NSERC Undergraduate Student Research Award
2017

For further information:
http://www.nserc-crsng.gc.ca/Students-Etudiants/UG-PC/USRA-BRPC_eng.asp

Scholarships are valued as follows (amount shown includes $4500 from NSERC):

Students who have completed Level 1: $6384
Students who have completed Level 2: $7300
Students who have completed Level 3: $8100
Students who have completed Level 4 or 5: $8500

The Department of Computing and Software is accepting applications for the following projects. Applications must be received in the CAS Departmental Office (ITB/202) no later than Thursday, February 9, 2016. Applications must include Part 1 of Form 202 (Application for an Undergraduate Student Research Award), available on the NSERC website, and official transcripts. The form must be completed electronically by logging into the NSERC website, then printed and signed prior to submission to the departmental office. The departmental submission should include a separate note indicating which project(s) you are interested in.

****Project # 1: A new approach to software development (J. Carette/S. Smith)**

Interested in game software? What about novel approaches to software design? If you said yes to both, then you're the person we're looking for! Our team is testing a new approach to software development centered on using 'recipes' to assemble knowledge from a central repository to form all required software artifacts, from requirements documents to tests and, of course, code.

One of our primary test cases is a physics engine for games; we would like to rebuild it using our approach. And we need help to do this.

Main requirements: a willingness to learn new ideas and new programming languages. Although the original engine is in C, our team also uses a lot of Haskell as well as many homegrown DSLs to get our work done.

****Project # 2: Computational, Combinatorial, and Geometric Aspects of Linear Optimization (A. Deza/F. Franek)**

Rational decision-making through quantitative modelling and analysis is the guiding principle behind optimization, a field with several far-reaching applications across engineering, sciences, and industry. In many cases, the problems can be formulated, or approximated, as linear optimization problems that involve maximizing or minimizing a linear function over a domain defined by a set of linear inequalities. The algorithmic issues are closely related to the combinatorial and geometric structure of the feasible region. The project focuses on the analysis of worst-case constructions leading to computationally highly challenging instances. The tasks of the student involve combining theoretical and computational approaches.

Required qualifications:
Strong computational and mathematical skills

****Project # 3: HOL Light QE (W. Farmer)**

Philosophers, logicians, and computer scientists have long been interested in metareasoning, that is, reasoning about reasoning itself. Reasoning is performed in a formal logic by manipulating symbols. Hence metareasoning in a formal logic involves reasoning about the manipulation of symbols. Traditional logics like first-order logic and simple type theory (a classical form of higher-order logic) do not provide much support for reasoning about symbol manipulation. To overcome this deficiency, we have developed a version of simple type theory called STTqe that includes quotation and evaluation operators like the quote and eval operators in the Lisp programming language. With these operators it is possible to reason about the interplay of the manipulation of symbols and what the manipulations mean mathematically.

HOL Light is a software system developed by John Harrison at the Intel Corporation that assists users in proving mathematical conjectures in a version of simple type theory. HOL Light is open source software written in OCaml. Although it is a relatively small system, it has been used to formalize many kinds of mathematics and to proof-check many proofs including the lion's share of Tom Hale's proof of the Kepler conjecture. This project will test out the ideas embodied in STTqe by producing a modified version of HOL Light called HOL Light QE that includes quotation and evaluation operators. A solid background in computer science or software engineering is required for this project. Knowledge of functional programming and higher-order logic would be considered a significant plus.

****Project # 4: Understanding Human Wayfinding Behavior in Indoor Environments through Smart Glass Data Analysis (R. Zheng)**

Researchers from fields as diverse as psychology, geography, and urban planning have explored how humans process and use spatial information, often with the goal of explaining why people make wayfinding errors or what makes one person a better navigator than another. Understanding wayfinding behavior is of particular interest in complex indoor environments and have commercial applications in signage design and location based services. However, existing research primarily relies on computer simulations, where players navigate through virtual mock-ups of physical buildings and their behaviours are recorded for analysis offline. In this project, we propose to develop a smart-glass based system to enable in-situ collection of visual and motion data, and data analysis algorithms to automate the characterization of way finding behaviours. Smart glasses such as Recon Jet and Google glasses feature front-view camera, 9-axis inertial measurement units (IMU) (e.g., accelerometer, gyro, digital compass), single-pixel infrared back-view sensor, head-up display, micro-processor and wireless communication modules.

The main tasks include developing algorithms and software implementation on 1) visual scene analysis to infer area of interests by combining heading information (from IMU), attentiveness and the amount of time spent on objects in the field of view from the captured video 2) Gait analysis to characterize movements during way finding.

Expected skills: client-server programming, communication, C(++), Python, Java Skills to gain from the project: mobile data analysis algorithms and computer vision tools

****Project # 5: MacQuest++ (R. Zheng)**

MacQuest is a campus navigation app developed by Wireless System Research Group at McMaster University. It has been downloaded over 800 times through Google play. We have identified many aspects that need to be improved to better service the campus community and visitors 1) graphical user interface 2) indoor localization precision 3) map completeness and accuracy and 4) ability to be used offline. By participating this project, you will work in a dynamic research and development team for our next release.

Expected skills: Android/iOS programming, Javascript Skills to gain from this project: mobile data analysis, geo-spatial database and map rendering

****Project # 6: Data centre thermal profiling (R. Zheng)**

The project aims to gain first-hand understanding of the relationship between computational workloads, heat dissipation, cooling unit power consumption in data centre environments. The student will work along side a team of engineers and researchers to develop an efficient data collection process and models.

Expected skills: linux operating systems, computer networks, embedded system programming, knowledge in thermal fluid dynamics Skill to be gained from the project: experiment design, sensing data analysis

****Project # 7: Cryptography (D. Stebila)**

My research is in cryptography, especially the areas of public key cryptography and cryptographic protocols, which aim to build and analyze useful encryption algorithms from mathematical problems in number theory and algebra. For example, a key component of Internet security today is based on the RSA algorithm, the security of which is based on the difficulty of factoring large numbers. An active area of research today is post-quantum cryptography, which aims to build cryptography on alternative mathematical problems, such as those involving lattices or error-correcting codes.

Projects can take a theoretical or applied angle (anywhere from proving theorems to writing software). The exact topic will be decided once we meet and discuss your interests. Students working with me on a USRA over the 16-week summer term would meet with me on a regular basis, and participate in my research group's activities, such as a bi-weekly reading group with my Masters students and post-docs. In past years I have had USRA students go on to publish papers on their summer project's work.

Minimum course requirements: basic discrete mathematics (CS 2DM3, CS 2FA3)

Preferable knowledge: some cryptography or information security (MATH 3CY3, CS 3IS3, CS 4C03), more number theory, or higher algebra (MATH 3H03, MATH 3E03)

****Project # 8: Model Based Design of an Autonomous Driving Testbed (M. Lawford)**

This project involves the creation of a scale model autonomous driving testbed using multiple RC cars on a test track at the McMaster Automotive Resource Centre (MARC).

The work will involve developing autonomous vehicle controls software in Matlab/Simulink and C/C++ code to create a testbed for easy experimentation with autonmous vehcile controls algorithms. The work will also involve the development of teaching material to allow middle school and high school students to experiment with their own algorithms dealing with, e.g. collision free intersection navigation. They goal is to get students interested in careers in STEM in general and autonomous driving in particular.

Experience with C/C++ programming of embedded systems, Matlab/Simulink and image processing is an asset.

****Project # 9: High Fidelity Controller Area Network (CAN) Modelling & Validation (M. Lawford)**

This project involves helping to set up Electronic Control Units (ECUs) on a CAN network to model in vehicle networks and then collecting data using a CAN bus monitor and comparing the bus timing and load data with a high fidelity simulation of the network produced by a tool developed at McMaster in collaboration with GM. Experience with embedded systems programming in C/C++ is required and familiarity with Matlab would be an asset.

****Project # 10: Development of Model Based Design Pacemaker Hardware Reference Platform (M. Lawford)**

This work involves testing and debugging a hardware reference platform using an ARM microcontroller and analog and digital components on a custom PCB. The design has many of the same features as a real pacemaker and will be used as part of a software certification challenge run by the McMaster Centre for Software Certification. The work will involve developing a Matlab/Simulink block library to allow easy model based development of software for the hardware platform.

Experience with C/C++ programming of embedded systems is required. Experience with Matlab/Simulink and PCB design is an asset.

****Project # 11: Software Development for Sensor Networks (E. Sekerinski)**

Several summer positions are available for a collaborative project that involves an industrial partner. Water quality is essential to our well-being but existing methods of testing water quality are expensive and slow. This project involves using small wireless sensor nodes that are suitable for off-grid application in remote areas. The tasks involve HW-SW interfacing of commercial sensors (e.g. dissolved oxygen, pH), developing a fault-tolerant software architecture that allows operation in harsh environments, code generation and reliability analysis from models, storage of sensor data in the cloud, and “big data” analysis for anomalies using machine learning.

Required qualifications include a strong programming background and, depending on the task, experience with hardware interfacing, code generation and analysis, or algorithms.