestion. Non-recyclable inorganic materials are headed to the landfill as inert. This technique allows to reduce the amount of landfilling while recovering what can be recycled as material and energy. The ultimate residue is stabilized and thus does not contribute to the release of greenhouse gases in landfills. In practice, several problems remain to be solved to enable the production of RDF of sufficient quality to be efficiently burned (higher heating value, water content and composition). Thus, the influence of the intrinsic heterogeneity of the physical properties of solid wastes, together with the type of process selected to produce the RDF, on its properties must be characterized and modeled.
The main objective of the research program is to design MBT processes for the production of RDF. To achieve this goal, several projects are defined such as the project entitled **Design a RDF production process suitable for the treatment of household waste for the city of Montreal.**

Main Tasks during the Internship
In this project, a global model of TMB solid waste processing to produce a RDF will be developed. This model will be used to design a pilot scale processing unit for the city of Montreal. A life cycle assessment of the different options available to produce RDF and of the utilization of RDF will done in this project.

Required Skills for the Internship
The candidate must have completed a Chemical Engineering undergraduate program and be enrolled in a graduate study program.

Supervisor
Mr Robert LEGROS, Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=36&Langue=A

#14 Area of Expertise: Chemical Engineering

Research Project Title
Photochemical Surface Engineering of Nanomaterials

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Main Tasks during the Internship
- Pursue the investigation of a novel photochemical surface treatment approach, photo-initiated chemical vapour deposition (PICVD), on nanomaterials
- Gain insight into the kinetics of the process, and the effect of contaminants
- Characterize the treated surfaces chemically and physically
- Design a scale-up approach to particles in a fluidized state

Required Skills for the Internship
- Reactor engineering and operation
- Surface characterization techniques (tensiometry, zeta potential, XPS, FTIR)
- Gas phase characterization (GC-MS, IR)
- Very strong communications skills
- Lab safety

Supervisor
Mr Jason TAVARES, Assistant Professor, Department of Chemical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=456&Langue=A

#15 Area of Expertise: Civil, Geological or Mining Engineering

Research Project Title
Development of Ultra-high Performances Fiber Reinforced Concretes and Characterization of their Mechanical Properties

University Cycle
1st cycle (undergraduate)

Background Information
In the last decade a new type of very durable concrete have been developed, it is named ultra-high performances fiber reinforced concretes (UHPFRC). They present very high mechanical properties, and very low porosity and permeability. One UPFRC have been produced at Polytechnique Montreal. The goal of the internship will be to modify the UHPFRC mix in order to reduce its CO2 emissions and increase its mechanical properties by using special mineral admixture.

Main Tasks during the Internship
- Produce UHPFRC mixes at the laboratory
- Measure UHPFRC properties at fresh state with standard laboratory tests (temperature, air content, volumetric weight, etc.)
- Measure UHPFRC properties at hardened state with standard laboratory tests (compressive strength, tensile strength, flexural strength, etc.)
- Analysis of results
- Produce a technical report

Required Skills for the Internship
- Have an excellent leadership and be autonomous to manage technical activities
- Have a good knowledge of concrete production and concrete properties
- Have a good dexterity and be familiar with manual works in order to carry out lab activities
- Have an excellent knowledge of Excel and Word software in order to analyze test results and prepare the technical report
- Having an experience in laboratory activities would be very valuable.

Supervisor
Mr Jean-Philippe CHARRON, Professor, Department of Civil, Geological and Mining Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=303&Langue=A

#16 Area of Expertise: Civil, Geological or Mining Engineering

Research Project Title
Evaluation of the Durability of Fiber Reinforced Concretes in Realistic Conditions Found in Structures

University Cycle
1st cycle (undergraduate)

Background Information
Durability of concrete structures depends mainly on concrete quality, presence of cracks within concrete and environmental expositions. Durability of concrete is generally evaluate on uncracked concrete specimens, which is not representative of real structure conditions. The goal of the internship will be to realize standard durability tests on cracked concrete specimens in order to provide unique and more realistic information on the durability of structures.

Main Tasks during the Internship
- Produce conventional concrete and fiber reinforce concrete mixes at the laboratory
- Realize tensile tests on concrete specimens in order to create cracks are various sizes within specimens
- Measure concrete durability after specimens have been cracked with standard laboratory tests (diffusion tests, permeability tests, absorption tests, porosity tests)
- Analysis of results
- Produce a technical report

Required Skills for the Internship
- Have an excellent leadership and be autonomous to manage technical activities
- Have a good knowledge of concrete production and concrete properties
- Have a good dexterity and be familiar with manual works in order to carry out lab activities
- Have an excellent knowledge of Excel and Word software in order to analyze test results and prepare the technical report
- Having an experience in laboratory activities would be very valuable.

Supervisor
Mr Jean-Philippe CHARRON, Professor, Department of Civil, Geological and Mining Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=303&Langue=A

#17 Area of Expertise: Civil, Geological or Mining Engineering

Research Project Title
Development of an Algorithm in Matlab to Determine the Entrapped Air Propagation in a Stormwater Pipe

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
The internship takes part of a research project based on the modelling of the transient flow occurring in a stormwater pipe systems which is facing strong rainfalls. A full dynamic model is being developed, to successfully solve the transient problem during all flow phases in the network. Taking the transient flow into consideration when designing the drainage system is extremely important because the more accurately the transient flow is predicted, the more effective the drainage system control will be. The experimental and numerical aspects of the study contributed, respectively, to a clear understanding of the mechanism forming transient flow and to evaluating consequences of the transition phenomenon, such as water geysers which are becoming common in Montreal because of intensive waterproofing of urban watersheds.

Main Tasks during the Internship
- Experimental and numerical work
- Algorithm development
- Case study application

Required Skills for the Internship
- Excellent skills in hydraulic numerical methods
- Matlab programming

Supervisor
Mr Musandji FUAMBA, Associate Professor, Department of Civil, Geological and Mining Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=317

#18 Area of Expertise: Civil, Geological or Mining Engineering

Research Project Title
Framework for the Systematic Validation of Tracking Improvements

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Main Tasks during the Internship
- Choosing an optimization approach to optimize tracking parameters based on tracking annotations (ie tracker training)
- Designing a cross-validation framework on a set of annotation videos, training on each video in turn and evaluating the tracking performance on the rest
- Testing the new framework with a few variations of an existing open source tracker (time permitting)

Required Skills for the Internship
- Good programming skills, i.e. at least the working knowledge of an object-oriented programming language like C++, Java or Python
- Good and rigorous software engineering habits (version control, compilation process using Make or CMake, etc.)
- It is desired but not required to have some knowledge of computer graphics, computer vision and machine learning
- Knowledge of Linux and the OpenCV library is a plus

Supervisor
Mr Nicolas SAUNIER, Associate Professor, Department of Civil, Geological and Mining Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=418

#19 Area of Expertise: Civil, Geological or Mining Engineering

Research Project Title
Video-based Analysis of Road User Behaviour

University Cycle
3rd cycle (Ph.D.)

Main Tasks during the Internship
- Brief review of existing models to describe road user behaviour, corresponding to zones of activity (dense sets of positions) and motion patterns (main trajectory paths), for applications such as intersection traffic control (queues, waiting time, etc.) and road safety analysis (motion prediction for the calculation of time to collision, "abnormal" behaviours and infractions, etc.)
- Validation of existing algorithms to learn activity zones (Gaussian models) and motion patterns (clusters with prototype trajectories)
- Evaluation of the performance of existing algorithms and if necessary, research of algorithmic improvements
- Application to different types of road users (drivers, cyclists and pedestrians)
- Application to evaluate road users' understanding of the operation of traffic facilities and signalization

Required Skills for the Internship
- Good programming skills, or a willingness to learn at least a high-level programming language such as Python
- Good and rigorous software engineering habits (version control, compilation process using Make or CMake, etc.) (or willingness to learn)
- It is desired but not required to have some knowledge of computer graphics, computer vision and machine learning

Supervisor
Mr Nicolas SAUNIER, Associate Professor, Department of Civil, Geological and Mining Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=418

#20 Area of Expertise: Computer and Software Engineering

Research Project Title
Identifying Bottlenecks in Build System Performance

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
When mentioning the term "software development", people immediately think about source code and programmers. Of course, many more activities play a role in software development, and many more artifacts than just the source code. One such artifact is the build system. This is the crucial infrastructure that developers use on a daily basis to compile and package the source code into executables and other deliverables, such that the developers can test their software after adding a new feature or bug fix. People typically use technologies like GNU Make, autotools, Maven, Ant, SCons, Rake, CMake or Gradle to implement their build system.

Since build systems are used so often and the software system that they build typically is huge, developers risk losing a lot of time waiting for their build to finish. It is not uncommon for very large systems to require hours to finish a build. For this reason, most build technologies provide incremental build modes to minimize the time a build takes, by just re-building the source code files that changed and reusing the previously built version of other files. In addition, most technologies also provide parallel build support that builds multiple files at the same time.

However, build technologies are not understood very well by software developers, and often use arcane technology that is hard to change. Furthermore, although build systems play a central role in software development, surprisingly little research has been performed on them up until a couple of years ago, and most of this research focused on the quality of the actual build system instead of on build system performance. As such, many companies end up with a slow build system and no concrete idea on how to speed up the build.

The goal of this internship is to study how the performance of a build system evolves during daily development, analyze and document which build system or source code changes are related to build system performance degradations and improvements, and apply our findings on a concrete open source system to validate our findings. This work will build on our existing MAKAO infrastructure for reverse-engineering GNU Make build systems (http://mcis.polymtl.ca/makao.html) as well as a new framework developed during a previous internship.

Similar to energy consumption in software, the performance of a build system cannot be easily estimated statically using just the build system code, one needs to run and measure the build process. Such measurements need to be done on multiple build configurations (a set of features to build on a specific platform and architecture). This is because a developer might have introduced a build problem on his development platform, but not on the other ones, or one specific feature might result in extra build steps to be executed for all other components of the system.

Once we have measured the performance per configuration, we automatically know how much time each file takes to build. We can use this information to calculate (instead of measure) the performance of incremental builds. For this, we can exploit MAKAO's underlying model of a build system execution. This model knows all the dependencies followed by the build system during execution, so it allows to find out which files need to be recompiled when a particular file changes.

Given the differences in programming languages, build system technologies and software project sizes, we will perform our measurements for multiple systems and multiple versions. For each of these, we will analyze the evolution of build performance across time using statistical techniques and visualizations. We will determine statistically significant increases and decreases in performance between versions, as well as fluctuation-heavy parts of the build system. We can also compare build performance per programming language, build technology and project size. In the end, our aim is to develop techniques and tools to help practitioners understand and improve the performance of their build system.

Main Tasks during the Internship

The project basically consists of a large empirical study on "real" open source distributions and projects. Our lab has significant expertise in such studies as well as the necessary tools and infrastructure. Since the more projects are analyzed, the better, more than one student can work on this project.
This proposal largely consists of the 3 typical software intelligence phases:

(1) Data Extraction: The student will search for open source systems with sufficient development history and online data sources, such as bug reports, mailing list messages and online fora. Then, the student needs to build multiple versions, for different configurations.

(2) Quantitative Analysis: The student first will gather simple statistics, like the evolution of the performance of full builds. This will give an initial idea about the scale of the data as well as possibly interesting parts of the data. Second, the performance of incremental builds will be calculated, followed by analysis of the resulting incremental performance.

(3) Qualitative Analysis: The student will manually study code changes and documentation for the versions with build system performance drops. By analyzing the qualitative data like mailing list discussions, the student will be able to identify possible causes of the performance problems. Through interaction with other people in the lab, these causes can be fleshed out into more general patterns that can be documented in a structured way.

The project is quite large in scope, so multiple internships could be offered. Furthermore, we believe that completion of phases (1) and (2) with some initial results for phase (3) would be a successful outcome of this project.

Required Skills for the Internship

Through this project, students will become experts in software intelligence, an emerging area many companies are trying to get into. To extract data, a student needs the motivation to actively contact open source developers, search online data sources, understand their format and interconnections, and use scripting languages (bash, perl, python, ...). For the quantitative analysis, (s)he again needs scripting languages and the desire to learn the R language to visualize data. For the qualitative analysis, (s)he needs persistence, conscience and patience to read through and summarize textual artifacts like bug reports and email threads.

About Us:

The lab on Maintenance, Construction and Intelligence of Software (MCIS) studies ultra-large scale software systems and the development processes and tools used to build them, in order to identify bottlenecks and problems, and to come up with innovative solutions and support. These solutions and support enable developers, testers, team leads, and everyone up until management level to develop software more effectively and in a better informed way, such that the typical risks associated with software development (not making the deadline, insufficient quality or running out of resources) are reduced or even mitigated.

In the context of this proposal, the mission of MCIS is to help practitioners understand and improve the performance of their build system. Through empirical research on software development process data stored in revision control systems (Subversion, Git, ...), mailing list archives, bug repositories (Bugzilla, Jira, ...), online documentation and any other kind of data source available, we build models and distill process knowledge that are immediately applicable in practice.

Supervisor

Mr Bram ADAMS, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=514&Langue=A
http://mcis.polymtl.ca/

#21 Area of Expertise: Computer and Software Engineering

Research Project Title
Swarm Robotics Playground Development

University Cycle
1st cycle (undergraduate)

Background Information
Swarm robotics is a discipline that studies fully decentralized approaches for the coordination of large-scale teams of robots (swarms). Research in this field is ambitious: robot swarms are envisioned for scenarios for which solutions are today impractical, too dangerous, or inexistent. From drones to self-driving cars, robot swarms are becoming pervasive, and are used in many kinds of applications. Examples of swarm robotic applications are search and rescue operations, industrial and agricultural inspection, coordinated vehicle platooning, space exploration, and medical or surgical activities. We envision a world where a designer can specify the behaviour of heterogeneous groups of robots, and package this behaviour in an application that can be installed on multiple robotic systems.

Swarm-based solutions will likely form the backbone for the upcoming self-driving car infrastructure, and will act as an enabling technology to make widespread consumer robotics a reality.

Main Tasks during the Internship
In this project, the student, inspired by Georgia Tech's Robotarium, will design and implement an arena for testing swarm robotics algorithm.

This includes a tracking system with an overhead camera, communication and control for the robots, and a simulator-in-the-loop step to emulate sensors or actuators that do not exist on the real robots. Ideally, the arena should be controlled remotely via a web interface.

Required Skills for the Internship
C++ programming, Linux, Python, web development is an asset

Supervisor
Mr Giovanni BELTRAME, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=508

#22 Area of Expertise: Computer and Software Engineering

Research Project Title
Wireless Robot Localization

University Cycle
1st cycle (undergraduate)

Background Information
Swarm robotics is a discipline that studies fully decentralized approaches for the coordination of large-scale teams of robots (swarms). Research in this field is ambitious: robot swarms are envisioned for scenarios for which solutions are today impractical, too dangerous, or inexistent. From drones to self-driving cars, robot swarms are becoming pervasive, and are used in many kinds of applications. Examples of swarm robotic applications are search and rescue operations, industrial and agricultural inspection, coordinated vehicle platooning, space exploration, and medical or surgical activities. We envision a world where a designer can specify the behaviour of heterogeneous groups of robots, and package this behaviour in an application that can be installed on multiple robotic systems.

Swarm-based solutions will likely form the backbone for the upcoming self-driving car infrastructure, and will act as an enabling technology to make widespread consumer robotics a reality.

One of the main issues for swarm robotics is the lack of accurate situated communication systems, that is to say mechanisms to estimate the location of the sender of a message received by a robot.

Main Tasks during the Internship
In this project we will experiment with Chronos, a localization system based on commercial wireless cards to determine the relative position between a group of wheeled and flying robots. The student will develop the software to implement Chronos' algorithm and test the accuracy of the system with real robots.

Required Skills for the Internship
Programming, some signal processing, Linux

Supervisor
Mr Giovanni BELTRAME, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=508

#23 Area of Expertise: Computer and Software Engineering

Research Project Title
A Library of Swarm Behaviors

University Cycle
1st cycle (undergraduate)

Background Information
Swarm robotics systems are envisioned for large-scale application scenarios that require reliable, scalable, and autonomous behaviors. Among the many hurdles towards real-world deployment of swarm robotics systems, one of the most important is the lack of dedicated tools, especially regarding software. In particular, one problem that has received little attention in the literature is programmability. In the past year, at MIST we created Buzz, a programming language designed to provide developers in swarm robotics a concise, yet powerful set of swarm primitives based on a decentralized execution model.

Main Tasks during the Internship
The aim of this project is to implement a set of widely known swarm behaviors that form the backbone of many, more complex swarm behaviors. This project will expose the student to a large body of research that is typically not taught in university: decentralized control of robot swarms.

Examples of behaviors that will be targeted are creation of spatial gradients, distributed consensus, flocking, pattern formation, and chaining.

Required Skills for the Internship
Prior programming experience in any language.

Supervisor
Mr Giovanni BELTRAME, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=508

#24 Area of Expertise: Computer and Software Engineering

Research Project Title
Probabilistic Real-Time Systems

University Cycle
3rd cycle (Ph.D.)

Background Information
For high-performance time-critical aerospace computer system, such as a satellite, the accurate timing prediction of software execution plays an important role. If events are not dealt with within a certain timeframe, the result may be catastrophic. However, to address increasing complexity in computer applications, more advanced architectures using multi-stage pipelines, several memory hierarchy levels and even Multi-Processor System-on-Chip (MPSoC) designs are proposed for high performance computing.

These traditional deterministic computer architectures make software timing behavior almost impossible to accurately predict. Normally the execution time of an application on a deterministic architecture follows a distribution that might have some corner cases which are beyond normal operations. A conservative estimation will place the Worse Case Execution Time (WCET) far away from the actual maximum time used by the application, especially when considering possible interactions with other tasks. This would lead to a large overestimation of the computing resources needed for the task. In this research project, we propose to address the issue using probabilistic real-time system software. The idea is that the timing behavior of a system can be defined by probabilistic metrics applied to software. With probabilistic software methodology for timing prediction, the execution time will have a smoother distribution and avoid corner cases.

This will reduce overestimation and time-critical system can benefit tremendous in terms of cost of integration, verification and certification.

Main Tasks during the Internship
The objectives of the project are (a) to define a methodology for probabilistic software development, and (b) demonstrate its effectiveness at system-level. The intern will collaborate with the MIST Lab's PhD students to demonstrate the software by implementing a Data Handling and Management System (DHMS) for a small satellite.

Required Skills for the Internship
Probability and statistics, Python programming

Supervisor
Mr Giovanni BELTRAME, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=508

#25 Area of Expertise: Computer and Software Engineering

Research Project Title
Primitives for Dynamic Task Allocation in Robot Swarms

University Cycle
3rd cycle (Ph.D.)

Background Information
Swarm robotics systems are envisioned for large-scale application scenarios that require reliable, scalable, and autonomous behaviors. Among the many hurdles towards real-world deployment of swarm robotics systems, one of the most important is the lack of dedicated tools, especially regarding software. In particular, one problem that has received little attention in the literature is programmability. In the past year, at MIST we created Buzz, a programming language designed to provide developers in swarm robotics a concise, yet powerful set of swarm primitives based on a decentralized execution model.

Main Tasks during the Internship
In this project, you will work on the definition of swarm primitives for dynamic task allocation. Task allocation is the problem of distributing and coordinating tasks among robots in a swarm. When task allocation must be performed dynamically, i.e., adapting the assignment to ever changing working conditions, this problem becomes extremely challenging.

The purpose of this work is to identify a small set of primitive, decentralized behaviors that, once combined, can produce effective task allocation algorithms. If successful, this project will provide a much needed platform for swarm robotics practitioners around the world.

Required Skills for the Internship
Proficiency with C and C++, excellent synthesis abilities

Supervisor
Mr Giovanni BELTRAME, Assistant Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=508

#26 Area of Expertise: Computer and Software Engineering

Research Project Title

Software Designs Analyses

University Cycle

1st cycle (undergraduate)

Background Information

In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

This focus is still relevant nowadays but must expand to two news "emerging" categories of systems. The first category includes all the networks of (intermittently) connected, heterogeneous devices with ill-defined and changing functionalities: the Internet of Things (IoT), which was put forward by Sun Microsystems and others and connects devices, animals, and people. Example scenarios of the IoT involve drought and forest fire prevention through environmental monitoring, energy management in smart homes to automatically adjust energy consumption depending on the occupants' habits, automatic checkout of groceries without scanning items individually at the cashier, and health monitoring and faster intervention in emergency situations.

The second category includes ultra-large scale systems that collect, store, analyse, and report on all the data generated by enterprises, by citizens, and, of course, by devices in the Internet of Things. These ultra-large scale systems include, but are not limited to, cloud platforms, REST services, map-reduce engines, NoSQL and in-memory databases. Example of ultra-large scale systems are point-of-sales systems connected to distributed, replicating in-memory databases in a large chain of grocery stories, which collect and store each and every items bought by clients and which analyse and report on the sales to improve the supply chain, to identify local trends, to forecast on the need for new items to satisfy clients' demands.

These two, new categories of systems are creating the conditions for a new software engineering crisis because the computing power and operational complexity of the IoT and of ultra-large scale systems increase but the software theories, methods, and tools to tackle this power and this complexity have lagged behind and are fragmented. Thus, there is a strategic need to focus software engineering research on the IoT and ultra-large scale systems, which are first and foremost driven by software, be it as firmware running the devices or communication protocols between devices and gateways or algorithms used to store and analyse the data from the devices and forecast trends.

Main Tasks during the Internship

The PADL meta-model developed by the Ptidej Team to represent programs in various programming languages can also describe designs. The student will integrate into the Ptidej Tools Suite the SDMetrics libraries for parsing XMI to create PADL models from XMI models.

Required Skills for the Internship

Knowledge of the XML meta-language. Good Java programming skills. Through this project, the student will further develop skills in programming by working on a large-scale tools suite that has been evolving for a decade. The student will also gain valuable skills in software designs and quality analyses.

Supervisor

Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#27 Area of Expertise: Computer and Software Engineering

Research Project Title
On-line Software Quality Analyser

University Cycle
1st cycle (undergraduate)

Background Information
In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

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The second category includes ultra-large scale systems that collect, store, analyse, and report on all the data generated by enterprises, by citizens, and, of course, by devices in the Internet of Things. These ultra-large scale systems include, but are not limited to, cloud platforms, REST services, map-reduce engines, NoSQL and in-memory databases. Example of ultra-large scale systems are point-of-sales systems connected to distributed, replicating in-memory databases in a large chain of grocery stories, which collect and store each and every items bought by clients and which analyse and report on the sales to improve the supply chain, to identify local trends, to forecast on the need for new items to satisfy clients' demands.

These two, new categories of systems are creating the conditions for a new software engineering crisis because the computing power and operational complexity of the IoT and of ultra-large scale systems increase but the software theories, methods, and tools to tackle this power and this complexity have lagged behind and are fragmented. Thus, there is a strategic need to focus software engineering research on the IoT and ultra-large scale systems, which are first and foremost driven by software, be it as firmware running the devices or communication protocols between devices and gateways or algorithms used to store and analyse the data from the devices and forecast trends.

Main Tasks during the Internship
The Ptidej Team develops an on-line software quality analysis tool. The project consists in contributing to this quality analysis tools by improving its usability (Web programming) and its feature (back-end programming). The Web programming includes securing the tool, improving its visual quality, implementing Ajax interactions. The back-end programming includes making available more features from the Ptidej Tools Suite, leveraging multi-code programming for parallelising computations, supporting high performance databases.

Required Skills for the Internship
Excellent Web technologies or Java programming skills. Databases, including if possible NoSQL and in-memory databases. Distributed programming. Through this project, the student will learn the development of Web application from the front-end to the back-end, including all the technologies used by forefront companies: Glassfish, Graddle, MongoDB, etc.

Supervisor
Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#28 Area of Expertise: Computer and Software Engineering

Research Project Title
Low Foot-print Meta-model for Ultra-large Scale Systems

University Cycle
1st cycle (undergraduate)

Background Information
In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

This focus is still relevant nowadays but must expand to two news "emerging" categories of systems. The first category includes all the networks of (intermittently) connected, heterogeneous devices with ill-defined and changing functionalities: the Internet of Things (IoT), which was put forward by Sun Microsystems and others and connects devices, animals, and people. Example scenarios of the IoT involve drought and forest fire prevention through environmental monitoring, energy management in smart homes to automatically adjust energy consumption depending on the occupants' habits, automatic checkout of groceries without scanning items individually at the cashier, and health monitoring and faster intervention in emergency situations.

The second category includes ultra-large scale systems that collect, store, analyse, and report on all the data generated by enterprises, by citizens, and, of course, by devices in the Internet of Things. These ultra-large scale systems include, but are not limited to, cloud platforms, REST services, map-reduce engines, NoSQL and in-memory databases. Example of ultra-large scale systems are point-of-sales systems connected to distributed, replicating in-memory databases in a large chain of grocery stories, which collect and store each and every items bought by clients and which analyse and report on the sales to improve the supply chain, to identify local trends, to forecast on the need for new items to satisfy clients' demands.

These two, new categories of systems are creating the conditions for a new software engineering crisis because the computing power and operational complexity of the IoT and of ultra-large scale systems increase but the software theories, methods, and tools to tackle this power and this complexity have lagged behind and are fragmented. Thus, there is a strategic need to focus software engineering research on the IoT and ultra-large scale systems, which are first and foremost driven by software, be it as firmware running the devices or communication protocols between devices and gateways or algorithms used to store and analyse the data from the devices and forecast trends.

Main Tasks during the Internship
The Ptidej Tools Suite integrates several different user-interfaces, including Swing-based and a Web-based interfaces. These interfaces use dedicated toolkits to display programs as UML-like class diagrams, enriched with quality-related information. This project aims at integrating new visualisation techniques and new libraries, such as PlantUML into the Ptidej Tools Suite, either in the Swing-based and–or the Web-based interfaces. Thus, the student will contribute to the understanding of programs and of their quality.

Required Skills for the Internship
Java programming as well as, if possible, graphic toolkits and visualisation libraries. Web programming is a must if the student is to add new visualisations to the Web interface. Through this project, the student will put to use designing and development skills for a real, large scale system and learn various graphical toolkits and libraries. Knowledge of these toolkits and libraries as well as experience gained in integrating them into real user-interfaces are interesting to many companies.

Supervisor
Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#29 Area of Expertise: Computer and Software Engineering

Research Project Title
Multi-language Parsers

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

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The second category includes ultra-large scale systems that collect, store, analyse, and report on all the data generated by enterprises, by citizens, and, of course, by devices in the Internet of Things. These ultra-large scale systems include, but are not limited to, cloud platforms, REST services, map-reduce engines, NoSQL and in-memory databases. Example of ultra-large scale systems are point-of-sales systems connected to distributed, replicating in-memory databases in a large chain of grocery stories, which collect and store each and every items bought by clients and which analyse and report on the sales to improve the supply chain, to identify local trends, to forecast on the need for new items to satisfy clients' demands.

These two, new categories of systems are creating the conditions for a new software engineering crisis because the computing power and operational complexity of the IoT and of ultra-large scale systems increase but the software theories, methods, and tools to tackle this power and this complexity have lagged behind and are fragmented. Thus, there is a strategic need to focus software engineering research on the IoT and ultra-large scale systems, which are first and foremost driven by software, be it as firmware running the devices or communication protocols between devices and gateways or algorithms used to store and analyse the data from the devices and forecast trends.

Main Tasks during the Internship
The Ptidej Team develop a unique tool suite composed of a generic and extensible meta-model to describe programs and to analyse their quality and a set of parsers to create models of programs in different programming languages. In particular, it has developed parsers for Java (source code and byte-code) and C++ (source code). It has also developed a parser for JavaScript. In this project, the students will contribute to evolving the JavaScript parser to create PADL models of JavaScript programs that are more precise and more useful for various kinds of analyses.

Required Skills for the Internship
Excellent Java and JavaScript programming skills. Knowledge of parsing and related concepts. Through this project, the students will acquire a unique perspective on the analysis of multi-language systems, which are nowadays the norms, with systems often comprising components in five or more programming languages (CSS, HTML, JavaScript, Java, C++, and SQL).

Supervisor
Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#30 Area of Expertise: Computer and Software Engineering

Research Project Title
P-MARt

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

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Main Tasks during the Internship
There do not exist "normal" software systems anymore: the computing power and complexity of novel systems, like Cloud services and devices connected to the IoT make all systems complex. To tackle the complexity of these systems, developers often resort to well-known programming idioms, design patterns, and architectural styles. However, the positive impact of these idioms, patterns, and styles is still an open-research question. To answer this question, one research direction focuses on collecting, cataloguing, and analysing "true" occurrences of these idioms, patterns, and styles to assess their real impact in real contexts. The aim of this project is to continue evolving the P-MARt repository of instances of idioms, patterns, and styles with other instances and performing analyses to understand the real impact of these instances and studying their evolution.

Required Skills for the Internship
Good programming skills, any programming language. Good design and architectural knowledge. Through this project, students will deepen their understanding of programming and designing and will become experts in pattern-based software quality.

Supervisor
Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#31 Area of Expertise: Computer and Software Engineering

Research Project Title
Improving Developers' IDEs

University Cycle
3rd cycle (Ph.D.)

Background Information
In the 1960's, the advances in computer hardware was making it more and more difficult for hardware engineers to write the software needed to harness the computing power and operational complexity of new computers, which led to the software engineering crisis and the birth of software engineering as an engineering discipline. Since then, software engineering has made great progress and proposed processes, e.g. agile methods for distributed teams, methods, e.g., interactive debugging, and tools, e.g., refactorings, to harness complexity. Yet, its focus has been mostly on software for "big box" consumer computers or for "well-defined" embedded systems, the former with lots of computing power and network connection, the latter with clear specifications and "slow" development cycle.

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Main Tasks during the Internship
Software engineering is intrinsically a human endeavour. Although it is based on sound mathematical and engineering principles, software developers play an important role during the development of software systems because, essentially, no two systems are identical. Therefore, the creativity of software developers as much as their expertise and experience are important during software development. Yet, the tools offered to software developers have often been built without explicitly considering the creativity of software developers. Therefore, the tools offered to software developers must be studied to understand how they help and impede software developers in general and their creativity in particular. Our laboratory uniquely owns eye-tracker systems to study software developers' use of tools to understand this use, to identify blocks to their creativity, and to recommend improvements.

Required Skills for the Internship

Good programming skills in Java. Interest in human-computer interactions. Knowledge of empirical studies. Through this project, the students will contribute to the advancement of the tooling for software developers, develop unique skills related to controlled and quasi-experiments, and will contribute to the development of more adequate software development tools.

Supervisor

Mr Yann-Gaël GUÉHÉNEUC, Professor, Department of Computer and Software Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=399

#32 Area of Expertise: Electrical Engineering

Research Project Title
Distributed Robotics

University Cycle
1st cycle (undergraduate)

Background Information
We are developing two experimental systems for distributed robotics, using ground robots as well as nano-quadrotors. One possible project would be to develop and implement a cooperative localization algorithm where the robots localize each other in a group simply from pairwise distance measurements obtained from a previously developed RF ranging system.

More information on our activities can be found here:
http://www.professeurs.polymtl.ca/jerome.le-ny/
http://www.polymtl.ca/robotique-mobile/en

Main Tasks during the Internship
The specific tasks of the student will be adapted based on his technical background and interests (ex: interest in theory vs. system design and programming), as well as the state of the project at the time of his/her arrival.

The student will be involved in tasks such as:

- Developing a tailored simulation/rapid prototyping environment for testing of algorithms.
- Developing the hardware and low level embedded software for the multi-robot setup.
- Implementing algorithms for localization and control (trajectory tracking) in software.
- Designing new multi-robot coordination algorithms.
- Programming robots via ROS (Robot Operating System) to execute the algorithms.
- etc.

Required Skills for the Internship
- Some background in one or more of the following areas is desired:
- Robotics, control systems, computer vision, embedded system programming, embedded system design (hardware), signal processing.

Supervisor
Mr Jérôme LeNY, Assistant Professor, Department of Electrical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=546&Langue=A

#33 Area of Expertise: Electrical Engineering

Research Project Title
Analysis and Design of Emerging Monitoring and Control Networks or Mobile Robotics

University Cycle
3rd cycle (Ph.D.)

Background Information
My group's research interests are broadly concerned with the design of sensor and actuator networks that are increasingly forming the technological substrate necessary to build intelligent environments (e.g., the much discussed "Internet of Things"), as well as autonomous systems.

More information on our activities can be found here:
http://www.professeurs.polymtl.ca/jerome.le-ny/
http://www.polymtl.ca/robotique-mobile/en

We use tools from control theory and systems theory, robotics, machine learning and computer science to study these systems.

In terms of applications, our current focus is on estimation and control in networked systems with en emphasis on security and privacy, with applications to intelligent transportation systems, demand response in smart grids, avionics networked control systems, distributed autonomous robotic teams, and quantitative methods to analyze human-automation interactions.

Main Tasks during the Internship
The topic for the internship would be defined jointly with the student directly prior to his arrival, based on his expertise and current PhD topic, advancement in his PhD program, and interests. I would see such an exchange as an opportunity to establish a collaboration with the student on a research topic of mutual interest, which could continue in the future.

Required Skills for the Internship
My group can receive for a short-term visit a current PhD student, preferably working in control theory, robotics or perhaps signal processing, with a taste for theory and an interest for the types of applications mentioned above.

Supervisor
Mr Jérôme LeNY, Assistant Professor, Department of Electrical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=546&Langue=A

#34 Area of Expertise: Electrical Engineering

Research Project Title
Sensors Comparison for the Detection of Movement Intent of the Upper Limb for the Control of Dynamic Systems

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
The real-time control of many domestic dynamic systems such as prostheses, slide presentations, or virtual reality games, requires the detection of movement intention of the upper limb. Today three main sensing technologies can be used for this, based on:

1. Muscle activity sensors (e.g. the Myo from www.thalmic.com/en/myo/);
2. Inertial measurement units or accelerometers (e.g. the Nintendo Wii);
3. Optokinetic or depth cameras (e.g. the Microsoft Kinect).

These sensing technologies and applications are available at our lab.

The objective of this project is to compare the ability of these sensing technologies for the detection of movement intention of the upper limb, to have a better knowledge of their importance in regards to various applications such as the control of prostheses, slide presentations, or virtual reality games.

Main Tasks during the Internship

- Get familiar with the various sensing technologies and codes (mainly in C++) available at the lab.
- Prepare and perform an experimental protocol with the support of our team and the research ethics board, to compare the various sensing technologies on participants from the lab.
- Analyse the ability of these sensing technologies, based on accuracy and time latency.
- Prepare demo videos on funny applications amongst the control of prostheses, slide presentations, or virtual reality games.
- Write a technical report on the results.

Required Skills for the Internship

- The interested student should have basic knowledge of coding in C++
- The interested student should have basic knowledge about instrumentation.
- Knowledge of clustering is a must.
- Priority will be given to candidates enrolled in a mechatronics program, computer science program or an electrical engineering program

Supervisor
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=434&Langue=A
Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A

#35 Area of Expertise: Mechanical Engineering

Research Project Title
Evolving Mathematical Expressions Using Genetic Algorithms for VO2 Max Kinematics Modelling

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information
VO2 max (also maximal oxygen consumption, maximal oxygen uptake) is the maximum rate of oxygen consumption as measured during incremental exercise, most typically on a motorized treadmill. Maximal oxygen consumption reflects the aerobic physical fitness of the individual, and is an important determinant of their endurance capacity during exercise.

Accurate classification of VO2 kinetics is essential to correctly interpret its control mechanisms. In order to achieve this there is a need to better model the evolution of the VO2 Max as a function of time.

Several works simplify this task by simply fitting the experimental data to that of a step response of a second order dynamic system spread over very specific time series ranges.

In this project we expect the student to apply genetic algorithm/programming methods to already existing experimental data in order to automatically evolve mathematical formulas without prior knowledge of the any possible trends. The goal being to obtain the best fitting and formula describing the VO2 Max kinetics.

Main Tasks during the Internship
- Get familiarised with VO2 Max kinetics protocols
- Get familiarised with VO2 Max kinetics data and existing mathematical models.
- Learn the use of genetic programming for formula generation, already existing tools can be used such as MEXE or FPEG.
- Propose options to mathematically describe the VO2 Max Kinetics
- Write a report on the results.

Required Skills for the Internship
- Coding skills in C++ OR MATLAB or any equivalent scientific language
- Analytic mind
- Good level of English or French
- Autonomy
- Priority will be given to candidates enrolled in a biomedical engineering program, a mechanical engineering program, mathematics program or a computer science program.

Supervisor
Mr Sofiane ACHICHE, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A
Mr Maxime RAISON, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=434&Langue=A

#36 Area of Expertise: Mechanical Engineering

Research Project Title
Designing and Prototyping a Self-Adaptive Gripper for a Baxter Robot

University Cycle
1st cycle (undergraduate)

Background Information
Mechatronic fingers and hands are used in a wide range of applications, from spatial teleoperation to medical devices. These hands are made of multiple systems, including the actuation, the transmission, the control scheme, and the sensors. In this project, the intern will have to design and manufacture a new version of the self-adaptive gripper designed in the Robotics Laboratory and show in Fig. 1. Self-adaptive, a.k.a. underactuated, fingers have less actuators than degrees-of-freedom (DOF). In the case of the fingers shown, only one DC motor is used in each 2-DOF finger. The drawing and CAD files of the current version of the gripper will be given to the student. The new gripper will have to include additional sensors to provide feedback and to improve the control (tactile, Hall effect, etc.). This new prototype will also have to include most of the electronics inside the palm to control the actuator, with the objective to be easily compatible with a Baxter Robot, also available in our lab (Fig. 2).

Figure 4: Self-Adaptive Gripper

Main Tasks during the Internship
The main objective is to design and manufacture a self-adaptive gripper. The intern will have to:

- Model the gripper (mechanical and electronic design) with respect to the existing robotic fingers of the laboratory and additional design parameters;
- Provide the drawings to manufacture the components of the prototype;
- Research standard parts needed to reduce the cost;
- Assemble the parts of the prototype and test it.

Figure 2: Baxter Robot

Required Skills for the Internship

- Excellent skills in computer-assisted design (CAD), CATIA preferably
- Prior experience in electronic prototyping is a must, especially PCB design;
- Having completed courses in electronics and statics.
- Excellent writing and speaking communication are mandatory

Supervisor
Mr Lionel BIRGLEN, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=341&Langue=A

#37 Area of Expertise: Mechanical Engineering

Research Project Title
Designing and Prototyping a Planar Differentially Driven Cable Robot

University Cycle
3rd cycle (Ph.D.)

Background Information
Cable manipulators are particular parallel robots where cables are used instead of rigid linkages to manipulate the moving platform (MP). This characteristic gives special properties to these mechanisms. That means in addition to some advantages of linkage-driven parallel robots, they have a simple structure, lightness and low inertia of the moving parts, a high dexterity, typically low friction, large workspace, etc.

On the other hand, they suffer from some drawbacks such as limits in the cable tensions, poor compactness, possible interferences between cables, and vibrations . Also, as a result of the unilateral nature of the cables which can only produce tension forces, redundancy in the actuation is necessary. This means that to completely constrain the MP of an n-DOF cable robot, m>n cables are required. Several researches have shown that using more cables results in larger workspace and generally better performance of the robot.

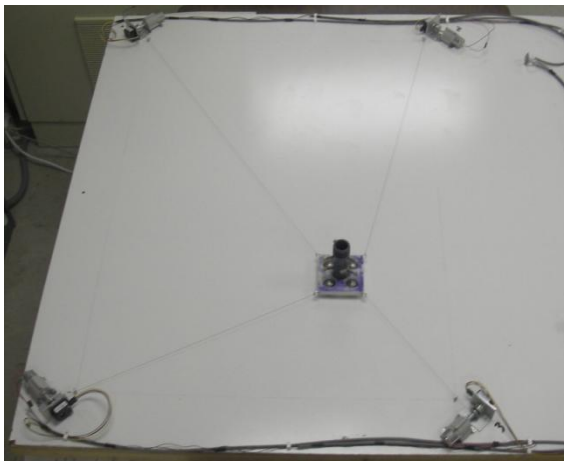


Figure 5 a planar cable robot with four cables

Figure 6 Skycam: a commercialized suspended cable robot

Therefore, in cable robots the number of required actuators is always greater than the number of degrees of freedom (DOF) which increases the cost and complexity of the control equipment. This issue is more critical if the more cables are used in the structure of the robot to obtain better the performance in terms of the size of the wrench-feasible and wrench-closure workspaces (WCW & WFW). Thus, to keep the number of actuators at minimum while the number of cables (and thus the performance of the mechanism) is increased, it was proposed to use cable differentials in the architecture of the cable-driven robots. They are used in different machines and mechanisms to distribute an actuation source to several degrees of freedom. These mechanisms were first introduced and their properties were described. Afterwards, through some examples it was shown that using these systems in the structure of planar cable-driven mechanisms increases their workspaces comparing to the fully-actuated cable robots driven by the same number of actuators. It is then required to design and built a small –scale prototype of this robot with a simple planar architecture to evaluate these results in practice. In a second step, it is also desired to use the same mechanical elements (motor+winch) to assemble a spatial mechanism.

Main Tasks during the Internship

Mechanical designing and manufacturing a prototype of a planar and spatial differentially actuated cable robot:

- Modeling the robot according to the existing schematic and design parameters;
- Providing the drawings for manufacturing the components of the prototype;
- Assembling the parts of the prototype and test it.

Required Skills for the Internship

Experience with the following techniques is desirable:

- Kinematics of parallel mechanisms
- Very good CAD skills, CATIA preferably
- Design of mechatronic devices (motor drives, gears, microcontroller, etc.)
- Excellent Matlab programming skills
- Excellent writing and speaking communication are mandatory

Supervisor

Mr Lionel BIRGLEN, Associate Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=341&Langue=A

#38 Area of Expertise: Mechanical Engineering

Research Project Title
3D Printing of Mechanical Microsystems

University Cycle
1st cycle (undergraduate)

Main Tasks during the Internship
This internship will be performed at the Laboratory of Multiscale Mechanics (LM2) of Polytechnique Montreal. Under the supervision of Prof. Therriault, the intern will assist a current PhD student with the realization of his research project. The LM2 is currently developing new 3D printing methods and various advanced materials with enhanced mechanical, thermal and electrical properties.

Required Skills for the Internship
- Strong Mechanical Engineering or Material Sciences background
- Interest for applied research, 3D printing technologies, CAD
- Familiar with material characterization (e.g., optical microscopy, SEM)
- Good team worker

Supervisor
Mr Daniel THERRIAULT, Professor, Department of Aerospace and Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A

#39 Area of Expertise: Mechanical Engineering

Research Project Title
3D Printing of Advanced Materials for Mechanical Microsystems

University Cycle
3rd cycle (Ph.D.)

Main Tasks during the Internship
This internship will be performed at the Laboratory of Multiscale Mechanics (LM2) of Polytechnique Montreal. Under the supervision of Prof. Therriault, the intern will assist a current Post-Doctoral Fellow with the realization of several research projects. The laboratory is currently developing new 3D printing methods (3D freeform printing, multi-materials printing) and various advanced materials with enhanced mechanical, thermal and electrical properties (e.g., nanocomposites, metallic-polymer, piezoelectric sensors).

Required Skills for the Internship
- Strong Mechanical Engineering or Material Sciences background
- Strong applied research experiences
- Experienced user of 3D printing technologies
- Design of advanced materials (e.g., thermoset or thermoplastic nanocomposites, twin-screw extruder, three-roll mixer)
- Material characterization (e.g., SEM, TEM, DSC, TGA, XRD, mechanical)
- Good team worker

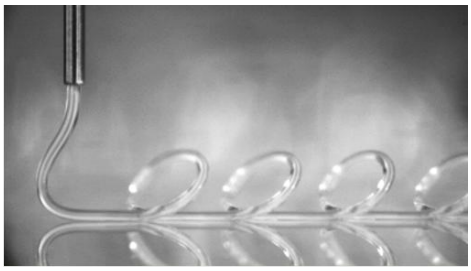
Supervisor
Mr Daniel THERRIAULT, Professor, Department of Aerospace and Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=294&Langue=A

#40 Area of Expertise: Physics Engineering and/or Materials Science

Research Project Title
Biomimetic of Spider Silk: Instability-assisted Microfabrication of Tough Fibers

University Cycle
1st cycle (undergraduate) or 3rd cycle (Ph.D.)

Background Information



Instability-assisted microfabrication.

Spider capture silk outperforms most synthetic materials in terms of specific toughness. We developed a technique to fabricate tough microstructured fibers inspired by the molecular structure of the spider silk protein. To fabricate microfibers (with diameter $\sim 30\mu m$) with various mechanical properties, we yield the control of their exact geometry to the liquid rope coiling instability. We flow a filament of viscous polymer solution towards a substrate moving perpendicularly at a slower velocity than the filament flows. The filament buckles repetitively giving rise to periodic meanders and stitch patterns. As the solvent evaporates, the filament solidifies into a fiber with a geometry bestowed by the instability. Tensile tests performed on fibers show interesting links between the mechanical properties and the instability patterns. Some coiling patterns give rise to high toughness due to the sacrificial bonds created when the viscous filament loops over itself and fuse. The sacrificial bonds in the microstructured fiber play an analogous role to that of the hydrogen bonds present in the molecular structure of the silk protein which give its toughness to spider silk.

Main Tasks during the Internship
The student will perform microfabrication experiments and material tests. He will also develop theoretical/numerical models to bring a better understanding of the process.

Required Skills for the Internship
A good understanding of fluid flow instability phenomena and the material science of polymers is necessary. Ideally, the candidate can perform finite element analyses with Ansys or some other commercial software.

R. Passieux, L. Guthrie, S. H. Rad, M. Lévesque, D. Therriault, and F. P. Gosselin, “Instability-Assisted Direct Writing of Microstructured Fibers Featuring Sacrificial Bonds,” Advanced Materials, vol. 27, no. 24, pp. 3676–3680, Jun. 2015.

Supervisor
Mr Frederick GOSSELIN, Assistant Professor, Department of Mechanical Engineering
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=542&Langue=A
Website: http://www.fgosselin.com