1. Integration and Management of On-line and Off-line Monitoring Bioprocess Data

Amine Kamen (amine.kamen@mcgill.ca)

Cell culture bioprocess development for production of biologics involves optimization of upstream process, downstream process and process analytical technologies. These operations are realized using a number of independent sets of equipment and instrumentation (for exemple: bioreactors, pilot unit for purification and HPLC systems). Each of this set generate experimental data within a specific data base and the systems from different vendors use different control and monitoring softwares. The main project goal is to integrate the process data in one single data base and select/develop a Man Machine Interface (MMI) that would allow communication, data acquisition and management from all the systems and instrumentation in a newly created laboratory for process development of viral vaccine production. The deliverable would be a user friendly MMI that would allow communication, acquisition and storage of process data with high level of integrity and safety, and historical data display for real time monitoring and supervision of the integrated biological process The candidate should have basic knowledge in bioprocess development and control and expert knowledge in communication protocols, data bases and MMI software engineering
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

2. Mobile LiDAR Acquisition

Frank Ferrie (frank.ferrie@mcgill.ca)

The goal of this package is to design a data acquisition and rendering package to support a Velodyne VLP-16 LiDAR (http://velodynelidar.com/vlp-16.html). Capable of working in outdoor environments, the VLP-16 is used to sample 3D scenes for later reconstruction within a computer. Running on a small laptop or tablet, the acquisition package would provide a user interface to the VLP-16, allowing the user to capture and store data for later transfer to a server. It would also have to be able to provide a rudimentary 3D rendering of the scene to provide feedback to the operator (e.g. completeness of the scan, quality of the data, etc.). Background in software engineering and development is required, along with some familiarity with embedded systems. Since the data will ultimately be manipulated in Matlab, familiarity with Matlab programming would be helpful.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 2 students

3. A465 Robot Interface to Matlab

Frank Ferrie (frank.ferrie@mcgill.ca)

The goal of this project is to develop a Matlab interface to a CRS A465 industrial robot, allowing researchers to use the device without having to acquire specialized knowledge about robot operation or programming. Most of the work will involve writing code in the Matlab environment that communicates with the robot controller using a serial line interface. A similar environment already exists for a G365 gantry robot system, adjacent to the A465 in the laboratory, allowing the user to generate trajectories for the robot, visualize them in simulation prior to execution on the robot.

However, there are considerable differences in both the architecture of the A465 as well as its controller requiring an entirely new design.
Prospective candidates for this project should have a strong background in software development and be familiar with embedded systems. There is also an opportunity here for some innovation in user interface design, e.g. how to hide the complexity of the system from a novice user while allowing an expert full control of the system.

Type of Project: Design Projects (teams of 2 or more students)

Recommended Number of Students: 2 students

4. Model-Based Design in DPM

Frank Ferrie (frank.ferrie@mcgill.ca)

One of the challenges of the Design Principles and Methods course is solving a complex design problem at the same time as learning the design tools, in this case mastering concurrent programming in Java. Recently the Mathworks has introduced a package for Simulink that supports the new EV3 controller used in the latest iteration of DPM. The EV3 package supports all the common devices provided in the Lego Mindstorms kit and has a sufficient set of methods to effect rudimentary designs. Fortunately this tool is extensible (not to mention technical support from the Mathworks).
The goals of this project are to evaluate the Simulink EV3 kit, determine its shortcomings, and write the necessary objects that will allow the course to be run entirely within the Simulink environment (or more properly, to see if this is possible in the first place).
Prospective candidates should be familiar with Matlab and Simulink (or be willing to learn) and have a good background in software development (extra points for familiarity with model-based design).

Type of Project: Design Projects (teams of 2 or more students)

Recommended Number of Students: 2 students

5. APC1. Automatic Gear Shifting Control System for Swift-shift Multi-speed Transmission

Alexei Morozov (alexvit@cim.mcgill.ca)

An automatic gear shifting control is required for multi-speed transmissions currently under development at McGill University under the Automotive Partnership Canada project. Two testbeds have been developed so far, henceforth referred to as APC1 and APC2. The APC1 system has seven speeds and four planetary gear sets, whereas APC2 has five speeds and two planetary gear sets with double dual-clutch. The electrical subsystem and a preliminary gear shifting control unit were built in ECSE 456/457 in F2014-W2015.
Students will work on the APC1 testbed, with seven inputs, i.e., four ring clutches, two multi-disk clutches and one input motor. A list of tasks required follows:
1. to implement speed feedback into the current Simulink model such that the controller can shift gears automatically according to the output speed,
2. to verify the electronic, electric, and software subsystems and modify them as needed,
3. to build a test model in Simulink that upshifts gradually from the first speed into the last speed, then followed by downshifting gradually into the first speed automatically, according to the output speed,
4. to implement the test model in the testbed and evaluate the gear-shifting process to analyze the performance of the controller,
5. to tune the controller to obtain optimum performance,

6. to migrate the control system to a new workstation (to be done cooperatively by both APC1 and APC2 teams after the two systems are fully working).
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

6. APC2. Automatic Gear Shifting Control System for Swift-shift Multi-speed Transmission with Double Dual-Clutches

Alexei Morozov (alexvit@cim.mcgill.ca)

An automatic gear shifting control is required for multi-speed transmissions currently under development at McGill University under the Automotive Partnership Canada project. Two testbeds have been developed so far, henceforth referred to as APC1 and APC2. The APC1 system has seven speeds and four planetary gear sets, whereas APC2 has five speeds and two planetary gear sets with double dual-clutch. The electrical subsystem and a preliminary gear shifting control unit were built in ECSE 456/457 in F2014-W2015. Students will work on the APC2 testbed, with seven inputs, i.e., two dual-clutches, two ring clutches and one input motor. A list of tasks required follows: 1. to implement speed feedback into the current Simulink model such that the controller can shift gears automatically according to the output speed, 2. to verify the electronic, electric, and software subsystems and modify them as needed, 3. to build a test model in Simulink that upshifts gradually from the first speed into the last speed, then followed by downshifting gradually into the first speed automatically, according to the output speed, 4. to implement the test model in the testbed and evaluate the gear-shifting process to analyze the performance of the controller, 5. to tune the controller to obtain optimum performance, 6. to migrate the control system to a new workstation (to be done cooperatively by both APC1 and APC2 teams after the two systems are fully working).
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

7. System Identity

Darcy Letemplier (dletemplier@ciaratech.com)

Today we rely on the end users to supply information when debugging and troubleshooting a system remotely. More often than not, the information that is given is either false or inaccurate. This causes misdiagnosis which in turn lengthens the troubleshooting process, increases our costs and upsets the customer. What we want to do is develop a piece of software that can be run on the clients systems that will collect a set of defined data to properly help diagnose the issue. This information would include serial numbers, logs, etc. This software should also offer test routines and burnin processes to stress the system.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

8. Thermoelectric Power Generation on CPU/Memory/Chipset

Eliot Ahdoot (eliota@hypertec.com)

The largest cloud computing companies have one main concern when purchasing servers that is its power use. Every watt consumed costs these approximately 6$/year. That being said we would like for you to develop a system that could take the power generated by a thermometric generator (installed on CPU, Memory, and or chipset) and redistribute the power into the server. The ultimate goal would be to reduce the power use of the machine as much as possible.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

9. Neuroscience Operant Chamber

Reza Farivar & Curtis Baker (reza.farivar@mcgill.ca & curtis.lee.baker@mcgill.ca)

Development of therapies and treatments for brain disorders almost always requires work in animal models in which the animals perform cognitive tasks to assess specific brain mechanisms. Training animals is typically time consuming and demanding. We plan to develop a system that will combine RFID tag reading for custom training of each socially-housed animal, combined with a visual stimulus display and reward system. The system will be innovative in that the animals participate in experimental data collection in a free-behaving context, without human handling or scheduling. The team of students will together design, build and develop software for a fully automated Neuroscience Operant Chamber. The project will require hardware integration (pressure sensors, volume sensors, RFID readers, eye tracking, visual display, touchscreen and reward dispenser), software development (visual stimulus design, behavioural response processing, database storage) and creative problem solving. The students should have background knowledge in simple CAD design (e.g., Google SketchUp or Solidworks), experience in hardware integration of USB-based sensors, software programming in Matlab or python, and understanding of basic database design. The students will be jointly supervised by Dr. Curtis Baker and Dr. Reza Farivar.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 3 students

10. Radio Frequency MRI Coils for simultaneous brain stimulation

Reza Farivar (reza.farivar@mcgill.ca)

Non-invasive brain imaging with MRI permits us to visualize brain structure and function. Using high-powered magnets, we can also non-invasively stimulate the brain and activate specific areas using a technique called Transcranial Magnetic Stimulation (TMS). However, so far we have not been able to do both at the same time--visualize the activity that we cause with TMS. My lab is designing a new system for brain stimulation during MRI. The system incorporates a new system for subject positioning as well as new MRI RF coils. The ECE Design project involves completing the design process and then building, testing and imaging with a new MRI RF coil.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

11. Spirit & Dust: An Interfaith Eco-justice App for Montrealers

Afra Saskia Tucker (afratucker@dio-mdtc.ca)

The project team will design and build a mobile application for Montrealers of diverse faith backgrounds who wish to understand and improve their relationship with the environment. The

application will provide materials from different traditions, practices, and value systems that relevantly and constructively engage the topic of environment and sustainable living. The application will provide practical tools, for instance databases and maps of product and service points in Montreal, to help users translate their learnings into actions towards a more eco-sustainable lifestyle. The content for the application will be sourced by a diverse and interfaith network of collaborators based in Montreal, including contributers from the McGill community (McGill's Office for Religious and Spiritual Life, the School of the Environment and the Faculty of Religious Studies). The application will have some open source features so users can share their own knowledge and add/update content. The project will require the development (capture requirements, design, implementation, test and deployment) of a web site, with a focus on the architecture design and code implementation. Programming language and tools are to be defined. The team will be oriented by an external advisor available during all phases of the project and will be supported by mentors in the phases of capturing requirements, testing, and deployment. Suggested number of students in the team: minimum 2, maximum 4.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 3 students

12. ePark Network Remote Control System

Julio Mayorga (j.mayorga@electricms.com)

Develop a remote-access control system to operate a network of isolated solar powered recharging stations for small electric vehicles, such as e-bikes, located in parks, university campuses, pedestrian streets, etc. The hardware and software that will be developed, will need to communicate status and actuate hardware enabling the remote operation of eParks, through a cellular network connection (GPRS/3G/4G or equivalent). The project would include the development of the complete back office of a web site and smartphone app enabling users to operate any ePark of the ePark Network. For example, an user, through his smartphone and standing next to an ePark, will be able to log in, punch a code, and unblock the ePark for recharging his(her) vehicle, for a limited time or energy. eParks are powered by photovoltaic panels and energy is stored in each ePark in batteries, therefore the complete system will need to be optimized in terms of power consumption.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

13. Energy-efficient remotely accessed solar-powered color LED display for video

Julio Mayorga (j.mayorga@electricms.com)

Develop a highly efficient LED (or equivalent) DC-powered full color display panel (approx. 0,5 sqr. meters surface) with minimal power consumption to be used in isolated eParks recharging stations for electric vehicles, which are exclusively powered by a photovoltaic solar panel with batteries, and remotely accessed through a cellular network connection (GPRS/3G/4G or equivalent) used for displaying video and images. The project will involve optimizing hardware in the recharging stations in order to minimize power losses yet be compatible with the rest of the recharging station control hardware.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 2 students

14. Perceptually Realistic Multimodal Walking

Cooperstock (jer@cim.mcgill.ca)

Our immersive CAVE environment (http://srl.mcgill.ca/projects/niw/) provides compelling graphical, auditory, and haptic (sense of touch) effects related to foot-ground interaction during walking on various (simulated) ground surfaces, such as ice, snow, gravel, and water. The haptic effects are produced by a physics engine and delivered through the floor, driven by an array of vibrotactile actuators. This project will allow for seamless transitions between the various graphical environments through foot-based gestures, and will change the ground properties, including density (e.g., snow compaction) and friction, that the user experiences in each of these.
Sub-projects include:
1. Port the Max/MSP and Pd patches responsible for rendering the haptic effects to an Android platform and integrate these with our new "haptic shoes" architecture, allowing the same effects to be delivered to users outside of a special lab environment.
Project Team: 1-2 members
Requires Android experience and strong programming skills; some experience with Max/MSP and/or Pd would be valuable.
2. Integrate graphical, auditory, and haptic effects through the Unity game engine to simulate heterogeneous ground surfaces with increased realism. For example, when a user walks on snow, an imprint of the shoe is made on the surface and the compacted snow will exhibit a different auditory and haptic response the next time someone applies pressure to the same area. This will be done by making dynamic adjustments to the scene description within Unity, and sending updated parameters, as appropriate, to the haptic rendering system.
Project Team: 1-2 members
Requires Unity experience and strong systems skills, as the architecture involves many components, both hardware and software.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

15. Haptic Shoes

Cooperstock (jer@cim.mcgill.ca)

Our lab recently developed a prototype haptic shoe-insole that uses four LRA actuators to deliver vibrational stimuli to the wearer's foot. Communication runs over BLE, such that the apparatus can be controlled from a smartphone. Potential applications span the gamut from mobile gaming to navigation assistance to rehabilitation therapy. This project will enhance the existing prototype, develop support tools for ongoing experimentation of the perception of haptic stimuli, and test the footwear in the context of engaging mobile gameplay.
Sub-projects include:
1. Augmentation of the electronics: To enhance our ability to model the user's activity and to deliver feedback at the optimum time during the gait cycle, the in-sole design must be expanded to include sensors for gathering pressure, flexion, stance, and acceleration. At the same time, audio transducers cam be embedded in the insole so that spatially coherent multimodal feedback can be provided to the user.
Project Team: 1-2 members
Requires students with electronics experience and working with Arduino-based platforms

2. Design of a multi-actuator haptic rendering authoring toolkit: This will allow for authoring of haptic effects in a manner that is reasonably independent of the number and placement of the actuators. Such a toolkit would also support investigation of the possibility of inducing haptic illusions through the relative timing of vibrational patterns over a set of actuators. For example, can the haptic shoe create the illusion of sliding without moving the foot?
Project Team: 1-2 members
Requires strong software development skills
3. Game augmentation: An engaging open source game will be selected and augmented with simulated ground properties and/or awareness of the activities of other players, such as their pace of movement or location, delivered through the haptic channel. Experiments will be conducted in conjunction with successive iterations of development and refinement to evaluate the benefits to game experience with the addition of the haptics effects.
Project Team: 1-2 members
Requires Android development experience.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

16. AUTOUR

Cooperstock (jer@cim.mcgill.ca)

Autour (autour.mcgill.ca) is an eyes-free mobile system designed to give blind users a better sense of their surroundings, using spatialized audio to reveal the kind of information that visual cues such as neon signs provide to sighted users. Sounds appear to come from locations surrounding the user, thereby conveying a sense of directionality and distance. This allows for parsimony of representation and less intrusive sound cues. Imagine the difference between a mechanical voice stating, "Restaurant, 50 meters, 60 degrees to your left" vs. a very short "Restaurant" spatialized in the correct direction. The app is presently in use by the Montreal blind community, and will soon be made available across Canada. Our plans for enhancing the current system include the following sub-projects as well as the two related projects that follow:
- updates to the Android port of the system
- video-based sensing of the state of traffic lights
- improvements to the information rendering algorithms to convey locations of points of interest, such that these can be communicated to users either egocentrically, i.e., based on the user's current position, or relative to nearby intersections, which is important when sensor error becomes too high to trust reported position and orientation
Project Team: 1-2 members
Requires iOS or Android development experience.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

17. WALKING STRAIGHT

Cooperstock (jer@cim.mcgill.ca)

The visually impaired community still faces many challenges with safely navigating their environment, including that of maintaining a straight path, particularly when crossing at street intersections. In response, we implemented our "Walking Straight" application on an existing consumer device, taking

advantage of the built-in sensors on smartphones and delivering its feedback through audio. However, gyro drift poses a serious problem to maintaining the user on a straight path and audio feedback is not suitable in a number of scenarios. This project will pursue the possibilities of leveraging additional sensors, including the smartphone camera, as a means of correcting for gyro drift, and ideally, investigate the use of haptic actuators embedded in the shoe as a means of providing feedback to the walker.
Project Team: 1-3 members
Require some background in image processing and/or familiarity with OpenCV, ideally but necessarily some signal processing and Kalman filter knowledge.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

18. Real-Time Emergency Response

Cooperstock (jer@cim.mcgill.ca)

Real-Time Emergency Response (rtER) (srl.mcgill.ca/rter) was a winner of the Mozilla Ignite challenge that called on teams to design and build apps for the faster, smarter internet of the future. Specifically, rtER allows emergency responders to collaboratively filter and organize real-time information including live video, Twitter feeds and other social media. It also makes live video from mobile users available "interactively" to response personnel.
Sub-projects include:
1. updates to iOS port of mobile client
2. integration of audio communication and recording from mobile client streams
3. migrating our existing HLS-based streaming architecture to the newer Dynamic Adaptive Streaming over HTTP (DASH) standard
4. implementing a security layer involving user accounts, access control, secure identification of video streams, and HTTPS encryption
5. enhancing the existing visualization architecture to better integrate live video and embed emergency-related information display
6. investigating feature-matching for dynamic video mosaicing from moving or multiple video streams
7. developing the infrastructure to support crowdsourced video analytics
8. implementing chronology-based "event timelines" that allow viewers to scroll back to previous states during review of an emergency or crisis event
Project Team: 1-4 members
Skills: strong software development ability, plus specific skills as relevant to the individual sub-project(s)

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

19. Mixed reality human-robot interaction for reduction of workplace RSI

Cooperstock (jer@cim.mcgill.ca)

As part of a multi-site FQRNT-funded project, we are investigating the use of mixed reality in a human-robot interaction scenario to reduce the risk to workers arising from repetitive strain injury. The concept is to provide workers with an interface that adequately conveys the visual, auditory, and haptic cues to permit efficient manipulation and control of their tools, but in a safe manner.

Depending on the nature of the workplace activity being considered (to be determined shortly), a combination of graphical augmentation through a see-through display and haptic mapping of the tool forces is likely to be necessary. For example, this might be achieved by telemanipulation of a power drill, with visual display of a close-up view of the contact between the tool and the surface being drilled, and transmission to the operator of reduced versions of the forces and vibrations that would normally be imparted by the drill to the operator's hands. To prepare for these requirements, the project will involve prototyping of both an augmented reality display of relevant aspects of the tool and mapping of forces, torques, and vibrations to the operator in a safe manner that facilitates effective operation.
Project Team: 1-2 members
Skills: Android (preferable) or Unity development experience for our augmented reality display

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

20. Augmented Reality Tools for Enhanced Training of First Responders

Cooperstock (jer@cim.mcgill.ca)

Augmented Reality Tools for Enhanced Training of First Responders (srl.mcgill.ca/responder) is intended to equip firefighters with a heads-up-display (similar to Google glass) that provides them with valuable information related to their task, e.g., pointers to the nearest exit point and a breadcrumb trail indicating the path taken to the present location. The system was developed initially with support from the Mozilla Gigabit Community Fund and trialed with firefighters in a simple training scenario. Our next steps are intended to add interactivity, allowing the firefighters to share information through the system, correlate their position with a map display, mark locations within the environment, and integrate additional data from external sensors such as the TI SensorTag.
Project Team: 1-3 members
Skills: strong software development ability, in particular on Android platform (for our augmented reality display); computer graphics experience would be highly desirable

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

21. Video tagger and classifier UI

Cooperstock (jer@cim.mcgill.ca)

Researchers at Stanford and Google recently demonstrated a deep learning architecture for video classification that obtains impressive results (http://cs.stanford.edu/people/karpathy/deepvideo/). However, they require a very large training set, and extensive training time (1 month). For rapid video classification tasks, this is problematic. Instead, we have developed a lightweight and fast video analysis framework that automatically classifies a collection of videos into different categories, e.g., sports, commercials, or music videos, based on manually labeled training data. We now need to develop the web-based UI front-end, based on Video.js that provides tagging support on top of popular video players (YouTube, Vimeo) so that labels can be assigned or edited manually between start and stop points, thus serving as the source of training data. In addition, the UI will allow the user to indicate a spatial region of interest within the video frames, helping focus the automated classifier on the relevant features. These features could be tuned either based on manual guidance or possibly through a further machine learning step.

Project Team: 1-3 members Skills: strong software development experience required; UI design experience would be beneficial
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 2 students

22. Enhanced Remote Viewing Capabilities from a Camera Array

Cooperstock (jer@cim.mcgill.ca)

Our camera array architecture, initially developed for remote viewing of surgical (medical) procedures, provides real-time viewpoint interpolation capabilities, allowing users to look around the scene as if physically present. We are now interested in applying this architecture to more general video-mediated activities, including face-to-face videoconferencing, and exploring the potential to leverage mobile interaction with the array in a manner that compensates for the limited screen real estate of mobile devices. This project will examine the qualitative experience of telepresence when using a smartphone display as a mobile window into the remote environment, and will investigate the options for rendering the interpolated output on a 3D display, e.g., Occulus Rift. Project Team: 1-2 members Skills: systems experience, good programming knowledge
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 2 students

23. Mining, Machine Learning, and Semiconductor Lifetime

Prof. Brett H. Meyer (brett.meyer@mcgill.ca)

Semiconductor integrated circuits (ICs) in automotive, aerospace, and health care domains often have strict lifetime requirements: ICs wear-out, and wearing out early can have significant consequences for the user. Estimating IC lifetime, however, is a computationally challenging task, as it requires statistical simulation (lifetime simulation of a number of sample systems to estimate the mean lifetime). To meet this challenge, we are developing a variety of techniques for accelerating lifetime estimation. Here's the catch: we have developed a technique that performs well in some cases and poorly in others, but it isn't clear why. Given the estimation technique, input system designs, your task will be to develop data mining or machine learning techniques to correlate properties of the input system (e.g., number of processors, amount of redundancy, power density, thermal profile, etc.) with estimation behavior (e.g., good prediction, bad prediction) with the ultimate goal of explaining the performance of the technique, and, time permitting, improving it. 2+ students. C/C++ programming and strong analytical skills required, data mining/machine learning experience recommended.
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 2 students

24. Front-and-Back Rehab

Joelle Pineau (jpineau@cs.mcgill.ca)

The goal of this project is to develop a camera-based vision system allowing power wheelchair users to improve their ability to safely drive in reverse. The project is in collaboration with researchers at the Reasoning and Learning Lab at McGill. Responsibilities include hardware setup of the camera system, software development (Android/IOS) to access data from a camera and project on the screen for the user, and implementation of machine learning and computer vision algorithms to automatically detect nearby objects. Final testing and validation on the wheelchair robot is expected.
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 2 students

25. Android x86 on User-Mode Linux

Muthucumaru Maheswaran (muthucumaru.maheswaran@gmail.com)

GINI (http://www.cs.mcgill.ca/~anrl/gini) is a networking toolkit we are developing at McGill for teaching and learning computer networks. In this toolkit, we use User Mode Linux (UML), to emulate the machines. UML is one way of running Linux on top of Linux. We already have a bare bones version of UML that was created by our group using the Linux From Scratch project. In this project, we are interested in creating a Android x86-based UML. Android x86 is a fork of the Android project to run it on the x86 architecture. Android x86 is already capable of running on a variety of devices including the generic PC and the virtual machine. We are interested in incorporating an Android based machine into GINI. One way we can do this is by running an existing Android x86 system and run it inside a QEMU virtual machine. However, such a solution will cause much disparity within the GINI virtual machines and the QEMU virtual machines could be much slower. Therefore, we want to create an Android x86 system that runs on UMLs. All modern Linux kernels come with UML support. So the Android x86 kernel which is based on a standard Linux kernel should have this support. A recompilation of the kernel with the proper build flags should enable this feature. Just recompiling and enabling the UML support in the kernel is not sufficient to get the UML going. We need to create file system. The newly created kernel should run on the file system we created with the Android x86 system to run the UML. To carry out this project, the students need to have a good understanding on Operating Systems. The students need to study the Android Linux boot process. They also need to understand how the Android OS is structured at least the boot process of the OS. Once the OS analysis is completed, they can design the Android x86 UML and implement it. This is a good project to get know Android - one of the fastest growing mobile operating systems.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

26. IEEE Signal Processing Cup - Algorithm

Mike Rabbat and Fabrice Labeau (michael.rabbat@mcgill.ca, fabrice.labeau@mcgill.ca)

Compete in the IEEE Signal Processing Cup! Variations in the electric network frequency (ENF) of the power grid can be used as a time-varying and location-dependent signature. These ENF variations can be captured by multimedia signals recorded near electrical activities (e.g., the subtle background hum in audio recordings), and hence could be used for information forensics such as determining the location where an audio recording was made.

The team working on the algorithm component of this project will design and implement a software system to classify ENF signals using signal processing and machine learning techniques. Training data will be provided by the competition for 10 different regions. Then, given a new ENF signal, the system must determine which (if any) of the 10 regions it comes from.
Note that this is part of an international competition organized through the IEEE Signal Processing Society. For more details about the competition see
https://piazza.com/class_profile/get_resource/icye2ht65871dz/idmtovvvqe74bq

Type of Project: Design Projects (teams of 2 or more students)

Recommended Number of Students: 2 students

27. IEEE Signal Processing Cup - Hardware

Mike Rabbat and Fabrice Labeau (michael.rabbat@mcgill.ca, fabrice.labeau@mcgill.ca)

Compete in the IEEE Signal Processing Cup! Variations in the electric network frequency (ENF) of the power grid can be used as a time-varying and location-dependent signature. These ENF variations can be captured by multimedia signals recorded near electrical activities (e.g., the subtle background hum in audio recordings), and hence could be used for information forensics such as determining the location where an audio recording was made.
The team working on the hardware component of this project will design and build a circuit / embedded system to sense and capture ENF signals. The circuit will include a transformer, analog-to-digital converter, and possibly an microcontroller kit such as the Arduino.
Note that this is part of an international competition organized through the IEEE Signal Processing Society. For more details about the competition see
https://piazza.com/class_profile/get_resource/icye2ht65871dz/idmtovvvqe74bq

Type of Project: Design Projects (teams of 2 or more students)

Recommended Number of Students: 2 students

28. Virtual Internet of Thing

Muthucumaru Maheswaran (muthucumaru.maheswaran@gmail.com)

Linux is powering many recent gadgets ranging from smart watches to smartphones. It is also backed by a hyper active community that is bringing the cutting edge OS research and development to Linux. One of the ideas that is generating much interest is virtualization. There are many different ways of virtualizing an operating system and one of them that is gaining traction in cloud computing systems is containers. Using containers, we isolate a bunch of processes from another bunch of processes. Despite the excitement surrounding containers, it is still a rapidly evolving technology. Many aspects the virtualization is still a work in progress.
In this project, we want to explore how this technology can be used to virtualize IoTs. We assume Linux is powering the IoT device, which could be an end device or a hub that is connecting many end devices to the Internet. With low overhead virtualization at an IoT device, we can create many virtual instances. Each instance can be restricted such that it can have access to a particular set of resources that are connected to the device. For example, suppose we have a IoT hub that is connected to a light and a fan. We can create two containers on the hub with one having controls for the fan and other having controls for the light. No matter what a program running in the container that has access to the light does it cannot affect the fan. In this project, we want to design and build a virtualizable IoT hub using Raspberry Pi to demonstrate this concept. This project would involve studying about Linux OS and container based virtualization in Linux (i.e., Linux containers). Then, you need to come up with a design for the virtualizable IoT hub based on the container mechanism. Lastly, you need to

implement the idea on the Raspberry Pi. You will receive significant guidance on Linux OS and container-based virtualization from our research group.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 3 students

29. Software Defined Networks in GINI

Muthucumaru Maheswaran (muthucumaru.maheswaran@gmail.com)

GINI (http://www.cs.mcgill.ca/~anrl/gini) is a networking toolkit we are developing at McGill for teaching and learning computer networks. At this time, it has support for legacy networks (non software defined networks) and physical devices like IoT. We can setup network topologies with virtual and physical devices in them. Some of the elements can be virtual routers that can be programmed by the students to implement a variety of different protocols. The GINI toolkit is developed in C, Python, and Linux. There is ongoing work in our group to introduce software defined networks into GINI. Software defined networks (SDNs) are a hot networking trend in the industry. By building SDN support into GINI, we can make GINI an ideal toolkit for teaching and learning computer networks. This project will focus on designing and implementing portions of a network flow switch and connecting the flow switch to an existing SDN controller. To implement the network flow switch you can reuse some of the components of an existing IP router that is provided with GINI. You can obtain a very good understanding of IP networking and SDNs by carrying out this project. We will provide good guidance on how to engage with the design and implementation of the SDN extensions of GINI.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 3 students

30. Design and Optimization of Transformer Cores

Prof. David Lowther (david.lowther@mcgill.ca)

Using material loss data from a number of industrial grade samples measured at the state-of-the-art facility in the computer aided design and magnetic measurements laboratory, the students will optimize the design of transformers for power engineering applications. The project will involve experimental data gathering, carrying out 2D/3D electromagnetic simulations, application of some modern loss prediction formulae and optimization of EM device using industrial software. The outcome of this project may also lead to an original publication.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

31. Otimization and Drive Design of a Switched Reluctance Motor for Traction Application

Prof. David Lowther (david.lowther@mcgill.ca)

This is a continuation of a previous design project in which a concept design of a switched reluctance motor for traction application was designed. In this phase of the project an electromagnetic model of the device will be developed to minimize torque ripple and consider drive options. In order to do this an ideal transient model of the machine will be developed first which will then be modified to consider real drive circuit options. The project will involve the 3D electromagnetic simulation of the

device and co-simulations of the electromagnetic solver using MATLAB/SIMULINK. The use of an industrial optimization software may also be necessary.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

32. Minimizing the Effects of Shrink Fitting on Electric Motors

Prof. David Lowther (david.lowther@mcgill.ca)

Manufacturing processes can change the magnetic properties of materials which ultimately affects device performance. In this project the effects of shrink fitting on the performance of an electric motor rotor will be minimized. By using multi-physics simulation techniques accurate model of an electric motor rotor will be developed and then optimized to enhance its performance. The project will include taking experimental data, mechanical stress analysis using an industrial software, 2D/3D electromagnetic simulations, application of some modern iron loss prediction formulae and design optimization. This will be an original design project and the results may be publishable.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

33. Design and Implementation of Electric Motor Control Strategies

Prof. David Lowther (david.lowther@mcgill.ca)

The main objective of this project is to design a control strategy for the automatic regulation of the position, speed, torque and other performances of a characterized 3-phase motor at different operating conditions. The project presents an opportunity for a student group within a laboratory setting to review the fundamentals of electric drives and motor control, to learn how to use a motor design simulation software (Infolytica MotorSolve/MagNet), to implement and test a real-time drive system (MATLAB Simulink), to characterize a selected motor using an experimental dyno setup, and to compare and design different motor control strategies for a given set of requirements. The simulation results of the motor and its control are then verified through an available experimental test bench.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

34. GradLounge: A Web-Based Academic Platform for Graduate and Post-Graduate Students

Shane McIntosh (shane.mcintosh@mcgill.ca)

We are developing a scalable web-based academic platform, called GradLounge, geared towards facilitating inter-and-intra departmental collaboration between McGill graduate students. Our central aim is to expedite problem solving and troubleshooting in research by facilitating knowledge flow within the University. GradLounge addresses this issue through individual profiles detailing the student's institutional information, proficiency in technologies and topics. Users will be able to solicit help based on their needs (topics, technology, or lab), and post public submissions or "ShoutOuts" that other users can discuss, follow, and form offline collaborations. Incentives and ratings will also be offered to facilitate participation and reward proficient and active users (i.e. gamification). To assist us in the development of the platform we are looking for a team of highly motivated software engineers. The main requirement for the project is having experience in web development.

Ideally we are looking for a team with interest and prior experience in both front and backend web development. Prior exposure to machine learning is a bonus but not required. The project components encompass the following (the exact deliverables can be adapted to the team's skills and interests):
> Web Development Frameworks:
This includes learning the open source minimalistic web development framework Flask (http://flask.pocoo.org). The programming language that will be used is Python.
> Machine Learning
Categorization of users based on their interactions with the platform along with clustering of collaborations based on 'document clustering'.
> Testing Framework
Automated testing and continuous integration. This will be based of TDD (test driven development).
> Data mining
The interaction data with the platform will be used for A/B testing and for finding related patterns and chaining user transactions to predict their behaviour.

Type of Project: Design Projects (teams of 2 or more students)

Recommended Number of Students: 4 students

35. Mining the Metadata of Millions of Software Repositories

Shane McIntosh (shane.mcintosh@mcgill.ca)

When developing software systems, teams produce heaps of data. As bugs are fixed and new features are added to software systems, change records are recorded in version control systems (e.g., Git). While these change records are often used for static bookkeeping purposes, recent work in the Mining Software Repositories (MSR) research discipline shows that these static software repositories can provide useful insight for future software decision making. For example, characteristics of the code that was defect-prone in the past can be leveraged to predict which areas of newly produced code are likely to be defective. These sorts of insights are useful for software development teams who need to prioritize their (often highly) limited quality assurance resources.
In this project, students will mine the metadata for almost 700,000 SourceForge projects and almost 8,000,000 GitHub repositories. The team of students will be exposed to the entire process of designing and executing an empirical study using this large collection of software repositories. The team will (1) formulate research questions, (2) perform a short literature survey, (3) design an experiment to address the research questions, (4) perform the experiment, and (5) write a short research paper to disseminate the results.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 2 students

36. MEMS micro-motor design, simulation and testing for optical applications

Frederic Nabki (frederic.nabki@mail.mcgill.ca)

MEMS (micro-electromechanical system) based devices are currently used in many applications such as accelerometers, microphones, projectors etc. This project will provide students with the opportunity to gain a deeper understanding of MEMS, which are gaining more and more importance in the electrical engineering world.

Last year, design project students started the design of a MEMS micro motor that will soon be submitted for fabrication and will be tested in early 2016. The goals of this follow-up project is to i) assist in finalising the design of a MEMS-based micro-motor ii) develop a simulation flow to better understand the micro-motor's expected behaviour iii) implement a test bench for its optical and/or electrical characterisation. The MEMS micro-motor is targeted towards an optical application. The project will require the students to familiarise themselves with MEMS micro-motors and their operating principles and testing procedures. Testing is expected to be done by optical and electrical means, and COMSOL will be used to simulate the devices. Accordingly, the students will be exposed to a wide range of concepts and hands-on opportunities. Overall, this project will be an opportunity to gain design, simulation and testing knowledge on MEMS-based technologies.
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 3 students

37. Loewner Matrix Based Macromodeling for Signal Integrity Analysis

Roni Khazaka (roni.khazaka@mcgill.ca)

In this thesis project, a macromodeling approach based on Loewner Matrix interpolation will be developed. This would allow the automated creation of spice compatible time domain macromodels based on frequency domain S-Parameter measurements or full-wave electromagnetic simulations. A matlab based implementation of the algorithm will be developed and released into the public domain.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

38. Transmission Line Macromodels based on Matrix Rational Approximation

Roni Khazaka (roni.khazaka@mcgill.ca)

In this project, a method for the automated generation of spice compatible transmission line models based on Matrix Rational Approximation will be developed. The method will also incorporate delay extraction in order to reduce the size of the macromodel and speed-up the simulation. This approach has applications in signal integrity analysis and in power systems analysis. An implementation of the algorithm in matlab will be completed and publicly released.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

39. Full wave analysis of boards and packages using partial element equivalent circuits (PEEC)

Roni Khazaka (roni.khazaka@mcgill.ca)

The project is a collaboration with Dr Al Ruehli. The objective is to create a matlab simulator based the PEEC approach in order to perform 3D full wave simulations. The matlab implementation of the algorithm will be publicly released.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

40. Statistical circuit simulation based on polynomial chaos theory

Roni Khazaka (roni.khazaka@mcgill.ca)

As component sizes shrink, uncertainty in in component dimensions and parameters has become a critical design limitation.This has lead to a need for efficient stochastic circuit simulation. In this project a non intrusive simulation method based on polynomial chaos and stroud cubature rules will be developed for obtaining the statistical moments of circuit outputs without the need for costly monte-carlo analysis.
Type of Project: Honours Thesis (single student working alone)
Recommended Number of Students: 1 student

41. Berkely MAPP project

Roni Khazaka (roni.khazaka@mcgill.ca)

In this project, a contribution to the open source Berkely MAPP project (http://mapp.eecs.berkeley.edu/) will be made and submitted. MAPP is an open source circuit simulator prototyping tool. In this project new functionality and analysis tools will be added to the MAPP software. This project can accommodate multiple teams working on different contributions.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 2 students

42. Adapting the Aspect-Oriented User Requirements Notation to Concern-Oriented Reuse

Gunter Mussbacher (gunter.mussbacher@mcgill.ca)

The Aspect-oriented User Requirements Notation (AoURN) is an advanced modeling environment to specify and analyze requirements with the help of feature, goal, and scenario models. AoURN allows complex systems to be built by assembling concerns with aspect-oriented composition techniques. Typical concerns are security, availability, reliability, and other system qualities as well as any domain-specific functionalities. Typical compositions are (a) merging based on mappings of model elements in one concern to those in another concern and (b) pattern-based composition which uses patterns to identify the locations where elements from different concerns need to be composed. This project will add new functionality to jUCMNav, an Eclipse/Java-based tool for AoURN, to improve the composition techniques available in jUCMNav in support of AoURN. Ultimately, this new functionality will provide necessary enhancements to enable concern-oriented reuse at a greater scale.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

43. Support for Activity Theory in jUCMNav

Gunter Mussbacher (gunter.mussbacher@mcgill.ca)

Activity Theory (AT) is a psychological paradigm that is useful to understand the relationships of diverse stakeholders in socio-technical systems. AT defines human activity as a system of several elements and their mediating relations (e.g., the ability of the Community to achieve the Aim of the activity by dividing up the work according to the Division of Labor, i.e., Division of Labor mediates between Community and Aim). This project will first add modeling support for Activity Theory to the jUCMNav tool, an Eclipse/Java-based tool for the specification of requirements models in the form of

feature, goal, and scenario models. The second part of the project will transform AT models into goal models based on provided relationships between AT and goal models.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

44. Battery Management System for the Alizeti Micro Solar Pumping System

François Bouffard (francois.bouffard@mcgill.ca)

This project consists in developing and prototyping the battery management system for the Alizeti microSolar pumping system. The students will have to design the battery health monitoring and energy management hardware and software. The industrial sponsor (Alizeti microTechnologies, Inc.) is looking for students with superior skills in electronics and programming. Skills and experience in power electronics and embedded systems will be clear assets. Please note that the sponsor will interview the teams wishing to do this project.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 2 students

45. : Optimization of a PMSM Drive Switching Frequency based on Experimental Loss Data

Prof. David Lowther (david.lowther@mcgill.ca)

In this project the pulse width modulation (PWM) switching frequencies of a permanent magnet synchronous machine (PMSM) will be optimized based on simulations using SIMULINK and validated using experimental results obtained from the loss measurement equipment at the CADLAB magnetic measurements laboratory. The project will include a variety of experimental aspects as well as implementation of simulations of motor drive system using MATLAB/SIMULINK. This will be a challenging project that may lead to original publications.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 4 students

46. Decoding visual stimuli from functional brain imaging data ('mind reading')

Amir Shmuel (amir.shmuel@mcgill.ca)

Multivariate classification algorithms applied to functional MRI (fMRI) data obtained at 3 Tesla can decode information segregated in cortical columns. This result is surprising given the large size of the voxels relative to the width of columns in the human brain (voxel size, 3×3×3 mm3; width of columns, 1 mm or less). The mechanism by which low-resolution imaging decodes information represented at a scale finer than the voxel size is not clear. Initial speculations suggested that aliasing of high spatial-frequency components, including the main frequency component of the columnar organization, could underlie this phenomenon. However, we have proven that these speculations were wrong. Several other mechanisms have been proposed as factors that can underlie the decoding of information pertaining to the stimulus orientation or to the stimulated eye. These include: (I) contributions from local irregularities in the columnar organization, (II) contributions from large-scale non-columnar organizations, (III) functionally selective veins with biased draining regions, and (IV) complex spatio-temporal filtering of neuronal activity by fMRI voxels that may carry information on the fine-scale neurophysiological response. However, despite the fact that the large body of human imaging studies use decoding based on information conveyed in fine

structures, the link to the underlying neural activity and to the hemodynamic mechanisms remains tenuous.
The project will determine the extent to which different spatial components of the hemodynamic response, including responses of various spatial frequencies and the responses of macroscopic veins, carry information on neuronal responses organized in cortical columns.
We have addressed the problem using analysis software developed by a PhD student, applied to brain responses to oriented gratings. The proposed project will address the same problem by slightly modifying the software and applying it to the brain's response to visual stimulation of one eye at a time (decoding of the stimulated eye).
The results can potentially be used for evaluating and optimizing fMRI data-acquisition parameters for decoding information conveyed by cortical columns. This will provide the basis for informed usage of fMRI and decoding techniques in exploring and discovering fine-scale functional organizations in regions of the brain where fine cortical maps have not been revealed. Furthermore, our results will set the stage for the use of fMRI-based decoding to monitor degradation of fine-scale functional responses in the diseased brain.

Type of Project: Honours Thesis (single student working alone)

Recommended Number of Students: 1 student

47. Investigation of brain functional connectivity using forward biophysical models and advanced signal processing methods

Georgios Mitsis (georgios.mitsis@mcgill.ca)

The observation that spontaneous brain activity is not random noise, but is specifically organized in the resting human brain, termed resting state networks (RSNs), has generated a new exciting avenue of neuroimaging research, as it suggests that it is not necessary to use externally induced experimental protocols to drive brain activity. Functional connectivity RSN measures hold great promise as potential biomarkers; however, in order to realize this potential, the nature of RSNs has to be better elucidated.
The objective of this project is to better understand the emergence of functional brain networks and their properties over multiple time scales by using forward models that link neural activity to the corresponding neuroimaging signals (fMRI, EEG or MEG) in order to generate realistic simulations and extract relevant functional connectivity measures and comparing them to experimental data. We are also interested in the effect of physiological fluctuations (heart rate, respiration, arterial CO2) on RSN properties and particularly on their nonstationary characteristics. Furthermore, through these simulations we will examine the role of the the hemodynamic response function (HRF), which quantifies the relation between the underlying neural activity and the regional blood flow variations that are the main source of BOLD signal variations. This relation is termed neurovascular coupling and its role has not been fully elucidated yet. Neurovascular coupling has important implications for the statistical interpretation of fMRI experiments, particularly in populations where this coupling may be altered (aging subjects and patients, e.g. Alzheimer's disease). Therefore, its role is important for accurate assessment of the true underlying neuronal connectivity from the BOLD fMRI connectivity measures. Essential skills: solid signal processing and systems theory knowledge, good Matlab programming skills. Desirable skills: some experience with neuroimaging data analysis.

Type of Project: Honours Thesis (single student working alone)

Recommended Number of Students: 1 student

48. Technologies, Network Architectures, and Resource Allocation for Future Mobile Network Infrastructure

Quang-Dung Ho (quang.ho@mcgill.ca)

The increasing penetration of smart mobile devices, exponential growths of mobile applications and network traffic, as well as diverse quality of service (QoS) requirements have been driving the need for technological innovations in radio access networks (RANs). This project focuses on the developments of new radio technologies (software-defined radio and networking, wireless virtualization, etc.) and associated network architectures/protocols, efficient dynamic resource allocation schemes (multi-cell cooperative user association/resource scheduling, QoS provisioning, learning-based medium access control, etc.) for Cloud-RAN, an innovative and enabling technology for the future mobile networks.
The students will work with graduate students and/or research associates in designing/developing network simulation tools and various software modules for software-defined network experimental platforms. They will also involve in designing and implementing TCP/IP-based communications protocols for information exchange,authentication, authorization and accounting. Besides, students will help to develop embedded software for Linux-based computing systems and software-defined radios, carrying system setups and experiments of new virtualization schemes.
The candidates should have good knowledge and working experience with object-oriented programming and software development. Besides, the following skills and experiences are great assets: Linux, Python, C/C++, Matlab, FPGA sub-module level design, Embedded system and software development, OpenFlow, IEEE 802.11 PHY and MAC, lab equipment use for hardware tests and measurements.
* Deliverable: a technical report describing the firmware/software developed for the simulation/experimental platform and functionalities, performance and simulation/experiment results of designed/implemented protocols.

Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)

Recommended Number of Students: 3 students

49. Real-time Indoor Localization and Tracking

Quang-Dung Ho (quang.ho@mcgill.ca)

Technology for real-time localization in outdoor environments is relatively mature and reliable. However, providing real-time localization in indoor environments is still a challenge. Some of the issues are due to severe attenuation and multipath fading in the complex indoor propagation environment. In this project, we investigate the effects of the deployment environment and radio configurations on the performance of indoor localization and tracking systems and develop signal processing and trajectory prediction algorithms suitable to improve their reliability and accuracy. Experiments will be performed on the operational WiFi-based indoor localization systems.
The student will work with graduate students and/or research associates (i) to prepare experimental configurations, (ii) to collect and analyze measured data, and (iii) to test newly developed algorithms, (iv) to implement algorithms and GUI modules.
The candidates should have good knowledge and working experience with computer programming/software development. Besides, the following skills and experiences are great assets: Matlab, C/C++ coding, SQL Server, ASP, Web interface development.

Deliverable: a technical report on the proposed algorithms, system setup, functionality, test results and performance (accuracy and speed of tracking) of proposed algorithms under different conditions.
Type of Project: Design Projects (teams of 2 or more students)
Recommended Number of Students: 2 students

50. Broadband Multi/Massive MIMO- Antenna Structures and Channel Measurements for Full-Duplex 5G

Quang-Dung Ho (quang.ho@mcgill.ca)

Multi-Input Multi-Output (MIMO) has been considered in wireless systems such as LTE, WiMAX, WiFi and new Massive MIMO is considered for the next 5G mobile telecommunications standard. Multiple antennas have to operate over wide frequency bands, and to be kept in a limited area without degrading the MIMO system performance, especially for small-size terminals. In this on-going project, we investigate and implement new promising antenna structures (such as EBG, Dielectric filled, etc.) and characterize them over different practical channels for application in the MIMO Full-Duplex systems. Some of the types of considered channel environments: controlled free-space (e.g., in anechoic chamber), simulated rich scattering (e.g., reverberation chamber), or practical indoor and outdoor environments. Students will have a chance to understand MIMO and Massive MIMO systems, antenna design, channel measurements, material selection techniques, and to work with real-life measurement facilities and testbeds. The students will study on the general concept of MIMO, radio-wave propagation in free-space and in rich-scattering environments; learn the operation principle of measurement equipments/facilities such as vector network analyzer, spectrum analyzer, anechoic chamber, reverberation chamber and/or MIMO testbeds; prepare measurement set-ups; assist graduate students and/or research associates to evaluate/analyze measurement/simulation results (e.g., using Matlab/C++). * Deliverable: a technical report on measured data and performance comparison of various multi-antenna structures in different situations
Type of Project: Design Projects (teams of 2 or more students), Honours Thesis (single student working alone)
Recommended Number of Students: 3 students