



CARLETON

**FACULTY OF  
ENGINEERING  
AND DESIGN**

**RESEARCH REVIEW**

# Research Review

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## How to Navigate

### STUDENTS AND ACADEMICS

This publication introduces you to each department or school, followed by their respective faculty members. Each individual faculty member has included their current areas of research and application, along with a list of selected activities. A comprehensive index can be found at the back of this publication to help guide you by specific areas of interest, as well as identify interdisciplinary topics and researchers.

Faculty members welcome inquiries about their research and graduate supervision.

Visit the Faculty of Graduate studies and Postdoctoral Affairs at [carleton.ca/fgpa](http://carleton.ca/fgpa) for more information on programs and graduate studies at Carleton.

### INDUSTRY LEADERS

This publication provides information regarding specific research areas for each department and school, as well as those of individual faculty members and researchers. Facilities and laboratories are also indicated by department and school.

To discuss collaborative research projects or funding, please contact:

[GradAdminEng@carleton.ca](mailto:GradAdminEng@carleton.ca)





# MESSAGE from the Dean (Acting)

The research-intensive Faculty of Engineering and Design at Carleton University is recognized as one of Canada's leading institutions in the study and research of engineering, architecture, industrial design and information technology. Our researchers have long been innovators and trail blazers – and we continue to drive forward solutions and technological innovations that will shape the future. Here you will see the research and human strengths of the Faculty, and begin to explore our areas of focus.



In partnership with government and industry, Carleton researchers are engineering and designing a higher standard. We focus on educational and research opportunities that emerge from and anticipate the changing needs of society. As the demand continues to increase for environmentally friendly options, secure and reliable infrastructure and fast analysis of “big data”, Carleton's expertise in sustainability, infrastructure resilience and data analytics continues to push research forward. Pioneering initiatives—including the first programs in aerospace engineering and communications engineering in the nation—put Carleton researchers at the leading edge of emerging industries and ahead of the curve in scientific thought.

We tackle the increasing demand for renewable energy, solutions for clean air and water, and more effective approaches for transportation. We make breakthroughs in health care through efficient and affordable diagnosis and therapeutic techniques. We put users at the centre of the rapid evolution in digital media and at the heart of the design of products and spaces.

Join us in our research endeavours. As a graduate student, faculty member, investor or industry partner, you can help to improve the global standard of living, solve pressing real-world problems and develop new economic opportunities.

**Fred F. Afagh, PhD, PEng, SMAIAA**



# MESSAGE from the Associate Dean of Research and Graduate Studies (Acting)

In these pages, you will explore the wide-ranging research innovations and unique projects undertaken by our faculty members and graduate students. Prospective graduate students will find mentors and the research projects that inspire further discovery. Industry leaders will find the academic partners who can take their research further or open up new avenues of investigation and application. Public and private funders will see the impact of their investment on the research areas that matter most to Canadians.



Research is at the core of the Faculty of Engineering and Design. Our faculty members teach and inspire undergraduate students through their own research and in supporting the Capstone design projects that educate the next generation of engineers and designers.

Graduate students push our intensive research enterprise further, crossing disciplines to find the best and most creative solutions. Faculty members conduct fundamental research in our established and traditional areas of strength, while also advancing research in emerging areas of concentration, such as "green" electronics; health-related applications of engineering; biomedical engineering; sustainable and renewable energy engineering; infrastructure protection and international security; human-computer interaction; and architectural conservation and sustainability.

Recent investments in infrastructure have resulted in new and refurbished laboratories and research space for graduate and faculty research programs, while new measures to further support and enhance our faculty continually invigorate our research endeavours. Our Faculty also includes a full-time Research Facilitator and Research Development Officer, responsible for identifying, promoting and managing high-value and high-impact research opportunities within the Faculty.

Our research impact can be seen on a number of fronts:

- Our average annual operating research grant is approximately \$25 million. About 50 percent of this funding originates from provincial, national and international industrial collaborative projects and research grants.
- Our graduate student population has grown to approximately 1,100 students.
- Research quality is reflected in our faculty's publications in leading international journals, presentations at major international conferences and membership on key editorial boards and conference organizing committees. Many faculty members also share their expertise in consulting roles with government and industry.
- Strong partnerships with leading government research laboratories and advanced technology private-sector companies in the National Capital Region are vigorously fostered. These partnerships expand opportunities for leading-edge research for our graduate students, faculty members, and our industrial and government collaborators.

I invite you to explore the snapshot of the Faculty of Engineering and Design's current research activities provided in this Research Review.

More detail on these activities can be found on our website [carleton.ca/engineering-design](http://carleton.ca/engineering-design).

**Qi-Jun Zhang, PhD, PEng, IEEE Fellow, CAE Fellow**

# Degrees

Our dynamic, research-intensive Faculty provides our graduate students with exceptional opportunities to pursue leading-edge fundamental and applied research. A long history of partnerships and collaboration with government and industry gives a strong practical emphasis to our research and provides unique opportunities for graduate students.

## MASTER'S DEGREE PROGRAMS

**Aerospace Engineering\* (MAsc, MEng) in:**  
Aeronautical and Space Engineering

**Architectural Studies (MAS) in:**  
The Culture of Practice  
**Architecture (MArch)**  
Architecture1 (MArch1)

**Bioinformatics (Collaborative Master's)**

**Biomedical Engineering\* (MAsc) in:**  
Biomechanics and Biomaterials  
Biomedical Image Processing  
Medical Informatics and Telemedicine  
Medical Instrumentation

**Civil Engineering\* (MAsc, MEng) in:**  
Environmental Engineering  
Fire Safety Engineering  
Geotechnical Engineering  
Structural Engineering  
Transportation Engineering  
Water Resources Engineering

**Design (MDes) in:**  
Industrial Design

**Electrical and Computer Engineering\* (MAsc, MEng) in:**  
Biomedical Engineering  
Computer-Aided Design for Electronic Circuits  
Computer and Software Engineering  
Computer Communications, Multimedia and Distributed Systems  
Digital and Wireless Communications  
Integrated Circuits and Devices  
Microwave and Electromagnetics  
Photonics Systems  
Signal, Speech and Image Processing  
Systems and Machine Intelligence

**Environmental Engineering\* (MAsc, MEng) in:**  
Air Pollution  
Management of Solid and Hazardous Waste  
Water and Wastewater Treatment  
Water Resources and Groundwater Management

**Human-Computer Interaction\*\* (MAsc, MA, MCS) in:**  
Human Perspective on Interacting with Computers (MA)  
Technology for Human Interaction with Computers (MAsc)  
Software Design (MCS)

**Information Technology (MIT) in:**  
Digital Media  
Network Technology

**Infrastructure Protection and International Security\*\*\* (MIPIS, MEng)**

**Mechanical Engineering\* (MAsc, MEng) in:**  
Biomedical Engineering  
Controls and Robotics  
Materials and Manufacturing  
Solid Mechanics and Design  
Thermal and Fluid Engineering

**Sustainable Energy Engineering\* (MAsc, MEng) in:**  
Efficient Electrical Energy Systems  
Mechanical Energy Conversion

**Technology Innovation Management\*\***  
**MAsc, MEng, MEnt in:**  
Communication Systems Engineering  
Engineering Management Processes

## DOCTORAL DEGREE PROGRAMS

**Aerospace Engineering\* (PhD) in:**  
Aeronautical and Space Engineering

**Architecture (PhD) in:**  
The Culture of Practice

**Civil Engineering\* (PhD) in:**  
Environmental Engineering  
Fire Safety Engineering  
Geotechnical Engineering  
Structural Engineering  
Transportation Engineering  
Water Resources Engineering

**Information Technology (PhD) in:**  
Digital Media

**Electrical and Computer Engineering\* (PhD) in:**  
Biomedical Engineering  
Computer-Aided Design for Electronic Circuits  
Computer and Software Engineering  
Computer Communications, Multimedia and Distributed Systems  
Digital and Wireless Communications  
Integrated Circuits and Devices  
Microwave and Electromagnetics  
Photonics Systems  
Signal, Speech and Image Processing  
Systems and Machine Intelligence

**Environmental Engineering\* (PhD) in:**  
Air Pollution  
Management of Solid and Hazardous Waste  
Water and Wastewater Treatment  
Water Resources and Groundwater Management

**Mechanical Engineering\* (PhD) in:**  
Biomedical Engineering  
Controls and Robotics  
Materials and Manufacturing  
Solid Mechanics and Design  
Thermal and Fluid Engineering

\* Joint program between Carleton University and the University of Ottawa

\*\* Joint program between the School of Information Technology, the School of Computer Science, and the Department of Psychology

\*\*\* Joint program between the Faculty of Engineering and Design and the Faculty of Public Affairs (NPSIA)

+ Joint program between the Faculty of Engineering and Design and the Faculty of Public Affairs (SPPA)

++ Joint program between the Faculty of Engineering and the Sprott School of Business

## Research Faculty

Civil and Environmental Engineering	30
Electronics	25
Mechanical and Aerospace Engineering	39
Systems and Computer Engineering	38
Azrieli School of Architecture and Urbanism	18
School of Industrial Design	7
School of Information Technology	12

**Total** **169**  
(includes incoming faculty)

## Graduate Studies

The Faculty of Engineering and Design at Carleton University offers a full range of graduate programs in engineering, industrial design, architecture, and information technology. Students have a choice between course-based or research-based master's programs and many are well funded through a combination of research assistantships, teaching assistantships, and scholarships.

Our graduate students benefit from a unique partnership with the University of Ottawa through the Ottawa-Carleton Joint Institutes. This provides access to a wide range of courses, expertise, research facilities and libraries, making our engineering graduate programs some of the largest in Canada.

With community, industry and government partners, our students perform cutting-edge research to unravel challenging problems and develop innovative solutions.

For more information about graduate studies at Carleton, visit [graduate.carleton.ca](https://graduate.carleton.ca).



# Research Facilities and Infrastructure

State-of-the-art facilities and infrastructure support the research of all departments and schools within the Faculty. These laboratories are housed in Carleton's Mackenzie Building, Minto Centre for Advanced Studies in Engineering, Canal Building, Azrieli Pavilion, Azrieli Theatre, and Human-Computer Interaction/Visualization and Simulation (HCI/VSIM) Building.

The **Azrieli School of Architecture and Urbanism** is home to the Carleton Immersive Media Studio, equipped with computer facilities for 3D real-time modeling, rendering and animation, 2D CAD, desktop publishing and illustration, and digital video, sound and image manipulation for research in architecture, urban design, heritage preservation and related disciplines. The school also houses the Carleton Solids and Tectonics Laboratory, dedicated to the study of materiality in architecture with research focused on secondary properties of materials and the combination of inorganic and organic materials. Additionally, the school features design/build studios and fabrication facilities for wood working, metal machining and welding, an assembly room for full-scale projects, a photographic studio and video editing suites.

The **School of Industrial Design** hosts three advanced laboratories, supervised by highly trained technicians that support a full range of modeling and prototyping needs. Digital facilities include five 3-D printers, two laser cutters and a vinyl cutter, a CNC milling machine, and three CNC router tables. Most current and traditional materials are supported with milling and machine lathes, metal forming equipment, a full welding station, vacuum formers, table saws, sanders and a sand blaster. For prototyping soft goods, there are three sewing machines for various weight materials, and mannequins and body forms. A spray booth is available for final finishes. Additionally, there is a free use lab for students to explore and work for extended hours in order to maximize a range of study schedules.

The **School of Information Technology** utilizes state-of-the-art labs which offer the latest technology and industry-standard equipment for interactive multimedia and design, network technology and photonics and laser technology,



Canal Building (top), HCI/VSIM building (bottom).

including Carleton's Facility for Nanoscience, Surfaces, and Sensor Interfaces, the Human-Oriented Technology Lab and the Carleton University Microfabrication Facility. The school also accesses the Alcatel-Lucent Advanced Networks Laboratory for research on mobile activity, mobile communications, flexibility enhancements for wireless communication networks, application domain, networking and optics.

The **Department of Civil and Environmental Engineering** is home to the Advanced Geotechnical Research Laboratory, used to study the effects of earthquakes on building materials. The department also houses a structures laboratory, centred on a strong floor facility used for stress testing of large structural components. Additional



facilities include the Delta Controls Laboratory, focused on experimentation with building systems design, and the Environmental Engineering Laboratory, utilized to evaluate innovative technologies for water and wastewater treatment and to study the fate and transport of compounds in the environment.

The **Department of Electronics** operates the Carleton University Microfabrication Facility, a unique campus cleanroom enabling the development of complementary metal-oxide-semiconductor (CMOS) electronics and the integration of CMOS with micro-electro-mechanical systems, sensors and photonic devices. The department is also home to the Carleton Laboratory for Laser Induced Photonic Structures, which supports fabrication and testing of fiber Bragg grating devices. Additional facilities include the Facility for Nanoscience, Surfaces, and Sensor Interfaces, which explores nanostructured materials and their applications, the Dipak and Tara Roy Advanced Sensor Processing Lab for collection and analysis of real-world sensor data, and Integrated Circuit Design and Measurement Labs, with support for layout, simulation, and comprehensive testing of analog, radiofrequency, and mixed signal integrated circuits.

The **Department of Mechanical and Aerospace Engineering** hosts a Bridgman vacuum furnace; servo-hydraulic materials testing equipment, and extensive computer-controlled machine shop capability, along with dedicated laboratories for the study of mitigating pollutants generated in combustion and microscale electrical co-generation. The department's Jo Yung Wong Laboratory for Terrestrial and Extraterrestrial Mobility, Guidance and Control, which enables research for Earth-bound off-road vehicles and extraterrestrial rovers. The department also maintains the

Pratt and Whitney Canada High-Speed Wind Tunnel for testing rotors for helicopters and wind turbines, as well as the H.I.H. Saravanamuttoo Gas Turbine Laboratory, which includes operational gas turbine engines to permit research into structural, aerodynamic and combustion technologies.

The **Department of Systems and Computer Engineering** is home to the Texas Instruments Embedded Processing Lab for the development of medical, sustainable energy and smart grid, automotive and home automation systems. It also operates the BlackBerry Teaching and Collaborative Research Centre for the development of mobile technology and wireless communication. Additional facilities include the Advanced Real-Time Simulation Laboratory, the Carleton University Biomedical Engineering laboratory, the Broadband Communications and Wireless Systems Centre and the Network Management and Artificial Intelligence Laboratory.

All departments and schools within the Faculty of Engineering and Design maintain high-performance computer networks based on powerful engineering workstations, providing excellent computing, CAD and computer visualization facilities specific to their research needs. Our departments also share extensive state-of-the-art research facilities in biomedical engineering and renewable energy, including the Hydro Ottawa Laboratory for Smart Grid Technologies. Mechanical and Aerospace Engineering and Systems and Computer Engineering are partners in the Centre for Advanced Visualization and Simulation.

Additional information on specific facilities within each department and school can be found in their respective sections of this publication.

## Research Chairs

Canada Research Chairs are dedicated to excellence and innovation in Canadian research and development. The program, run by the federal government, aims to make Canada one of the world's top countries in research and development by investing in research professorships.

<b>Jacques Albert</b> Canada Research Chair in Advanced Photonic Components (Tier I)	<b>Ian Beausoleil-Morrison</b> Canada Research Chair in Innovative Energy Systems for Residential Buildings (Tier II)	<b>Alex Ellery</b> Canada Research Chair in Space Robotics and Space Technology (Tier II)	<b>Sreeraman Rajan</b> Canada Research Chair in Sensor Systems (Tier II)
<b>Winnie N. Ye</b> Canada Research Chair in Nano-scale Integrated Circuit Design for Reliable Opto-electronics and Sensors (Tier II)	<b>George Hadjisophocleous</b> NSERC* Industrial Research Chair in Fire Safety Engineering	<b>Banu Örmeci</b> Jarislowsky Chair in Water and Global Health; Canada Research Professor	<b>Andy Adler</b> Canada Research Professor
<b>Matthew Johnson</b> Canada Research Professor	<b>Peter X. Liu</b> Canada Research Professor	<b>Abhijit Sarkar</b> Canada Research Professor	

\* Natural Sciences and Engineering Research Council of Canada (NSERC) Industrial Research Chairs develop research efforts in fields for which there is an important industrial need and provide an enhanced training environment for graduate students.

# Selected Research Funding Awards

NSERC		
CRC TIER 2		
\$500,000	Sreeraman Rajan	Canada Research Chair in Sensor Systems
CREATE		
\$1.65M	Mario Santana	Engineering Students Supporting Heritage and Sustainability (Heritage Engineering)
\$1.65M	Anthony Whitehead	Collaborative Learning of Usability Experiences (CLUE)
CRD		
\$625,000	Ehab Zalok	Improving the Fire Endurance of Concrete Block Masonry Walls Towards Next-Generation Performance Based Fire Standards
\$230,000	Joanna Rocha	Development and Evaluation of Noise Measurement Techniques in Low- and High-Speed Wind Tunnels
SNG		
\$5.5M	Matthew Johnson	Flare Emissions from Unconventional Oil and Gas Extraction and Processing: An NSERC Strategic Network for Cleaner Fossil Fuels
SPG		
\$462,000	Jacques Albert	All-Fiber Frequency Doubled Light Sources From Engineered Glass Layers
SPG-ANR		
\$277,000	Banu Örmeci	Next Generation Sludge Treatment: Optimization of Treatment Performance through Online Monitoring of Holistic Sludge Properties
SSHRC		
Partnership Grant		
\$2.5M	Stephen Fai	New Paradigm/New Tools for Architectural Heritage in Canada
CFI		
Innovation Fund		
\$7.5M	David Lau	Multi-Hazard Test Facility for Built Infrastructure Protection and Resilience
JELF		
\$314,000	Oren Petel	Diagnostic and Biomechanical Surrogate Development for Head Injury Reduction Using High-speed X-ray Fluoroscopy
\$160,000	Anh Pham	Novel in situ Remediation Technologies for Treatment of Contaminated Soil and Groundwater
ORF-ERA		
ERA 10		
\$100,000	Liam O'Brien	Engineering Approaches to Addressing Sustainability-Related Behaviours in Buildings
ERA 11		
\$100,000	Audrey Girouard	Developing Deformable User Interfaces to Improve Manual Dexterity
ON M&F		
OMAFRA		
\$200,000	Shawn Kenny	Integrating Climate Change Effects within an Asset Management Framework for Rural Infrastructure
Ontario		
Smart Grid Fund		
\$483,000	Xiaoyu Wang	Grid Based Active Transactional Demand Response (GREAT-DR) System
Industry		
CISCO		
\$1.0M	Mohamed Ibnkahla	Sensor Technology for the Internet of Things
Other		
Jarislowsky Foundation		
\$2.0M	Banu Örmeci	Jarislowsky Chair in Water and Global Health

\* Funding amounts listed are approximate.

# DEPARTMENT OF Civil and Environmental Engineering

# CARLETON

As a leader in critical areas of civil and environmental engineering research, the department has an integrated research enterprise that addresses important quality-of-life issues. Under the supervision of expert faculty members, more than 170 graduate students study complex problems and design innovative solutions clustered around core themes.

## Core Themes

- **Engineering for public safety, health and security** research focuses on the performance-based design of built facilities, health issues associated with air and water quality, and the safety of infrastructure and transportation systems in the face of natural and human threats, such as fire.
- **Hazard mitigation and risk assessment** encompasses a range of approaches from experimental and numerical hazard modeling and risk assessment to mitigation measures for earthquakes, landslides, fires, transportation of dangerous goods and hazardous materials, blasts and high-impact loads, soil liquefaction, and environmental health risks.
- **Infrastructure engineering and sustainability** reflects the unique responsibility of civil engineers to build lasting, functional and aesthetic infrastructures at optimum life-cycle cost. Research on advanced materials, sensor technologies for structural health monitoring, energy-efficient building simulation, secured energy infrastructure, intelligent transportation systems, civil engineering applications of GIS and GPS, infrastructure rehabilitation and asset management, advanced compaction techniques



**Banu Örmeci, Environmental Engineering Professor and Jarislowsky Chair in Water and Global Health, was named the recipient of the 2016 Partners In Research (PIR) Engineering Ambassador Award.**

for highway and airfields pavement, and durability of construction materials are part of this theme.

- **Environmental sustainability** is a driver in integrating research from multi-mode transportation systems to life-cycle analysis of construction materials to management of groundwater resources to bio-based technologies as the building blocks of a sustainable development strategy.
- **Historic site recording, conservation and sustainability** is focused on the documentation and restoration of historic structures and the retrofit and upgrading of existing structures to reduce their carbon footprint and energy use. Collaborative research projects in Canada and around the world are conducted in collaboration with leading organizations such as the Heritage Conservation Directorate in Canada, the Getty Conservation Institute and ICOMOS.

Within civil engineering, the primary areas of research include geotechnical, structures, transportation, construction materials, fire safety, risk analysis, and safety and security of civil engineering infrastructures.

Within environmental engineering, the primary areas of research include air pollution, waste management, subsurface contamination, water and wastewater treatment and environmental impact assessment.

Through the Bachelor's degree in Architectural Conservation and Sustainability Engineering, the department has research strength in the area of historic site recording, documentation and restoration, and energy-efficient building simulation of new and historic buildings.

## Research Facilities

- **Structures Laboratory**, with an 11- by 27-metre strong floor, for testing of large structural components.
- **Advanced Geotechnical Research Laboratory** to study the effects of earthquakes on buildings.
- **Environmental Engineering Laboratory** to develop innovative solutions to environmental problems.
- **Canal Building Simulation Lab** provides real-time and historical data for the building's performance at 7,000 measurement points, including temperature, occupancy, relative humidity, carbon dioxide, lighting and power use. These data, combined with detailed dynamic simulations, allow students and researchers to study and optimize building operations for comfort and energy use.

## Research Groups and Focus Areas

### AIR QUALITY

Collaborative research with Environment Canada's Emissions Research and Measurement Division at the Thornton Environmental Technology Centre in Ottawa involves projects that:

- characterize volatile organic compound and particulate matter emissions from motor vehicles
- develop an Ottawa microenvironment database for air pollutants outdoors and in vehicles.

### CENTRE FOR ADVANCED ASPHALT RESEARCH AND TECHNOLOGY

The centre has generated \$1.4 million in research grants and contracts over the past decade. It has been involved in the development of the third and final prototype of the unique Asphalt Multi-Integrated Roller (AMIR) for commercial use on Canadian roads and airports in cooperation with Ontario Ministry of Transportation (MTO), IRAP-NRC, and private companies including paving contractors and consulting firms. The final product is expected to revolutionize the compaction process of asphalt mixes and improve the long-term performance of asphalt pavements. Research projects include:

- developing the final AMIR roller including field demonstrations and validations, with support from NSERC, private industry, MTO and NRC
- developing in-situ permeability criteria for hot mix asphalt pavements in Ontario, with support from MTO.

### CENTRE FOR GEOSYNTHETICS RESEARCH INFORMATION AND DEVELOPMENT

Geotechnical, transportation and structural engineers integrate research activities on geosynthetics applications for reinforced systems in soil, concrete, asphalt and pipeline systems. Recent research projects include field and laboratory testing of steel-reinforced concrete slabs with secondary polymeric reinforcement to impact loads including blast and explosive, and development of suppressive shields for safe explosives transport. The centre has generated more than \$2.5 million in research grants and contracts since its establishment.

### INDUSTRIAL WASTE

Hard rock and oil sands mining are key industries in the Canadian economy facing substantial challenges to their sustainability. Carleton researchers are leaders in minimizing impacts from residuals (tailings) of hard rock and oil sands mining. The scale of tailings impoundments is vast, as are the challenges associated with potential impacts, such as water recovery from the tailings, contamination of groundwater and surface waters, and reclamation of impoundment footprints.

Researchers are working with hard rock and oil sands mining operations run by Canadian companies in Alberta, Africa, South America and Australia. A large collaborative research project jointly funded by the oil sands industry consortium, Canada's Oil Sand Innovation Alliance and the federal government, aims to accelerate reclamation of tailings impoundments. This will substantially contribute to improving the sustainability of the oil sands industry.

### INFRASTRUCTURE PROTECTION AND INTERNATIONAL SECURITY

In collaboration with Carleton's Faculty of Public Affairs, engineers conduct research to increase Canada's preparedness, resiliency to, and recovery from an attack on or natural disaster affecting national critical infrastructure.

Research areas include:

- blast and impact load effects on infrastructure systems;
- hazard mitigation and threat risk assessment methodologies;
- storage and transportation of energetic materials;
- vulnerability assessment of critical infrastructure systems; and
- public health safety and real-time monitoring of water delivery and distribution networks and systems.

### OTTAWA-CARLETON BRIDGE RESEARCH INSTITUTE

This integrated, multi-disciplinary research unit of Carleton and the University of Ottawa explores all aspects of bridge engineering, with emphasis on problems related to material performance, durability, and structural and geotechnical engineering. Projects include:

- long-term monitoring of the Confederation Bridge to study ice forces, thermal effects, traffic, wind and earthquake activity and the development of structural health monitoring technologies for bridge management and decision support in collaboration with the University of Calgary.



- techniques and procedures for remote, networked and hybrid testing of large-scale bridge structures using internet-based, multi-site virtual laboratory testing and simulation techniques with the National Center for Research on Earthquake Engineering (NCREE) in Taiwan.

Funding and sponsorship: NSERC, PWGSC, MTO, SCBL and private industry partners. Research collaboration: NCREE, NRC, PWGSC, NSC.

## OTTAWA-CARLETON EARTHQUAKE ENGINEERING RESEARCH CENTRE

North American and global earthquake engineering problems are explored through links to scientists and research institutions worldwide, as well as university, industry and government agencies in Canada. Research topics include earthquake engineering ground motions, dynamics of structures, advanced structural systems and design for earthquake resistance, and seismic design code and standard development.

## OTTAWA-CARLETON GEO-ENGINEERING RESEARCH CENTRE

A collaborative venture between Carleton and the University of Ottawa, the centre furthers knowledge in geotechnical and geoenvironmental engineering through research projects with industry. Members are involved in research in soil mechanics, rock mechanics, foundation engineering, geoenvironmental engineering, municipal- and mine-waste management, hydrogeology, soil and foundation dynamics, earthquake engineering and urban geotechnical engineering.

## TRANSPORTATION RESEARCH CENTRE

Building intelligent transportation systems that incorporate advanced traffic control and traveler information systems into highway infrastructure is one way our researchers make roads, cars and drivers smarter with tools that improve planning, traffic control and vehicles. Diverse research projects include travel demand management, the land-use impacts of telecommuting, energy and environmental factors in urban transportation, and sustainable transportation.

Sponsors include the Ontario Ministry of Transportation, Transport Canada and AUTO21, a federal Centre of Excellence, and more than 120 industry, government and institutional partners.

Carleton served as co-leader of the Canadian Automobile Research Simulation (CARS) project as a part of the research network in Intelligent Systems and Sensors, testing extensive navigation assistance and complex driver information systems with simulated road, driver and vehicle conditions. The centre has completed sponsored projects worth more than \$1.5 million.



**Architectural conservation and sustainability engineering students working with Professor Mario Santana Quintero traveled to Ouarzazate, Morocco, as part of project to develop and apply a methodology for the documentation, emergency stabilization and integrated conservation planning for the rehabilitation of earthen architecture settlements.**

## WASTE MANAGEMENT

Developing innovative and alternative waste management strategies reduces our environmental footprint and greenhouse gas emissions. Our researchers are improving waste management practices by developing and enhancing waste-to-energy alternatives and through a life-cycle assessment approach to evaluate waste management strategies.

## WATER AND WASTEWATER TREATMENT

Safe and efficient drinking water and wastewater treatment are among the most pressing issues for cities and towns across Canada. Our researchers, collaborating with municipalities and consulting companies, are improving the performance of treatment processes and developing new treatment technologies for water and wastewater by examining:

- the fate and persistence of pathogens and chemicals during treatment processes;
- fouling rates of bioreactor membrane systems;
- removal of endocrine disruptors, pharmaceuticals and recalcitrant compounds;
- ultraviolet disinfection and advanced oxidation processes; and
- treatment and disposal of biosolids.

## Graduate Programs

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The MEng, MASc, and PhD in civil engineering and in environmental engineering are offered jointly with the University of Ottawa through the Ottawa-Carleton Institute for Civil Engineering and the Ottawa-Carleton Institute for Environmental Engineering.

Read more about faculty members' research at [carleton.ca/cee/faculty-and-staff](http://carleton.ca/cee/faculty-and-staff)



### A.O. Abd El Halim, PEng, FCSCE, CAE Fellow

*Professor*

#### RESEARCH AND APPLICATION

Safety and security of transportation infrastructure; improving the engineering resistance of civilian critical infrastructure to blast loads and attacks; analytical and theoretical modeling of asphalt pavement systems; design and development of the AMIR asphalt compactor; experimental and laboratory investigations; field evaluation and assessment; use of geosynthetics to reinforce civil engineering systems; life-cycle analysis and economics of transportation. Applications

include development of protective shields for transporting hazardous materials, enhancing the resistance of concrete structures to blast loading through the use of steel/polymer grids, assessment of critical oil infrastructure, and improved lifespan of roadways.

#### SELECTED ACTIVITIES

- Director, Infrastructure Protection and International Security program
- Member, technical committees in TRB, CSCE and CTAA



### Onita Basu, PEng

*Associate Chair (Graduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

Biosustainability in water and wastewater systems; biofiltration optimization; investigation of alternative disinfection technologies; impact of integrated processes in dynamic systems; optimization of full-scale systems; kinetic analysis of treatment-associated water quality parameters; membrane fouling control and cleaning strategies; implementation of suitable technology in low income countries.

#### SELECTED ACTIVITIES

- Committee Member, CAWQ Eastern Canadian Symposium on Water Research (2016)
- Engineering project lead for interdisciplinary water quality and resources project in rural Tanzania (2014 - Present)



### Abass Braimah, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Study of blast and impact load effects on structures to develop mitigation strategies for critical infrastructure protection; structural response to extreme loads; use of advanced composite materials in civil engineering structures.

#### SELECTED ACTIVITIES

- Chair, sub-committee on CSA A279 - Technical committee on Blast Resistant Buildings
- Member; CSA Technical subcommittee on Blast Resistant Window Anchor Systems
- Member, ASCE Technical Committee on Blast, Shock, and Impact



### Scott Bucking

*Assistant Professor (Cross appointed 50% to the Azrieli School of Architecture and Urbanism)*

#### RESEARCH AND APPLICATION

Tools and technologies to enable the development of net-zero energy communities; optimization of net-zero community design; development of building integrated photovoltaic technologies; community rendering using video game engines; building information model development to improve

the interoperability of tools and to better manage community assets throughout the entire building life-cycle.



### Jeffrey Erochko

*Assistant Professor*

#### RESEARCH AND APPLICATION

Wood/timber engineering; high-performance seismic-resistant systems; self-centering systems for buildings and bridges; passive damping and isolation of structures; rehabilitation of wood structures; hybrid wood/steel structures; non-linear dynamic modeling. Application includes the

development of new construction methods and new strategies for the seismic design of mid-rise wood buildings.

#### SELECTED ACTIVITIES

- Member, Board of Directors and Chair, Policy Committee – Canadian Association for Earthquake Engineering



### John Gales

*Assistant Professor*

#### RESEARCH AND APPLICATION

Concrete sustainability; engineered timber; design of steel high-rise construction; human behaviour in fire. Application includes structural fire performance in design and construction.

#### SELECTED ACTIVITIES

- Voting member of American Society for Testing Materials committee on Fire Standards, American Society of Civil Engineers Standing committee of Fire protection
- Editorial board member of the Springer-Nature Journal Fire Technology.



### Ning Guo

*Assistant Professor*

#### RESEARCH AND APPLICATION

Computational geomechanics; multiscale modelling; multiphysics modelling; development of theoretical and numerical models for accurate modelling of porous and granular materials and related engineering design and applications.

#### SELECTED ACTIVITIES

- International Society of Soil Mechanics and Geotechnical Engineering



### George Hadjisophocleous, PEng, FSFPE

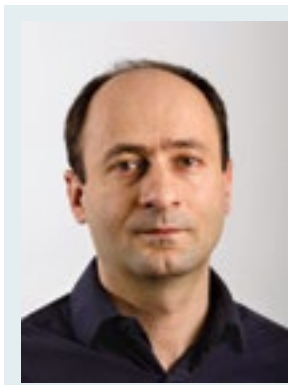
*NSERC Industrial Research Chair in Fire Safety Engineering; Professor*

#### RESEARCH AND APPLICATION

Fire risk analysis of buildings; fire and smoke movement modeling; computational fluid dynamics; smoke management; fire safety in tunnels and subway stations; fire development in train and subway cars; fire performance of timber connections and performance of cross-laminated timber panels in fire.

#### SELECTED ACTIVITIES

- Member, IAFSS Executive Committee
- Member, Editorial Board, Fire Technology
- Coordinator, CIB W-14 Fire Safety
- Visiting Professor, European University of Cyprus



### Amir Hakami

*Associate Professor*

#### RESEARCH AND APPLICATION

Air quality modeling; forward and adjoint sensitivity analysis; air pollution economics; uncertainty analysis; data assimilation; inverse modeling; satellite observations of atmospheric composition. Applications include air pollution exposure and health effects, air quality forecasting, air pollution decision support, air quality and climate change, optimal design of control strategies,

integration of satellite observations with models, and inverse modeling of emission inventories.

#### SELECTED ACTIVITIES

- Member, CMAS, UNC external advisory board





### Yasser Hassan, PEng

*Professor*

#### RESEARCH AND APPLICATION

Modeling of roadway alignments; effect of driver perception and behaviour; probabilistic highway design; reducing collision risk through better design and consideration of human factors; design consistency and its relation to traffic safety.

#### SELECTED ACTIVITIES

- Member, Transportation Research Board Committee on Operational Effects of Geometrics (AHB65) (2007-2016)
- Associate Editor, Canadian Journal of Civil Engineering
- Member, Editorial Board, International Journal of Advances in Transportation Studies



### Neal Holtz

*Associate Chair (Undergraduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

CAE; design codes and standards; software development; computer-aided learning; 3D computer graphics modeling; databases and internet-based information services with a focus on computer-based representation of

technical documents, such as building codes and standards, and the integration of these with applications software.



### Jagmohan Humar, PEng, FCAE, FCSCE, FEIC

*Distinguished Research Professor*

#### RESEARCH AND APPLICATION

Dynamics of structures; response of structures to seismic ground motion; analysis of soil-structure interaction and dam-reservoir-foundation interaction under dynamic loading; dynamic response of bridges; displacement-based seismic design. Applications include the development of a national code for earthquake resistant design.

#### SELECTED ACTIVITIES

- Editorial board member, International Journal Structural Dynamics and Earthquake Engineering (2008 - Present)
- Member, Canadian Standing Committee on Earthquake Design (1995 - Present)
- Member, Executive of Canadian Association for Earthquake Engineering (2003 - Present)



### Karim Ismail, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Modeling of sustainable and non-motorized modes of transportation; crowd dynamics; application of computer vision technologies for data collection and behavioural analysis; road safety analysis: surrogate safety measures, vision-based road safety analysis and holistic safety analysis with focus on sustainable modes of transportation; highway

design; development of probabilistic standards for highway geometric design, reliability and risk analysis; modeling and evaluation of intelligent transportation systems with focus on freight; simulation of cargo and carrier movements at border and inland inspection stations.



### Shawn Kenny, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Development of numerical procedures using computational mechanics and finite element methods to examine stress concentrations, large deformations, strain localizations and propagation of instabilities within the fields of geotechnical and structural engineering; centrifuge and physical modelling techniques; remote sensing technologies. Applications include accurate and reliable prediction of system demand, load effects and mechanical performance, as well as solutions for energy pipelines and civil transportation systems which may be subject to deformation geohazards, such as ground subsidence, slope movement, frost heave, and thaw settlement.

#### SELECTED ACTIVITIES

- Chair and Member, Technical Subcommittees, Canadian Standards Association, Z662 Oil and Gas Pipeline Systems (2008 - Present)
- Associate Editorial Board, Journal of Pipeline Engineering (2008 - Present)
- Session Chair, International Pipeline Conference (2004 - Present)



### Ata Khan, PEng, FITE, FCSCE

*Professor*

#### RESEARCH AND APPLICATION

Intelligent transportation-cognitive vehicle; modeling and simulation; safety, efficiency, and sustainable development; engineering economics; energy and environmental factors in transportation; policy and planning. Applications include urban and intercity transportation, multimodal transportation, traffic management and control, road safety, and urban planning.

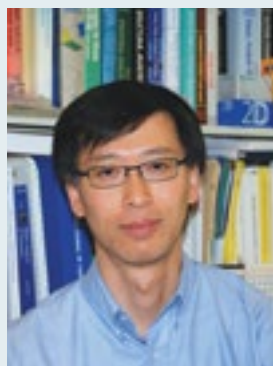


### Heng Aik Khoo, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Steel structures and pipelines; modeling and testing to predict the performance of steel pipelines and structures subjected to different loading conditions; ductile fracture and low cycle fatigue; constitutive relationship. Applications include performance evaluation and the development of design guidelines for steel structures and pipelines.



### David Lau, PEng, FCSCE

*Professor*

#### RESEARCH AND APPLICATION

Structural dynamics and earthquake engineering; structural health monitoring and assessment of bridge structures; development of intelligent systems for infrastructure asset management and decision support; application of information technologies in structural engineering; rehabilitation of existing bridges, liquid storage tanks and other infrastructure; seismic application of advanced composite materials.

#### SELECTED ACTIVITIES

- Chair, Seismic Working Group and Member, ISO Offshore Structures, Harmonized Canadian Advisory Committee
- Member, Seismic Activities on Non-Structural Components in Building Applications, ISO Technical Committee
- Member, Seismic Risk Reduction of Operational and Functional Components of Buildings, Canadian Standards Association



### William (Liam) O'Brien, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Modeling and field study of occupant behaviour to support better building design; simulation-supported building performance design; solar buildings; building controls and operations; visualization of building performance data; daylighting and shading devices. Applications include comfortable, optimized building design and reduced energy usage.

#### SELECTED ACTIVITIES

- President, Canadian Chapter of International Building Performance Simulation Association
- Subtask leader, four-year International Energy Agency task force on building occupant modelling and simulation



### Banu Örmeci, PEng

*Jarislowsky Chair in Water and Global Health; Canada Research Professor*

#### RESEARCH AND APPLICATION

Optimization of wastewater and biosolids treatment processes; disinfection of drinking water and wastewater; removal of emerging contaminants; advanced ultraviolet processes; fate of pathogens through treatment processes; nutrient removal and recovery; bioenergy from wastewater and sludge; real-time monitoring. Applications include development and commercialization of innovative treatment technologies and the protection of public health and the environment.

#### SELECTED ACTIVITIES

- Chair, International Water Association (IWA) Specialist Group on Sludge Management
- Past President and board member, Women in Science and Technology (WISE) Ottawa Chapter
- Board member and regional director, Canadian Association on Water Quality



### Anh Le-Tuan Pham

*Assistant Professor*

#### RESEARCH AND APPLICATION

Environmental aquatic chemistry and biogeochemistry; remediation of contaminated soil and groundwater; treatment of oil sands water and boiler blowdown water, fate and transformation of emerging contaminants; biogeochemical processes affecting the fate of trace metals in natural and engineered systems; passive sampling techniques for monitoring metals.



### Mohammad T. Rayhani, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Advanced foundation systems; geotechnical implications of climate change; modern landfill design; soil and foundation improvement solutions for seismic-resistant design. Applications include foundation design and construction, infrastructure development in the North (pipelines, bridges, airports and highways) and seismic retrofitting techniques for foundations.

#### SELECTED ACTIVITIES

- Section Chair; Canadian Geotechnical Society
- Member, Educational and Research Committee, Canadian Society for Civil Engineers
- Director: Geoengineering Research Group





## Mario Santana Quintero

*Assistant Professor*

### RESEARCH AND APPLICATION

Architectural conservation; recording, documentation and information systems in cultural heritage resources; advanced 3D surveying and visualization techniques; risk assessment of heritage places; preventive maintenance. Applications include modeling of built heritage structures and the development of capacity-building strategies for heritage conservation.

### SELECTED ACTIVITIES

- Director, NSERC Create Heritage Engineering Program
- Board member, International Council of Monuments and Sites (ICOMOS)
- Past president, ICOMOS Heritage Documentation Committee (CIPA)
- Co-Editor, Journal of Cultural Heritage Management and Sustainable Development



## Abhijit Sarkar, PEng

*Canada Research Professor; Associate Professor*

### RESEARCH AND APPLICATION

Uncertainty quantification (UQ) in extreme-scale computational models; high performance computing for UQ; domain decomposition algorithms for stochastic systems; scalable parallel iterative solvers for stochastic finite element method; Bayesian statistical inference for nonlinear dynamical systems; data

assimilation using nonlinear filtering; non-Gaussian (sampling-free) filtering for data-intensive (big data) computational models in extreme-scale. Applications include structural dynamics, fluid-structure interaction, nonlinear aeroelasticity, seismic wave propagation, acoustics, and flow through disordered porous media.



## Edward Sherwood, PEng

*Associate Professor*

### RESEARCH AND APPLICATION

Reinforced and pre-stressed concrete structures; concrete durability and corrosion; masonry structures; integration of modern materials; rehabilitation techniques and analytical methods with current concrete design practices; application of advanced composite materials in concrete construction; design methods for structures incorporating

fibre-reinforced concrete, high-performance concrete and high-strength reinforcement; design methods for structures incorporating fibre-reinforced concrete; design and upgrading of concrete infrastructure for extreme events such as blast, impact and fire; shear behaviour of large, lightly reinforced concrete structures.



### Paul H. Simms, PEng

*Professor*

#### RESEARCH AND APPLICATION

Unsaturated soil mechanics; microscale modeling of porous media; evaporation and cracking in porous media; rheology of non-Newtonian fluids; coupled analysis of fluid flow, heat flow, and volume change in porous media; surface deposition of thickened tailings; underground backfill; unsaturated flow modeling; reclamation cover design for waste impoundments. Applications include shallow geothermal energy, sensor design for unsaturated soils, and mine waste management for hard rock mining and oil sands surface mining.

#### SELECTED ACTIVITIES

- Chair, Canadian Geotechnical Society Committee on Mining Geotechnique, (2015 - Present)
- Chair, Ottawa Geotechnical Group, (2014-2016)
- Technical Chair, Canadian Geotechnical Conference (2017)
- Associate Editor, Canadian Geotechnical Journal (2015 - Present)
- Technical Advisor on mine waste remediation, Ouje-Bougoumou Cree Nation



### Siva Sivathayalan, PEng

*Professor*

#### RESEARCH AND APPLICATION

Geotechnical earthquake engineering; liquefaction; laboratory testing; constitutive relations; geosynthetics and geofoams; design of foundations, slopes, and retaining walls.

#### SELECTED ACTIVITIES

- Secretary, Canadian Foundation for Geotechnique



### Paul J. Van Geel, PEng

*Chair; Professor*

#### RESEARCH AND APPLICATION

Hydrogeology; groundwater; contaminant transport; movement, distribution and remediation of immiscible fluids such as oil, gasoline and solvents entering the subsurface due to spills, leaks or improper disposal; transport of landfill leachate, petroleum hydrocarbons and chlorinated solvents in the subsurface environment; multiphase flow; waste management; bioreactor landfill design and optimization; waste-to-energy alternatives; life-cycle assessment of waste management strategies; biological clogging of unsaturated soils; septic systems. Applications include assessment and clean-up of contaminated sites (brownfields), design of bioreactor landfills and alternative

waste management facilities, design of septic systems to treat wastewater from homes and small commercial/industrial facilities, and comparison of waste management strategies using life cycle assessment (LCA) to assess costs, energy use and environmental impacts.

#### SELECTED ACTIVITIES

- Associate Editor, Journal of Contaminant Hydrology
- Member, CNSC Independent Geoscience Advisory Group

**Ehab Zalok, PEng***Associate Professor***RESEARCH AND APPLICATION**

Fire-structure interaction; material flammability; reinforced concrete, masonry, and steel structures; evaluation of structural aspects of fire safety in buildings using experimental work and computer modeling; identification of fire hazard in buildings by analyzing thermal response of structures and resistance of building elements under different fire scenarios; development of performance-based fire-structural designs. Applications include analysis of structural fire resistance

in commercial and residential buildings, development of fire resistant materials, members, and structures, and the prevention of progressive collapse and multiple building blazes.

# DEPARTMENT OF Electronics

CARLETON

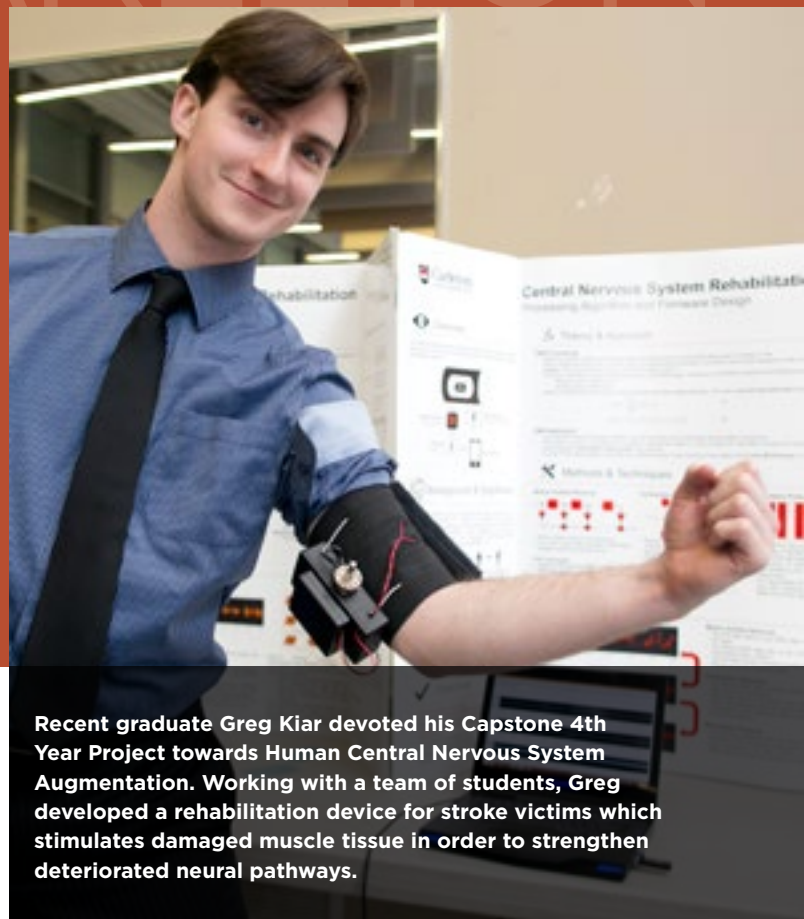
Carleton is a leader in advanced components for communications, computing and sensing applications. Our emphasis on hardware development and verification, our ability to fabricate innovative foundation technologies in a unique campus clean room, and our powerful modeling and CAD tools allow us to address the complex and multidisciplinary issues related to the design, integration and testing of advanced components.

## Core Research Areas

### ADVANCED COMPONENTS FOR COMMUNICATIONS, COMPUTING AND SENSING APPLICATIONS

Research focuses on advanced components to boost speed, efficiency, accessibility and agility of communications and information processing systems. Applications are geared to enhancing the performance-to-cost ratio with innovative technologies to reduce power consumption, interference and manufacturing costs, and to improve process tolerance. Two concepts being pursued are:

- System on a chip: advanced multi-functional components with automated manufacturing processes. Research involves miniature complementary metal oxide semiconductor (CMOS) radio transmitter chips with embedded antennas.
- System in a package: mixed technology integration combined with optical and opto-electronic components.
- Carleton also has expertise in micro-electro-mechanical (MEMS) systems-based circuits, which integrate micro-mechanical elements and sensors with electronics on silicon chips.



Recent graduate Greg Kiar devoted his Capstone 4th Year Project towards Human Central Nervous System Augmentation. Working with a team of students, Greg developed a rehabilitation device for stroke victims which stimulates damaged muscle tissue in order to strengthen deteriorated neural pathways.

### COMPUTER-AIDED DESIGN FOR VERY LARGE SCALE INTEGRATION (VLSI)

We develop next-generation CAD algorithms and design automation tools for efficient and accurate modeling, analysis and optimization of electronic circuits and interconnects, as well as high-speed components and systems, from wireless to optical systems in photonics. Special areas involve simulating radio frequency circuits and MEMS to predict system response. New neural-network-based algorithms are used for fast modeling and optimization of microwave circuits and devices. Powerful CAD tools and methodologies are developed for analysis of signal integrity in high-speed VLSI systems.



## MICRODEVICE FABRICATION AND GREEN ELECTRONICS

A combination of sensing, communication and self-powering capabilities is merged into high-speed electronics on silicon chips. Our research explores opportunities to integrate photonic, electronic and micro-mechanical devices onto a single platform at our on-site fabrication facilities. Applications cover telecommunications, microelectronics, biophotonics, and chemical and mechanical sensor manufacturing. Specific projects include integration of the widely used CMOS circuit technology with optical communication components or with silicon sensors for X-ray monitoring in biomedical applications. Greater functionality, while preserving low fabrication costs, allows wider application of photonic devices in biomedical diagnostics, environmental testing and communications. In addition, polymer-based devices and nanotechnology are being investigated to allow energy harvesting and storage for a variety of eco-friendly applications.

## Research Facilities

### COMPUTER-AIDED ENGINEERING RESEARCH LABORATORY

Next-generation CAD algorithms and design automation tools for efficient and accurate modeling, analysis and optimization of electronic circuits and interconnects are developed here. Research focuses on issues common to high-speed circuits and interconnects:

- signal integrity;
- modeling and simulation;
- design tools for radio frequency and wireless applications;
- design tools for MEMS and opto-electronic applications; and
- mixed-domain simulation.

Research also covers the optimum use of multiple CPU cores and multiple-thread algorithms for efficient computational effort.



**Jacques Albert, Canada Research Chair in Advanced Photonic Components (right), and PhD student Alexander Beliaev (left) are using standard optical fibre to develop a device that can quickly detect toxins in drinking water or diseases in humans.**

### NEUROMODELER LABORATORY

Researchers are using advanced neuromodeling techniques for computer-aided design of high-frequency electronic circuits.

- Dynamic neural-network-based techniques are being used for behavioural modeling of non-linear circuits directly from external data with applications in optimizing high-speed, high-frequency IC packages and receiver/transmitter circuits;
- Fast neural-network-based models are developed for high-frequency components, both linear and nonlinear, using EM-based training for passive component models and physics-based training for active device models; and
- Techniques for circuit design and yield optimization use passive/active neural models.

### CMC INTEGRATED CIRCUIT DESIGN LABORATORY

This lab has the capability for design, optimization and layout of analog ICs, mixed-signal and digital ICs, radio frequency/microwave ICs, monolithic microwave ICs, electro-optic and photonic devices. Researchers work with some of the latest computer workstations capable of computationally intensive CAD simulations. Industry standard IC simulation and design software includes Agilent ADS, Cadence Design Systems, Matlab, HSPICE, Spectre, Sonnet and HFSS. Software for simulation of photonic devices includes OptiBPM, OptiFDTD, COMSOL and APSS.

### BROADBAND INTEGRATED CIRCUIT MEASUREMENT LABORATORY

Research at this lab includes analog and radio frequency (RF) integrated circuit design. Widespread applications include amplifiers to help cell phones pick up very faint signals, components to enable wireless connection to the internet, and wireless heart-rate monitors. The lab has test capability for:

- RF circuits, such as oscillators and low-noise amplifiers, and RF passive components;
- broadband and electro-optical circuits;
- analog, mixed signal and digital circuits including processors and controllers used in a system on a chip; and
- wafers, using a probe station.

### MICROWAVE AND ELECTROMAGNETICS LABORATORY

To investigate microwave devices and circuits for communications applications, the lab is equipped for RF-, microwave- and millimetre-wave testing of packaged or on-wafer devices and components. Active opto-electronic devices and circuits can be characterized along with RF, MEMS, antennas, multi-layer circuits, on-wafer and packaged devices. The lab is equipped with a probe station with four positioners and high-frequency probes and a large anechoic chamber with associated signal sources and components for accurate, fully automated antenna characterization.

## CARLETON UNIVERSITY MICROFABRICATION FACILITY (CUMFF)

The seamless monolithic integration on a single chip of photonic, electronic and micro-mechanical functionality will have a significant impact on industries such as telecommunications, microelectronics, biophotonics, and chemical and mechanical sensor manufacture. Silicon-based photonics, in particular, has the potential to reshape the opto-electronics industry.



**Winnie N. Ye, Canada Research Chair in Nano-scale Integrated Circuit Design for Reliable Opto-electronics and Sensors, uses the Carleton University Microfabrication Facility to fabricate silicon-based photonic devices.**

Research focuses on system-on-a-chip integration of sensor functions and photonic devices with control electronics. CUMFF is one of only a select few Canadian research laboratories in university, government or industry capable of integrating CMOS electronics with sensors or other devices in silicon. Building on more than 25 years of experimental research on mainstream micro-electronics applications (including process technology, device physics and innovative circuit techniques), CUMFF supports projects on silicon photonics, biomedical devices, wireless communication and MEMS integrated with CMOS. The lab is also used to enhance with additional components the capabilities of commercial CMOS and BiCMOS chips through post-processing.

## ADVANCED PHOTONIC COMPONENTS LABORATORY

Researchers in this lab deal with novel devices and systems based on photonic waveguides made of glass, in fibre or planar configurations. The main fields of application focus on optical sensing and active devices in glass for lasers and modulators.

## CANADIAN PHOTONICS FABRICATION CENTRE (CPFC)

Carleton was a founding partner of the CPFC, located at the National Research Council Canada (NRC), which draws on facilities and research expertise in photonic materials and devices at the NRC's Institute for Microstructural Sciences. Carleton researchers have access to equipment, research activities and incubation facilities for projects at a national level and in collaboration with photonics technology clusters within Canada. Projects involve silicon on insulator (SOI) and control of stress-induced birefringence, where splitting of light in SOI waveguides improves component functionality in telecommunications systems. Other research covers very fast switching of optical signals in indium phosphide devices.

## Partners and Collaborators

Close ties provide rich research opportunities with partners such as Ericsson, IBM, Best Medical Canada, PMC Sierra, the federal Communications Research Centre, the Department of National Defence and the National Research Council Canada. Our academic alliances also extend around the world, from the University of Arizona and Georgia Institute of Technology to l'Institut National des Sciences Appliquées de Toulouse and Finland's University of Oulu. CUMFF is run with industry and government collaborating partners including Thomson-Neilsen Electronics (Best Medical Canada), NRC, CRC, IBM, Transonic Scisense Inc, Gennum (Semtech Corp), Celestica, and Group IV Semiconductor (Leapfrog Lighting).

## Funding and Sponsorship

Research activities are funded by federal granting agencies, often in collaboration with industrial partners in electronics, communications, photonics, and related application areas. Joint initiatives involve academics, industry partners and government scientists with ties to global corporations and international organizations. The local high technology community is also engaged through Carleton's participation in the Ottawa region's technology research clusters.

## Graduate Programs

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The MASc, MEng, and PhD in Electrical and Computer Engineering are offered through the Ottawa-Carleton Institute for Electrical and Computer Engineering, a joint institute between Carleton's Department of Systems and Computer Engineering, Carleton's Department of Electronics, and the University of Ottawa's School of Electrical Engineering and Computer Science. This arrangement offers our students access to a wide range of graduate courses in ECE.

Read more about faculty members' research at [doe.carleton.ca/people](http://doe.carleton.ca/people)



### Ramachandra Achar, PEng, IEEE Fellow, EIC Fellow

*Professor*

#### RESEARCH AND APPLICATION

Signal and power integrity; multi-physics tools and methodologies; circuit modeling, simulation and optimization; high-speed interconnects; parallel algorithms; model reduction techniques and macromodeling; mixed-domain digital, analog, radio frequency, microelectromechanical systems and optoelectronic design and analysis; electromagnetic interference and electromagnetic compatibility; non-linear circuit analysis and modeling. Applications include next-generation design automation

methods and tools to manage emerging complex multi-physics based high-speed and mixed-domain modules, spanning various design domains of chip, package, PCBs and systems.

#### SELECTED ACTIVITIES

- General Co-Chair, IEEE SIPI (2016), IEEE NEMO (2015)
- Chair, IEEE Ottawa Joint Chapter of CAS/SSC/ED Societies (2005-2016)



### Jacques Albert, ING (Quebec), Fellow OSA

*Canada Research Chair in Advanced Photonic Components (Tier I); Professor*

#### RESEARCH AND APPLICATION

Design, fabrication and characterization of photonic components; fibre lasers; optical fibre sensors; photosensitivity; photonic packaging; state-of-the-art laser irradiation facilities to design, fabricate and characterize optical components and sub-systems; nanophotonic and plasmonic coatings on optical fibers. Applications include the development of advanced new devices in biomedical instrumentation, oil and gas exploration and

exploitation, structural and environmental sensing, and telecommunications.

#### SELECTED ACTIVITIES

- Program committee member (2015-2016): Optical Sensors (OSA), Asia-Pacific Optical sensors, Optical Fiber Sensors, Workshop on Specialty Optical Fiber
- Evaluation committee member (2015-2016): FQRNT Quebec-Chine Program, UQTR Research chair selection, Laval University Graduate program Evaluation in EE



### Rony E. Amaya, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Adaptive integrated active antennas and filters; gallium nitride (GaN), gallium arsenide (GaAs), and silicon (Si) based reconfigurable monolithic microwave integrated circuits (MMICs); active, switchable and tunable engineered surfaces; system-on-package (SOP) integration; miniaturized integrated sensors; high efficiency and high power integrated electronics for aerospace and automotive applications; high efficiency radio frequency (RF) wireless power transfer (WPT) and energy scavenging; capacitive and inductive contactless communications; galvanic isolation for high voltage electronic systems.

Applications include 5G wireless systems, adaptive cellular base stations and backhauling, integrated switched power electronics and energy conversion, intelligent reconfigurable wireless systems with spectrum awareness and interference mitigation, as well as wireless long-range telemetry and power charging for next generation radio frequency identification (RFID) and the Internet of Things (IoT). Aerospace applications include commercial and military radar surveillance, robust navigation and communication systems for uninhabited aerial vehicles (UAVs) and smaller, lighter, adaptive aerospace wireless systems.



### Mohamed Atia

*Assistant Professor*

#### RESEARCH AND APPLICATION

Real-time embedded systems, sensor-fusion, signal processing, estimation, machine learning, artificial intelligence; multi-sensors integrated navigation, guidance, and control; simultaneous localization and mapping; attitude and heading reference systems (AHRS); vision/Radar/LiDAR-aided navigation, localization and mapping. Applications include Self-driving cars, unmanned systems, unmanned aerial vehicles (UAV), Location-

Based Services (LBS), mobile robots, intelligent machines, machine control, surveying, mapping, and monitoring systems.

#### SELECTED ACTIVITIES

- EAssociate Editor, IET Electronic Letters
- Session Chair, The International Systems Conference, Ottawa (2014)
- Member, Institute of Navigation (ION)



### Robert Gauthier, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Photonic crystals and photonic quasi-crystals bandgap and defect state engineering focusing on integrated optic device designs for optical communications and biosensing applications, as well as fundamental research in theoretical foundations of bandgaps in circularly symmetric dielectric structures; laser trapping, manipulation, orientation and

ablation of micron-sized objects; simulation software development for physics and engineering applications.

#### SELECTED ACTIVITIES

- Editorial board member, Journal Optics and Laser Technology



### Pavan Gunupudi, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Computer-aided design automation of chip level and printed circuit board (PCB) level high speed systems; signal integrity; multi-physics optical-electrical system simulation; electrical and optical device modelling; model-order reduction. Applications include high-speed very-large-scale integration (VLSI) circuits, radio frequency (RF) and microwave circuits, silicon-photonics and microwave-photonics.

#### SELECTED ACTIVITIES

- Member, Technical Program Committee, IEEE Workshop on Signal and Power Integrity





### Shulabh Gupta

*Assistant Professor*

#### RESEARCH AND APPLICATION

Electromagnetics and microwave engineering; real-time radio signal processing; dispersion engineering; antennas; leaky-wave structures; metamaterials and metasurfaces; Fourier optics; wave propagation; microwave photonics. Applications include ultrafast signal processing, spectrum analysis, real-time sensing, high-speed radio communication, smart antenna communication, and millimeter wave devices and communication systems.



### Robert G. Harrison, IEEE Life Senior Member

*Distinguished Research Professor*

#### RESEARCH AND APPLICATION

A novel positive-feedback theory based on both quantum and classical physics provides accurate modeling of major and minor hysteresis-loop phenomena up to high order, in numerous ferromagnetic materials, taking into account temperature, Barkhausen and stress effects. Applications include the development of general-purpose design

software for magnetics-based systems and mechanisms, such as electric vehicles, wind-turbine generators, power-grid transformers, and linear actuators.

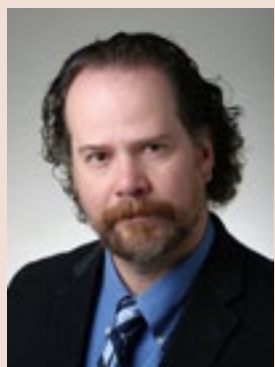


### Tad Kwasniewski, ING (Quebec)

*Professor*

#### RESEARCH AND APPLICATION

20 Gigabit per second and higher serial data communications circuits, including digital CDR, equalization and transmitter/receiver design; millimeter Wave Frequency Synthesizer Circuits; Fractional-N DLL synthesizer. Applications include integrated circuits for wireline communications, frequency synthesis and wireless communications.



### Leonard MacEachern, PEng (Nova Scotia)

*Associate Chair (Graduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

Microelectronics; high-speed and low-power mixed-signal circuits and optoelectronics; analog-to-digital converters, time-to-digital converters, biosignal sensors and circuits. Applications include biomedical/biosensor circuits and wearable technologies.

#### SELECTED ACTIVITIES

- Carleton CMC Representative
- Carleton emSYSCAN director



### Ralph Mason, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Radio frequency and mixed-signal integrated circuit design; analog integrated circuit design techniques, tools, circuit and systems; volume manufacturing and low-power circuits. Applications include low-power wireless integrated circuits and low-noise digital phase-locked loops.



### Steven McGarry, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Organic and hybrid organic/inorganic semiconductor device physics and technology, including device design, characterization, fabrication processes, and modeling; complex electronic/ionic systems using organic and hybrid materials; nanostructured and nanocomposite materials. Applications include generation, modulation and detection

of optical signals, design and fabrication of neuromorphic devices and systems, power generation and integrated storage using novel photovoltaic device structures and polymer super/ultracapacitors, and application of “soft technologies” to flexible or conformal devices and systems.



### Michel Nakhla, PEng, IEEE Fellow, CAE Fellow

*Chancellor's Professor*

#### RESEARCH AND APPLICATION

Parallel processing, modeling and simulation of high-speed interconnects; signal integrity; packaging; non-linear circuits; multidisciplinary optimization; model-reduction techniques; statistical analysis; wavelets and neural networks; optoelectronic systems; design centering; thermal design; electromagnetic radiation and interference. Application includes the design of radio frequency (RF) and very-large-scale integration (VLSI) high-speed circuits and systems.

#### SELECTED ACTIVITIES

- Associate Editor, IEEE Transactions on Components, Packaging and Manufacturing Technology
- Member, Executive Committee, IEEE International Signal Propagation on Interconnects Workshop (SPI)
- Member, CAD committee (MTT-1), IEEE Microwave Theory and Techniques Society
- Member, Technical Program Committee, IEEE MTT-S International Microwave Symposium, Phoenix, Arizona (2015)
- Member, Technical Program, IEEE Electrical Performance of Electronic Packaging and Systems, San Jose, California (2015)



### Calvin Plett, PEng

*Professor*

#### RESEARCH AND APPLICATION

Analog, mixed signal radio frequency (RF), and microwave integrated circuits in complementary metal-oxide semiconductor (CMOS), bipolar plus CMOS (BiCMOS), or silicon-germanium (SiGe); fully integrated, low-power radio with on-chip antennas; fully integrated frequency synthesizers with wider tuning range and lower noise. Applications

include analog and RF integrated circuits for wireless and wireline communications and for wireless biomedical sensors.

#### SELECTED ACTIVITIES

- Senior Member, IEEE
- Program Co-Chair, SBCCI (2015)



### John W. M. Rogers, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Radio frequency (RF) integrated circuits; fractional-N frequency synthesizers; wireless applications including ultra-wide band and wireless local area networks; wireless and coaxial TV tuners. Applications include low-power, miniature integrated circuits chips for wireless communications.



### Maitham Shams, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

High-speed and low-power circuits; system on chip; delay estimation and optimization; modern asynchronous circuits; arithmetic blocks; energy estimation and optimization; radio frequency (RF) logic circuits; computer architecture; logical balance; complementary metal-oxide-semiconductor (CMOS) logic

styles; digital signal processor (DSP) and wireless. Applications include microprocessors and application-specific integrated circuits (ASICs), DNA detection, artificial eyes and artificial organs.



### Tom Smy, PEng

*Professor*

#### RESEARCH AND APPLICATION

Physical simulation of thin film processing and thermal, electrical, and electromagnetic phenomena; the development of a multi-energy domain opto-electronic simulator (Optispice) in collaboration with Optiwave (Ottawa). Optispice has a wide variety

of applications in optical, sensor and telecommunications systems. Additional simulation research application includes the development of silicon chip technology and the creation of nano-structured thin films.



### Alan Steele, PEng

*Special Assistant to the Provost for Student Academic Engagement; Associate Professor*

#### RESEARCH AND APPLICATION

Non-linear properties of optical fibre that provide a route to optical pulse generation and shaping; optical switching; optical bistability and instabilities; fibre gratings; mode-locking of fibre lasers; simulation of photonic systems. Applications include optical communications and optical sensors, and fibre structures that allow further control and

manipulation of optical pulses. Additional research includes the use of new technology in teaching, project work and design education.

#### SELECTED ACTIVITIES

- Founding member, Canadian Engineering Education Association





### Barry Syrett, PEng

*Associate Chair (Undergraduate Studies); Professor*

#### RESEARCH AND APPLICATION

Radio frequency (RF)/microwave devices and circuits, including modeling of electronic devices and circuit design (microwave and monolithic microwave integrated circuits) at RF and microwave frequencies; tunable or programmable microwave circuits in metamaterials. Applications include wireless

and satellite communications, integrated microwave systems and wireless sensing systems.

#### SELECTED ACTIVITIES

- PEO technical examiner



### R. Niall Tait, PEng

*Chair; Professor*

#### RESEARCH AND APPLICATION

Micro-fabrication and micro-electro-mechanical systems (MEMS); thin film processing materials and technologies; silicon and MEMS sensors and sensor integration; infrared sensing and imaging; silicon photonic and plasmonic devices; amorphous semiconductor devices; micro-fluidic effects

and devices. Applications of high performance MEMS and plasmonic devices include gas sensing and biosensing, environmental monitoring, blood analysis and pathogen detection in food and water.



### N. Garry Tarr, PEng

*Chancellor's Professor*

#### RESEARCH AND APPLICATION

Silicon semiconductor device physics and technology: device design, fabrication processes, characterization, modeling and application in integrated circuits and optoelectronics; monolithic integration of optical components with complementary metal-oxide-semiconductor (CMOS) electronics

for sensing and communications; integrated waveguide optical devices in silicon-on-insulator; silicon sensors for ionizing radiation for biomedical applications; silicon photovoltaics.



### **Xiaoyu Wang, PEng (Alberta)**

*Associate Professor*

#### **RESEARCH AND APPLICATION**

Power system analysis; integration of renewable and distributed energy resources; power quality; power system real-time simulation; power electronics; smart grid application. Applications include distributed generation anti-islanding protection and hybrid storage units for grid-connected photovoltaic systems.

#### **SELECTED ACTIVITIES**

- Technical Program Committee Co-Chair, the 2016 Electrical Power and Energy Conference (EPEC), Ottawa
- Chair, IEEE task forces on Interfacing Techniques for Simulation Tools
- Vice Chair of the IEEE Reliability & Power Electronics Societies Joint Chapter, Ottawa



### **Jim Wight, PEng**

*Chancellor's Professor*

#### **RESEARCH AND APPLICATION**

Antenna and array structures (at 5 GHz and 30 GHz) for carrier-grade Wi-Fi; antennas (at 406 MHz and 236 MHz) for emergency locator transmitters (ELTs) in commercial aircraft flight data recorders; polarization agile antennas and radio architectures for Internet of Things (IoT) and radio frequency identification (RFID) energizers, readers, locators and trackers; gallium nitride (GaN) high-electron mobility

transistor (HEMT) based high-power multi bit phase shifter circuits; GaN power-amplifier linearization circuits; multilateration (MLAT) and multiple-input and multiple-output (MIMO) surveillance radars; spoofing and anti-spoofing of GPS receiver synchronization circuits. Applications include wireless and satellite communications, GPS and radio navigation, and surveillance, tracking and imaging radar.



### **Winnie N. Ye, PEng**

*Canada Research Chair in Nano-scale Integrated Circuit Design for Reliable Opto-electronics and Sensors (Tier II); Associate Professor*

#### **RESEARCH AND APPLICATION**

Design, fabrication and characterization of silicon-based photonic devices; athermal waveguide devices; optical bio-sensors; polarization rotators; multimode ring filters; silicon-based and plasmonic-enhanced solar cells; stress engineering; subwavelength gratings (SWGs); all-optical switching. Applications include telecommunications, biomedical and environmental sensing, biophotonic diagnostic tools and photovoltaics.

#### **SELECTED ACTIVITIES**

- Editorial Board Member for Scientific Reports, a journal from Nature Publishing Group, the publishers of Nature (2015 - Present)
- Technical Sub-Committee Member, IEEE International Conference on Group IV Photonics (2015)
- Technical Program Committee Member, IEEE International Conference on Group IV Photonics (2016)
- Member, NSERC Strategic Committee in the Information and Communications Technologies Panel (2015-2016)
- Senior Member, IEEE
- Chair, IEEE Women in Engineering Ottawa Chapter



## **Q. J. Zhang, PEng, IEEE Fellow, CAE Fellow**

*Acting Associate Dean (Research and Graduate Studies); Professor*

### **RESEARCH AND APPLICATION**

Electronic computer-aided design (CAD); neural networks; optimization; high-frequency electronic/electromagnetic modeling and design; methodologies and tools for designing high-speed and high-frequency electronic circuits in wireline and wireless electronic systems. Applications include microchip design, electronic packaging design and wireless front-end design.

### **SELECTED ACTIVITIES**

- Member, Editorial Board, IEEE Transactions on Microwave Theory and Techniques
- Member, Technical Committee on CAD (MTT-1) of the IEEE MTT Society
- Member, Technical Program Review Committee, IEEE MTT-S International Microwave Symposium, San Francisco, California (2016)
- General Chair, IEEE MTT-S International Conference on Electromagnetic/Multiphysics Modeling and Optimization, Ottawa, Canada (2015)

# DEPARTMENT OF Mechanical and Aerospace Engineering

CARLETON

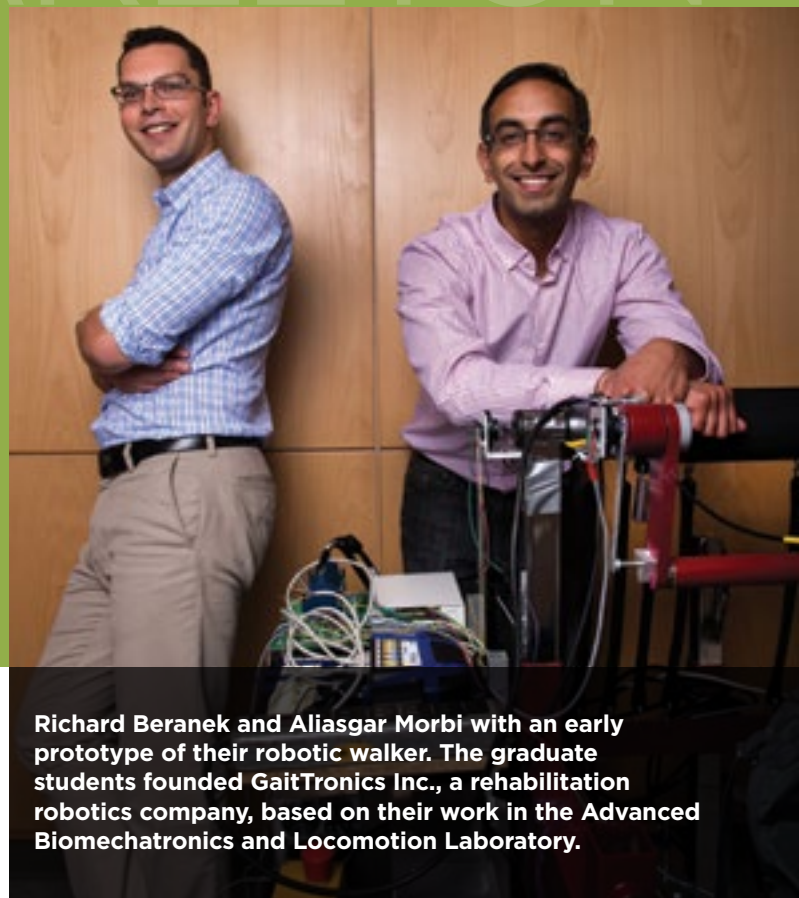
Nearly 40 years of research associated with advancing gas turbine technology exhibits the department's continuing dedication to application-based, cross-disciplinary research. That same approach is propelling innovative developments and designs in uninhabited aerial vehicles, flight simulators, and rotorcraft and wind-turbine structures, along with cutting-edge research in areas such as energy, robotics and biomedical devices.

Our researchers are leaders in advancing aerodynamics, vehicle dynamics and simulation technologies, biomedical engineering and design of devices, health monitoring and management systems, design optimization of advanced materials and structures, convective heat transfer characteristics in supercritical fluids with application to nuclear-reactor cooling, robotics, navigation, combustion, and the development of sustainable energy sources.

Complementing extensive experimental research, the department is at the forefront of the development and application of innovative analytical and numerical techniques for problem solving in the fields of solid mechanics, fracture mechanics and fluid mechanics. Cutting-edge research involves development of the Quasicontinuum Method, the Boundary Integral Equation Method, Finite Element Methods for solid-mechanics applications and computational fluid dynamics algorithms.

## Research Facilities

Our transonic to low-speed wind tunnels, large-scale water channel, unique material processing and surface-coating equipment laboratories, simulator platform, robotics laboratories, and extensive computational facilities for parallel computing support our extensive programs related



**Richard Beranek and Aliasgar Morbi with an early prototype of their robotic walker. The graduate students founded GaitTronics Inc., a rehabilitation robotics company, based on their work in the Advanced Biomechanics and Locomotion Laboratory.**

to internal and external aerodynamics, aeroacoustics, aeroelasticity, combustion, system design and performance, high-temperature materials and coatings, and repair and overhaul technologies.

- These facilities, and the H.I.H. Saravanamuttoo Gas Turbine Laboratory, support one of the largest university-based gas turbine technology research groups in Canada.
- A whirl tower supports the experimental rotor programs of the Rotorcraft Research Group.
- Researchers in sustainable energy conversion have access to a thermohydraulics test facility, a fully instrumented house for building energy systems research, a facility for the study of energy storage systems, two wind tunnels optimized for the study of wind-turbine aerodynamics, combustion facilities and a gas turbine engine modified for alternative fuel combustion research.



- Materials and manufacturing processes researchers benefit from our high-temperature vacuum Bridgman furnace, air plasma spray facility, welding equipment, optical and scanning electron microscopes and vacuum treating furnace.
- Researchers in structures and materials have access to several Instron material testing machines covering a wide range of load configurations.
- Space system design researchers use the Jo Yung Wong Laboratory for Terrestrial and Extraterrestrial Mobility, Guidance and Control, along with a facility optimized for the study of formation flying of mobile robots.
- The Carleton flight simulator platform, the marine dynamics facility and the terramechanics facility support research projects on vehicle dynamics, control systems and related simulation systems.
- The biomechanics and locomotion laboratory, aerosol research facility, and tissue engineering laboratory support research in a range of biomechanical engineering applications, including biomedical devices, rehabilitation robotics and pharmaceutical drug delivery systems.

## Research Focus

### AERODYNAMICS

Focused on gas-turbine internal flows, aerodynamics of lift-generating surfaces on fixed-wing and rotary-wing aircraft, spacecraft and rocket propulsion systems, and wind turbines, our research specifically examines:

- aerodynamics of inter turbine ducts;
- passive and active control of boundary layer transition and turbulence mixing performance of gas-turbine lobed mixers;
- instability and laminar-to-turbulent transition in separated and free shear layers;
- aerodynamics and aero-acoustics of rotorcraft blade/vortex interactions;
- design of ejector-engine nozzles; and
- aerodynamics of unmanned aerial vehicles operating at low altitude and in wind gusts.

### AEROSPACE STRUCTURES

Research concentrates on optimizing aircraft design and evaluating new materials, processes and technology for aircraft structural applications. Several servo-hydraulic materials and structure test systems are available to researchers with current projects related to:

- fibre metal laminates for aircraft structures that provide improved damage tolerance, integrity and fatigue properties;
- multidisciplinary design optimization of composite airframes;
- smart structures to reduce rotorcraft noise and vibration;
- dynamics and aerodynamics of shipboard helicopter operation; and
- understanding fatigue nucleation and short fatigue crack growth behaviour of aerospace aluminum alloys.

### BIOMEDICAL ENGINEERING

The application of mechanical engineering to the biomedical field is a rapidly growing area of research. Faculty have strong collaborations with biomedical engineering research centres, the pharmaceutical industry and manufacturers of medical devices. Current research programs involve:

- evaluation of polymers for implantable medical devices;
- design of prosthetic limbs and wrist implants;
- development of assistive devices for mobility and balance;
- designing robotic and virtual reality systems for stroke rehabilitation;
- dynamics and control of actuators for variable-stiffness limbs;
- fracture fixation and bone regeneration using tissue engineering;
- two-phase flows associated with aerosol generation from commercial pharmaceutical inhaler devices and deposition losses in oral and nasal airways;
- tumour chemotherapy enhancement using a microbubble infusion pump;
- mathematical modeling of the cardiovascular system;
- design optimization of the Intra Aortic Balloon Pump;
- assessment of load support and diffusion in multiphasic cartilage tissue, and their role osteoarthritis; and
- intelligent vision systems for robotic-assisted surgery.

### SUSTAINABLE ENERGY CONVERSION

Advanced research involves evaluation and modeling of two-phase flows with applications in automotive air conditioning systems, fuel cells, solidification processes, building energy optimization, heat pipes and oil flares.

Applications deal with satellite thermal control, gas turbine cooling and materials processing and cooling of electronic microprocessors, along with research in:

- zero-emission, gas-turbine-based plants for power generation;
- bio-fuel combustion in gas turbines;
- mathematical modeling and manufacturing of two-phase capillary pumped heat transfer devices such as conventional heat pipes and loop heat pipes;
- efficient and environmentally friendly automobile air conditioning systems;
- measurement and modeling of soot formation in multi-component fuels;
- pollutant emissions and control of oil-field flares;
- stratified combustion;
- micro-cogeneration based upon fuel cells and Stirling cycles;
- development of efficient building energy conversion and energy storage systems;
- building performance simulation;
- optimization of solar energy utilization; and
- alternative cooling approaches.

## MATERIALS AND MANUFACTURING PROCESSES

Our researchers concentrate on optimizing the processing, microstructure and properties of advanced materials, and are developing extensive experimental programs and computer simulation methods. Areas of focus include:

- titanium aluminide intermetallics for low-pressure and low-power turbine blades;
- investigation of processing, composition and phase stability of single crystal superalloys for high-pressure turbine blade applications;
- mathematical and computational modeling to design ceramic thermal barrier coatings with high reflectance to radiation in advanced gas turbine engines;
- development of special elements and techniques for adaptive and automatic finite element analysis, for thermal and stress analysis of welds and related manufacturing processes;
- integration of a graphical user interface for the preprocessing of hexahedral elements derived from freemeshed tetrahedral elements;
- modeling of dendrite growth, development of micromacro models of solidification processes, and phase field micromechanics models of the martensitic transformation;
- development of innovative superalloys and their composites for high-temperature wear/corrosion applications;
- development of new coatings and coating processes for thermal erosion and resistance;
- manufacture and properties of carbon nanotube-polymer matrix composites;
- experimental and analytical investigation of durability and damage tolerance of aerospace polymer matrix composite (PMC) components under realistic service conditions including static, fatigue and impact loading;
- physics-based modelling and simulation of growth of fatigue damage in PMCs; and
- development of structural health monitoring using guided and bulk ultrasonic waves to monitor aerostructures in flight.

## SOLID AND FRACTURE MECHANICS

We develop advanced methods for fatigue and fracture assessment of engineering structures in the pressure vessel, aerospace, automotive and offshore industries. Our research enables realistic correlations of fatigue and fracture properties from laboratory test specimens to full-scale engineering structures, and:

- finite element modeling of materials damage to develop a physics-based holistic life prediction methodology for aerospace components and structures;
- efficient boundary element methods for stress analysis;
- exact volume-to-surface integral transformation in the development of boundary integral equations for anisotropic bodies with body forces and/or thermal effects;
- fracture mechanics of advanced composite materials;

- stress analysis of micro-electronic packaging;
- multi-scale modeling of plasticity and fracture in metals; and
- development of the Quasicontinuum Method for mixed continuum and atomistic simulation of the mechanical response and fracture mechanics of polycrystalline materials.

## ROBOTICS, CONTROL, GUIDANCE AND NAVIGATION

This area of research is dedicated to advanced application of robots and control/navigation of autonomous vehicles and satellites. To explore these topics, our researchers have access to industrial robots for testing control and calibration strategies. Some of our projects include:

- robot mechanical systems and kinematic calibration;
- mechanism synthesis and applied dynamics
- development of innovative simulator motion platforms with unlimited rotational degrees of freedom;
- sensor fusion techniques and control of autonomous formation flying;
- design and development of active systems for control of rotorcraft blade dynamics;
- coordinated control of multivehicle systems and autonomous vehicles engineering;
- systems control and estimation theory;
- linear, nonlinear and learning control and estimation theory;
- fleet of small and large fixed-wing and rotary-wing uninhabited aircraft systems (UAS) for the development of novel UAS platforms, sensor payloads and applications including access to off-campus flying sites;
- human robot interaction, stability of haptic systems;
- balance control in legged locomotion; and
- vision-based indoor localization and mapping technology.

## SPACE TECHNOLOGY

Our work on satellite, rocket and other spacecraft engineering is dedicated to low-cost space launch systems, hypersonic and high-speed flows, inertial technology and air-breathing propulsion concepts and includes:

- rocket-based combined-cycle engines for more efficient use of atmospheric oxygen during launch;
- guidance, navigation and control for proximity operations with uncooperative spacecraft;
- computer vision for rendezvous and docking in space;
- application of loop heat pipes for spacecraft thermal control; and
- space robotics, satellite servicing and planetary rovers.

## Partners and Collaborators

Department research benefits from strong relationships with external research centres locally and globally. Research collaborations and funding arrangements exist with several institutes of the National Research Council of Canada, Environment Canada, Natural Resources Canada, National Defence, the Ottawa Hospital and the Canadian Space Agency. Major industry partners include Pratt & Whitney Canada Inc., United Technologies, Deloro-Stellite, Indal Technologies, Liburdi Engineering, Magellan Aerospace, Augusta SpA., Atomic Energy of Canada Ltd., Rolls-Royce Canada and the Petroleum Technology Alliance of Canada, among many others. Faculty have been successful at supporting research through grants from NSERC, the Ontario Centres for Excellence, the Canada Foundation for Innovation, and the Ontario Research Fund.

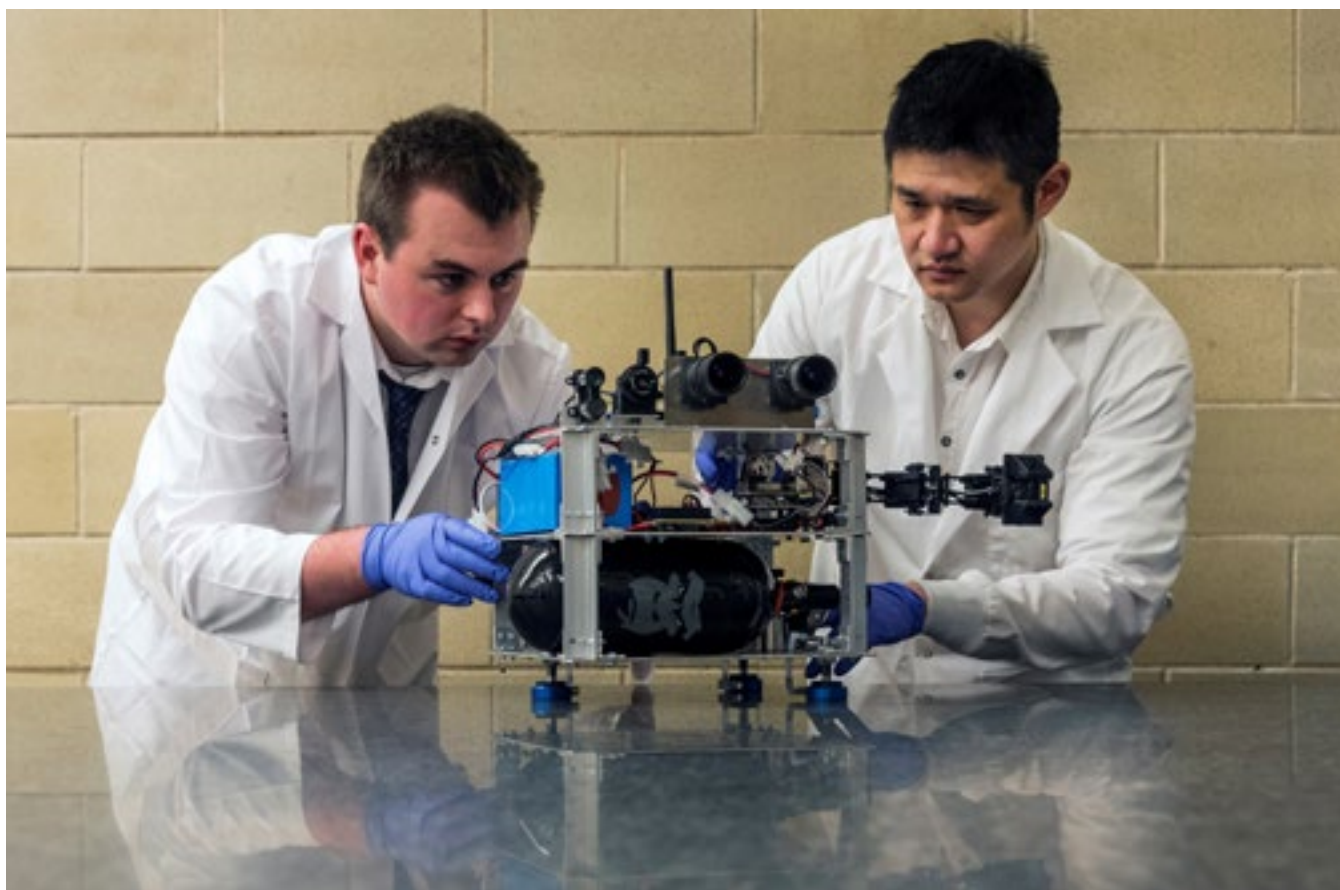
The scope of graduate student research is expanded through exchange agreements with leading universities including Delft University of Technology, the University of Glasgow and the University of Sao Paulo.

## Graduate Programs

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The MASc, MEng, and PhD in aerospace and mechanical engineering are offered through the Ottawa-Carleton Institute for Mechanical and Aerospace Engineering, a joint institute between Carleton's Department of Mechanical and Aerospace Engineering and the University of Ottawa's Department of Mechanical Engineering. The MASc and MEng in biomedical engineering is offered through the Ottawa-Carleton Institute for Biomedical Engineering, a joint institute of four academic units at Carleton and three at the University of Ottawa.

The recently established MASc and MEng in Sustainable Energy Engineering and Policy enables students to study the policy and engineering aspects of energy generation, conversion, distribution and utilization in an interdisciplinary setting.



**The Spacecraft Robotics and Control Laboratory uses air-bearing free-floating platforms to experimentally validate autonomous spacecraft guidance, navigation and control systems.**

Read more about faculty members' research at [carleton.ca/mae/staff-and-faculty-listing](http://carleton.ca/mae/staff-and-faculty-listing)



### Fred F. Afagh, PEng, SMAIAA

*Acting Dean; Professor*

#### RESEARCH AND APPLICATION

Development of smart structure technologies for aerospace and energy applications, including helicopter rotors and horizontal axis wind turbine blades; structural modeling of thin-walled, open and closed cross-section beams; dynamic modeling and analysis of control and postural stability; elastic and dynamic stability analysis of various structural systems and elements.

#### SELECTED ACTIVITIES

- Organizing Committee Member, Design and Production Series Conferences



### Mojtaba Ahmadi, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Robotic systems design, including manipulators and mobile robotic systems; safety, control and accessibility in human robot interaction with focus on linear, nonlinear and learning controllers; general mechatronic design and simulation, including biomechanics and bio-inspired robotics; medical robotics to assist rehabilitation and gait training for post-stroke patients; fall detection and prevention in elderly and assistive devices for people with balance impairment. Aerospace applications include robotics in wind tunnel testing, captive trajectory simulation, aerospace manufacturing and process control, robot-assisted task execution, magnetic signature minimization and UAVs.

#### SELECTED ACTIVITIES

- Conference Chair, Controls, Dynamics Systems and Robotics Conference, CDSR (2016)
- Chief Editor: International Journal of Mechanical Engineering and Mechatronics
- Plenary speaker, International Conference on Engineering Design and Science (2016)
- Planning committee and institute contact, Innovative Designs for Accessibility (IDeA) competition (2012-2016)



### Andrei Artemev, PEng

*Professor*

#### RESEARCH

Development of computer simulation methods for structure and properties of solid materials and structure evolution in phase transformations; phase field models of domain structures in thin ferroelectric films and nano-composites; micro-macro models

of phase transformations and phase-field micromechanics models of the martensitic transformation; computer modeling and damage analysis of functional composite materials.





### Ian Beausoleil-Morrison, PEng

*Canada Research Chair in Innovative Energy Systems for Residential Buildings (Tier II);  
Professor*

#### RESEARCH AND APPLICATION

Lead investigator of the Urbandale Centre for Home Energy Research, located on Carleton's main campus; evaluation of novel energy conversion and storage systems for buildings, including seasonal storage of solar thermal energy for space and water heating; research in low-energy buildings and building performance simulation.

#### SELECTED ACTIVITIES

- Co-editor, Journal of Building Performance Simulation
- Fellow and Past-President of International Building Performance Simulation Association
- Theme Leader of NSERC Smart Net-Zero Energy Buildings Strategic Research Network



### Cynthia Cruickshank

*Associate Professor*

#### RESEARCH AND APPLICATION

Design and optimization of advanced building energy systems, including research related to high performance buildings, energy efficient insulation materials, solar-assisted heat pumps, solar absorption cooling and thermal storage (sensible, latent and chemical); healthy building solutions, including net-zero energy building designs to reduce greenhouse gas emissions, effective and durable upgrades for existing building envelopes to reduce energy consumption, solar combi-systems

for space and water heating, optimization of control strategies to shift on-peak energy consumption to off-peak periods, and commercialization of scalable clean-energy solutions.

#### SELECTED ACTIVITIES

- Member, Technical Research Committee, Canadian Home Builders Association



### Mostafa El Sayed, PEng

*Assistant Professor*

#### RESEARCH

Multiscale mechanics of ultralight hybrid materials and structures; fluid structure interaction (FSI) and thermo-elastic-plastic interaction; additive manufacturing. Applications include material mapping in materials selection design, load recovery, and airframe structural development and design optimization pertaining to future concepts of passenger and cargo transports, spacecraft and UAV's.

#### SELECTED ACTIVITIES

- Technical program committee, International Workshop on Recent Advances in Robotics and Sensor Technology for Humanitarian Demining and Counter-IEDs (2016)





### Alex Ellery

*Canada Research Chair in Space Robotics and Space Technology (Tier II);  
Associate Professor*

#### RESEARCH AND APPLICATION

Mars and lunar rover exploration, including planetary micro-rover development, autonomous rover navigation, robotic science by planetary rovers, forward model augmentation to manipulator feedback control, and micro-penetrator development; biomimetic development, such as muscle-like behaviours for robotic manipulators; lunar base infrastructure development, including onsite resource utilization, 3D printing, and self-replicating machines

for lunar colonization; Mars, Europa and Enceladus astrobiology, with applications in solar powered satellites and space-based manipulators for on-orbit servicing.

#### SELECTED ACTIVITIES

- Chair for 3D Printing in Mechatronics session of IEEE Int Conf on Industrial Technology 2016, Taipei



### Jason Etele, PEng

*Associate Chair (Graduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

Design of next-generation launch vehicles using the “exchange inlet”, an air breathing Rocket Based Combined Cycle (RBCC) concept; experimental and numerical investigation of building generated turbulence and its effect on the flight of small unmanned aerial vehicles; dielectric barrier discharge (DBD) actuator simulation and design.

#### SELECTED ACTIVITIES

- JSPS Long Term Fellowship Visiting Researcher, Japanese Aerospace eXploration Agency (JAXA), Kakuda Space Center



### Daniel Feszty, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Vibration and noise control; helicopter aerodynamics; wind turbine aerodynamics with focus on wake interference effects and wind farm layout optimization; energy harvesting via unsteady flows; flow control and stiffness control; experimental rotor design, manufacturing and testing; computational aeroelasticity. Applications include vibration control for robotic camera platforms, as well as novel aerodynamic concepts to increase the

power output of wind farms and to improve the noise signature, passenger comfort, efficiency and performance of helicopters.

#### SELECTED ACTIVITIES

- Director, Aerospace Research Unit, Rotorcraft Research Group
- Carleton University's delegate to CRIAQ



### Hanspeter Frei, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Prediction of hip fractures using finite element method and prevention of osteoporotic hip fractures using tissue engineering approaches; design of novel implants for the repair of osteoporosis-related fractures in order to limit premature disability and significantly improve patient mobility and quality of life.



### John Gaydos, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Capillarity and surface fluid mechanics applied to measurement techniques for liquid-fluid surface tension and interfacial energy; contact angle and line tension on patterned surfaces; application of semiconductor fabrication

processes to microfluidic device research and development. Applications include the development of nano-technology and the miniaturization of many devices.



### John Goldak, CAE Fellow

*Distinguished Research Professor*

#### RESEARCH AND APPLICATION

Designer driven nonlinear transient finite element method (FEM) analysis of manufacturing processes such as welding, heat treating and casting to optimize the design and production of real production parts in mechanical structures such as tractors, ships and automobiles; software environments that enable designers to accurately simulate and optimize the manufacturing processes and in-service behavior of complex structures such as an automobile frame. Applications include simulating the process of high pressure die casting for components for the automotive industry, simulating welding

structures such as tractor frames to manage distortion that impacts manufacturing costs and residual stress that impacts fatigue life, and simulating the heat treatment of gears to predict distortion, residual stress and hardness and then optimize the heat treating process.

#### SELECTED ACTIVITIES

- Member of Advisory Committee of American Welding Society on Standards for Verification and Validation of Computational Weld Mechanics
- Joining and Welding Research Institute, Osaka University, Osaka, Japan



### Junjie Gu, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Energy storage materials and systems, including two-phase flow and heat transfer, vapour compression heat pumps and refrigeration, absorption refrigeration, carbon dioxide heat pump water heaters, and liquefied natural gas (LNG) systems; biomass

and coal gasification; waste-heat recovery and utilization; subcritical, transcritical and supercritical carbon dioxide cycles.

#### SELECTED ACTIVITIES

- Founder, Carleton Student Branch, ASHRAE



### M. John D. Hayes, PEng, CSME Fellow

*Associate Chair (Laboratory Operations), Professor*

#### RESEARCH AND APPLICATION

Robotic mechanical systems; kinematic calibration; mechanism synthesis; applied dynamics; theoretical kinematics; simulation; machine vision; visual servoing (vision-based robot control); simulator motion platform design. Applications include autonomous industrial robotics, biomedical robotic devices and control of moving platforms (specifically the Atlas Motion Platform).

#### SELECTED ACTIVITIES

- President, Canadian Committee for the Theory of Machines and Mechanisms
- Treasurer, Canadian Society for Mechanical Engineering
- Chair, CCToMM Symposium on Mechanisms, Machines, and Mechatronics (2016)



### Xiao Huang, PEng

*Professor*

#### RESEARCH AND APPLICATION

Material and coating designs, including ceramic matrix composite, thermal barrier and corrosion resistance coatings and bio-compatible materials and coatings; manufacturing optimization; additive manufacturing; brazing, welding and sintering; material integrity assessment and failure investigation. Applications involve gas turbine, aircraft, automotive and energy sectors.

#### SELECTED ACTIVITIES

- Session organizer, Manufacturing, Materials and Metallurgy Committee, International Gas Turbine Institute, Turbo Expo
- Visiting scholar, Zhejiang University of Technology
- Member of the College of Reviewers, Ontario Centres of Excellence



### Rishad Irani, PEng

*Assistant Professor*

#### RESEARCH AND APPLICATION

Mechatronic systems; applied multibody/domain dynamics and control; motion compensation systems; rope/cable dynamics; contact modelling; marine systems; emphasis on system-level approach in order to enhance control algorithms, system modelling, machine vision, robotic actuation, and mechanical design of marine deck machinery and robotics.

Application includes the reliable launch, recovery and transfer of any load or object from two independent vehicles irrespective of weather conditions or relative motions.

#### SELECTED ACTIVITIES

- NATO - Industrial Advisory Group (NIAG), Committee Member of Study Group 171 and 187



### Matthew Johnson, PEng

*Canada Research Professor*

#### RESEARCH AND APPLICATION

Technology to quantify soot/black carbon emissions in atmospheric plumes of gas flares and other sources; novel approaches for detection and quantification of fugitive emissions in the upstream energy industry; pollutant emissions from turbulent flames and gas flares, especially emissions associated with hydrofracturing; techno-economic analysis of opportunities from mitigation of greenhouse gas emissions in the upstream energy industry;

experimental fluid mechanics; use of laser diagnostics. Application includes reduction of pollution, especially emissions associated with upstream energy production in Canada.

#### SELECTED ACTIVITIES

- Member of Canadian Standards Association technical committee developing federal standards for fugitive and vented emissions in the Canadian oil and gas industry



### Abu Syed Kabir

*Assistant Professor*

#### RESEARCH AND APPLICATION

Physical metallurgy of structural metals; thermo-mechanical processing; microstructure-property relationship; mechanical testing and failure analysis; materials characterization; texture and anisotropy of materials; welding and joining; coating and tribology; additive manufacturing (3D printing). Applications include lightweight

and fuel efficient automotive and aerospace structural components, and materials for high temperature applications such as turbine blades in aircraft engine.

#### SELECTED ACTIVITIES

- MetSoc Materials Sector Committee (2016)



### Tarik Kaya, PEng

*Associate Chair (Undergraduate Studies); Professor*

#### RESEARCH AND APPLICATION

Two-phase heat transfer; instability of evaporating meniscus; heat pipes and loop heat pipes; mathematical modeling and manufacturing of two-phase capillary pumped heat transfer devices. Applications include spacecraft thermal control and electronics cooling.



### Jeremy Laliberté, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Novel aerospace vehicle conceptual design, with concentration on uninhabited aircraft systems; lightweight materials and structures; structural health monitoring; out-of-autoclave manufacturing of polymer composites; low velocity impact damage testing and modeling; durability and damage tolerance of advanced materials.

#### SELECTED ACTIVITIES

- Associate editor, Journal of Unmanned Vehicle Systems
- Organizing committee member for the CASI AERO 2017 and CANCOM 2017 Conferences
- Director of the Carleton Aerospace Research Unit



### Rob Langlois, PEng

*Professor*

#### RESEARCH AND APPLICATION

Theoretical, computational, and experimental research in the areas of applied multibody dynamics, mathematical modelling and computer simulation and vehicle dynamics. Applications include shipboard aircraft operation, shipboard mechanical systems, high speed craft suspension seating, flight simulator development, postural stability

analysis, human performance at sea and vehicle and system simulation.

#### SELECTED ACTIVITIES

- Associate Director of the Carleton University Visualization and Simulation Centre





### Jie Liu, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Instrumentation and measurement, including smart sensing and ultra-low magnetic field sensing (using magnetic tunnel junction sensors); intelligent mechatronic systems and machine learning, with applications to intelligent robotic vacuum cleaners; health condition monitoring, prognostics and management, and vibration and system control for machinery such as gas turbine engines; power storage with applications in automotive, military and communication sectors, including lithium ion battery management systems and remaining useful life prediction for aircraft auxiliary power unit starters.

#### SELECTED ACTIVITIES

- Steering Committee Member, IEEE Prognostics and Health Management International Conference (2015-2016)
- Arrangements Chair and Local Host, IEEE Prognostics and Health Management International Conference (2016)
- Editorial Board Member, Chinese Journal of Aeronautics - Elsevier (2015-2016)



### Rong Liu, PEng

*Professor*

#### RESEARCH AND APPLICATION

High-temperature oxidation, fatigue and creep of superalloys; high-temperature fracture toughness modeling and mechanics of superalloy coatings; 3D laser print of nickel-based alloys; amine corrosion investigation of stellite alloys and stainless steel; erosion and wear resistance of superalloys. Applications include gas turbine engines of power generation plants, novel additive manufacturing techniques and efficient forming of products.

#### SELECTED ACTIVITIES

- Session Chair, International Conference on Automotive and Mechanical Engineering (ICAME) Tokyo, Japan (2015)
- Expert Professor, Research Center of Laser Processing Technology and Engineering, Zhejiang University of Technology, China
- Committee Member and Reviewer of World Academy of Science, Engineering and Technology, International Science Council



### Edgar A. Matida, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Aerosol science and technology (characterization and deposition); nozzle sprays; computational fluid dynamics; laser-doppler velocimetry and particle image velocimetry; dispersed two-phase random-walk models and dispersed two-phase impinging jets. Applications include pharmaceutical aerosols (pressurized

metered dose inhalers) and add-on spacer devices, nasal drug delivery, diesel fuel characterization, and wind turbines.

#### SELECTED ACTIVITIES

- Member, Editorial Board, Journal of Aerosol Medicine and Pulmonary Drug Delivery



### Glenn McRae, PEng

*Professor*

#### RESEARCH AND APPLICATION

Examination of hydrogen solubility, diffusion, and delayed hydride cracking in zirconium alloys used in the nuclear industry (specifically at the Chalk River Laboratory and Argonne National Laboratory); corrosion of high performance alloys; new methods to measure and implant hydrogen in metals; sustainable energy engineering for residential buildings;

design of biofuel reactors; use of biofuels for steel production; design of targets for medical isotope production with cyclotrons; coupling neutron-activation analysis and single photon emission computed tomography to make a non-invasive 'nSPECT' bone-cancer imager and a calibration 'flood' source.



### Ronald E. Miller, PEng

*Chair, Professor*

#### RESEARCH AND APPLICATION

Development of interatomic potentials for material science, including multiscale and molecular dynamics simulations of metallic systems; high-performance computing applications of multiscale modeling in materials science and nano-mechanics. Applications include oil breakdown mechanisms, delayed hydride cracking in nuclear reactors, and effects of radiation on materials in nuclear reactors.

#### SELECTED ACTIVITIES

- Short Course, "Modeling Materials", Friedrich-Alexander-Universität and Engineering of Advanced Materials (EAM) Cluster of Excellence Erlangen-Nürnberg, GERMANY (2015)
- Invited Speaker, Necas Seminar on Continuum Mechanics, Charles University, Prague, Czech Republic, (2015)
- Member of the Board of Directors, openkim.org



### Fred Nitzsche, PEng

*Professor*

#### RESEARCH AND APPLICATION

Smart structures; aeroelasticity of fixed and rotary wings; individual blade control in helicopters; aeroelastic reduced-order models; aeroelastic energy harvesting; intelligent horizontal and vertical axis wind turbines and farms. Applications include active vibration and noise reduction in helicopter rotors and wind turbines, vertical fin buffeting alleviation in fighter aircraft, electric energy harvesting from aeroelastic vibrations and energy output optimization for wind turbines and wind farms.

#### SELECTED ACTIVITIES

- Guest Professor: Technical University of Delft, The Netherlands; Visiting Professor: Polytechnic Institute of Milan (POLIMI), University of Rome "La Sapienza", University of Rome III, Italy; German Aerospace Centre (DLR), Technical University of Braunschweig, Germany; University of São Paulo, Brazil
- Associate Fellow: American Institute of Aeronautics and Astronautics (AIAA)
- Member: AIAA Structural Dynamics Technical Committee and International Organizing Committee of International Conference on Adaptive Structures Technologies



### Oren E. Petel, PEng

*Assistant Professor*

#### RESEARCH AND APPLICATION

Shock and blast wave physics; impact mechanics; high-strain rate deformation of multiphase materials; optimization of cermet (heat-resistant materials made of ceramic and sintered metal) for biomimetic armour; nanotube modification of polymers; smart materials for protective applications; injury biomechanics of concussion; development of deformable headforms with integrated strain-based diagnostics for helmet testing and concussion prevention. Applications include the prevention of personal injury through

the integration of novel materials in personal protective equipment for blast wave, ballistic impact and general blunt impact.

#### SELECTED ACTIVITIES

- Scientific Programme Committee Member - Military Aspects of Blast and Shock 2016 Conference
- Member of the American Physical Society, Shock Compression of Condensed Matter Topical Group



### Joana Rocha, PEng

*Assistant Professor*

#### RESEARCH AND APPLICATION

Aeroacoustics and acoustics; aircraft and wind-turbine noise; turbulent-flow induced noise; experimental aeroacoustics; wind tunnel testing; turbulence modelling; bio-inspired aircraft structural design for noise reduction; analytical and numerical modelling for noise and vibration prediction; human speech. Applications include community noise reduction, development of quieter aircraft concepts and advanced wing trailing edge

concepts, simulation of flight conditions, structural design enhancement for reduced noise and vibration, and aircraft cabin design optimization.

#### SELECTED ACTIVITIES

- Associate Editor, Canadian Acoustics Journal Member of the Board of Directors, Canadian Acoustical Association



### Donald Russell, PEng (Nova Scotia)

*Clerk of Senate; Associate Dean (Academic Planning and Policy); Professor*

#### RESEARCH AND APPLICATION

Dynamics and modeling of mechanical systems; biomechanics; interaction between mechanical and biological systems; prosthetic limbs; biomechanics of piano playing and related injuries; patient simulators.

#### SELECTED ACTIVITIES

- Past-President, Canadian Medical and Biological Engineering Society
- Adjunct Professor, School of Music, University of Ottawa



### Henry M. J. Saari, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Processing (powder metallurgy, casting, brazing and heat treatment) and properties of gas turbine materials (titanium aluminides, superalloys); corrosion of materials in supercritical carbon dioxide; supercritical carbon dioxide Brayton cycle development. Applications include advanced gas turbine technology for high-efficiency power generation and new, lightweight, high-

temperature materials to improve efficiency and power output of gas turbine engines.

#### SELECTED ACTIVITIES

- Executive Member, ASM International, Ottawa Valley Chapter



### Jurek Sasiadek, PEng

*Professor*

#### RESEARCH AND APPLICATION

Guidance, navigation and control; robotics; sensor and data fusion; mechatronics; unmanned aerial vehicles (UAVs); mobile robots; intelligent and adaptive control systems; autonomous systems; non-linear control; cooperative robot control; vision systems; global positioning systems; inertial navigation systems. Aerospace applications include autonomous flying planes and helicopters, mobile robots for security, and spacecraft formation flying. Additional applications include energy systems, power

plant stations, and heart and cardiovascular health monitoring using imaging and computerized tomography (CT) methods.

#### SELECTED ACTIVITIES

- Director, American Council of Automatic Control
- Member, Council, International Federation of Automatic Control
- Technical Committee Member, AIAA Guidance, Navigation and Control



### Steen A. Sjolander, PEng

*Chancellor's Professor; Pratt and Whitney Canada Research Fellow*

#### RESEARCH AND APPLICATION

Axial-flow compressors and turbines; experimental techniques for low-speed and transonic aerodynamics of turbomachinery; flow control for turbomachinery; gas turbine engines; low emissions; greenhouse gas reduction; supercritical carbon dioxide power cycles. Applications include aircraft and industrial gas turbine engines, power generation units for low-emission and lower temperature, and alternative heat sources.

#### SELECTED ACTIVITIES

- Member, Turbomachinery Committee, American Society of Mechanical Engineers
- Member, College of Reviewers, Canada Research Chairs Program



### Andrew D. Speirs, PEng

Assistant Professor

#### RESEARCH AND APPLICATION

Pathomechanisms of osteoarthritis; femoroacetabular impingement; quantitative analysis of medical imaging. Application includes combining in vitro testing, medical image analysis and finite element analysis to better understand the potential mechanical causes of osteoarthritic (OA) degeneration of joints.



### Choon-Lai Tan

Professor

#### RESEARCH AND APPLICATION

Computational mechanics/stress analysis; boundary element methods; fracture mechanics; anisotropic thermoelasticity; mechanics of composites.

#### SELECTED ACTIVITIES

- Member, Editorial Board, *Computer Modeling in Engineering and Sciences*, *Electronic Journal of Boundary Elements*, *Advances in Fracture Mechanics*, book series, WIT Press, U.K.

- Conference sessional chair, International Conference on Computational & Experimental Sciences; Boundary Element Techniques conferences
- Member, International Scientific Committee, International Conference on Computational & Experimental Sciences; Boundary Element Techniques conference series; Asia-Pacific International Conferences on Computational Methods in Engineering



### Steve Ulrich, PEng

Assistant Professor

#### RESEARCH AND APPLICATION

Adaptive control theories; intelligent machine learning; computer vision; robotics; nonlinear optimization techniques; real-time path-planning algorithms; orbital mechanics and dynamics modeling. Applications include intelligent aerospace robotic vehicles, free-floating robotic manipulators, robotic capture mechanisms, spacecraft formation flying, proximity operations, rendezvous and docking, and autonomous spacecraft guidance, navigation and control.

#### SELECTED ACTIVITIES

- Associate Editor, American Control Conference (2015-2016)
- Technical Area Chair, Aerospace Robotics, AIAA Guidance, Navigation and Control Conference (2016-2017)
- Program Committee Member, 20th IFAC Symposium on Automatic Control in Aerospace (2016)
- Member, IFAC Technical Committee on Adaptive and Learning Systems
- Member, AIAA Guidance, Navigation and Control Technical Committee
- Member, AIAA Space Automation and Robotics Technical Committee





### **Xin Wang, PEng**

*Professor*

#### **RESEARCH AND APPLICATION**

Solid mechanics; linear and nonlinear fracture mechanics; finite element method; fatigue and fracture analyses of engineering materials and structures; structural integrity assessment methods; material characterization and numerical simulation of material damage and failure process. Applications include the development of advanced manufacturing processes for metal forming industries and the assessment of engineering component fatigue and fracture in pressure vessel and offshore and aerospace industries research.

#### **SELECTED ACTIVITIES**

- Member of Scientific Committee, Session Organizer/Chair – ASME International Conference on Offshore Mechanics and Arctic Engineering (2014-2017)
- Member of Scientific Committee, 14<sup>th</sup> International Conference on Fracture, Rhodes, Greece (2017)
- Member of Editorial Board – Advances and Applications in Mechanical Engineering and Technology (Scientific Advances Publishers, ISSN: 0976-142X), Journal of Aeronautics & Aerospace Engineering, (OMICS Group, ISSN: 2168-9792)
- Member of Technical Committee – ASTM E08 on Fatigue and Fracture Mechanics



### **Jo Y. Wong, CEng, PEng, FIMechE, FASME, FCSME**

*Distinguished Research Professor*

#### **RESEARCH AND APPLICATION**

Ground transportation technology; vehicle mobility on terrestrial, extraterrestrial, and subsea surfaces; road vehicle dynamics; applications of advanced technologies to vehicle engineering, including air cushion technology and magnetic levitation systems.

#### **SELECTED ACTIVITIES**

- Member, Editorial Boards of Vehicle System Dynamics, International Journal of Heavy Vehicle Systems, and Journal of Terramechanics
- Fellow and Former President, International Society for Terrain-Vehicle Systems



### **Metin I. Yaras, PEng**

*Professor*

#### **RESEARCH AND APPLICATION**

Numerical and experimental study of fluid flow and heat transfer phenomena; with a focus on flow instability, transition and turbulence; transition control in separated shear layers; aerodynamics of lobed mixers with three-dimensional inflow velocity fields; aerodynamics of low-Reynolds number airfoils for gas-turbine, UAV-propeller and wind-turbine applications; direct numerical simulation and experimental study of convection heat transfer in supercritical

fluids as related to the cooling of fuel rods in Generation-IV nuclear reactors; development of a novel hydrokinetic turbine for tidal-current and river applications with improved power-to-size ratio; computational study of blood flow in the aorta.

# DEPARTMENT OF Systems and Computer Engineering

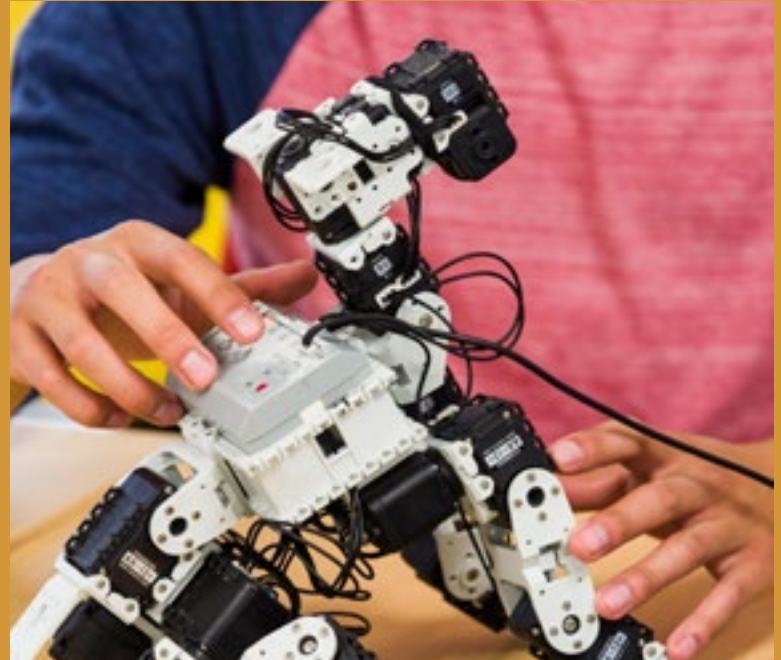
# CARLETON

The Department of Systems and Computer Engineering is one of the largest and most research-intensive departments of electrical and computer engineering in Canada and is recognized as one of the world leaders in software engineering and computer systems engineering.

The department's comprehensive research strengths include communications, software design, computer systems, biomedical engineering, and technology management. Our communications researchers are internationally recognized for their expertise and are collaborating with leading industrial partners to develop the next generation of broadband wireless communication networks. We have developed a strong group of biomedical researchers who have developed better methods for diagnosing diseases, improved the computer-assisted analysis of medical data and researched innovative systems, such as surgical simulators for training doctors. The department also has a prominent research group in simulation and visualization.

Our software engineering research team is ranked as one of the best in the world and is internationally renowned. Team members have developed new methods of software validation and verification and have made advances in computer network intrusion detection.

Our team of computer systems researchers has been thriving for more than three decades, leading Carleton's computer systems engineering program to be ranked as one of the best in the world. Researchers are developing new algorithms for cloud computing and security, as well as



Fourth year Capstone projects for students include the development of a “robotic guide dog.” Student teams develop and refine a system for navigation, communication and response.

methods of artificial intelligence and multi-agent learning algorithms with applications in robotics.

## Core Themes

### COMPUTER SYSTEMS ENGINEERING

Reliable computer systems are fundamental to many modern systems. This requires careful engineering of software as well as trustworthy hardware-software co-design for systems that involve computers as an embedded element. Research is underway to devise effective middleware techniques for providing interoperability and performing resource management in large distributed systems, with applications to cloud computing. There is a substantial effort to model and improve the performance and reliability of software systems ranging from embedded communications software to enterprise service systems.

## SOFTWARE ENGINEERING

Research focuses on technology evaluation (empirical software engineering) as well as the development of improved methodologies. Our overall objective is to offer effective and efficient methodologies to develop dependable software systems in aerospace, health care, telecommunications and security. Research pertains to many aspects of software engineering, including, but not limited to:

- requirement engineering;
- model-driven engineering (mainly UML-based software development);
- software architectures;
- product lines;
- aspect-oriented programming;
- verification, validation and testing; and
- software maintenance.

## COMPUTER COMMUNICATIONS, DISTRIBUTED SYSTEMS AND MULTIMEDIA

Research focused on advanced computer networks and contemporary computer applications includes:

- traffic modeling;
- algorithmic performance analysis;
- MPEG video;
- multicasting;
- IP;
- network security;
- information assurance;
- network architecture and applications;
- multimedia;
- animation;
- computer vision;
- virtual reality environments; and
- real-time, parallel and distributed systems.

## DIGITAL AND WIRELESS COMMUNICATIONS

Reliable, efficient communication of voice and data (including images and video) is a cornerstone of the modern economy. Research in this area covers all aspects of communication, including:

- mobile wireless systems;
- optical networks;
- network traffic modeling and protocols;
- cellular, ad hoc and sensor networks;
- cross-layer optimization;
- compression algorithms;
- UAV communications;
- Internet of Things (IoT);
- physical layer technologies;
- software defined networks (SDN);

- intelligent transportation systems; and
- wireless standards.

## SIGNAL, SPEECH AND IMAGE PROCESSING

Focused on the acquisition and processing of data, including acoustic, voice, image, video and biomedical signals, research examines compression of data and reliable transmission over noisy wireless channels as the volume of data increases. Applications include:

- noise reduction;
- speech quality enhancement;
- Voice-over-Internet-Protocol; and
- improved video conferencing.

## SYSTEM AND MACHINE INTELLIGENCE

Computer-based systems can undertake more advanced functions as their 'intelligence' increases. Research addresses issues on the spectrum of machine intelligence, from classical optimization and control to new methods such as genetic algorithms and swarm intelligence. Applications include improved:

- design of systems;
- control of robots;
- control of prostheses; and
- diagnosis of disease.



## BIOMEDICAL ENGINEERING

Our research reflects the diversity and interdisciplinary of biomedical engineering. Our department focuses on the analysis of biomedical signals, with particular emphasis on:

- ultrasound;
- NMR/MRI;
- electrical impedance tomography;
- infrared imaging;
- electrocardiography;
- electromyography;
- heart sounds;
- 'electronic nose' sensor data; and
- multisensory stethoscopes.

Alongside our work in the analysis of biomedical signals, we develop biomedical instruments and devices, such as improved user interfaces for assistive devices, which rely on our strengths in signal processing and artificial intelligence. There is significant research activity in biomedical informatics, including both bioinformatics and clinical informatics.

### TECHNOLOGY INNOVATION MANAGEMENT

The development and commercialization of new technologies is a process as complex as the technologies themselves. Research focuses on commercialization and business development beyond the laboratory, including methods to grow technology businesses, particularly during the early stages of the technology lifecycle. Applications include:

- capturing value from technology in open environments;
- product development management;
- venture capital and technology company creation; and
- management in the development of telecommunications technology-intensive products and services.

## Research Facilities

### TEXAS INSTRUMENTS EMBEDDED PROCESSING LABORATORY

The lab equips the next generation of engineers with the skills to develop innovative solutions across a wide array of electronics in some of the most exciting markets, including medical, sustainable energy and smart grid, automotive, and home automation. In addition to using Texas Instruments (TI) embedded processors to power these systems, students also have access to TI's broad portfolio of analog technologies for a complete system solution.

### ALCATEL-LUCENT ADVANCED NETWORKS LABORATORY

Carleton is the only Canadian university selected for Alcatel-Lucent's Research Partner Program, which fosters innovation through strategic research partnerships. The laboratory is equipped with three ATM switches, bridges and interface cards. Research focuses on computer networks to improve network management, performance, and quality of service through rapid analysis and quality control.

### MITEL NETWORKS AND ANALOG DEVICES INCORPORATION VOIP LABORATORY

Based on the Mitel Integrated Communications Platform (ICP3200), the laboratory is equipped with 20 development stations, each with a PC and three phones (analog, digital, and IP). Other equipment includes:

- a speech quality analyzer;
- speech recognition system;
- video cameras; and
- quality-of-service testing equipment.

Research concentrates on Internet telephony, next-generation telephone equipment and services, and systems technology. Advanced technology in speech

quality enhancement, high-fidelity stereophonic sound for telephones, and voice and speaker recognition is also pursued.

### REAL-TIME AND DISTRIBUTED SYSTEMS LABORATORY

Performance and resource management aspects of parallel and distributed systems are explored, including matching the software architecture to the system requirements and evaluating implementation architectures (e.g., for scalability). New methodologies for hardware-software co-design are under development, such as the formalization of Use Case Maps notation and ways of designing event-driven software through software computer-aided design. Software performance engineering is also studied, including methods for predicting the performance of concurrent systems.

### SOFTWARE QUALITY ENGINEERING LABORATORY

The laboratory focuses on applied software engineering research and is dedicated to developing new methodologies and prototype tools to produce higher quality software. Activities concentrate on the verification and validation of software systems with an emphasis on object-oriented systems and high-dependability systems. Model-driven development and object-oriented analysis and design with the Unified Modeling Language (UML), software quality assurance and control based on quantitative methods, and experimental software engineering are studied. The laboratory researches automated testing of object-oriented, distributed, and real-time systems and automated support for impact analysis of object-oriented designs and change management.

### BIOMEDICAL ENGINEERING LABORATORY

Laboratory equipment includes:

- three thermographic cameras;
- a sixteen-channel biological signal acquisition system for collecting myoelectric signals, ECGs, and EEGs;
- AlphaMOS Prometheus and Cyranose electronic noses;
- electrical impedance tomography and respiratory inductance plethysmography systems;
- a benchtop NMR spectrometer; and
- ultrasonic medical imaging/measurement systems.

Advanced technologies being developed for diagnostics and treatment include:

- signal processing and compression of medical data in noisy environments;
- artificial intelligence systems for estimating clinical outcomes in neonatal intensive care and other medical situations;
- intelligent sensor systems for remote monitoring;
- myoelectric control of upper arm prostheses, prediction of gene regulation and protein structure and function through bioinformatics;
- diagnostic aid tool for rheumatoid arthritis;
- imaging of regional lung function using electrical impedance tomography; and



- ultrasonic medical imaging and diagnosis as well as applications in telesurgery and telemedicine.

Collaborators include the Children's Hospital of Eastern Ontario, University of Ottawa Heart Institute, Ottawa Hospital Rehabilitation Centre, Health Canada, and the SCO Health Service.

### ADVANCED REAL-TIME SIMULATION LABORATORY

With a high-performance computing platform to support an advanced real-time simulation engine (including hardware in-the-loop and graphics workstations for human interaction), the laboratory is devoted to research into real-time modeling and simulation, and the creation and execution of very large and complex models with strong timing requirements. Research includes mechanisms for automatic generation of executable models derived from specifications of the systems and formal methods for modeling and simulation. Focus is on practical projects using advanced development tools and 3D visualization, such as model-based development of embedded and real-time applications, parallel and distributed simulation techniques, and interoperability of executing models.

We collaborate with McGill University, Concordia University, ACIMS (University of Arizona, USA), *Polytech de Marseille*, *Université de Nice/INRIA Sophia-Antipolis*, *Université Blaise Pascal* (France). The laboratory is a member of the Carleton University Centre for Visualization and Simulation.

### HUAWEI-TELUS INNOVATION CENTRE FOR ENTERPRISE CLOUD SERVICES

A venue for cutting-edge research in cloud computing, students, faculty and industry partners research problems associated with enterprise clouds, including management of computing, on-demand storage and network resources, data-centre networking, scalability, business continuity and security.

### Partners and Collaborators

Carleton University's location in the nation's capital provides easy access to major government research laboratories such as the National Research Council, the Communications Research Centre, Defence Research and Development Canada, and National Defence Canada.

### Funding and Sponsorship

Our research is supported by a wide array of industry leaders including: Alcatel, Bell, BlackBerry, Ericsson, Huawei, IBM, IDT Canada, Intel, Mitel, Samsung, TELUS and many others. Several industrial partners have donated fully equipped laboratories for use in research and graduate training, including Alcatel-Lucent, BlackBerry, Huawei, IBM, Mitel, TELUS and Texas Instruments.



**Biomedical engineering students are developing new algorithms to assess asthma and obstructed breathing and comparing them to existing methods. Here, a spirometer measures the volume of air breathed in and out, while the sealed plethysmograph chamber detects changes in pressure to monitor lung volume and effort.**

### Graduate Programs

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The MASc, MEng, and PhD in electrical engineering are offered through the Ottawa-Carleton Institute for Electrical and Computer Engineering, a joint initiative between Carleton's Department of Electronics and the University of Ottawa's School of Information Technology and Engineering. This arrangement offers our students access to a wide range of graduate courses in electrical and computer engineering.

The MASc, MEng, and MEnt in technology innovation management provide advanced education at the interface of telecommunications technology and technology management.

The MASc and MEng in biomedical engineering are interdisciplinary degree programs offered through the Ottawa-Carleton Institute for Biomedical Engineering, which combines the resources of several departments at Carleton University and the University of Ottawa, and draws upon the expertise of medical research units.



Read more about faculty members' research at [sce.carleton.ca/dept/sce.php/people\\_faculty](http://sce.carleton.ca/dept/sce.php/people_faculty)



### Andy Adler, PEng, SMIEEE

*Canada Research Professor*

#### RESEARCH AND APPLICATION

Development of novel biomedical measurement devices and medical image and signal processing algorithms; electrical impedance tomography for monitoring of lung and heart functions; biometrics imaging and security systems and associated algorithms, measurement devices, and privacy and security aspects; image reconstruction algorithms for ill-conditioned systems with correlated data; statistical models to compare human-versus-machine face recognition;

demonstrated vulnerabilities in biometric encryption; measuring parameters for conducted energy weapons safety.

#### SELECTED ACTIVITIES

- Maintainer of open source toolkit for Impedance Imaging ([www.eidors.org](http://www.eidors.org))
- Member, Canadian Advisory Committee, ISO JTC1/SC37 Biometrics



### Victor Aitken, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Control systems; state estimation; data and information fusion; redundancy; sliding mode systems; non-linear systems; vision, mapping and localization; sensing, control and state estimation methods for navigation and guidance of unmanned vehicle systems; vision, state estimation and information fusion for robotics and biomedical applications. Applications include large scale robotic landmine detection systems for the Canadian

military, automation of underground mining machines for Canadian industry, and detection and analysis of eye motion for automation of retinal surgery.

#### SELECTED ACTIVITIES

- Member, IEEE International Conference on Automation and Logistics
- Member, IEEE International Workshop on Robotic and Sensor Environments



### Samuel A. Ajila, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Software requirements engineering; model driven approach and aspect oriented design; cloud resource provisioning and management; software deployment in the cloud and multi-tenancy; big data analytics, including software repository, multi-media, and networks radio traffic data. Applications include software intensive systems, industrial processes and

software new product development (S-NPD), and cloud service provider and data centres.

#### SELECTED ACTIVITIES

- Member, Portland International Center for Management of Engineering and Technology (PICMT)



### Tony Bailetti

*Director of Technology Innovation Management (TIM) program; Associate Professor*

#### RESEARCH AND APPLICATION

Technology commercialization and company creation; distributed product development; open source software; design and implementation of methods to grow technology businesses, particularly in open environments and during the early stages of the technology life cycle; capture value from technology in open environments; design and development of complex products.

#### SELECTED ACTIVITIES

- Vice-President, Research, Executive Council, Engineering and Technology Management Education and Research Council



### Amir Banihashemi, PEng, SMIEEE

*Professor*

#### RESEARCH AND APPLICATION

Information theory and coding; network coding; joint source-channel coding and distributed source-channel coding; space-time coding and processing; theory and implementation of iterative coding schemes; compressed sensing; multimedia transmission over internet and wireless links; cooperative coding and communication; analog decoding. Applications include digital and wireless communications, communication networks, and signal processing.

#### SELECTED ACTIVITIES

- Section Chair of NSERC's Electrical and Computer Engineering Evaluation Group (2014-2016)
- TPC member, ICC (2014-2016)
- TPC Member, Globecom (2014-2016)



### Adrian D. C. Chan, PEng, SMIEEE

*Professor*

#### RESEARCH AND APPLICATION

Biomedical engineering; biological signals (ECG, EMG, EEG); biomedical signal quality analysis; assistive devices; signal processing; colour image processing. Applications include multi-modal, non-invasive sensor systems for remote and/or portable monitoring (such as ambulatory ECG monitoring for myocardial ischemia detection), technologies to support independent living and accessibility, and image processing for computer aided diagnosis in histopathology.

#### SELECTED ACTIVITIES

- Chairperson, Advisory Board READ (Research Education Accessibility and Design) Initiative (2012 – Present)
- Track Chair (Biosignal Processing), World Congress on Medical Physics and Biomedical Engineering (2015)
- International Program Committee Member, IEEE International Workshop on Medical Measurement and Applications (MeMeA) (2015)



### John Chinneck, PEng

*Professor*

#### RESEARCH AND APPLICATION

Optimization (i.e., determining an optimal choice when restricted by constraints); mathematical programming; operations research; modeling; mixed-integer programming; linear and non-linear programming, especially global optimization; heuristics; infeasibility analysis; algorithms to analyze and debug optimization models and to speed optimization solutions. Recent applications include improved task allocation in cloud computing, channel assignment in wireless mesh networks, 3G communications network planning, and data classifiers.

#### SELECTED ACTIVITIES

- Editorial Board, Constraints journal (2011 - Present)
- Technical Program Committee, Learning and Intelligent Optimization Conference LION 10 Ischia Island, Italy (2016)
- Program Committee, International Conference on Operations Research and Enterprise Systems, Rome, Italy (2016)
- Program Committee, International Conference on Operations Research and Enterprise Systems, Lisbon, Portugal (2015)



### Richard Dansereau, PEng, SMIEEE

*Associate Dean (Student Affairs); Professor*

#### RESEARCH AND APPLICATION

Digital signal processing; biomedical signal processing; multimodal and/or multi-channel signal separation and enhancement; compressive sensing; sparse signal processing; blind source separation; non-negative matrix and tensor factorization; joint audio-visual processing, scalable wavelet image/video compression; robust error-resilient video transmission; video quality metrics; quality

of service (QoS); wavelets; fractal measures; chaotic dynamic systems. Applications include compressive sensing in radar, single channel speech separation, speech enhancement using visual cues, speaker tracking, musical instrument separation from mixed recordings, fetal ECG signal separation from maternal ECG signal using phonocardiogram side information, and EMG signal decomposition to extract motor unit action potential rings.



### Mohamed El-Tanany, PEng

*Professor*

#### RESEARCH AND APPLICATION

Transmission techniques for wireless channels, with emphasis on experimental work and use of realizable digital signal processor (DSP) algorithms; wireless and wired communication systems; digital signal processing for modeling and compensation for non-linearity and phase noise in Long-Term Evolution (LTE) physical layer; software defined radio receivers; synchronization of communications receivers

for wireless radio channels; analysis based on measurement data collected through non-destructive-testing. Applications include wireless sensor area networks in smart home environments and robust transmission techniques for wireless sensor networks in environments where the propagation conditions are particularly difficult, resulting in time varying rich multipath profiles.



## Babak Esfandiari

*Professor*

### RESEARCH AND APPLICATION

Agent-based system; network computing; trust management and reputation systems. Applications include decentralized data sharing systems, peer-to-peer networks, and autonomous robots.

### SELECTED ACTIVITIES

- Editorial Boards of: Computational Intelligence, Journal of Trust Management
- Program Committees: IEEE Conference on Privacy, Security and Trust,
- IFIP Conference on Trust Management, AAAI Video Competition



## Greg Franks, PEng, SMIEEE

*Associate Professor*

### RESEARCH AND APPLICATION

Software engineering; analytic performance modeling using “layered queues”; discrete event simulation of distributed computer systems; reverse engineering of distributed software systems through trace analysis; model building, solution and analysis process; operating systems; operating system schedulers. Applications include an expanded use of modeling tools and the setting of performance budgets for components in

order to develop feasible designs, locate bottlenecks, and plan resources for installed systems, leading to reducing risk and substantial cost savings for performance-sensitive projects.

### SELECTED ACTIVITIES

- Member of the program committee, International Workshop on Load Testing of Large Software Systems (2014-2015)



## Monique Frize, PEng, IEEE Fellow, CAE Fellow

*Distinguished Research Professor*

### RESEARCH AND APPLICATION

Biomedical engineering; thermal medical image collection and analysis to assess pain, potential musculoskeletal injuries in piano players, and level of inflammation in rheumatoid arthritis patients; ethics for engineers; women in science and engineering; artificial intelligence tools applied to decision making in the clinical environment, such as in estimating pre-term births and delivery mode and outcomes for neonatal intensive care infants; medical equipment management in industrialized and developing countries; thermal imaging.

### SELECTED ACTIVITIES

- Council member, International Union for Physical and Engineering Sciences in Medicine
- Editorial Boards, Biomedical Engineering Online, Medical Engineering & Physics
- President, INWES Education and Research Institute



### Rafik A. Goubran, PEng, IEEE Fellow, CAE Fellow

*Acting Vice-President (Research and International); Professor*

#### RESEARCH AND APPLICATION

Digital signal processing and its applications in biomedical engineering, sensors, smart homes, and speech processing; echo and noise cancellation, pattern recognition, and classification; patient monitoring using non-intrusive sensors (pressure-sensitive mats); environmental sensors (radio frequency identification and electronic noses); smart-phone based sensors (accelerometers); wearable sensors (electrocardiogram, skin conductance, breathing); heart and lung sound analysis; thermal imaging; smart hearing aids; speech quality enhancement; broadband and stereophonic Voice over Internet Protocol (VoIP); smart multimedia VoIP terminals.

#### SELECTED ACTIVITIES

- Co-Leader and Research Scientist, TAFETA, Elisabeth Bruyere Research Institute (2005 - Present)
- Member, Technical Program Committee, IEEE-MeMeA and IEEE-I2MTC (2009 - Present)
- Former Dean, Faculty of Engineering and Design, Carleton University (2007-2016)
- Executive Committee, Global Engineering Deans Council (2013-2016)
- Chair, Council of Ontario Deans of Engineering (2009-2011)



### James Green, PEng, SMIEEE

*Associate Professor*

#### RESEARCH AND APPLICATION

Proteomics and biomedical informatics, including characterization of protein structure, interaction and function from sequence and the prediction of post-translational modification of proteins; machine learning; pattern classification; high performance computing on multicore processors. Applications include real-time patient monitoring, hardware acceleration of bioinformatics algorithms, computational identification of thyroid response elements, and development of novel assistive devices for persons with disabilities and the elderly.

#### SELECTED ACTIVITIES

- Associate Editor, Journal of Medical and Biomedical Engineering
- Track Co-Chair (Bioinformatics), World Congress on Medical Physics and Biomedical Engineering (2015)
- Vice-Chair, IEEE EMBS Ottawa Chapter



### Roshdy H. M. Hafez, PEng, SMIEEE

*Professor*

#### RESEARCH AND APPLICATION

Wireless theory; local access technologies; orthogonal frequency-division multiplexing (OFDM) and 3G/4G/5G broadband wireless access; machine to machine (M2M) and the Internet of Things (IoT); local area networks (LANs) and ad-hoc networking; wireless ad-hoc networking and rapid deployment of transportable wireless access points; self-organizing networks; heterogeneous networks

and adaptive radio coverage; radio frequency (RF) design and integrated fibre/wireless local loops with applications in sensors networking. Additional applications include wireless network dimensioning, intelligent wireless video coverage and event detection, improved security for voice over Long-Term Evolution (LTE) networks, and integrated Project 25 (P25)/Terrestrial Trunked Radio (TETRA)/LTE for robust, reliable broadband.





## Changcheng Huang, PEng, SMIEEE

*Professor*

### RESEARCH AND APPLICATION

Traffic modeling and fast simulation techniques; network congestion control and quality of service (QoS) mechanisms; network failure detection and protection mechanisms; internet architecture and protocols; network protocol design and implementation; resource allocation and optimization in wireless and sensor networks; stochastic control in computer networks; modelling and simulation techniques; reliability mechanisms for optical

networks. Applications include multimedia networking, traffic engineering for carrier networks, the Internet of Things (IoT), big data, and 5G wireless networks.

### SELECTED ACTIVITIES

- Associate Editor, Photonic Network Communications, Springer
- Technical Committee Member, ICC (2015), Globecom (2015), NaNA (2016), ACP (2016)



## Mohamed Ibnkahla, PEng, SMIEEE

*Cisco Research Chair in Sensor Technology for the Internet of Things; Professor*

### RESEARCH AND APPLICATION

Wireless sensor networks; Internet of Things (IoT); cognitive radio networks; adaptive signal processing; reconfigurable networks; sensor integration; radio frequency identification (RFID) systems. Applications include smart homes and smart cities, security and safety, healthcare, smart grids, renewable energies

and green society, intelligent transportation systems, environment monitoring, and retail and logistics.



## Thomas Kunz, SMIEEE

*Professor*

### RESEARCH AND APPLICATION

Network protocols and architectures for multihop wireless networks, including mobile ad hoc networks (MANETs), mesh networks, sensor networks, and vehicular ad hoc networks (VANETs); clock synchronization and localization in wireless sensor networks and fixed networks; Internet of Things (IoT) application, such as smart grids and smart homes; software-defined networks (SDNs) and network function virtualization (NFVs) for next-generation wired and wireless networks.

### SELECTED ACTIVITIES

- TPC Co-Chair, 8<sup>th</sup> EAI International Conference on Ad Hoc Networks (AdHocNets) (2016)
- Co-Guest Editor, Special Issue "Ad Hoc Networking and Emerging Applications," ACM/Springer Mobile Networks & Applications (MONET)
- Technical Committee Member, Canada's Centre of Excellence in Next Generation Networks (CENGN)
- Serve on a number of TPCs of international conferences, including IFIP Networking, ICC, Globecom, and Milcom (2015-2016)



### Yvan Labiche, PEng, SMIEEE

*Chair, Associate Professor*

#### RESEARCH AND APPLICATION

Software engineering; software verification and validation; model-based testing; software testing (unit/integration/system, functional/structural, procedural, object-oriented, and real-time); model-driven development; unified modeling language (UML); search-based software engineering; empirical software engineering; technology evaluation. Applications include telecommunication software; security (network intrusion detection), airworthiness software, and health care (medical imaging systems).

#### SELECTED ACTIVITIES

- General Chair of the 27<sup>th</sup> IEEE International Symposium on Software Reliability Engineering
- Associate Editor, Journal of Software Testing, Verification and Validation



### Ioannis Lambadaris, PEng

*Professor*

#### RESEARCH AND APPLICATION

Applied stochastic processes; stochastic optimization and optimal control; next generation internet (NGI) architectures; cloud computing; software defined networking (SDN); network function virtualization (NFV) orchestration, management and performance analysis; radio frequency (RF) transceiver architectures, RF design, high-speed signal

integrity, process control block (PCB) design; real time RF spectrum sensing. Applications include queue management, resource allocation and scheduling, wireless sensor networks for remote control and surveillance, and performance analysis of computer and communication networks.



### Peter Xiaoping Liu, PEng, SMIEEE

*Canada Research Professor*

#### RESEARCH AND APPLICATION

Network-based teleoperation and telerobotics; context-aware networks; haptics; robots and intelligent systems. Applications include telesurgery, minimally invasive surgery, and surgery training systems.

#### SELECTED ACTIVITIES

- Associate Editor, IEEE Transactions Automation Science and Engineering



## Chung-Horng Lung, PEng, SMIEEE

*Professor*

### RESEARCH AND APPLICATION

Software engineering and architecture analysis; cloud computing; data analytics; Internet of Things (IoT); computer networks, software-defined networking, traffic engineering. Applications include increasing system, software and network performance, improving software quality, and enhancing network robustness.

### SELECTED ACTIVITIES

- Director of the Ottawa-Carleton Institute for Electrical and Computer Engineering
- Workshops co-chair, IEEE International Conference on Computers, Software & Applications (2016-2017)
- Technical Program Committee member of several international conferences, including IEEE ICC and IEEE GLOBECOM (2010-2016)



## Samy A. Mahmoud, PEng, SMIEEE

*Professor Emeritus*

### RESEARCH AND APPLICATION

Optical and infrared sensors; sensors networks; signal processing and embedded computing systems. Applications to biomedicine include wearable sensor devices with wireless communications capability (to monitor the cardio-vascular daily activity of patients). Environmental applications include wireless chemical and bio sensors networks deployed over large geographic areas and in water reservoirs (to detect pollutants, harmful biological agents and other carcinogens). Applications for transportation include vehicle-to-vehicle communications and

boundary mapping in areas experiencing low visibility conditions (to provide early warning signals to motorists).

### SELECTED ACTIVITIES

- Senior Evaluator, European Program for Research (2010-2015)
- General Chair, Intelligent Transportation Technologies Conference (2015)
- Former Dean, Faculty of Engineering and Design, Carleton University (1998-2006)
- Former Acting President and Vice Chancellor, Carleton University (2006-2008)



## Shikharesh Majumdar, PEng, SMIEEE

*Professor*

### RESEARCH AND APPLICATION

Resource management on wireless sensor networks and clouds and grids; cloud-based platforms for big data analytics; Internet of Things (IoT) and sensor-based systems; mobile web services; extensible markup language (XML) filtering and forwarding; middleware; operating systems; telecommunication systems; smart

facilities management; distributed systems; performance modeling and optimization. Applications include utility computing, cloud computing, scientific computing, high performance systems, sensor-based bridge infrastructure management, as well as batch, real-time and streaming data analytics.



### Ian Marsland, PEng

*Associate Chair (Undergraduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

Digital communication; wireless communication; error control coding; polar codes; equalization; multiple-input and multiple-output (MIMO) systems; iterative detection and decoding; advanced receiver architectures for efficient wireless communication systems. Application includes wireless systems that are capable of serving more people with increased reliability and transmission speeds.

#### SELECTED ACTIVITIES

- Technical Program Committee, IEEE Vehicular Technologies Conference (2015-2016)
- Member, PEO Emerging Disciplines Task Force



### Yuu Ono, PEng, SMIEEE

*Associate Professor*

#### RESEARCH AND APPLICATION

Biomedical sensors, techniques and systems regarding physiological monitoring, medical imaging and diagnosis, and biological tissue characterization. Applications include real-time monitoring, control and optimization of material processes, ultrasound measurement and imaging, and non-destructive evaluation of products and structures.

#### SELECTED ACTIVITIES

- Scientific Committee, ICBES'16, Budapest, Hungary (2016)
- Advisory committee, Technical program committee, IEEE EMBS ISC, Ottawa (2016)
- Member, Organizing committee, Ultrasonic Electronics Symposium, Tsukuba, Japan (2015)
- Secretary, IEEE EMBS Ottawa chapter (2015 - Present)



### Trevor W. Pearce, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Real-time systems and operating systems; embedded systems; real-time simulation; computer engineering education. Applications include an increased use of modeling and simulation in the engineering of real-time systems and improving the application of hard real-time system performance prediction by accounting for run-time overheads more accurately.

#### SELECTED ACTIVITIES

- Member, Drafting Committee, IEEE Standard Modeling and Simulation, and High Level Architecture



## Dorina C. Petriu, PEng, SMIEEE, CAE Fellow, EIC Fellow

*Chancellor's Professor*

### RESEARCH AND APPLICATION

Software performance engineering; model-driven software development; real-time and distributed software; model transformations; integrating performance and dependability analysis in the software development process. Applications include improving non-functional requirements of real-time systems in domains with strong performance and dependability constraints, such as aerospace, healthcare and telecommunications.

### SELECTED ACTIVITIES

- Editorial Board, Software and Systems Modeling (SoSyM), Springer journal.
- Steering Committee and Technical Program Committee Member, ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MODELS)
- Technical Program Committee Member, ACM/SPEC International Conference on Performance Engineering (ICPE)
- Technical Program Committee Member, ACM International Conference on the Quality of Software Architectures (QoSA)



## Sreeraman Rajan, SMIEEE

*Canada Research Chair in Sensor Systems (Tier II); Associate Professor*

### RESEARCH AND APPLICATION

Signal processing; sensor data processing; biomedical signal processing; multi-modal, non-invasive sensor systems for remote and/or portable monitoring (i.e. continuous vital signal monitoring using contactless sensors); signal processing for detection, identification and tracking relating to defence and security (i.e. sensing through walls); machine learning for pattern classification.

### SELECTED ACTIVITIES

- Chair, IEEE EMBS Ottawa Chapter (2009 - Present)
- Steering Committee member for IEEE MeMeA and IEEE MWSCAS Conferences
- Member, IEEE MGA Admission and Advancement Committee (2015 - Present)
- Associate Editor, Canadian Journal of Electrical and Computer Engineering



## Howard Schwartz, PEng, SMIEEE

*Professor*

### RESEARCH AND APPLICATION

Reinforcement learning, adaptive control, robot control, and system identification and estimation; computer learning, with focus on robotic applications; fuzzy control, system identification and estimation developed to automatically adjust and adapt robot behaviour; genetic algorithms and game theory. Applications include working with industry to enhance robot situational

awareness for bomb disposal, use of robots for perimeter security, multi-robot learning in security, mapping and search and rescue, and working with industrial partners to develop learning models for cellular network synchronization.

### SELECTED ACTIVITIES

- Associate Editor, IEEE Transactions on Cybernetics





### Jérôme Talim, PEng

*Assistant Professor*

#### RESEARCH AND APPLICATION

Internet of Things (IoT) modeling; resource allocation, pricing and reservation in a cloud computing environment. Applications include the development of web desktop and rich internet applications and mobile applications, as well as general framework for collaborative working environments.



### Eranga Ukwatta, PEng

*Assistant Professor*

#### RESEARCH AND APPLICATION

Medical image analysis; image segmentation and registration of medical images (MRI, CT, Ultrasound, PET), myocardial tissue characterization, machine learning for application in medical imaging; computational modeling of the heart; computer vision; pattern recognition. Applications include automated methods to extract clinically

relevant biomarkers from medical images (MRI, CT, Ultrasound, PET), diagnosis and monitoring of atherosclerosis plaque burden in the arteries, risk assessment of patients with myocardial infarction (heart attack), and personalized modeling of the heart for clinical diagnosis and prognosis.



### Gabriel A. Wainer, SMIEEE

*Associate Chair (Graduate Studies); Professor*

#### RESEARCH AND APPLICATION

Modeling and simulation methodologies; real-time and embedded systems; parallel and distributed simulation; web-service oriented simulation. Applications include forest fire spread prediction and mapping, embedded real-time software development, biomedical applications, computer networks performance, defense and emergency response, crowd and evacuation simulation, and simulation in architecture.

#### SELECTED ACTIVITIES

- Director-At-Large; Board of Directors. Society for Modeling and Simulation International; San Diego (2014-2017)
- Special Issues Editor of Simulation: Transactions of the Society for Computer Simulation International (SCS) (2008 - Present)
- Member of the Editorial Board of IEEE Computing in Science and Engineering (2012 - Present)
- Member of the Editorial Board of Wireless Networks, Elsevier (2009 - Present)



## Michael Weiss

*Associate Professor*

### RESEARCH AND APPLICATION

Open source; business ecosystems; mashups; patterns; social network analysis.



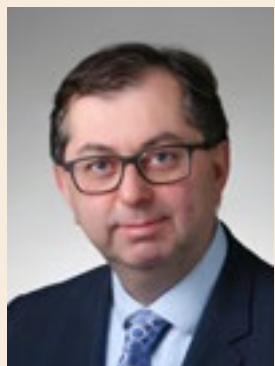
## Charles Murray Woodside, PEng, SMIEEE

*Distinguished Research Professor*

### RESEARCH AND APPLICATION

Use of performance models (such as unified modeling language (UML), traces, and big data methods) to understand and remove sources of performance degradation in complex computer systems; performance, reliability and security tradeoffs of operational configuration (such as adaptive operation or autonomic control); regression to estimate performance models; model simplification; optimal

assembly of components; rapid adaptation. Widespread applications include web services, enterprise computing, microservices systems, embedded systems, cloud deployment optimization, the Internet of Things (IoT), and sensor networks.



## Halim Yanikomeroglu, PEng, IEEE Fellow

*Professor*

### RESEARCH AND APPLICATION

Physical, medium access and networking layers; cross-layer aspects of wireless communications systems and networks; Internet of Things (IoT); radio access network (RAN) architectures; sensor networks; mesh networks; radio resource management; cognitive radio, spectrum, opportunistic spectrum access; signal constellation design; noncoherent communications; faster-than-Nyquist signaling; cooperative communications; HetHetNets (heterogeneous traffic distribution in heterogeneous wireless cellular networks, Stochastic geometry; User-In-the-Loop (UIL); drone networks, UAV communications; wireless caching.

Applications include tactical communications and personal cellular and wireless communication standards, systems and networks (including 4G, 5G, and beyond-5G cellular, wireless local area network (WLAN)).

### SELECTED ACTIVITIES

- Distinguished Lecturer, IEEE Communications Society
- Distinguished Speaker, IEEE Vehicular Technology Society
- Steering Committee, Organizing Committee, and Technical Program Committee Member of several international conferences

# AZRIELI SCHOOL OF Architecture and Urbanism

# CARLETON

Architecture is a built reflection of our culture and an active participant in changing culture. Architects have a deep concern for society, culture and the urban environment, and a passion for turning imagined ideas into reality.

The Azrieli School of Architecture and Urbanism is a place of exuberant exploration, academic integrity and artistic agency. With a commitment to experimentation and invention, the school houses the finest facilities in fabrication and digital technologies that allow students to imagine a future that is different from the world of today.

Our school is recognized nationally and internationally as having unique research trajectories in the fields of structural imagination, hand drawing and digital media, simulation and digital fabrication, materiality, conservation, sustainable



**Desirea Cronsberry's thesis, *Steelcity Living*, advances a vision that reoccupies the Hamilton site of U.S. Steel Canada from private industry to public habitation. Through the adaptation, remediation and preservation of its industrial ruins, the design gives a new model of mixed-use programming that provides new opportunities to live, work and play, seeking to begin a new conversation about affordable homeownership in these post-industrial cities.**

construction technologies, modern architecture and modernity, urban design, suburban re-design, critical practice and critical theory, lighting and set design, architectural histories, and the improvement of the physical and mental well-being of building occupants.

## Research Labs

### CARLETON IMMERSIVE MEDIA STUDIO (CIMS)

The CIMS is a Carleton University Research Centre dedicated to the development of digital and hybrid workflows for architectural rehabilitation and conservation. Affiliated with the Azrieli School of Architecture and Urbanism, CIMS brings together an interdisciplinary group sharing expertise in Architecture, Art history, Canadian Studies, Computer

Science, Engineering, and Information Technology. Our research agenda incorporates digitization (laser scanning, photogrammetry), building information modelling (BIM), simulation (building performance, what-if scenarios), digital and digitally assisted fabrication (robotics, CNC, 3D printing), and digitally assisted story telling (virtual and augmented reality, web-based narratives).

CIMS is home to two tri-council training programs: NSERC CREATE Heritage Engineering (Professor Mario Santana, PI) and SSHRC Partnership New Paradigm / New Tools for Architectural Heritage in Canada (Professor Stephen Fai, PI). Located in the Visualization and Simulation Building (VSIM), the facility is equipped with access to LightPath and CANet4 connectivity. CIMS' state-of-the-art digitization and fabrication technologies include Leica C10 and P40 laser scanners and Kuka KR6 and KR360 robots.

### **CARLETON SOLIDS AND LIGHT TECTONICS LABORATORY FOR STUDIES IN MATERIALITY (CSALT)**

Research in the CSALT laboratory focuses on the understanding, application and invention of the material culture of architecture, construction and design. Our objective is to research traditional material cultures, particularly those properties that have been displaced or forgotten. This historical framework acts as a springboard to inform new material understandings and "hybrid" constructions that contribute to the betterment of new and sustainable architecture and culture.

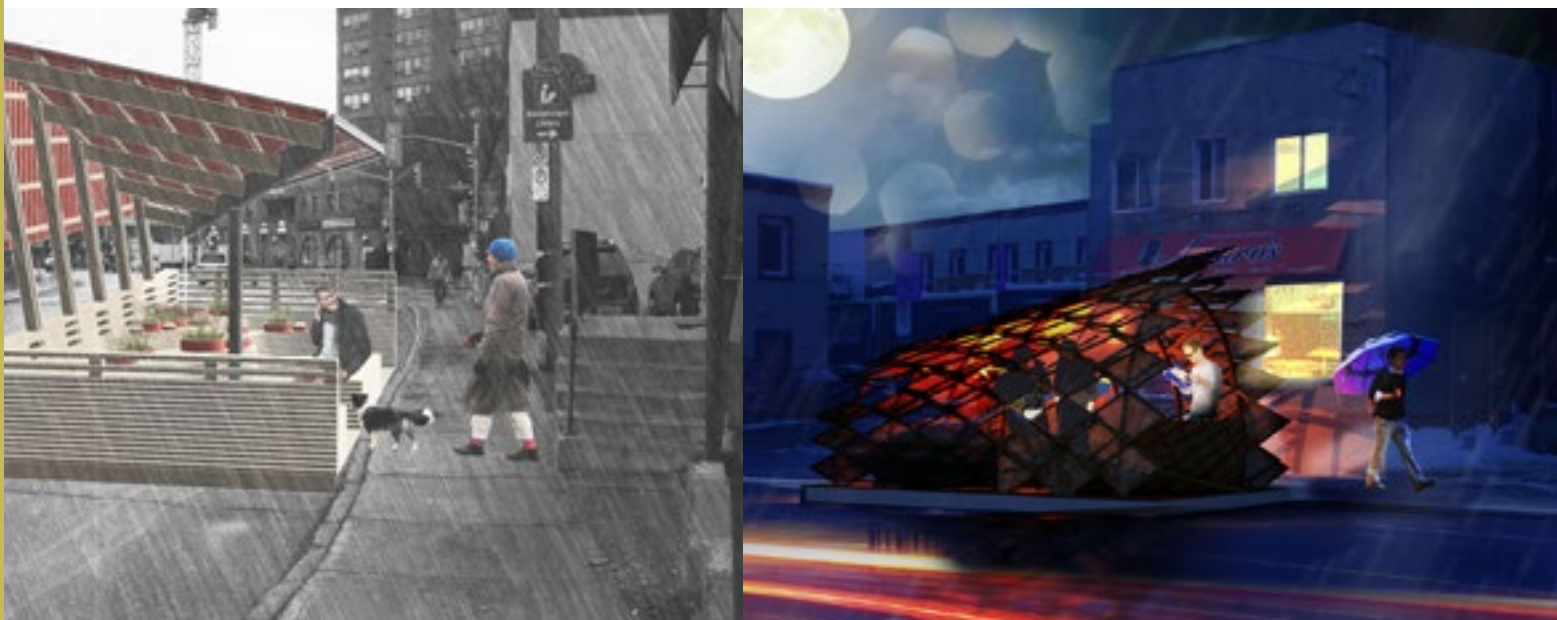
## **Research Groups and Focus Areas**

### **CARLETON INTERDISCIPLINARY DE-FORMATION RESEARCH UNIT**

Conducts interdisciplinary research that explores the relationships between design, culture, and the evolution of structural, technological and scientific innovations. The evolving research investigates the versatile and generative potential offered by complex processes and systems lurking throughout the environment and in biology, along with their related material, cultural, and technological implications. Through a diversity of scales, the work seeks to investigate how complex structures, forms and cultural motifs emerge and evolve into richly corresponding inter-relationships. The morphological diversity revealed by this research offers new insights into the complexity within natural processes as revealed by modern analytical tools and such related theories as Emergence.

### **DIGITAL FABRICATION**

The Azrieli School of Architecture and Urbanism has developed digital thinking and making to augment its established research and pedagogy on craft and making. Students use emerging fabrication facilities for innovative projects such as the community focused parklet projects, as part of the inaugural Streetsides Spots program, and the on-going Digital Reef installations. Research in computation is focused on social implications and emerging modes of representation, considering the poetic, haptic qualities of new digital architecture.



**Two groups of undergraduate students from the Azrieli School of Architecture and Urbanism were awarded grants in 2016 to create parklets for Ottawa's Vanier and Glebe neighbourhoods as part of a design-build studio taught by Professor Johan Voordouw. A concept first created in San Francisco, the street-side parks are the size of a parking space and contain live plants. Fourth-year students Tori Hamatani, Trevor Whitten, Mitchell Gray and Simon Petepiece designed the Vanier parklet, named Water Garden (left). The Glebe parklet, known as Nük (right), was designed by fourth-year students Jason Surkan, Ben Cottrill and Alex Marttinen.**



## ECOLOGICALLY POSITIVE COMMUNITY [EPC] DESIGN RESEARCH GROUP

The Ecologically Positive Community [EPC] design research lab is focused on investigating the maximum ecological performance potential of buildings and landscapes in the context of developed and developing countries. These projects investigate how to effectively generate ecologically positive communities through performance based building and community design. Developed in collaboration with leading psychology, geography, engineering, business, and public policy research departments, the integration of these traditionally isolated research streams generates symbiotic interrelationships that improve the output and scope of the projects and overall research trajectory of the lab. Students gain expertise in developing interdisciplinary sustainable research and design projects. This expertise is increasingly sought in both academia and professional practice, yet difficult to find.

## HERITAGE CONSERVATION AND SUSTAINABILITY

The research in heritage conservation focuses on fully understanding historical constructions and to allow a new life through contemporary use. Projects include restoration on modernism historical facades, adaptive reuse, and rehabilitation on existing structures. The school is dedicated to expanding knowledge and to train young generations about how to improve the quality of heritage buildings and to readapt these historical constructions with new uses and sustainable historical construction, all the while respecting the structure and traditional materials.

## MIND-BODY ARCHITECTURE FOR WELL-BEING

Architecture may contribute to a broader discussion about the well-being of residents, staff and visitors in health care facilities. Medical facilities deserve a close-up reading of the everyday spaces that are critical to well-being. The re-readings of historical, modern and contemporary hospitals requires reading into physical sections of building elements, questioning their maintenance and durability, while asking for more than an ordering of parts and labeling of materials, to reach into cultural, religious, political, economical and everyday tales of assembly in the architecture of healthy places. This research aims to define a field of mind-body architecture for well-being, through the design of seminal details for healthy spaces starting from infra-ordinary observations on the everyday operations of existing facilities.

## NSERC-CREATE HERITAGE ENGINEERING PROGRAM

The NSERC CREATE Heritage Engineering Program is a research, training, and internship program for PhD, Masters, and undergraduate students and post-doctoral fellows. It provides students with hands-on opportunities to work and learn in the built heritage industry, in addition to their degree program. The program is fully funded for Masters and PhD students and post-doctoral fellows through the federal government's NSERC CREATE grant program, with additional support from Carleton University.

Heritage Engineering is a multi-disciplinary program, with opportunities for students in engineering, architecture, information technology and Canadian Studies. The program

is supported by industry collaborators who provide key training and internship opportunities for students. Funded internships are offered in private industry, public sector and international organizations in Canada, USA, Germany, France, Italy and Thailand.

NSERC CREATE Heritage Engineering provides students with sector-specific skills and experience that will benefit Canada's built heritage industry, assist graduates in finding careers in the heritage sector and support the documentation and conservation of our built heritage resources.

## Graduate Programs

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The Azrieli School of Architecture and Urbanism offers four graduate programs. The Master of Architecture is a studio-based, accredited professional program that focuses on innovation and creativity within theoretical and practical parameters. The Graduate Diploma in Architectural Conservation further develops knowledge and skills in the theory and practice of architectural conservation. The Master of Architectural Studies is a research-intensive post-professional program. The PhD in Architecture offers candidates opportunities to develop significant research contributions in the culture of practice.



**The 'Digital Wood' thesis project by graduate student, Steven Schuhmann. The beam prototype is constructed of layers of wood veneer with wood grain aligned to the principle compressive and tensile forces to develop a more efficient timber structural system.**



Read more about faculty members' research at [carleton.ca/architecture/faculty-and-staff](http://carleton.ca/architecture/faculty-and-staff)



## K. S. Andonian, MRAIC

*Professor*

### RESEARCH AND APPLICATION

Knowledge and info-technologies in architecture; story of architecture and logic of decision-making in design; color, texture and materiality of the other; examination of architecture and philosophy, including thesis of architecture and architecture of thesis; systems design and social, economic, cultural and environmental sustainability; genetics of urbanism; globalization, gentrification and urbanization.

### SELECTED ACTIVITIES

- Member, International Conference Organizing Committee, InterSymp, Baden-Baden, Germany (2006-2016)
- Organized and chaired 1st through 9th International Symposia on Architecture of 21<sup>st</sup> Century - In Search of New Paradigms, Baden-Baden, Germany (2008-2016)



## Manuel Antonio Báez, MRAIC

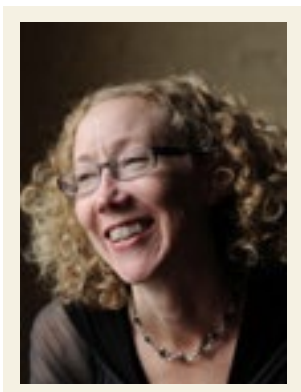
*Associate Professor*

### RESEARCH AND APPLICATION

Investigation of fundamental integrative principles of form, structure and generative processes in nature, architecture, and engineering; development of research-related design concepts, construction systems, processes and educational methods; interdisciplinary research inspired by the nature of materials, integrative processes, morphology, developmental biology, and complexity/emergence theory.

### SELECTED ACTIVITIES

- Architect/Artist Residency, Pelling Lab for Biological Manipulation, University of Ottawa (2016-2017)



## Catherine Bonier

*Assistant Professor*

### RESEARCH AND APPLICATION

Architectural and urban design, history, and theory; 17th to 21st century studies of the built environment centered on water, infrastructure, and ideas of health and balance; synthesis of scientific ideas, technological frameworks, and cultural histories; focus on civic works, public health, and urban environment; changing ideas of equilibrium and democracy and their relationship to water, infrastructure, and landscape; issues of urban water and remediation in historical and contemporary context. Application includes the visualization

and promotion of new methods of integration of water, technology, and infrastructure with sustainable and equitable urban environmental design.

### SELECTED ACTIVITIES

- Conference theme Chair and panel moderator, Designing for Change: Environmental Design Research Association (EDRA) 45<sup>th</sup> Annual Conference, New Orleans - "Sacrifice and Resilience: Designing for Loss." (2014)



## Sheryl Boyle

*Associate Professor*

### RESEARCH AND APPLICATION

Sensory studies in early modern Europe; epistemic practices; material culture studies; architectural and material narratives; prefabrication and design.

### SELECTED ACTIVITIES

- Member, Centre for Sensory Studies, Concordia University



## Yvan-pier Cazabon, MRAIC

*Associate Director (Professional Programs); Associate Professor*

### RESEARCH AND APPLICATION

History and theory of architectural technology; critical review of building practice and material application in diverse climates, with emphasis on Canadian materials, construction techniques and design; international development and analysis with focus on historical conservation and preservation; theatre and performance, including set-design and construction, lighting design, and artistic direction.

### SELECTED ACTIVITIES

- Production of Shakespearean plays, a collaboration between the School of Architecture and Urbanism and the Department of English Language and Literature (2013-2016)



## Roger Connah

*Associate Professor*

### RESEARCH AND APPLICATION

Literacy and hybrid critical writing; critical fictions and expanded architecture (critical pedagogies); radical cartographies & relational urbanism; the use and abuse of contemporary philosophy in architecture; calligraphisms: information and cognitive mappings (graphics, film and communication); trans-architectures; architecture, agency and activism; interdisciplinary practices for architecture.

### SELECTED ACTIVITIES

- Direct Aid-Design Build Project, Tha Pho Minority High School, Luang Prabang
- Dinzeze Arquitetcos Founding Consultant, Luanda, Angola
- English editor and urban collaborator, Meganom Architects, Moscow
- Curator, Calligraphisms (Exhibition 2018)



## Janine Debanné

*Associate Chair (Undergraduate Studies); Associate Professor*

### RESEARCH AND APPLICATION

History and theory of architecture; modernist residences of the National Capital Region (1950-70), emphasizing interpretation and explanation of the cultural significance of built ensembles and artifacts in Canada; postwar dwelling; reception and appropriation of built architecture, including documentation from the point of view of dwellers and architects;

architectural dimensions and drawing; ideation tool. Applications include formulation of housing design strategies in urban areas, design teaching, urban analysis and planning, design of public spaces, and public understanding of architecture.



## Mariana Esponda

*Associate Professor*

### RESEARCH AND APPLICATION

Sustainable heritage conservation with focus on social and economic practices, balancing cultural and natural heritage, and integrating environmental construction techniques; interaction between traditional and new materials in adaptive reuse. Applications include adapting historical constructions for new purposes and improving the quality of heritage buildings while respecting structural integrity, craftsmanship and traditional materials.

### SELECTED ACTIVITIES

- Visiting Professor, European Master of Historical Construction (SAHC)
- Member, ICOMOS Canada Scientific Committee
- Guest editor: International Journal of Architectural Heritage



## Stephen Fai, MRAIC

*Associate Professor*

### RESEARCH AND APPLICATION

Representation of architecture; religion in architecture; microhistories; documentation and dissemination of ethno-cultural methods of construction; biomedical visualization; sophisticated techniques of building information modeling in the field of heritage conservation.

### SELECTED ACTIVITIES

- Director, Carleton Immersive Media Studio



### Lucie Fontein

*Associate Professor*

#### RESEARCH AND APPLICATION

Hospitable design with an emphasis on daylighting, ethical practice, practical wisdom (phronesis), and the work of Carmen Corneil.

#### SELECTED ACTIVITIES

- Visiting professor, University of Cincinnati



### Benjamin Gianni

*Associate Professor*

#### RESEARCH AND APPLICATION

Housing history, typology and policy; urban and suburban morphology; historical development of suburbs; planned communities; urban design; post-WWII urbanism; smart growth and sustainable urbanism; renewal and redevelopment of public housing stock; urbanism in China.

#### SELECTED ACTIVITIES

- Vice-Chair and Chair, Building Committee, Board of Directors, Ottawa Art Gallery
- Co-organizer, International Conference on Chinese and African Sustainable Urbanization, Ottawa (2015)



### Federica Goffi

*Associate Director (Graduate Studies); Associate Professor*

#### RESEARCH AND APPLICATION

History of visual representation; study of sustainability and historical preservation; hybrid technologies and history of construction; aural architecture; healthy spaces; history and theory of the notion of conservation; micro-historical studies focused on time in its threefold nature of 'time', 'weather', and 'tempo'.

#### SELECTED ACTIVITIES

- Member of AHRA (Architectural Humanities Research Association)



## Paul Kariouk

*Associate Professor*

### RESEARCH AND APPLICATION

Twentieth-century architectural history and theory; history and theory of landscape architecture; relationships between collective identity, memorialization and urban space.

### SELECTED ACTIVITIES

- Board of Advisors to the Dean for the School of Architecture, University of Virginia



## Stanley Loten

*Distinguished Research Professor*

### RESEARCH AND APPLICATION

Mesoamerican archaeology; architecture and the sites of Tikal, Guatemala; architecture of Altun Ha, Beliza and Lamanai, Belize; Andean archaeology; architecture at the pre-Inca site of Marcahuamachuco, Peru. Application includes controlling architectural stratigraphy in ancient architectural structures of Central America and the Andean region.



## Giancarlo Mangone

*Assistant Professor*

### RESEARCH AND APPLICATION

Sustainable design, including mitigation and reversal of local and global natural ecosystem degradation; ecologically positive community development; ecological performance of buildings and landscapes; development of hybrid infrastructure, spatial building systems, and nature integrated buildings and communities.

### SELECTED ACTIVITIES

- Scientific committee member, Windsor Conference on Thermal Comfort (2016)
- Scientific advisory committee member, Urban Ecologies International Conference (2015)
- Research session moderator, Architectural Research Centers Consortium Conference, Social + Behavioral (2015)





## Inderbir Singh Riar

*Associate Professor*

### RESEARCH AND APPLICATION

History and historiography of modern architecture, urban utopias, world's fairs, and postwar Canadian architecture and urbanism; megastructures and Canadian modernism; late-modern legacies of CIAM and Team 10.



## Jill Lahn Stoner

*Director; Professor*

### RESEARCH AND APPLICATION

Research and creative work to address the wicked problems of our time, less in the pursuit of solutions than to deepen this debate: how to approach a spatial future for which we can no longer plan. The work takes form in visionary urban proposals, tactical interventions into structures of power, and critical writing on the contemporary built landscape.

### SELECTED ACTIVITIES

- Board member, RAIC
- Manuscript Review, MIT Press



## Johan Voordouw

*Assistant Professor*

### RESEARCH AND APPLICATION

Relationship of existing architectural conventions with digital architecture and craft; computational design; emerging fabrication and building techniques; hybrid modes of representation; history and theory of architecture (1990 - Present).

# SCHOOL OF Industrial Design

CARLETON

The School of Industrial Design's highly regarded program produces graduates with the ability to design products, systems, services, and experiences with consideration of how they are related to environmental, societal, and economic factors, and their contribution towards a better quality of life.

Our school conducts applied research in the areas of materials and manufacturing processes, prototyping methods, advanced visualization, extreme environments, sustainable design, research methods and strategic design planning. We have established an extensive track record with industry-sponsored research in the areas of emergency response equipment and services, healthcare and hospital environments, smart interactive products and systems, and furniture systems and products for home and work.

## Research Facilities

Ranked among the best in North America, our facilities include advanced physical and digital modeling and testing laboratories with 3D scanners, laser cutters, CNC milling systems, and a range of rapid prototyping machines including 3D printer pods. We provide a safe, professional and dynamic environment where students can learn the technical skills to build their projects under the supervision of trained technicians.



**In collaboration with the Canadian Paralympic Foundation, students design prototype sport equipment.**

## Graduate Programs

[graduate.carleton.ca/programs](https://graduate.carleton.ca/programs)

The Master of Design advances knowledge of how design development processes can be informed through collaborative interdisciplinary intersections in theory and practice. Graduates gain analytical and interpretative skills through discussion and writing, develop knowledge of research methods in design and related disciplines, and complete team-based projects in collaboration with external professionals.

Read more about faculty members' research at [id.carleton.ca/about-sid/people/faculty/](http://id.carleton.ca/about-sid/people/faculty/)



### WonJoon Chung

*Graduate Program Coordinator; Associate Professor*

#### RESEARCH AND APPLICATION

Theory, principles and techniques for design education; design of group ideation techniques; development of theoretical framework for interdisciplinary design collaboration; improvisation in design collaboration; development of idea visualization technique; curriculum development for integrated wearable 3D design course (specifically at Yonsei University, South Korea).

#### SELECTED ACTIVITIES

- Steering Committee Member, Design Research Association in the US and Canada



### Çağla Doğan

*Assistant Professor*

#### RESEARCH AND APPLICATION

Product design research and education for sustainability, including integrated scales of design and production (i.e. relationships among batch production, mass production, craft, do-it-yourself and open design); localization and personalization for product value, longevity and meaning; sustainable design considerations for resource effectiveness and post-use; generative design research methods; exploratory research, grounded theory and research through design;

idea generation tools for design education, including experience reflection modeling (ERM), generative focus group (GFG) and biomimicry sketch analysis (BSA).

#### SELECTED ACTIVITIES

- Session Co-Chair, Academic and Vocational Curriculum Development, LearnX Design – The Third International Conference for Design Education Researchers, The Art Institute of Chicago (2015)



### Stephen Field

*Assistant Professor*

#### RESEARCH AND APPLICATION

System design methods; sustainable housing and energy efficiency; socio-cultural cooperative approaches for product innovation and development; design visualization and exploration methods at levels ranging from abstraction to definitive multi-dimensional representations. Applications include design education and curriculum development,

design and development of energy efficient fenestration products and assemblies with applicable manufacturing processes, and team based design projects bringing together local government, business leaders, and manufacturing expertise in Northern Arctic communities.



### Lois Frankel

*1125@Carleton Academic Director; Associate Professor*

#### RESEARCH AND APPLICATION

Design thinking approaches to project development; ethnographic design research, interaction design relating to aging, disability, and fitness; participatory design; sensory design detailing; user-centred and user experience design. Applications include sensory design aspects of industrial design curriculum, interactive product design research, wearable computing devices, and jewellery design.

#### SELECTED ACTIVITIES

- Sensory Design Editor of the Routledge journal, "The Senses and Society"
- Academic Director of 1125@Carleton
- Program Planning Committee Member and Strand Coordinator, IASDR (International Association of Societies of Design Research) Conference (2015)



### Thomas Garvey

*Director; Associate Professor*

#### RESEARCH AND APPLICATION

Product development and design for extreme and minimal environments; housing and urban density and its resultant impacts on contemporary approaches to lifestyle design and living environments; historical minimalist design philosophy; design education and curriculum development within universities and in collaboration with external organizations. Specific applications include student housing proposals for Welinkar Institute of Management Development and Research in Mumbai, in-patient room prototypes in collaboration with Clemson University and the Spartanburg Regional Healthcare System, and the use and design of equipment and services for the fire

management program of the Ontario Ministry of Natural Resources and Forestry's Aviation Forest Fire and Emergency Services Branch.

#### SELECTED ACTIVITIES

- Voting representative, XXIX General Assembly, International Council of Societies of Industrial Design (ICSID) and World Design Organization (WDO), Gwangju, South Korea.
- Invited delegate (Shelter sub-theme), Interdesign Mumbai: Humanizing a Metropolis, 2-week workshop to address social and infrastructure challenges facing the growing city of Mumbai.



### Bjarki Hallgrímsson, PEng

*Associate Professor*

#### RESEARCH AND APPLICATION

Prototyping and modelmaking methods; manufacturing methods and process selection, digital manufacturing; maker culture; universal design; turnkey product development; biomimicry in design; ambulatory devices; facilitation of human centered design approaches in interdisciplinary teams; design in low income communities with a focus on Africa (working with non-governmental organization).

#### SELECTED ACTIVITIES

- Research, Education, Accessibility and Design (READ) Advisory Board



## Chantal Trudel

*Assistant Professor*

### RESEARCH AND APPLICATION

Analysis of human factors and design methods to improve design in complex sociotechnical systems in order to support health, safety, wellbeing, access, acceptance and performance; human factors in designing for clinical work processes; design for infection prevention and control; design considerations for aging populations; manual materials handling in forestry fire fighting.

### SELECTED ACTIVITIES

- Member, The Canadian Healthcare Human Factors Consortium
- Member, University of Nottingham Human Factors Healthcare Research Group
- Graduate Member, Chartered Institute of Ergonomics & Human Factors
- Full Member, Human Factors and Ergonomics Society



# SCHOOL OF Information Technology

CARLETON

From gaming and virtual worlds, to the next generation of secure wireless networks and the information resource systems they facilitate, to advanced IT using lasers and photonics, the School of Information Technology examines the technologies that will shape the future of business, big data, health care, manufacturing, and leisure.

Research programs in the School of Information Technology have three main themes: networking, interactive multimedia technologies, and photonic and laser technologies.

## INFORMATION RESOURCE MANAGEMENT RESEARCH

Information resources and how people access information play an increasingly important role in the infrastructure of every element of modern technological society. Research in information resource management covers all aspects of big data including:

- information modelling;
- information search;
- information interaction and Visualization;
- information security and privacy; and
- information management.

## INTERACTIVE MULTIMEDIA RESEARCH

Advances in multimedia systems, human-computer interaction, and related technologies are changing the face of art, entertainment, communication, and many other



**Researchers in network technology investigate stealthy worm attacks, Internet traffic flow, and increasing the mobility of wireless devices.**

services. Interactive multimedia is a broad research area that brings together topics from computer animation and game design to virtual reality, immersive environments, and multimedia-rich web applications. It deals with how new hardware and software systems can be used to create, interact with, and perceive new digital media content.

Our facilities include motion capture studio, rendering farm, sound studio, prototyping equipment, and general purpose multimedia labs with audio/video equipment. The group has close ties with industry, such as IBM, Avaya, and Microsoft, and collaborates with researchers from Canadian and international universities. Research is supported by federal and provincial funders, such as NSERC, SHHRC, OCE and ORNEC.

## NETWORKING RESEARCH

Computer communication networks play an ever-evolving role in the infrastructure of all businesses in modern technological society. Research in networking covers all aspects of communication network, including:

- design;
- architecture;
- protocols;
- management; and
- control, security, and information assurance schemes for wireless/wired networks.

The group has secured grants from funding sources such as CFI, NSERC and OCE, and enjoys collaborations with major government labs, universities across Canada and around the world, and global industrial leaders, such as Cisco, Alcatel-Lucent, Avaya, and Solana Networks.

## OPTICS AND LASER TECHNOLOGY

Photonics and Laser Technology (PLT) influences virtually all aspects of modern life. From routine tasks such as checking email on a smart phone to performing complex life-saving laser surgery, PLT, the science of generating and harnessing light, has profoundly affected all sectors of industry, entertainment and communication. Industries affected by PLT research include:

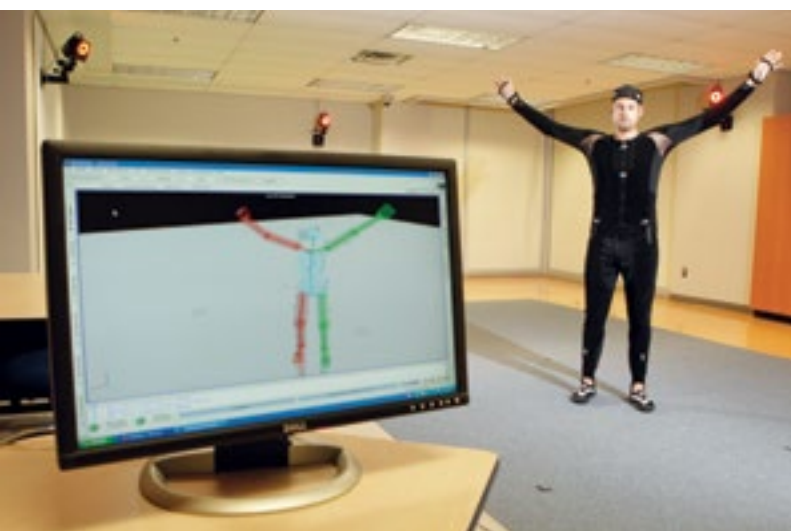
- telecommunications (optical networks, components);
- health (sensors and laser surgery);
- auto/aerospace manufacturing (high-power lasers);

- oil and gas (extreme environment sensing);
- entertainment (holograms, lasers, displays, etc.);
- mobile technologies (multiple optical components);
- clean energy (solar cells); and
- lighting (interior design, architecture).

## Graduate Program

[graduate.carleton.ca/programs](http://graduate.carleton.ca/programs)

The School of Information Technology offers thesis-based research programs at the PhD and Master's levels in Digital Media, as well as a coursework-based professional Master's program in Network Technology. A thesis-based Master's Program in Human-Computer Interaction is also offered in collaboration with 13 schools and departments at Carleton (ranging from Architecture and Industrial Design to Computer Science, Business, Psychology, and Journalism).



Capture processing for animation, games and interactive applications.



Active gaming using accelerometer sensor networks as input to a dancing game.

Read more about faculty members' research at [www.csit.carleton.ca](http://www.csit.carleton.ca)



### Ali Arya

*Graduate Program Coordinator; Associate Professor*

#### RESEARCH AND APPLICATION

Multimodal human-computer interaction; educational technologies; social and collaborative virtual environments; computer games; artificial intelligence; digital art. Applications include Carleton Virtual (a 3D virtual environment for education and research), computer games, smart homes, museum navigation systems, and intelligent framework for procedural animation of human behaviours.

#### SELECTED ACTIVITIES

- Editorial Board, International Journal of Computer Games Technology
- Editorial Board, Open Cybernetics & Systemics Journal
- Conference Technical Committee, Euromedia, VS-GAMES, GET



### Audrey Girouard

*Associate Professor*

#### RESEARCH AND APPLICATION

Analysis of human-computer interaction, reality-based interaction, and deformable user interactions with next generation adaptive user interfaces. Applications include flexible smartphones and tablets displays, bendable game controllers and flexible styluses, wearable computing, and novel devices for health, accessibility, and rehabilitation (such as bendable devices for the blind).

#### SELECTED ACTIVITIES

- Organizer, Tangible for Health Workshop, ACM CHI Conference on Human Factors in Computing Systems (2016)
- Program Committee Member, ACM CHI Conference on Human Factors in Computing Systems and Graphics Interface Conference
- Steering Committee, ACM TEI Tangible, Embedded and Embodied Interaction Conference



### Chris Joslin

*Associate Professor*

#### RESEARCH AND APPLICATION

Real-time medical simulation, tracking, and imaging; scalable video coding and adaptation; physics-based and spatial audio reproduction; virtual reality and collaborative virtual environments; tracking soft surface objects. Applications include pre-operative planning tools for surgeons, surgical training and evaluation tools for complex operations, user and device personalized video streaming, audio reproduction for games and collaborative systems, fully collaborative immersive environments for training and testing, and realistic facial animation.

#### SELECTED ACTIVITIES

- Journal Editorial Boards: International Scholarly Research Network Computer Graphics Journal; International Journal of Creative Interfaces and Computer Graphics; International Journal of Communications, Network, and Systems Science
- Member, Joint Technical Committee 1, Sub-Committee 29 (Coding of Audio, Picture, Multimedia and Hypermedia Information), Standards Council of Canada (2005-present)
- Member, Technical Committee: International Conference on Multimedia Expo; ACM Multimedia; Computer Animation and Social Agents; IEEE Virtual Reality; Signal-Image Technology & Internet-Based Systems



## Ashraf Matrawy, PEng, SMIEEE

*Associate Professor*

### RESEARCH AND APPLICATION

Resilient and secure network and application architectures; information security evaluation, attack-resilient networks; software-defined networking. Applications include security and geolocation, and securing new computing paradigms such as cloud computing, pervasive mobile applications and the Internet of Things (IoT).

### SELECTED ACTIVITIES

- Member, Editorial Board, IEEE Communications Surveys and Tutorials Journal
- Technical Program Committee member, IEEE CNS (Communications and Network Security), IEEE ICC (International Conference on Communications), IEEE Globecom (Global Communications Conference)



## Omair Shafiq

*Assistant Professor*

### RESEARCH AND APPLICATION

Data Modeling and Organization; Machine Learning; Big Data Analytics; Deep Learning Frameworks; Services Computing; Cloud Computing; Social Network and Media Analytics. Applications include dynamic business to business and customer integration, personalized web search, effective monitoring and management of complex, and large-scale and dynamic systems.

### SELECTED ACTIVITIES

- Journal Reviewer, IEEE Transactions on Services Computing (2016), ACM Computing Surveys (2016), Springer

Journal of Social Network Analysis and Mining (2011-2015), IEEE Communications Magazine (2014)

- Program Committee Member, IEEE Information Reuse and Integration (2010-2016), Doctoral Consortium of RuleML (2016), Semantic Big Data Workshop at ACM SIGMOD (2017)
- Program Co-chair, International Symposium on Foundations and Applications of Big Data Analytics (2015), PhD forum and posters track at IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (2015-2016)



## Wei Shi

*Associate Professor*

### RESEARCH AND APPLICATION

Cloud and big data infrastructure; security in computer networks; big data privacy; mobile agents and actuator networks; wireless sensor networks. Applications include big data analytics, cloud computing, smart world systems, and data dissemination.

### SELECTED ACTIVITIES

- Technical Program Committee Member, International Symposium on Web of Things and Big Data (WoTBD), IEEE Games, Entertainment and Media (IEEE GEM)
- Journal Reviewer, ACM Transactions on Multimedia Computing, Communications, and Applications (2016), Journal of Pervasive and Mobile Computing (2016), International Journal of Health Geographics (2015), International Journal of Parallel, Emergent and Distributed Systems (2015), Journal of Emerging Technologies in Web Intelligence (2015), Elsevier's Journal of Information Sciences (2015)





### Christopher Smelser

Acting Director, Associate Professor

#### RESEARCH AND APPLICATION

Laser fabrication of optical components; light-matter interaction; fibre Bragg grating design and development; hybrid optical component design; non-linear optics. Applications include optical sensor technology for implementation in structural, bio-chemical and environmental monitoring.

#### SELECTED ACTIVITIES

- Technical Program Committee Member, Bragg Gratings, Photosensitivity and Poling in Glass Waveguides Topical Meeting (BGPP) (2016)



### Marc St-Hilaire

Associate Professor

#### RESEARCH AND APPLICATION

Computer networks; network planning, architecture and optimization; mobile computing; cloud computing; software defined networks (SDN); wired and wireless communication networks; wireless sensor networks; smart home networking. Applications include smart homes, planning algorithms for service providers, and wireless and wireline communication systems.

#### SELECTED ACTIVITIES

- Steering committee for the 1st International workshop on Research Advancements in Future Networking Technologies (RAFNET) (2016)
- Track Co-Chair for the 13th IEEE Consumer Communications and Networking Conference (CCNC) (2016)
- Publicity Co-Chair for the International Conference on Selected Topics in Mobile & Wireless Networking (MoWNet) (2016)
- Tutorial and Keynote Co-Chair for the 6<sup>th</sup> International Conference on Network of the Future (NOF) (2015)



### Robert Teather

Assistant Professor

#### RESEARCH AND APPLICATION

Human-computer interaction; virtual reality; 3D user interfaces; game user interfaces; spatial interaction; target selection; immersive displays; novel input devices and interaction techniques; information visualization in games. Applications include effective immersive virtual environments, enhanced mobile user interfaces, and understanding of player behavior and improved interaction in video games.

#### SELECTED ACTIVITIES

- Program Co-Chair, ACM Spatial User Interaction (2016-2017)
- Publication Chair, IEEE Virtual Reality (2016)
- Poster Co-Chair, ACM Spatial User Interaction (2013-2015)
- Posters Co-Chair, IEEE 3D User Interfaces (2015)
- Review Editor, Frontiers in Virtual Environments (2014 - Present)
- Reviewer, VR (2016), CHI (2016), CHI Play (2015), MobileHCI (2015), TVCG





## Anthony Whitehead

*Associate Professor*

### RESEARCH AND APPLICATION

Entertainment technologies, video processing; computational video; image processing; computer vision; sensor networks as input devices; pattern matching; graphics. Applications include video games, medical and therapeutic devices, television and film visual effects, animation systems, and personal sensor networks.

### SELECTED ACTIVITIES

- Chair, Human Computer Interaction program



## Richard Yu

*Professor*

### RESEARCH AND APPLICATION

Cross-layer/cross-system design in wireless-based systems; security; green information technologies. Applications include cellular networks, ad hoc networks, the Internet of Things (IoT), communication-based train control (CBTC) systems, and intelligent transportation systems (ITS).

### SELECTED ACTIVITIES

- Lead Series Editor, IEEE Transactions on Vehicular Technology - Connected Vehicles Series
- Editor, IEEE Journal on Selected Areas in Communications (JSAC) - Series on Green Communications and Networking
- Co-Editor-in-Chief, Ad Hoc and Sensor Wireless Networks Journal

## Fostering Entrepreneurship

Carleton's Faculty of Engineering and Design fosters creative and inspirational researchers who are recognized by their communities for their work and the projects they explore. For a full list of our research highlights and faculty achievements, please visit: [carleton.ca/engineering-design/news](https://carleton.ca/engineering-design/news) and [carleton.ca/engineering-design/research](https://carleton.ca/engineering-design/research).

Our Faculty attracts and inspires researchers who take strategic risks and think creatively. Carleton's academic focus on entrepreneurship encourages and supports our students to identify market opportunities for their ideas and commercialize their research.

More than 100 companies and start-ups have been created by Carleton alumni and faculty members, including established industry leaders such as GasTOPS, Solantro Semiconductor Corp. and ZIM Corp., along with new game-changers such as Smart Rotor Systems Inc. and GaitTronics.

# CARLETON



Full Motion CH-149 Cormorant Experimental Flight Training Device at the Carleton University Visualization and Simulation Centre.

## INCOMING FACULTY

### Hicham Chaoui

Assistant Professor, Department of Electronics

### Burak Gunay

Assistant Professor, Department of Civil and Environmental Engineering

### Ozayr Saloojee

Associate Professor, Azrieli School of Architecture and Urbanism

## GRADUATE STUDENT ENROLMENT (Fall 2016)

STUDENT LEVEL	MASTER'S	PHD
<b>Academic Unit</b>		
Aerospace Engineering	59	13
Architectural Studies	5	-
Architecture	111	19
Biomedical Engineering	17	-
Civil Engineering	91	46
Design	24	-
Digital Media	4	8
Electrical and Computer Engineering	224	142
Environmental Engineering	31	12
Infrastructure Protection and International Security	50	-
Human-Computer Interaction	12	-
Mechanical Engineering	69	38
Network Technology	7	-
Sustainable Energy Engineering	24	-
Technology Innovation Management	102	-
<b>Total</b>	<b>830</b>	<b>278</b>

# A Brief History of the Faculty of

For more highlights, visit [carleton.ca/engineering-design/about/faculty-history](http://carleton.ca/engineering-design/about/faculty-history).

**1942**

**Carleton College is founded.**

**1957**

The School of Engineering is established.

**1963**

The Faculty of Engineering is established.

**1968**

The School of Architecture is established.

**1973**

The School of Industrial Design is established.

**1983**

The Ottawa-Carleton Institute for Electrical and Computer Engineering was formed.

**1984**

The Ottawa-Carleton Institute for Civil Engineering and the Ottawa-Carleton Institute for Mechanical and Aerospace Engineering are established.

**1992**

The Minto Centre for Advanced Studies in Engineering opens.

**2000**

Ottawa-Carleton Institute for Environmental Engineering is created.

# Engineering and Design

**2002**

Carleton University and Algonquin College establish the School of Information Technology, which offers the Bachelor of Information Technology.

**2003**

The Azrieli Pavilion building opens, housing the School of Information Technology, the National Capital Institute of Telecommunications, and the graduate program in architecture.

**2006**

The Ottawa-Carleton Institute for Biomedical Engineering is established.

**2007**

The Centre for Advanced Visualization and Simulation and the Human-Computer Interaction building opens.

**2008**

The School of Architecture is renamed the Azrieli School of Architecture and Urbanism in honour of an endowment from alumnus Dr. David J. Azrieli.

**2011**

The Canal Building opens, housing state-of-the-art laboratories and research facilities in biomedical engineering, and sustainable and renewable energy engineering, including the Hydro Ottawa Laboratory for Smart Grid Technologies.

**2012**

Carleton opens the Huawei-TELUS Innovation Centre for Enterprise Cloud Services, the BlackBerry Teaching and Collaborative Research Centre, and the Delta Controls Laboratory.

**2013**

Carleton celebrates the 50th anniversary of the Faculty of Engineering and Design.

**2017**

Carleton celebrates its 75<sup>th</sup> anniversary.



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