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Poster Abstracts 2016

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ADVANCED MATERIALS AND NANOTECHNOLOGY

Green Synthesis of Ultra-Strong Graphene Oxide Hydrogels with Superior Contaminant Adsorption Capacity

By Nariman Yousefi and Professor Nathalie Tufenkji

Graphene oxide (GO) hydrogels have been recently shown to be excellent sorbents for water contaminants due to their versatile surface chemistry and high specific surface area. Unlike colloidal GO, the resulting hydrogels can be easily recovered from the decontaminated water and recycled for further use. However, most GO hydrogels suffer from poor mechanical properties and cannot endure multiple recovery cycles. We report here a novel strategy based on the use of 1D nanomaterials to synergistically improve the mechanical properties and contaminant adsorption capacity of the nanohybrid GO hydrogels. We also show that the use of 1D nanomaterials extensively inhibits the restacking of GO nanosheets, thus resulting in hydrogels with higher available surface area for contaminant adsorption. Finally, we demonstrate that an ultrastrong nanohybrid hydrogel with a storage modulus of up to 800 kPa has a remarkable capacity for uptake of a range of water contaminants.

Surface Characterization of β-Hematin Synthesized by Two Methods: Implications in Antimalarial Drug Testing

By Elizabeth Guerra and Professor Marta Cerruti

During the intraerythrocytic stage of malaria, the parasite digests hemoglobin and produces an insoluble crystal called hemozoin as a detoxification step. This material has become an attractive target to develop new antimalarials that bind to its surface to inhibit further crystallization. Although the bulk crystalline properties of hemozoin have been extensively studied, the surface properties remain poorly defined. In this work we use spectroscopic and adsorption techniques to study the surface properties of synthetic hemozoin, hematin anhydride, obtained by two different methods. We have recently shown that the two methods of synthesis produce crystals with different surface characteristics, such as amount of water adsorbed and extent of surface carboxylation. These results mean that the methodology to synthesize hematin anhydride affects its surface reactivity. Mapping these surface interactions will define possible surface binding modes for proteins, immunogenic agents, and antimalarials.

Overcoming Brittleness in Ceramic and Glasses using Micro-Architecture and Bioinspiration

By Zhen Yin and Professor Francois Barthelat

Highly mineralized biological materials boast unusual combinations of stiffness, strength and toughness currently unmatched by engineering materials. High mineral contents provide stiffness and hardness, while weaker interfaces with intricate architectures channel propagating cracks into toughening configurations. We applied these ideas from nature to the design of novel types of glasses, ceramics and other brittle materials. Our bio-inspired materials are fabricated through laser engraving technique to carve weak interfaces into the initially continuous materials. These materials were made of at least 95%vol. of hard ceramics or glasses and containing interfaces made of deformable polymers with attractive solid and rheological properties. Guiding cracks along weak interfaces offers a great control over deformation and failure modes, enabling crack deflection, crack bridging, process zone toughening and large deformations. The bio-inspired approach provides a new pathway to toughening glasses, ceramics or other hard and brittle materials, with applications in architectural glass, glass containers or touch screens. The bio-inspired materials we fabricated serve as entry points to a vast design space where micro-architecture and interface behavior govern mechanical response and performance.

Development of Antimony Doped Snx-$W_{(1-x)}$-Oxide Photo-Electrocatalysts for Environmental Applications

By Saloumeh Ghasemian and Professor Sasha Omanovic

Thin Snx-$W_{(1-x)}$-oxide coatings (x = 0, 0.2, 0.4, 0.6, 0.8 and 1) doped with antimony (~3 at.%) were formed on a Ti substrate by thermal deposition and used for catalytic oxidation of organic contaminants in wastewaters and for water disinfection. Electrochemical and surface characterization techniques were used to determine the surface microstructure and elemental composition of the coatings. Their photo-electrocatalytic activities were examined for degradation of phenol red dye. Based on the screening results, the Sb-doped Sn0.8-W0.2-oxide electrode was chosen for further tests: electrochemical disinfection of water inoculated with bacteria and photo-electrochemical degradation of Carbamazepine. The electrode rapidly and effectively inactivated 107 CFU/mL bacteria, in less than 1 min, by employing a current density of 10 mA/cm^2. By applying the same current density, it also degraded 90 % of 0.2 mg/L Carbamazepine in less than 2 minutes.

Detection and Characterization of Metal Nanoparticles in Biosolids and Sludge from Municipal Wastewater Treatment Plants

By Arshath Abdul Rahim and Professor Subhasis Ghoshal

Engineered nanoparticles (ENPs) are being extensively used in a variety of industrial and consumer products due to their properties leading to an increased release in the environment. A significant fraction of ENPs entering WWTP is likely to be removed with settled sludge. Currently, there is a scarcity of data on the presence and abundance of ENPs in municipal sludge and biosolids, and robust data in needed for conduction environmental risk assessments and biouptake assessments for the ENPs. The SP ICP-MS operating parameters were optimized and validated by performing control experiments with biosolids aqueous extracts spiked with Ag and Cu ENPs of specific sizes with approximate mean sizes ranging from 25 to 150 nm for Ag and Cu with concentration in the range of 10^7 to 10^9 NPs/g of dry biosolids and 10^7 to 10^{10} NPs/g of dry sludge in samples from eight different municipal WWTPs across Canada.

Dissolution of Silver Nanoparticles in Municipal Wastewater by Single Particle ICP-MS

By Mehrnoosh Azodi and Professor Subhasis Ghoshal

Ag nanoparticles (nAg) are used in various consumer products and a significant fraction is eventually discharged with municipal wastewater (WW). In this study we assessed the release of Ag from polyvinylpyrrolidone (PVP)- and citrate-coated 80 nm nAg in aerobic WW effluent and mixed liquor and the related changes in nAg size, using single particle ICP-MS (spICP-MS). The concentration of dissolved (non-particulate) Ag in WW effluent was 0.9±0.02 ppb at 72 h and was 47% lower than in deionized (DI) water, in batch reactors spiked with 5 x 10^6 PVP-nAg particles/mL (10 µg/L), an environmentally relevant concentration. The dissolved Ag was partly reformed into ~22 nm nAg by sulfidation over 168 h while the parent nAg mean diameter decreased to 64.3±0.7 nm. Reformation of nAg did not occur in DI water, and humic or fulvic acid solutions. Dissolution experiments with PVP- and citrate-coated nAg in WW mixed liquor showed qualitatively similar dissolution trends.

From Folding to Creasing through the Multi-scale Pattern Landscape of Tulips

By Pardis Rofouie, Professor Damiano Pasini, and Professor Alejandro Rey

We present a model to investigate the formation of surface patterns in biological materials through the interaction of anisotropic interfacial tension, bending elasticity, and capillarity at their free surfaces. Focusing on the cholesteric liquid crystal (CLC) material model, the generalized shape equation for anisotropic interfaces using the Rapini-Papoular anchoring and Helfrich free energies is applied to understand the formation of multi-length scale patterns, such as those found in floral petals. The chiral liquid crystal-membrane model is shown to be analogous to a driven pendulum, a connection that enables generic pattern classification as a function of bending elasticity, liquid crystal chirality and anchoring strength. The unique pattern-formation mechanism emerging from the model here presented is based on the nonlinear interaction between bending-driven folding and anchoring-driven creasing. The predictions are shown to capture accurately the two-scale wrinkling of certain tulips. These new findings enable not only to establish a new paradigm for characterizing surface wrinkling in biological liquid crystals, but also to inspire the design of functional surface structures.

Effects of Multiwall Carbon Nanotubes on Ice and Gas Hydrate Phase Change Processes

By Jason Ivall, Professor Phillip Servio and Professor Sylvain Coulombe

Multiwall carbon nanotubes (MWCNTs) are graphitic materials recognized for a multitude of remarkable properties. Our research group studies the freezing of liquid water into ice and gas hydrates and exploits these properties to modify various aspects of the phase change processes. Our work has shown that stainless steel meshes coated with MWCNTs exhibit a reduced wettability that lowers the adhesion of water to the substrate. These superhydrophobic characteristics are important for surfaces where contact with water must be avoided. Aqueous nanofluids made from surface-functionalized MWCNTs facilitate nucleation and accelerate growth in gas hydrate forming systems, which improves the capacity for natural gas storage and CO2 sequestration. Finally, the behavior of MWCNTs throughout the phase change process is profiled to better understand the mutual effects between MWCNTs, water and the phase change process. The long-term stability of nanofluids is shown through phase change cycling experiments.

Functionalization of Silk Fibroin through Anionic Fibroin Derived Polypeptides

By Gabriele Griffanti and Professor Showan Nazhat

Silk fibroin (SF) based materials are frequently considered as templates for mimicking biomineralization. Silk fibres allow apatite formation in solutions that mimic body fluid where sericin induces this deposition through its carboxyl groups, which act as nucleation sites. However, sericin has been shown to induce immune responses and must be removed from silk based biomaterials to ensure greater biocompatibility, which in turn significantly hampers apatite deposition.

The digestion of an aqueous solution of SF with α-chymotrypsin generates a set of anionic fibroin derived polypeptides (Cs), which have been demonstrated to rapidly induce the mineralization in dense collagen gels. In this study, it was hypothesized that the incorporation of Cs into a silk based material would induce apatite deposition. Moreover, the potential role of Cs in mediating the proliferation and osteoblastic differentiation of seeded mesenchymal stem cells was also investigated.

Development of Mg-6Al Cast Alloys with Increased Ductility for Automotive Crashworthy Components

By Konstantinos Korgiopoulos and Professor Mihriban Pekguleryuz

The increased tendency for reduced CO2 emissions and fuel economy has made magnesium alloys attractive lightweight materials in transportation industry. The Mg-Al based alloys present an optimum combination of ductility and strength at 6 wt.% Al, but higher ductility is needed for crashworthiness. This can be accomplished by improving the ductility of the matrix (stacking fault energy, c/a ratio) and the intermetallics (intrinsic ductility, morphology, distribution, size). The present poster seeks to develop a better understanding of the relation between the ductility and the modification of Mg17Al12 intermetallics via trace additions. In the design stage, thermodynamic calculations are conducted via the FactSage™ software to predict phase formation. Different Mg-Al alloys with Er or Y and different amounts of Al addition are experimentally investigated through scanning electron microscopy, and X-ray diffraction. The mechanical behaviour is evaluated via room-temperature tensile and compression tests.

AEROSPACE ENGINEERING

Dynamic Modelling and Adaptive Control of a Cable Actuated System

By Harsh Godbole and Professor James Forbes

In this paper a unique lumped mass dynamic model of a single degree of freedom cable is derived. The dynamic model of the cable takes into account the variation in mass of winch and cable as the cable rolls over the winch, and uniformly distributes the mass over the entire length of cable. Rigid and elastic dynamics of the cable are decoupled using the assumption that the mass of the payload is much larger than the equivalent mass of the cable and winch. An adaptive controller is then defined with the help of filtered error between desired and actual trajectories. Passivity based analysis is then conducted to ensure that the system remains input-output stable.

Robust Controller Design using the Large Gain Theorem

By Ryan Caverly and Professor James Forbes

Controller synthesis methods are presented that invoke the Large Gain Theorem and the concept of minimum gain to guarantee robust closed-loop input-output stability. The Large Gain Theorem provides a guarantee of robust stability in the proposed controller synthesis methods, which parallels the use of the Small Gain Theorem to guarantee robust stability in H-infinity controller design. A significant benefit of the Large Gain Theorem includes the ability to accommodate unstable uncertainties, which cannot be directly accounted for with the Small Gain Theorem. The proposed controllers are synthesized to either maximize robustness or maximize performance while satisfying a linear matrix inequality that enforces the stipulations of the Large Gain Theorem. Numerical examples are presented to illustrate the effectiveness of the proposed controller synthesis methods.

Deformation of Multiblock Structured Three-Dimensional Viscous Mesh on Multi-Element Body Using the RBF Methodology

By Krishna Roka Magar and Professor Siva Nadarajah

While the multi-block structured three-dimensional mesh provides an excellent ability to mesh a complex three-dimensional multi-element body for numerical simulations in a parallel computing environment, the Radial Basis Function (RBF) methodology provides a simple method for deformation while also preserving the fine layer of viscous mesh at large deformation and being easily parallelizable. Presented herein is the methodology to deform the three-dimensional multi-block structured mesh using the RBF methodology. The major issue that arises while combining the two facets is that while the multi-block structured mesh contains repeated grid points at the block interfaces with different versions of information, the interpolation requirement of the RBF methodology requires that the RBF points be distinct. The preprocessing step that removes any ambiguity of the grid points by forming the master list corresponding to the repeating grid point is devised by using the Block Identity and Computational Index of the grid point. This method has been found to be significantly faster and robust compared to the brute force method that only uses the physical coordinate of the grid points. The quality of deformation obtained from the reduced RBF set of points selected based on the curvature of geometry is then examined.

Optimization-based Anisotropic hp-Adaptation for High-Order Methods

By Nicolas Ringue and Professor Siva Nadarajah

This research project targets the development of algorithms for computational aerodynamics. We present a general framework for hp-adaptation of high-order finite element discretizations for compressible flow simulation. Using the sensitivities of an adjoint-based error estimate, our method seeks optimal element mesh size h and polynomial degree p distributions. This approach results in an optimal hp-mesh tailored to yield the most accurate prediction of a quantity of interest, such as aerodynamic coefficients, at a given computational cost. The proposed approach features a reduced dependence on the initial mesh compared to established adjoint-based adaptive methods. It provides a unifying framework where adaptation choices such as isotropic/anisotropic, h-/p-refinement/coarsening do not only rely on local arbitrary measures of the solution's anisotropy and smoothness, but rather where a globally optimal distribution of degrees of freedom is sought to minimize the error in the chosen quantity of interest.

Semismooth Newton Solver for Periodically-Forced Solutions to Unilateral Contact Formulations

By Yulin Shi and Professor Mathias Legrand

Vibratory modes of either autonomous or periodically-forced mechanical systems undergoing unilateral contact condition are studied. The complementarity contact condition is reformulated as root set of Lipschitz continuous function, which allows the implementation of Galerkin methods in seeking periodic solutions. Semismooth Newton method is used to solve the resulting nonsmooth equations. The results are validated by the reference to the steady modes revealed by time-stepping methods. Frequency-energy plots are used to show the nonlinear resonances. The proposed method successfully captures the frequency-energy dependence phenomena like the sub-harmonic resonance, internal resonances and bifurcation.

Development of Ignition Resistance Magnesium Alloys for Commercial Aircraft Cabin Components

By Luis Villegas Armenta and Professor Mihriban Pekguleryuz

The low density of magnesium (Mg) is a promising asset for weight reduction of commercial aircraft. However, the perceived risk of fire in a post-crash scenario restricts the use of Mg alloys as part of cabin components. To deal with this drawback, our research team is focused on developing new Mg alloys that can resist high temperatures without ignition through the addition of alkaline earth and rare earth elements. The selection of these elements must follow certain requirements such as high oxygen affinity, ability to form a compact oxide or exhibit surface active behavior. Furthermore, the interaction between these elements must be analyzed in order to understand more complex protection mechanisms. In our most recent work, a novel alloy based on the Mg-Sr-Ca system has been developed which exhibits a high ignition temperature.

Global Surrogate Models for Non-linear Structural Dynamics

By Ahmed Bayoumy and Professor Michael Kokkolaras

Simulating flexible multi-body dynamics and nonlinear structural dynamics using finite element (FE) black boxes is extremely computationally expensive analysis. A possible remedy is using approximation models in lieu of FE black boxes in the simulation-based design optimization process. However, the dynamic responses of flexible structures are irregular and non-smooth versus time, hence they are difficult to be approximated accurately. As a result, Design of experiment (DoE) techniques using surrogate models face a lot of challenges to deal with such responses. However, most of the commercial FE black boxes produce other useful information about the structure other than the dynamic responses which can help in building adequate surrogate models. In this work, we are using the software package DACE program to construct a kriging approximation model based on the data outputs of a FE black box to approximate the dynamic response of a flexible cantilevered beam under large acceleration loads.

BIOENGINEERING

Investigating the Corrosion Behaviour of a Novel Biodegradable Metallic Stent

By Jennifer Frattolin and Professors Stephen Yue, Olivier Bertrand, and Rosaire Mongrain

Coronary artery disease (CAD) is the leading cause of death in the developed world. The current trend of CAD treatment has seen an innovative shift from permanent metallic stents to the implementation of novel biodegradable materials. A novel manufacturing process is proposed that utilizes cold gas-dynamic spraying (CGDS) to fabricate a metallic stent with significantly reduced grain size. Iron and stainless steel 316L powders are combined to form an amalgamate with enhanced mechanical strength and a controllable degradation rate, due to the resulting microgalvanic reaction. Femto laser techniques are utilized to produce stents composed of 80% iron and 20% stainless steel 316L. The in vitro degradation behaviour of the stent is investigated using static and dynamic corrosion tests. It is determined that the dynamic corrosion rate of the proposed stent is equal to 0.202 mm/year, which is consistent with other developing metal-based biodegradable stents.

Tissue-Mimicking Construct of Abdominal Aortic Aneurysm in Endovascular Aneurysm Repair

By Zinan He and Professor Rosaire Mongrain

Abdominal aortic aneurysm (AAA) is a silent but potentially fatal pathological condition due to the dilation of abdominal aorta along with progressive wall degeneration. Endovascular aneurysm repair (EVAR) is a percutaneous approach to restore a healthy blood flow in AAA through stent-graft implantations. However, current failures of both vascular tissue and EVAR treatment reflect our inadequate knowledge of the complex aortic wall biomechanics in EVAR assessment. In this study, a tissue-mimicking construct (TMC) of AAA is developed using polyvinyl alcohol cryogel (PVA-C), consisting of the major factors in AAA wall degeneration (wall stiffening, thrombus, calcification). Since the mechanical behaviour of PVA-C can be tailored to represent various biological tissues, this TMC could become an academic training/demonstrating platform for medical specialists. The ultimate goal is to combine the experimental analysis using this TMC, along with our existing numerical simulations and clinical records, to develop a virtual planning tool for EVAR.

Improving the Re-Endothelialization of Vascular Substitutes via Peptide-based Endothelial Progenitor Cells Recruitment

By Mohamed Elkhodiry and Professor Corinne Hoesli

Delayed endothelialization of vascular prosthesis after percutaneous coronary intervention increases the risk of in-stent thrombosis and restenosis, decreasing the long term patency of the implants. In this study, we investigated the ability of a novel peptide, RGD-TAMRA, in inducing the adhesion and expansion of endothelial progenitor cells (EPCs) from peripheral blood as an approach to promote the re-endothelialization of vascular substitutes. Peripheral blood mononuclear cells were isolated and seeded on RGD-TAMRA modified polystyrene surfaces or on control collagen coated surfaces. The resulting late outgrowth endothelial cell colonies from both surfaces expressed endothelial markers, did not express hematopoietic markers, and were able to form tubular networks after 4 hours of seeding on Matrigel. As expected, cytoskeletal and cellular alignment occurred after 6 hours of exposure of the ECFCs to 25 dyn/cm^2 wall shear stress. Applying similar surface modifications to vascular substitutes could potentially enhance their long-term in vivo performance.

Design and Optimization of Targeted Drug Delivery System-of-Systems

By Ibrahim Chamseddine and Professor Michael Kokkolaras

According to Statistics Canada's most recent study, cancer is the leading cause of death in the country. It is responsible for 30% of the total deaths - a proportion that has been stagnant since 2000. Cancer is characterized by the loss of growth control and disruption of tissue organization. Anti-cancer drugs are commonly associated with intolerable side effects due to their high cytotoxicity. This reveals an urgent need to develop targeted drug delivery systems that eradicate diseased cells while sparing normal ones. The most established approach for targeting drugs to intended cells is by systemic administration of drug-carrying nanoparticles that are designed to adhere to specific tissues. The mechanical properties of the nanoparticles have a great influence on the particle hemodynamic circulation and thus on the delivery efficiency. However, a comprehensive review of nanoparticle studies over the past 10 years, including different physical properties of the nanoparticles and several cancer types targeted, revealed a median delivery efficiency of merely 0.7%. To increase drug efficiency and reduce toxicity, an optimization framework needs to be developed to determine the optimal values of the nanoparticle design variables in a dynamic and uncertain setting that characterize malignant neoplasms. A targeted drug delivery system-of-systems composed of nanoparticles acting as drug vehicles is being designed and optimized to enhance anti-cancer drug administration to solid tumors. Two versions of nanoparticles are being considered to enable the distribution of sufficient drug at the core and periphery of the tumor while ensuring a minimal leakage outside the tumor margins. The transport of nanoparticles in the tumor's cells and vessels is modeled analytically using fluid mechanics, mass transport, and pharmacology principles implemented in MATLAB and COMSOL. Using a robust optimization formulation and validated analytical models to design nanoparticles is expected to maximize the drug delivery efficiency and minimize the tumor cells proliferation rate to ensure a continuous decay of the tumor volume with minimal toxicity.

Processing Effects on the Bioactivity of Sol-Gel-Derived Borate Glasses

By William Lepry, Gabriele Griffanti, and Professor Showan Nazhat

Recently, a wide range of sol-gel derived borate glasses (SGBGs) have demonstrated rapid conversion rates to bone-like mineral (hydroxy-carbonated apatite, HCA) when placed in physiological environments. While the sol-gel process has been well studied for silica-based systems, little information exists for borate-based glasses. Therefore, we will discuss how the processing parameters affect the textural properties and in vitro bioactivity. Different precursors affected the gel forming ability but still resulted in increased porosities and specific surface areas. Regardless of composition and processing route, all glasses rapidly converted to HCA in simulated body fluid within 1 day and as little as 2 hours for most glasses according to infrared-spectroscopy, x-ray diffraction, and scanning electron microscopy. Ion chromatography showed rapid ion release which was most influenced by calcination temperature. This work indicates that by controlling the sol-gel processing parameters, SGBGs can be modified for a wide range tissue engineering applications.

A Microfluidic Paper-Based Origami Nanobiosensor for Label-Free, Ultrasensitive Immunoassays

By Hao Fu and Professor Xinyu Liu

Gas hydrates are crystalline solids composed of an outer water cage and a small non-polar gas molecule (e.g. methane) We present the first microfluidic paper-based origami nanobiosensor (origami μPAD), which integrates zinc oxide nanowires (ZnO NWs) and electrochemical impedance spectroscopy (EIS) biosensing mechanism, for fast (<25 min), label-free, ultrasensitive immunoassays. The device reveals an ultralow limit of detection (LOD) of 60 $fg \cdot mL^{-1}$ (>100 times lower those of existing μPADs) for rabbit immunoglobulin G in phosphate-buffered saline. The test of human immunodeficiency virus p24 antigen in human serum with a low LOD of 300 $fg \cdot mL^{-1}$ (>33 times lower than a commercial test kit) is also demonstrated.

A Portable Paper-Based Platform for Multiplexed Electrochemical Detection of HIV and HCV in Serum

By Chen Zhao and Professor Xinyu Liu

We present a portable paper-based microfluidic platform for multiplexed electrochemical detection of antibody markers of HIV and Heptatitis C virus (HCV) in serum. This is the first paper-based immunosensing platform, with multiplexing and telemedicine capabilities, for diagnosing HIV/HCV co-infection. The platform is capable of simultaneous enzyme-linked immunesorbent assays (ELISAs) on eight samples. It can produce multiple measurement data for HIV and HCV markers from a single run, and its wireless communication module can transmit the results to remote sites for telemedicine. The unique integration of paper-based microfluidics and mobile instrumentation renders our platform portable, low-cost, user-friendly, and high-throughput.

The Artificial Pancreas: A Closed-Loop System for Glucose Regulation in Type 1 Diabetes

By Anas El Fathi, Professor Ahmad Haider, and Professor Benoit Boulet

Type-1 diabetes people suffer from the life-long burden of self-injecting external insulin to regulate their blood glucose concentration. Tight glucose regulation is critical for health, as a sustained elevation of glucose levels leads to long-term macrovascular and microvascular complications, and low glucose levels may lead to confusion, blurred vision, or even coma. The emergence of real-time non-invasive glucose monitoring sensors and portable insulin infusion pump opened the doors towards a closed-loop delivery system, termed the artificial pancreas. Recent clinical studies have shown the merit of the artificial pancreas to maintain glucose levels in the target range for 70-75% of the time. Yet, effective closed-loop is challenged because of the inter- and intra-patient variability, diverse daily activities, the slow action of subcutaneously-infused insulin, and meal consumption.

Advanced control and estimation algorithms are used in order to ensure tighter glucose control, especially after meal consumption.

Estimation of Exercise with Energy Expenditure Sensor Information with T1D Patient Data for the Guidance of Artificial Pancreas

By Amirreza Sedaghat, Professor Ahmad Haider, and Professor Benoit Boulet

Physical activity is recommended for all people with diabetes, including those with type 1 diabetes. In recent years, researchers have made significant advances to develop an artificial pancreas that regulates sugar levels in type 1 diabetes. The artificial pancreas is a closed-loop delivery system that is composed of a glucose sensor, an infusion pump, and an algorithm to direct insulin and glucagon delivery. Exercise remain a challenge to artificial pancreas systems as glucose levels can fall rapidly due to increased insulin sensitivity and glucose uptake in muscles. Those glucose-lowering effects usually result in episodes of hypoglycemia. Automatically detecting exercise, and adjusting the algorithm parameters, might improve glucose control during exercise without adding patient's burden (e.g., announcing the exercise to the algorithm).

INFORMATION AND COMMUNICATIONS TECHNOLOGY

A Real-Time Multiple-Sensor System for Monitoring Pedestrian and Vehicular Traffic Networks

By Asad Lesani and Professor Luis Miranda-Moreno

Intelligent transportation systems depend on technologies to obtain valuable road metrics, such as travel times, speeds, and volumes. Novel ways of collecting anonymous data from road users across multiple modes are becoming more recognized in literature and industry. Bluetooth detectors have been widely researched as a way of detecting smartphones and vehicles while maintaining anonymous identity across multiple detection sites. This paper proposes a smartphone detection system using wireless Internet (WIFI) signatures from mobile devices in a similar way to Bluetooth, but with a higher detection rate due to the higher usage of WIFI over Bluetooth. The system is tested on mixed-mode and pedestrian-only facilities with 9-20% accuracy for vehicular traffic and greater than 20% accuracy for pedestrian-only routes with multiple sensors. These initial findings look promising, making the possibility of building a combined WiFi/Bluetooth system that take advantages of both sources of data.

Evaluation of Shape Description Metrics applied to Human Silhouette Tracking

By Olivier St-Martin Cormier and Professor Frank Ferrie

Many computer vision applications compare the shapes of objects, but few papers provide meaningful comparisons between different shape distance metrics. This paper will begin by summarily describing six metrics that are widely used in the literature. Then a set of criteria to evaluate metrics will be described and a methodology to test the performance of these metrics will be presented. Finally, experimental results, based on the task of tracking articulated human posture from silhouettes, will be used to determine which metric is best suited to the purpose of human tracking. We find that most of the metrics evaluated herein are valid and perform properly to some extent, but that two of them present more desirable behaviors and robustness to noise.

Hybrid Optimal Control of an Electric Vehicle with a Dual-Planetary Transmission

By Ali Pakniyat and Professor Peter Caines

A hybrid systems framework is presented for the analysis and optimal control of electric vehicles equipped with seamless dual stage planetary transmissions. A feature of special interest is that, due to the perpetual connectedness of the motor to the wheels via the seamless transmission, the mechanical degree of freedom changes during the transition period. These circumstances where autonomous and controlled state jumps at switching instants are accompanied by changes in the dimension of the state space are reflected in the definition of hybrid systems and the corresponding statement of the Hybrid Minimum Principle. Furthermore, the state-dependent motor torque constraints which impose mixed input-state constraints are converted to state-independent input constraints via a change of variables and the introduction of auxiliary discrete states. Optimal control problems for the minimization of acceleration duration and the energy consumption for the acceleration task are formulated within the presented framework and simulation results are presented.

Passivity Enforcement using Incomplete Complex Frequency Hopping

By Yi Qing Xiao, Muhammad Kabir, and Professor Roni Khazaka

Macromodeling is an important technique for designing circuits such as multiport interconnects. However, generated macromodels can be non-passive, which can cause stability problem in simulations when combined with other models. In this poster, an efficient passivity enforcement algorithm for S-parameter based macromodels is proposed. The approach is based on the perturbation of the imaginary eigenvalues of the Hamiltonian Matrix. The CPU cost savings are obtained by selective computation and perturbation of a subset of the imaginary eigenvalues. The proposed approach is shown to be efficient compared to existing state of the art methods.

Parallel Transient Simulation of Power Delivery Networks using Model Order Reduction

By Marco Kassis and Professor Roni Khazaka

On-chip power delivery networks have become an important design bottleneck while posing a significant challenge to design automation tools due to their large models. In this research, we propose a method that decouples the power delivery network into multiple independent segments. This is then followed by model order reduction of each of the partitions to a more concise model that is significantly less costly to simulate. Time-domain simulations are then performed on all the reduced models simultaneously, recasting the problem as a reduced parallel simulation problem that can take advantage of modern multi-core CPUs. Numerical examples are used to illustrate the accuracy and efficiency of the proposed method.

Continuous Integration Practices in Open Source Web Applications

By Keheliya Gallaba and Professor Shame McIntosh

Continuous Integration (CI) is a popular software development practice, where code changes are automatically tested for regression as they are contributed. CI is especially popular among web applications, where organizations have control over the entire delivery process. Despite the popularity of CI practices, little is known about how CI tools are used by real web applications in the wild. A better understanding of current CI practices will provide useful insights for software engineering researchers, developers, and CI tool and service providers. To that end, we analyze the CI configuration files of 8980 open source projects that use the GitHub for collaboration and TravisCI to manage the CI process. We apply data mining and machine learning techniques to better understand the common practices, challenges, and limitations of current CI practice. Preliminary results show that JavaScript is the most common language among software projects using the TravisCI platform.

Estimating Build Time by Mining Dependency Graphs

By Ruiyin Wen and Professor Shane McIntosh

Build systems are an integral part of software engineering that automates the process of compiling, testing and packaging software systems. While building a 'hello world' program takes only a few seconds on most modern computers, it may take hours, if not days, to build large software projects. Since modern build tools do not provide estimates of how long a build will take, development teams are not able to effectively plan human and computer resources. To fill this gap, we develop a tool to forecast the time needed to execute the build system by mining build dependency graphs. Preliminary results from two open source projects show that our tool can accurately forecast the time that is needed for most builds within a 5% margin of error.

Model Predictive Control of Building Indoor Temperature: A MATLAB-TRNSYS Co-simulation

By Sayani Seal, Dr. Vahid R. Dehkordi and Professor Benoit Boulet

A study of the performance of the model predictive control (MPC) for the radiant floor heating systems is presented. The radiant floor has several advantages over conventional baseboard heaters commonly used in houses. For example, it provides comfortable uniform heating without exposure to very high temperatures. Also, its performance can be improved using renewable energy sources as in hydronic radiant floor or by connecting them to heat-pumps. Yet baseboards are more popular because of their lower installation and equipment cost.

Also, applications of MPC in building climate control have been an important field of interest for the past few years. Different problems regarding indoor temperature control, charging and discharging of the active thermal energy storage devices, energy consumption control of the HVAC system etc. are being addressed by using MPC. MPC is flexible in solving specific optimization problems based on forecast information and/or historical records of different parameters.

SUSTAINABILITY IN ENGINEERING AND DESIGN

Public Image: Determining the Effects of Users' Image of Public Transit on Loyalty

By Dea van Lierop and Professor Ahmed El-Geneidy

In recent years researchers have begun to explore how users' opinions about public transit influence user satisfaction and future behavioural intentions. Based on an analysis of survey data collected along a bus route in Montreal, Canada, this paper assesses whether users' image of public transit influences their satisfaction and loyalty to public transit. Two binary logit models are developed and the results reveal that having a positive image of transit increases users' odds of being satisfied and of intending to continue using transit in the future. Based on our findings, we suggest that loyalty constructs in public transit research should be composed of users' image of public transit, their overall satisfaction with a particular service, and, passengers' intentions to continue using the service in the future. Overall, this study is useful for researchers and transit agencies aiming to better understand and increase loyalty among current and future public transit users.

Planning for Access: A Critical Assessment of Accessibility Objectives and Indicators in Metropolitan Transportation Plans

By Genevieve Boisjoly and Professor Ahmed El-Geneidy

Accessibility, the ease of reaching destinations, is increasingly seen as an alternative to the mobility oriented planning paradigm, as it captures the multiple benefits provided by land use and transportation systems. However, although accessibility has been extensively researched, it is still largely marginalized in transportation planning practice. Accordingly, this study aims to critically assess how accessibility is incorporated into metropolitan transportation plans and translated into performance indicators around the world. This research assesses 32 recent metropolitan transport plans from North America, Europe, Australia and Asia. The results suggest that accessibility objectives are generally included in transport plans, yet few plans have accessibility-based indicators that can guide their decision-making processes. Our findings show that in order to foster accessibility-based approaches to transportation planning, plans need to have clearly defined accessibility goals with a distinction between accessibility and mobility. Furthermore, multi-criteria analysis approaches including accessibility indicators need to guide the decision-making process.

Evaluating the Relationship between Socially (Dis)advantaged Neighbourhoods and Customer Satisfaction of Bus Service in London

By Emily Grisé and Professor Ahmed El-Geneidy

Customer satisfaction surveys are often used to monitor customer perceptions of service quality. This study examines satisfaction with bus service across neighbourhoods of varying levels of socio-economic status (SES). Using customer satisfaction survey data collected by Transport for London between 2010 and 2015, multi-level regression modeling is used to estimate the relationship between overall satisfaction and social deprivation of the area in which bus routes were operating. The results indicate lower levels of satisfaction along routes serving low SES neighbourhoods, which appears to be attributed to (1) low satisfaction with service characteristics related to an individual's experience and quality of the bus and (2) conditions of the bus stop and shelter. Findings from this paper shows the importance of including cleanliness and bus internal quality as one of the performance indicators when contracting bus services, to ensure that all customers receive the same quality of service in the region regardless of their SES.

Application of Geothermal Energy in Mining Operations

By Leyla Amiri, Dr. Ali Ghoreishi and Professor Ferri Hassani

Underground mines have a ready supply of geothermal energy at their depths that is not being utilized at all. The geothermal energy can be recuperated from active mines through a closed loop system and/or an open loop system.
The resulting geothermal fluid can be used for heating or cooling purposes depending on the season and available applications.

Design, Implementation, and Characterization of a Gravity Heat Pipe

By Janakiraman Boopathy and Professor Rabi Baliga

Gravity heat pipes (GHPs) are closed tubes partially filled with the liquid and vapor phases of a working fluid. The bottom portion of the tube is heated and performs as an evaporator. The upper portion of the tube is cooled and serves as a condenser. The central portion of the tube is effectively adiabatic. Vapor generated in the evaporator moves upwards and condenses in the condenser; and the condensate returns back to the evaporator under the action of gravity. GHPs have no mechanical moving parts, very high thermal conductance, and a wide operating temperature range. So they are attractive for many applications: examples include HVAC and refrigeration systems, enhanced latent-heat thermal energy storage units, permafrost preservation systems, and geothermal systems for deicing roads and bridges. A GHP operating with water was designed and constructed. Details of this GHP and the results of an experimental investigation are presented and discussed.

A Decision-Support Tool for Estimating Extreme Design Rainfalls

By Truong Huy Nguyen and Professor Van-Thanh-Van Nguyen

In recent years, it has been recognized that society has become more vulnerable to extreme storm events. Many studies have been carried out to investigate the variation of these extreme storms. Of particular interest for water infrastructure design is the investigation of the probability of occurrence of the extreme rainfalls, or the constructions of rainfall intensity-duration-frequency (IDF) curves, in the current climate and in the context of climate change. This paper presents the development of a decision-support tool for statistical modeling of extreme rainfall processes (SMExRain). The proposed tool can be used in assisting stakeholders and decision-makers to identify the most suitable distribution(s) that could provide accurate extreme rainfall estimates. In addition, SMExRain produces IDF curves for both the current climate and for the projected climate change using different climate scenarios produced by global climate models. These IDF curves are the inputs for various water infrastructure design and management.

Constrained Control of the Friction and Wear in Sliding Tribological Systems: An Automotive Case Study

By Hossein Vahidalizadeh and Professor Benoit Boulet

This work considers the constrained control problem of the friction regimes in sliding lubricated surfaces with the purpose of speed synchronization, wear reduction and increasing the lifetime of the friction lining material. The controller design method is based on solving a set of linear programming (LP) problems in the offline phase, which results in a piecewise affine (PWA) feedback law. The case study here is the engagement process of the synchromesh cone clutch system. Such a system performs the clutchless gear shifting in a 2-speed automated manual transmission (AMT) of an electric vehicle. In this study, the dynamic model and frictional behavior of the cone clutch system is investigated by considering the involved lubricated friction regimes. Finally, the controller is designed and implemented on a real-time embedded industrial controller. The closed-loop control system is applied on a test rig developed at the McGill Centre for Intelligent Machines (CIM).

Make Everything Smart of Electric Vehicles - Integrate with Newest Technologies

By Di Wu and Professor Benoit Boulet

Dashboard display screen with programmable controller is part of the electric vehicle control system. With CAN (Control Area Network), it's programmed with options for vehicle entire control system, negation information and battery smart charging network information. The programmable controller can compute the optimal algorithm and optimal charging suggestion will prompt on display screen.

Observer-Based Backstepping Controller Design for Gear Shift Control of a Seamless Clutchless Two-Speed Transmission for Electric Vehicles

By Saman Rahimi, Ali Pakniyat, Mohamed H. Helwa, and Professor Benoit Boulet

The main aim of this research is to design an observer-based backstepping controller to provide fast, smooth, and efficient gearshifts for a novel seamless and clutchless two-speed transmission for electric vehicles. The state observer estimates the input and output torques of the transmission and the angular velocities of the on-coming and off-going gears. The backstepping controller tracks the optimal trajectory corresponding to the minimum shifting time and energy dissipation during the gearshift operations. In order to validate the performance of the observer-based controller, the driveline of an electric vehicle equipped with the proposed transmission is modeled in MATLAB/Simulink by utilizing SimDriveLine library.

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MIAE is an initiative of the Lorne Trottier Chair in Aerospace Engineering to foster interest in Aerospace Engineering among undergraduate and graduate students and awareness of the multi-disciplinary and multi-cultural environment in which they may work as future engineers working in the Aerospace Industry. Students accepted into the Institute will be given the opportunity to participate in a number of 500 to 1000 hours Research Projects proposed by the Aerospace Companies. The Institute is also creating at McGill a special environment where the students will have access to a secure room with complete computer facilities, so that they will be able to work in their projects with the support of their professors. The MIAE students will also be given the opportunity to participate in other activities, organized to give them a comprehensive view of the Aerospace Industry and its challenges, such as plant visits and specially designed courses.
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The Centre for Intelligent Machines (CIM) is an inter-departmental inter-faculty research group which was formed in 1985 to facilitate and promote research on intelligent systems. Intelligent systems and machines are capable of adapting their behaviour by sensing and interpreting their environment, making decisions and plans, and then carrying out those plans using physical actions. The mission of CIM is to excel in the field of intelligent systems, stressing basic research, technology development and education. The members of CIM seek to advance the state of knowledge in such domains as robotics, artificial intelligence, computer vision, medical imaging, haptics, systems and control, computer animation and machine and reinforcement learning. http://www.cim.mcgill.ca/

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McGill Engineering is ranked one of Canada's top two Engineering Schools in rankings published by the U.S. News & World Report, and on the international level scores higher than well-known U.S. schools such as Columbia, Yale, Northwestern, Penn State and Texas A&M University. The 2011 ranking breakdown by discipline varies between 15th spot and 34th in the world in the fields of Chemical, Civil, Computer, Electrical and Mechanical Engineering. Our Faculty places 29th overall in the U.S. News & World Report listing of the world's 300 engineering and technology schools. http://www.mcgill.ca/engineering/

The **McGill Engineering Student Centre (MESC)** offers many services to undergraduate students, integrating the Student Affairs Office (SAO), academic advising and peer tutoring, and the Engineering Career Centre (ECC).

The **Student Affairs Office (SAO)** is an engineering student's one-stop-shop for advising, peer tutoring, scholarships and awards, exchange and study abroad programs, counselling, orientation, administrative questions, and many other student services. The office is responsible for administering policies on student records, student assessment, and implementing the accreditation process on programs. Students are encouraged to contact MESC in all matters related to their student experience, and is also a primary resource for information on other services within the Faculty and across the University.

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