Faculty of Engineering

PRIORITIES 2017

The purpose of this document is to provide input from the Faculty of Engineering to the University of Victoria strategic plan process. The Faculty of Engineering priorities in this document reflect the values and priorities of the UVic Strategic Plan and the UVic Research Strategic Plan. We acknowledge with respect the Lkwungen-speaking peoples on whose traditional territory the University of Victoria stands, and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.

VISION
The Faculty of Engineering strives to be recognized as one of the top engineering and computing science schools in Canada. We value academic excellence and aim to be both welcoming and inclusive. Through knowledge of science and technology, and experience with their application to creative problem solving, our graduates support the economic and cultural development of society and help protect the natural environment.

MISSION
Create diverse career opportunities for our students and economic, social and environmental benefits for our community through engineering and computing science.

REPRESENTATIVE RESEARCH THEMES
Data science and digital technologies
Energy systems
Smart cities and infrastructure
Biomedical engineering
FACULTY OF ENGINEERING PRIORITIES

INCLUSIVENESS AND DIVERSITY
Strengthen sense of belonging and being supported for all people in our Faculty

- Encourage diversity in faculty and staff complement
- Support diverse research activities including engineering, science, applied science and scholarly work on teaching and learning
- Increase proportion of women students—Engineers Canada aims for 30% women new licensees by 2030
- Actively work with the university to recruit more indigenous students
- Increase the number of international students

QUALITY TEACHING AND RESEARCH
Deliver high quality teaching and research in our diverse programs and research disciplines

- Sustain our commitment to open competitions and merit in recruiting at all levels
- Increase research funding by working with each other, with community partners, other faculties and universities
- Establish new programs to broaden the student population—Engineering Science, Chemical Engineering
- Create more international experiences opportunities for our students
- Improve retention of first year students
- Continue to assess learning outcomes and refine continuous improvement strategies in all programs
- Optimize undergraduate studies operations and processes
- Increase number of second year students who are placed in their discipline of choice
- Establish high quality professional masters programs
- Keep our undergraduate and graduate programs current
- Enhance the graduate student experience
- Recognize, celebrate and reward success stories
- Ensure continued CEAB accreditation of all Engineering programs

COMMUNITY ENGAGEMENT
Graduate students as global citizens prepared to contribute to society

- Foster outreach to youth, teachers and parents through various channels including Science Venture
- Provide experiential learning opportunities for undergraduate and graduate students
- Develop strategic academic and industrial partnerships across Canada
- Encourage development of national and international connections in research and education
- Engage with the indigenous community
- Secure the philanthropic support required for our priority initiatives
- Encourage volunteer work with non-profit organizations in the community

RESEARCH AND INNOVATION
Enable and strengthen our environment to support world-class research and innovation

- Increase research funding
- Train more highly qualified personnel in areas that are in high demand in industry and academia
- Support startup of new faculty research programs
- Improve access to specialized research laboratory infrastructure—aerospace, biomedical, materials, structures
- Identify and support selected promising research fields
- Establish new research centre in data science and foster collaboration across the university
- Encourage industrial collaboration as well as scientific and engineering leadership for the benefit of Canada
- Embrace entrepreneurship
- Recognize and celebrate collaboration and leadership
- Enhance the Faculty’s reputation as a world-class leader in Engineering

RESOURCES
Diversify revenue beyond traditional university budget model for financial sustainability

- Increase research and laboratory space per student to national norms
- Increase faculty-student and staff-student ratios to provincial norms
- Provide appropriate work space for course-based projects and student design competition teams
- Fund professional masters with tuition revenue
- Recruit more international students to increase revenue while maintaining program quality
# Table of Contents

<table>
<thead>
<tr>
<th>Link</th>
<th>Research Program</th>
<th>Last</th>
<th>First</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>➡️</td>
<td>Advanced Techniques for Signal and Geometry Processing</td>
<td>Adams</td>
<td>Michael</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Multidimensional Systems Design and Implementation</td>
<td>Agathoklis</td>
<td>Pan</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Dynamics and Digital Manufacturing (DDM)</td>
<td>Ahmadi</td>
<td>Keivan</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Microengineered Systems for Disease Modeling and Drug Delivery</td>
<td>Akbari</td>
<td>Mohsen</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Improving Performance and Energy Efficiency in GPGPUs</td>
<td>Baniasadi</td>
<td>Amirali</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Soft-switched high-frequency power converters for alternative energy systems</td>
<td>Bhat</td>
<td>Ashoka</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Nanoscale materials and sensor technologies enabling a diversity of applications</td>
<td>Bhiladvala</td>
<td>Rustom</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Advanced Substrate Integrated Waveguide Components</td>
<td>Bornemann</td>
<td>Jens</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Advanced Optical Instrumentation for Astronomy</td>
<td>Bradley</td>
<td>Colin</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Computer Vision-Based Environmental Monitoring</td>
<td>Branzan Albu</td>
<td>Alexandra</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Sustainability and Resiliency Transformation of the Built Environment</td>
<td>Bristow</td>
<td>David</td>
<td>CIVIL</td>
</tr>
<tr>
<td>➡️</td>
<td>West Coast Wave Initiative (WCWI)</td>
<td>Buckham</td>
<td>Brad</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Safe Drinking Water for Low-Resource Communities</td>
<td>Buckley</td>
<td>Heather</td>
<td>CIVIL</td>
</tr>
<tr>
<td>➡️</td>
<td>Wireless networking supporting Internet-of-the-Things</td>
<td>Cai</td>
<td>Lin</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Mechatronics</td>
<td>Cheng</td>
<td>Mantis</td>
<td>CSC</td>
</tr>
<tr>
<td>➡️</td>
<td>The MOD(ularity) Squad</td>
<td>Coady</td>
<td>Yvonne</td>
<td>CSC</td>
</tr>
<tr>
<td>➡️</td>
<td>Assistive Robotics and Mechatronics Laboratory (ARMLab)</td>
<td>Constantinescu</td>
<td>Daniela</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Stochastic Energy Systems Modeling, Optimization and Operation</td>
<td>Crawford</td>
<td>Curran</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Software Engineering Global interAction Laboratory (SEGAL)</td>
<td>Damian</td>
<td>Daniela</td>
<td>CSC</td>
</tr>
<tr>
<td>➡️</td>
<td>Engineering Entrepreneurship</td>
<td>Darie</td>
<td>Ted</td>
<td>CSC</td>
</tr>
<tr>
<td>➡️</td>
<td>Biomedical Systems</td>
<td>Dechev</td>
<td>Nikolai</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Post Moore Era Computing</td>
<td>Dimopoulos</td>
<td>Nikitas</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Energy Systems Analysis</td>
<td>Djilali</td>
<td>Ned</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Wireless Connectivity Fabric for Internet of Things</td>
<td>Dong</td>
<td>Xiaodai</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Green Transportation and Quantitative Intelligent Systems</td>
<td>Dong</td>
<td>Zuomin</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Sustainable drinking water and sanitation in Canada and abroad</td>
<td>Dorea</td>
<td>Caetano</td>
<td>CIVIL</td>
</tr>
<tr>
<td>➡️</td>
<td>Growth of Semiconductor Bulk Single Crystals</td>
<td>Dost</td>
<td>Sadik</td>
<td>MECH</td>
</tr>
<tr>
<td>➡️</td>
<td>Audio and radio signal processing</td>
<td>Driessen</td>
<td>Peter</td>
<td>ECE</td>
</tr>
<tr>
<td>➡️</td>
<td>Explaining and Architecting Intelligent, Connected Software Systems</td>
<td>Ernst</td>
<td>Neil</td>
<td>CSC</td>
</tr>
</tbody>
</table>
# Table of Contents

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Title</th>
<th>Authors</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using computational methods to optimize energy use in buildings, districts and cities</td>
<td>Evins Ralph</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Network of Living Campuses</td>
<td>Froese Thomas</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Machine learning, Neuroscience and Computational Linguistics</td>
<td>Fyshe Alona</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Resource Management in Next-Generation Networks</td>
<td>Ganti Sudhakar</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Cryptography &amp; Telecommunications Research</td>
<td>Gebali Fayez</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Free and Open Source Software (FOSS)</td>
<td>German Daniela</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Development of Biomechanical Understanding and Mechatronic Devices to Improve Orthopaedic Training, Assessment and Surgery</td>
<td>Giles Joshua</td>
<td>MECH</td>
<td></td>
</tr>
<tr>
<td>Groundwater Science and Sustainability research group</td>
<td>Gleeson Tom</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Advancing Technology Based on Light at the Nanometer Scale</td>
<td>Gordon Reuven</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Intelligent Communication Networks</td>
<td>Gulliver Aaron</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Innovative Materials and Infrastructure Management</td>
<td>Gupta Rishi</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>UVic’s Advanced Microscopy Facility</td>
<td>Herring Rodney</td>
<td>MECH</td>
<td></td>
</tr>
<tr>
<td>Computer Architecture</td>
<td>Jackson LillAnne</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Computational and Logical Foundations of Security</td>
<td>Kapron Bruce</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Infrastructure for a Low Carbon Planet</td>
<td>Kennedy Chris</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Algorithm design for very large graphs and distributed networks</td>
<td>King Valerie</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Negative capacitance effect in devices for integrated circuits design and applications and development of organic thermoelectrics for use as a renewable energy source</td>
<td>Kwok Harry</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Mining and analyzing personal behaviour using hardware accelerators</td>
<td>Li Kin Fun</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Evaluation of scour susceptibility of infrastructures and recycling of Slurried Wastes</td>
<td>Lin Cheng</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Nanospectroscopy Using Integrated Ultrahigh Quality Factor Microcavities</td>
<td>Lu Tao</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Analysis and design of digital filters for image processing</td>
<td>Lu Wu-Sheng</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>Signal Processing Algorithms</td>
<td>McGuire Michael</td>
<td>ECE</td>
<td></td>
</tr>
<tr>
<td>New algorithms for representation learning and lifelong learning</td>
<td>Mehta Nishant</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Materials and Technologies for Next Generation Green Buildings</td>
<td>Mukhopadhyaya Phalguni</td>
<td>CIVIL</td>
<td></td>
</tr>
<tr>
<td>Software Engineering for Intelligent Cyber Physical Systems</td>
<td>Müller Hausi</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Graph and Combinatorial Algorithms</td>
<td>Myrvold Wendy</td>
<td>CSC</td>
<td></td>
</tr>
<tr>
<td>Mathematical modeling of complex materials</td>
<td>Nadler Ben</td>
<td>MECH</td>
<td></td>
</tr>
<tr>
<td>Table of Contents</td>
<td>Faculty</td>
<td>Author</td>
<td>Department</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>---------</td>
<td>-------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Cyber-security, Privacy and High-tech Entrepreneurship</td>
<td>Neville</td>
<td>Stephen</td>
<td>ECE</td>
</tr>
<tr>
<td>Fluid-Structure Interactions and Flow-Induced Noise</td>
<td>Oshkai</td>
<td>Peter</td>
<td>MECH</td>
</tr>
<tr>
<td>Computer Networks</td>
<td>Pan</td>
<td>Jianping</td>
<td>CSC</td>
</tr>
<tr>
<td>Nanoscale Materials for Electronics and Energy</td>
<td>Papadopoulos</td>
<td>Chris</td>
<td>ECE</td>
</tr>
<tr>
<td>Portable Platforms for Telecommunication, Security, and Biomedical Applications</td>
<td>Rakhmatov</td>
<td>Daler</td>
<td>ECE</td>
</tr>
<tr>
<td>Energy Conversion and Thermal Systems</td>
<td>Rowe</td>
<td>Andrew</td>
<td>MECH</td>
</tr>
<tr>
<td>Energy Systems: The 2060 Project</td>
<td>Rowe</td>
<td>Andrew</td>
<td>MECH</td>
</tr>
<tr>
<td>Combinatorial Algorithms</td>
<td>Ruskey</td>
<td>Frank</td>
<td>CSC</td>
</tr>
<tr>
<td>Advanced Control for Intelligent Cyber-Physical Systems</td>
<td>Shi</td>
<td>Yang</td>
<td>MECH</td>
</tr>
<tr>
<td>Laboratory of Reconfigurable Computing Engineering</td>
<td>Sima</td>
<td>Mihai</td>
<td>ECE</td>
</tr>
<tr>
<td>Multiscale Heterogeneous Computational Electromagnetics</td>
<td>So</td>
<td>Poman</td>
<td>ECE</td>
</tr>
<tr>
<td>Foundations of Data Analytics</td>
<td>Srinivasan</td>
<td>Venkatesh</td>
<td>CSC</td>
</tr>
<tr>
<td>Human Problem Solving in the Cognitive Era</td>
<td>Stege</td>
<td>Ulrike</td>
<td>CSC</td>
</tr>
<tr>
<td>Human and Social Aspects of Software Engineering</td>
<td>Storey</td>
<td>Margaret-Anne</td>
<td>CSC</td>
</tr>
<tr>
<td>Non-equilibrium Thermodynamics and Kinetic Theory of Gases</td>
<td>Struchtrup</td>
<td>Henning</td>
<td>MECH</td>
</tr>
<tr>
<td>Unmanned Air Systems and Related Technologies</td>
<td>Suleman</td>
<td>Afzal</td>
<td>MECH</td>
</tr>
<tr>
<td>Design of Durable and High-Performance Steel Structures</td>
<td>Sun</td>
<td>Min</td>
<td>CIVIL</td>
</tr>
<tr>
<td>Real-Time Modeling and Tracking of Dynamic Geometry</td>
<td>Tagliasacchi</td>
<td>Andrea</td>
<td>CSC</td>
</tr>
<tr>
<td>Sensible Analytics for Massive Interlinked Data and Social Networks</td>
<td>Thomo</td>
<td>Alex</td>
<td>CSC</td>
</tr>
<tr>
<td>Epitaxial Semiconductor Thin Film Growth for Optical Devices</td>
<td>Tiedje</td>
<td>Tom</td>
<td>ECE</td>
</tr>
<tr>
<td>Detection and Response for Emerging Cybersecurity Threats</td>
<td>Traore</td>
<td>Issa</td>
<td>ECE</td>
</tr>
<tr>
<td>Computer Analysis of Audio and Music</td>
<td>Tzanetakis</td>
<td>George</td>
<td>CSC</td>
</tr>
<tr>
<td>Environmental Informatics</td>
<td>Valeo</td>
<td>Caterina</td>
<td>MECH</td>
</tr>
<tr>
<td>Software Engineering for Medical Systems</td>
<td>Weber</td>
<td>Jens</td>
<td>CSC</td>
</tr>
<tr>
<td>Sensors for Extreme Environments</td>
<td>Wild</td>
<td>Peter</td>
<td>MECH</td>
</tr>
<tr>
<td>The Willerth Lab: Bioprinting Neural Tissue</td>
<td>Willerth</td>
<td>Stephanie</td>
<td>ECE</td>
</tr>
<tr>
<td>Network Science</td>
<td>Wu</td>
<td>Kui</td>
<td>CSC</td>
</tr>
<tr>
<td>Paradigms for Intelligent 3D Models</td>
<td>Wyvill</td>
<td>Brian</td>
<td>CSC</td>
</tr>
<tr>
<td>Advanced Wireless Communications</td>
<td>Yang</td>
<td>Hong-Chuan</td>
<td>ECE</td>
</tr>
<tr>
<td>Understanding the Environment through Computer Vision and Deep Learning</td>
<td>Yi</td>
<td>Kwang Moo</td>
<td>CSC</td>
</tr>
<tr>
<td>Compiler Construction</td>
<td>Zastre</td>
<td>Michael</td>
<td>CSC</td>
</tr>
<tr>
<td>Innovative Lateral Load Resisting Systems for Mid- and High-Rise Timber Buildings</td>
<td>Zhou</td>
<td>Lina</td>
<td>CIVIL</td>
</tr>
</tbody>
</table>
Advanced Techniques for Signal and Geometry Processing
Dr. Michael Adams, Aurora Research Group
Department of Electrical and Computer Engineering, Faculty of Engineering
University of Victoria

Research program summary
The research program is focused on the development of advanced techniques for signal and geometry processing as well as various software packages for use in industry and academia. The signal and geometry processing techniques developed are crucial components of the information technology systems of today and tomorrow. The software packages produced cover a wide range of application areas from image compression systems to tools for teaching.

Significant research projects: Contributions and impact
Signal and geometry processing techniques: Numerous techniques for handling nonuniform sampling of images have been developed. These methods are able to yield much more concise representations of images than previously proposed methods, for a fixed computational cost.

Software packages: Two software packages developed include JasPer and Aristotle. JasPer is a software tool kit for image compression that supports the JPEG-2000 codec. This software has a very large user base and is employed by many commercial products and Linux distributions. Aristotle is a software package to assist in the marking of programming assignments. This software has proven to be extremely beneficial in the teaching of a number of university courses.

HQP training and impact
The research program trains graduate students at the Master's and Ph.D. level. Students receive training in areas such as signal and geometry processing, advanced programming techniques, and software development tools. Individuals with expertise in these areas are in high demand in industry as well as academia and of great benefit to the information and communications technology sector of the Canadian economy.

Publications
Advanced Techniques for Signal and Geometry Processing
Dr. Michael Adams, Aurora Research Group
Department of Electrical and Computer Engineering, Faculty of Engineering
University of Victoria

Research program summary
The research program is focused on the development of advanced techniques for signal and geometry processing as well as various software packages for use in industry and academia. The signal and geometry processing techniques developed are crucial components of the information technology systems of today and tomorrow. The software packages produced cover a wide range of application areas from image compression systems to tools for teaching.

Significant research projects: Contributions and impact

**Signal and geometry processing techniques**: Numerous techniques for handling nonuniform sampling of images have been developed. These methods are able to yield much more concise representations of images than previously proposed methods, for a fixed computational cost.

**Software packages**: Two software packages developed include JasPer and Aristotle. JasPer is a software tool kit for image compression that supports the JPEG-2000 codec. This software has a very large user base and is employed by many commercial products and Linux distributions. Aristotle is a software package to assist in the marking of programming assignments. This software has proven to be extremely beneficial in the teaching of a number of university courses.

HQP training and impact
The research program trains graduate students at the Master’s and Ph.D. level. Students receive training in areas such as signal and geometry processing, advanced programming techniques, and software development tools. Individuals with expertise in these areas are in high demand in industry as well as academia and of great benefit to the information and communications technology sector of the Canadian economy.

Publications
Multidimensional Systems Design and Implementation
Professor Pan Agathoklis
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria

Research program summary
Multi-dimensional (MD) Systems are used to process signals which have more than one independent variable. These variables can be temporal or spatial, continuous or discrete. As such multidimensional systems encompass a large variety of dynamical systems based on partial difference, partial difference and differential-difference equations. Some of the most important applications of MD systems include image, video and light field processing as well as processing of broadband signals carried by plane waves.

Research in the area of light field processing, deals with new techniques for depth filtering, refocusing and image based rendering, using a 4D representation of light fields. This approach will allow carrying out the design in the 4D frequency domain and using design methods developed for 2D and 3D systems. This lead to techniques which are considerably more computationally efficient than current state of the art light field processing methods. Research in the area of image and video processing, focuses on the reconstruction of images/video from gradient data obtained either from processing in the gradient domain or from measurements like the Shack-Hartmann wavefront sensor. The approach is wavelet based, multiresolution which further allows the use of Poisson solvers at each resolution level to improve accuracy. Video editing, vision-realistic rendering are some of the applications being considered.

Significant Research Projects: Contributions and impact
- Developed new techniques for evaluating stability and performance of MD systems
- Published one of the first paper on 5D filtering for light field videos
- Developed a new method for reconstruction of images and video from gradient data and showed how it can be used for editing and other applications.

HQP training and impact
Currently I am supervising 3 Ph.D. students and 2 M.A.Sc students. Former students have been employed in industry and academia in Canada and abroad.

Publications
Dynamics and Digital Manufacturing (DDM)
Keivan Ahmadi, PhD
Department of Mechanical Engineering
Faculty of Engineering
University of Victoria

Research program summary
Similar to how the influx of smart devices are changing our lives in areas such as how we shop, learn, and socialize, smart factories are also poised to change how we manufacture products. Inside a smart factory, cyber-physical systems will communicate through the Internet of Things to create a network that joins the virtual world with the physical. The research at DDM contributes to the development of smart factories by studying virtual manufacturing systems (VMS), robot-assisted manufacturing, and real-time monitoring of manufacturing processes. The innovative manufacturing systems that are developed at DDM directly contribute to the sustainable growth of the Canadian manufacturing, which generates over $600B in annual revenues and is a critical driver for economic growth.

Significant Research Projects: Contributions and impact
A) Since its establishment in 2016, DDM group has joined CANRIMT—an NSERC strategic network in advanced manufacturing with the overarching objective of developing intelligent manufacturing systems. CANRIMT includes researchers from seven Canadian Universities and several major manufacturing companies such as Boeing, Pratt and Whitney Canada, and Honda Canada. In this network, DDM group is responsible for enhancing the capabilities of Virtual Machining Systems (VMS), physics-based computer simulations that represent physical manufacturing operations in digital manufacturing systems. The focus of the research at DDM is to extend the capabilities of VMS to simulate the machining (e.g. drilling) processes of advanced composite materials that are increasingly used in aerospace, marine, and automotive industries.

B) In collaboration with the Danish Advanced Manufacturing Research Centre (Denmark) and Dynamic Structures (Port Coquitlam, BC), DDM group is developing an intelligent robotic machining system for high-performance and high-precision manufacturing applications. For example, this system will enable the development of mobile machining systems for manufacturing, maintenance, and overhaul of next generation wind turbine components. In another example, the real time sensing and control system of the machining robot will enable the manufacturing of high precision optics that are used in the construction of advanced telescopes.

HQP training and impact
Current DDM group consists of two PhD, six MSc, and two undergraduate students. Students gain knowledge about fundamentals topics such as dynamics and signal processing; they also receive hands-on training about manufacturing, robotics, and vibration measurement and analysis. The communicated skills prepare the graduates of DDM for technical jobs in modern Canadian manufacturing sector that increasingly demands expertise in flexible automation and digital manufacturing.
Microengineered Systems for Disease Modeling and Drug Delivery
Mohsen Akbari, PhD, Assistant Professor (makbari@uvic.ca), Google Scholar
Director of Laboratory for Innovations in Microengineering (LiME)
Department of Mechanical Engineering, Faculty of Engineering, University of Victoria

Research program summary
Research at the LiME lab spans diverse fields including microfluidics, materials science, chemistry, cell biology, drug delivery, and advanced biomanufacturing. My group provides an active learning and highly collaborative and interactive environment for students to gain hands-on experience in the design and development of innovative microscale platforms for applications in tissue engineering, disease modeling, and drug delivery. Our mission is to establish a unique and interdisciplinary research and educational program that can have a significant impact on the quality of human life. Since joining UVic, part of my team's efforts has focused on the engineering of cancer models that can be used to better understand disease progression and drug screening. These models will minimize our reliance on animal models that are expensive, have interspecies variations, and have ethical challenges. Additionally, we developed several innovative drug delivery platforms for on-demand and localized delivery of drugs for treating slow-healing wounds and cancers. These platforms may significantly improve the quality of life and will reduce the economic burden on the patients and the healthcare system. Our research is supported by the generous funding we received from the University of Victoria, CIHR, CFI, NSERC, and BC Cancer Foundation.

Significant Research Projects: Contributions and impact (IF: Impact Factor)

*Advanced biofabrication of tissues:* We developed advanced fibrous tissue-like constructs from cells, biomaterials, and bioactive molecules for engineering of complex organs in the peripheral nervous system, skeletal muscle, and skin. We combined two well-established technologies of 3D printing and textile with microfluidic fiber spinning to the structural and cytoarchitectural complexities of native tissues. These engineered tissues are used for disease modeling and developing innovative drugs for the better treatment of life-threatening diseases such as cancer and neurological disorders. We published several papers in prestigious Journals including *Advanced Materials* (IF:20) and *Advanced Functional Materials* (IF:12.3).4,5

HQP training and impact
This multidisciplinary program equips my HQP with skills useful for future employment in the life sciences and medical device sectors, including employment with our industrial partners. All my trainees acquire experimental skills in fluid mechanics, biomaterials, microfabrication as well as cell studies and molecular biology. They acquire ample modeling skills using numerical simulation used in the R&D industry; a key asset in the competitive marketplace and a foundation for entrepreneurship. All my students contribute to high-impact research and publications and have received several awards including the Innovative Research with Industry-Partnership Potential Award and several Travel Awards.

Improving Performance and Energy Efficiency in GPGPUs
Dr. Amirali Baniasadi
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
We explore and build power-aware GPGPUS relying on a less aggressive approach to computing but still capable of delivering acceptable results. We perform a deep analysis of General Purpose Graphic Processing Units (GPGPUs) and develop both hardware and software solutions to reduce energy consumption and improve efficiency while maintaining accuracy within acceptable limits. While our hardware solutions focus on designing new and efficient Graphic Processing Units, our software solutions use a compiler based approach to identify opportunities to trade accuracy and performance for low-complexity computing.

Significant Research Projects: Contributions and impact
My past work has impacted the field in several ways. First, it has provided better insight into how GPGPUs are built. Moreover, we offer solutions to reduce programming development effort while maintaining performance. We have also optimized GPGPU hardware by designing new processor components. Finally we have built resilient GPGPUs, which consume less energy compared to previously designed systems. This final contribution is critical as the persistent trend in society is that computing infrastructures grow in sizes and energy demands. This demand can impact the environment negatively if proper measures are not taken. The practice of using computing resources while minimizing environmental consequences is referred to as green computing. Meeting the increasing energy demand of computing cautiously requires attention at every level including designing, manufacturing, using, and disposing of computers. We contribute to designing more environment-friendly systems by exploring ways to reduce power dissipation and as an indirect achievement lower heat. Both achievements are important goals of green computing.

HQP training and impact
I supervise students to achieve an in-depth understanding of hardware and software design. In addition to the five current HQP, I have trained 19 HQP in the past six years. PhD and Masters students were trained under my supervision at UVic. The training that I have offered has had high impact. As a result, 21 HQP have co-authored publications with me in the last six years.

Publications
Soft-switched high-frequency power converters for alternative energy systems

Dr. Ashoka K.S. Bhat, Dep. of Electrical and Computer Engineering, Faculty of Engineering, University of Victoria

Research program summary

World-wide increased energy demand with environmental concerns, alternative energy sources either integrated to the existing power grid or in a micro-grid utilizing hybrid ac and dc buses are becoming popular to ensure increased electrical energy security. The outputs of these energy sources vary widely including some operational limits, e.g.: permanent magnet synchronous generators (PMSG) used with wind turbines generate ac output of varying voltage and frequency; linear synchronous generators used in sea wave energy conversion have fluctuating power with varying amplitude and frequency output voltage waveform; fuel cells generate wide varying low voltage dc (22 to 41 V) having slow transient response for load changes while they are very sensitive to ripple currents. When different energy sources are connected to a dc bus a bidirectional dc/dc converter is needed for battery or ultracapacitors charging as well as to supply the dc bus. A dc to ac inverter is required for utility interface to augment power generation or for standalone operation. Therefore, to satisfy the constraints imposed by these energy sources, low cost, highly efficient power electronic converters are indispensable part of such systems. This is possible using soft-switching converters operating with low losses and high switching frequencies having a number of advantages (e.g., high efficiency, small size, light weight, reduced EMI, low component stresses). Thus, our main objectives are: (1) to propose, analyze and design new high-frequency (HF) transformer isolated soft-switching single-phase and 3-phase power converter topologies (unidirectional and bidirectional dc/dc, dc/ac for utility interface and ac/dc with high power factor for PMSG and linear generators); (2) to develop soft-switched electronic transformers for direct ac/ac conversion; (3) interleaved operation for high power applications; and (4) to study the performance of designed converters using INTUSOFT SPICE or PSIM simulation software and building prototype experimental converters. Proposed converters will have reduced size and weight (due to high switching frequency, low losses and HF transformer isolation) reducing their cost while satisfying the stringent requirements of energy sources. Ac/dc and ac/ac converters developed for wind and sea-wave generators will have high power factor, low harmonic distortion, some of them will have single stage power conversion with HF transformer isolation. With huge potential for power generation from sea wave and wind energy in Canada.

HQP training and impact

With increased energy demand and environmental concerns, use of alternate energy sources has become inevitable and power electronic converters are indispensable for efficient use of these energy sources. This trend has created world-wide heavy demand for highly qualified power electronics engineers especially trained with emphasis on application to alternative energy systems. This research proposal has trained and is expected to train several graduate and undergraduate students in the area of power electronics with emphasis on application to alternative energy systems. They will be trained in analysis, design, simulation and building of experimental converters. Example: list of 3 students graduated (+ several undergraduate project groups were supervised, 44 students).


Publications

Nanoscale materials and sensor technologies enabling a diversity of applications

Early detection of cancer, low-cost, high-performance electrodes for solar & display technologies

Dr. Rustom Bhiladvala, Nanoscale Mechanics & Materials Laboratory
Department of Mechanical Engineering / CAMTEC / IESVic / CBR
Faculty of Engineering, University of Victoria

Research program summary
We have demonstrated [1] specific detection of a few molecules of a prostate cancer biomarker (PCA3), using vibrating nanowires, about a thousandth of a human hair thick. A distinguishing feature was the nanoscale assembly method developed with colleagues at Penn State University [2], refined by us [3] to provide cancer clinicians' stated needs: (1) large arrays of sensitive, specific detectors of cancer biomarkers at cost low enough for clinical use and (2) detection of multiple types of disease marker molecules on the same chip. Traditional nanofabrication techniques can be used to make sensitive devices, but they cannot meet these clinical needs. We sense molecule binding by using a laser beam to measure change in nanowire vibration frequency. Understanding and removing artifacts due to laser-nanowire interaction poses challenging research questions for our students, who work to translate these landmark demonstrations into clinical tools for use in the early detection of cancer.

The field-directed assembly technique used for cancer sensing was recently extended by Dr. Sam in our group, to enable long chains of nanowires to be deposited on glass. She showed [4] that carefully controlled NW chains can be made sparse enough to keep the glass transparent, while making it electrically conductive; this allows a low-cost, high-performance replacement for electrodes used in solar electric power generation, cellphones and large area electronic blackboards. Our research group has attracted industry sponsorship and support for work on such applications.

Significant Research Projects: Contributions and impact
Besides the impact of our publications evidenced by citations, we have been approached by industry partners through our RPKM office. Two US patents have been filed (one accepted), we have had 5 Engage/(+) grants and are working on a CRD application with a current partner.

HQP training and impact
All of our graduate research alumni either have jobs in industry, as engineering analysts (Mercedes Benz, Intel), nanomaterials R&D (Group NanoXplore) leaders, have opted for further graduate study (UBC) or secured postdoctoral positions (MITACS/I2X). Undergraduate students (about 30) have enjoyed work with us and contributed new ideas, or special skills to several aspects of our research, through NSERC USRA fellowships, or international fellowships for students from Germany, India, China and Brazil. Several have gone on to graduate study (UVic, UT, UBC).

Publications
Advanced Substrate Integrated Waveguide Components
Professor Jens Bornemann — The CADMIC Group http://www.ece.uvic.ca/~jbornema/cadmic.html
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
The principal objective of this research program is to elevate Substrate Integrated Waveguide (SIW) technology to a state in which it provides a complete, technically feasible and low-cost solution to current and future wireless millimetre-wave systems and networks such as 5G, the Internet of Things and radio astronomy. That includes the capability of low-loss filter, diplexer and antenna component design as well as the integration of active, nonlinear and surface-mount devices.

Significant Research Projects: Contributions and impact
1) Substrate-Mounted Waveguide (SMW) technology is introduced and demonstrated to allow low-loss filter and diplexer realization that is adaptable to low cost, high volume production by employing standard printed circuit board (PCB) processes. 2) The integration of active components in SIW technology is achieved with respect to amplifiers, variable phase shifters and tunable filters. 3) New concepts for multiple pass- and multiple stopband filters are introduced. 4) Advanced SIW antennas and arrays allow entire millimetre-wave systems (e.g., for 5G) to be integrated on a small single substrate.

HQP training and impact
All graduate students, postdocs and research associates are trained in a number of different software packages that are used in industry for the design of RF/wireless/microwave/millimeterwave components. They are experienced in prototyping circuits, interacting with industrial prototype manufacturers, operating vector network analyzers, especially with respect to de-embedding of transitions and antenna measurements, as well as error analysis, trouble shooting and solution finding. Graduate students make tremendous contributions to this research program which is evidenced by a number of publications in high-ranking journals.

Publications
Advanced Optical Instrumentation for Astronomy
Professor Colin Bradley
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research Program Summary
Professor Bradley’s research laboratory has been at the forefront of astrophysical instrumentation research since 2002 and has undertaken critical research projects for both national and international astronomy projects; in particular, the next generation of ground-based extremely large optical telescopes. For example, the Thirty Meter Telescope project and the European Extremely Large Telescope. These telescopes are either under construction or in the detail design phase and are completely dependant on such technologies for successful operation in the coming two decades.

Significant Research Project
The laboratory was awarded a Canada Foundation for Innovation (CFI) grant in 2010 called “The Multi Object Adaptive Optics Test Bed”. The total project award was $6,200,00 and brought together international and national research institutes. The test bed instrument was entirely designed and built at UVic by a team of scientists, research engineers and graduate students. The instrument achieved a major milestone by being the first highly complex multi-object adaptive optics instrument to be successfully installed on an 8-m class telescope. The instrument completed a successful set of trials (2014-2016) on the Subaru telescope (Mauna Kea, Hawaii). The research results have been widely published and all next generation telescope teams are employing the research deliverables.

HQP Training and Impact
The research program has provided leading-edge research experience and training for outstanding graduate students and post-doctoral researchers in optics, real-time computing, control systems and software engineering. Past graduate students have gone onto PhD studies at international universities or assumed prestigious post-doctoral research positions at institutes such as the Jet Propulsion Laboratory.

Publications
Computer Vision-Based Environmental Monitoring
Dr. Alexandra Branzan Albu, Associate Professor
Department of Electrical and Computer Engineering, cross-listed with Computer Science
Faculty of Engineering, University of Victoria

Research program summary
Recent advances in computer vision have initiated a revolution in the way that they can be applied to complex problem domains. One such domain is the field of environmental monitoring, which is of critical importance for the study of ecosystems and climate change processes. My long-term objective is to champion a paradigm shift in environmental monitoring methodologies, from resource-intensive, small-scale studies towards automatic, data-driven, quantitative analysis of complex natural environments. I focus on providing computer vision-based solutions to Big (Visual) Data problems, which are on the rise in environmental sciences.

Significant Research Projects: Contributions and impact
Recent climate changes significantly impact the distribution and behavioural patterns of many species. It is therefore imperative to develop novel techniques to monitor species at risk, as well as modifications in their behaviour, which may be triggered by environmental changes. A method for re-identifying individual pond turtles using images of their plastron was proposed in [1]. Changes in the behaviour of wild fish caused by exposure of their natural habitat to boat noise are studied in [2]. This is the first proposed automated method for analyzing subtle movements of a highly territorial animal in its natural underwater habitat. Detection of sea stars was proposed in [3]. The relevance of computer vision techniques for automated species abundance estimation is discussed in [4], which compares the performance of three groups of humans (untrained volunteers, undergraduate students, and experts) and of a custom-designed algorithm for a fish detection and counting task.

HQP training and impact
I currently supervise two M.A.Sc., four Ph.D., and one postdoctoral fellow. I am particularly proud of leading a gender-balanced group, given that the international computer vision research community sees little participation from women. Four of my current HQPs are women, as well as five of my recent M.A.Sc. and Ph.D. graduates. My group also features a balanced mix of Canadian and international students; its cultural diversity contributes to a great work climate and lively discussions. I strive for cultivating and maintaining a sense of community and belonging in my group by designing collaborative projects and assigning specific tasks to each student. All my trainees have been involved in disseminating their research in conference and journal publications. One may note that the vast majority of my publications have a student as first author.

Publications
Sustainability and Resiliency Transformation of the Built Environment

Assistant Professor David N Bristow, PhD, EIT
Cities and Infrastructure Systems Lab (CISL)
Department of Civil Engineering, Faculty of Engineering
Member, Institute for Integrated Energy Systems
University of Victoria
Board Member, Sustainable Urban Systems Section of the Int. Society for Industrial Ecology

Research program summary
I am interested in how the component parts of buildings, cyber-physical systems, infrastructure and cities interact – how these interactions can create more sustainability and more resilience to shocks and stresses. I ask questions such as: (1) How do resilience and sustainability decisions impact one another? (2) How can the benefits of individuals’ systems be valued in a broader system? (3) how can we adapt our built form to a changing climate and other risks? And (4) How can we accelerate recovery from disruption?

Significant Research Projects: Contributions and impact
I created the Graph Model for Operational Resilience (GMOR) to support recovery planning from large multi-infrastructure disasters or multi-system failure (an invention disclosure and provisional patent application have been filed). The tool is in use in many research projects, including application with the District of North Vancouver. Other contributions include the study of energy and material stocks and flows of society, including the first assessment of energy buffer capacities in the urban metabolism – an essential element in determining city-wide tolerances to disruption – and developed an infrastructure planning tool for city-wide greenhouse gas emissions. My work also extends to design and retrofit of buildings that achieve lowered risk of operation, heightened sustainability and an improved return on investment.

HQP training and impact
Within 13 months of starting, the CISL lab saw 3 Undergraduate Research Assistants (including 1 NSERC USRA), 1 Master's student, 1 PhD student and a Postdoctoral Fellow - with more already set to join. The HQP come from different areas within engineering, architecture and computer science for the interdisciplinary opportunities. Skills are developed, variously in areas of civil and systems engineering, infrastructure and urban planning, building science, decision science, numerical modeling, and data science with application to sustainability, resiliency, risk, and climate change mitigation and adaptation. Students work on methods and applications in partnership with industry and government.

Publications
- Bristow, D., 2017. How spatial and functional interactions between operations and infrastructure leads to resilient recovery. Submitted to ASCE JIS
- Bristow, D.; Hay, A., 2016. Graph model for probabilistic resilience and recovery planning of multi-infrastructure systems. ASCE JIS.
West Coast Wave Initiative (WCWI)
Professor Brad Buckham
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
For Pacific Canada, wave energy is a predominant renewable energy resource that has long been targeted for commercial development. Despite the prevalence of this renewable energy resource and a legislated mandate to exploit clean energy sources, wave energy does not appear in the BC Integrated Resource Plan, nor is it one of the options pursued by the >50 BC remote communities that are actively seeking technical pathways to wean off diesel fueled energy generation. The roadblock to wave energy development has been uncertainty in the measurements of the natural wave energy resource, the assessments of the portion of that resource that can be extracted by technology and the plans for synchronizing the extracted wave energy with demand (referred to as “integration”). The WCWI is focused on building the data sets, computational tools and subsequently the social license that are prerequisites to incorporating wave energy in community, regional or provincial energy planning.

‘Gross’ resource assessment — develop a coastal wave propagation model based on the freeware SWAN that provides spectrally and directionally resolved wave energy estimates over the BC coast. Operate that model in both hindcast and forecast modes and validate through field measurements taken from a fleet of directional wave monitoring buoys that are positioned around Vancouver Island.

‘Net’ wave energy resource assessment — Develop a Wave Energy Converter (WEC) simulation facility capable of producing <1s resolved descriptions of WEC motions, reaction forces and power production for any wave condition recorded in the raw assessment. The simulation facility was built around a core formed from the commercial code ProteusDS.

‘Usable’ wave energy resource assessment — partner with consulting engineers developing clean energy projects for remote communities on the West Coast of Vancouver Island and determine the extent of the diesel fuel savings that can be realized using a WEC.

Significant Research Projects: Contributions and impact
The bulk of the WCWI resources assembled over the past 6 years were funded through an Natural Resources Canada ecoENERGY Innovation Initiative (ecoEII) award, an NSERC Strategic Projects Grant, a grant from the Pacific Institute for Climate Solutions, private sector partner contributions and a grant from Marine Renewables Canada (a non-government organization that represents the Canadian marine energy sector). Current funding is provided by the CFI, Western Economic Diversification (WD), a pair of NSERC CRD grants, various NSERC Engage grants and the Discovery Grant program. The recent CFI award is part of the C-PROOF (Canadian Pacific Robotic Ocean Observing Facility) initiative (joint with SEOS) and will see a larger buoy capable of wind profiling installed off the Van Isle West Coast. That wind data will be key to expanding wave energy modeling into the floating offshore wind turbines. That wind data set will be the first of its kind on the Canadian Pacific coast.

The very recent WD support is for a new laboratory PRIMED (Pacific Regional Institute for Marine Energy Discovery) to be built at the UVic Marine Technology Centre. PRIMED will be a receptacle for WCWI outputs, and PRIMED staff will use those outputs working in partnership with remote community leadership and Marine energy technology developers. PRIMED’s role is to uncover the techno-economic rationale that are needed to acquire the financial support for first-of-a-kind remote community marine energy technology deployments. Those deployments will need to be funded through other awards (likely from Sustainable Development Technology Canada and/or the BC Innovative Clean Energy Fund), and those proposals will be built on techno-economic rationales produced through PRIMED.
Safe Drinking Water for Low-Resource Communities

Dr. Heather Buckley
Department of Civil Engineering, Faculty of Engineering, University of Victoria

Research program summary

Metal releases into groundwater and surface water from untreated mine tailings hydrocarbon extraction are persistent hazards to human and environmental health. As a country rich in mineral resources, Canada has legal and ethical responsibility to ensure that water resources remain safe for use in communities and in natural habitats surrounding resource extraction. Ensuring that all communities have safe drinking water is a critical challenge for Canadian research.

The vision for this research program is to empower remote and Indigenous communities in Canada and internationally by making water monitoring and treatment safe, affordable, and accessible, improving human and environmental health outcomes. Opportunities span from the selective detection of contaminants of concern to the development of inherently safer water treatment technologies, following the principles of green chemistry for rational molecular design. Specifically, two streams of research guide this program: (1) In-field detection of trace inorganic water contaminants, and (2) Extraction of mineral resources from waste streams.

The Buckley group takes a molecular approach to the detection and removal of critical water contaminants at active and legacy sites of intensive resource extraction. The novelty of this program lies in the creation of sensors specifically designed to bind and report species of concern to human and environmental health. We will develop affordable sensors that allow real-time monitoring of water quality, empowering communities in Canada and globally to ensure that they have reliable access to safe drinking water. The knowledge gained through sensor deployment will inform targeted development of treatment strategies and technologies both in our research group and the broader water treatment community.

Significant Research Projects: Contributions and impact

Dr. Buckley’s previous work includes the design and practical implementation of safer alternative chemistries, resulting in avoided health and environmental impacts on water systems and human habitations. These include safer preservatives for consumer products (incorporated into R&D at Method Home), waterproof additives for high quality shelter (250+ roofs installed by ReMaterials in Ahmedabad, India), and low-cost removal of natural contaminants from groundwater.

HQP training and impact

This program provides a unique, interdisciplinary training environment for HQP in the Canadian research system, spanning the disciplines of civil and environmental engineering, synthetic chemistry, and green chemistry and teaching valuable communication and project management skills through collaborations with public health experts, community, and industry stakeholders to tackle a globally relevant challenge of providing safe, secure drinking water to all people.

Publications

Wireless networking supporting Internet-of-the-Things
Professor Lin Cai, Communications & Networking Lab (CN Lab)
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
After the explosive growth in the past three decades, the Internet is still in the early stage, and its growth will accelerate in the following decades thanks to the demand of Internet-of-the-Things (IoT), which can be used in a broad range of industries from traditional manufacturing to services sectors, as well as to further modernize agriculture and enhance security. Wireless communication and networking technologies are critical for future IoT applications that are anticipated to reduce costs, improve productivity and efficiency, and discover new revenue sources. The research program in the CN Lab led by Dr. Lin Cai aims to develop effective wireless networking solutions to enable various IoT applications for future smart cities and smart societies.

Significant Research Projects: Contributions and impact
Since 2016, Dr. Lin Cai has led the NSERC/MOST Strategic Project, Networked Electric Vehicles (EVs) for Green Intelligent Transportation, which is a joint Research Project supported by NSERC, Canada and MOST, Taiwan. Researchers from University of Victoria are in collaboration with the top researchers and industries in Waterloo, Toronto, and Taiwan. By collaborating with international industry sponsors and researchers, the project delivers new technologies aiming to foster a competitive edge for both Canadian and Taiwan information and communication technology (ICT) industries and manufacturers for EVs, charging stations, and accessories.

Dr. Cai has been the recipient of the NSERC Discovery Accelerator Supplement Grants twice in a row, in 2010 and 2015, respectively, and the Best Paper Awards of the IEEE ICC 2008 and the IEEE WCNC 2011. She is a Distinguished Lecturer of the IEEE VTS Society since 2015.

HQP training and impact
Students and postdoc fellows trained in CN Lab have received numerous awards and scholarships nationally and internationally. They published extensively in top-tier journals and conferences. They have all been successful in launching their careers in academia or industries.

Publications
- Please see http://www.ece.uvic.ca/~cai/public.html for the list of publications.
The MOD(ularity) Squad
Professor Yvonne Coady
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
Recent research efforts from the MOD(ularity) Squad include building scalable systems for Earth Observation and Urban planning. Support for this work comes from an NSERC Collaborative Research and Development grant with IBM, a Mitacs Accelerate grant with Urthecast, and research grants through MEOPAR and the SALA Lab at UBC. In addition to systems and software engineering challenges, the group has tackled more contemporary issues of UI/UX in applications that require exploratory analytics and modified interfaces. Support for these efforts include an NSERC Discovery grant for deployment tools in distributed clouds, a Mitacs Accelerate grant for context-aware language analysis, a Mitacs Accelerate grant for accessibility-enhanced interfaces, and an NSERC Collaborative Research and Development grant with Ericsson for virtual reality based spatial analytics within data centers. Current research projects include mixed reality systems, citizen science, and new programming paradigms and future pedagogical directions for immersive applications.

Significant Research Projects: Contributions and impact
The squad held 13 additional industry collaborations co-funded by NSERC or Mitacs over the last four years. As a result of this work, Dr. Coady was a co-recipient of the University of Victoria’s Knowledge Mobilization Award in 2015.

HQP training and impact
Together, this group has coauthored over 170 papers and Dr. Coady has (co)supervised over 40 graduate students. The squad has gone on to careers with Microsoft, Apple, Verizon, and teaching at UBC. Dr. Coady continues to work on issues of professional education and applied research as an Adjunct with the Master’s of Digital Media program at the Center for Digital Media. Her most recent effort includes co-designing a course for the Indigenous Matriarchs 4 (IM4) project with Loretta Todd and Emily Carr University. While on sabbatical in 2017, Dr. Coady started RAVR (Research in Augmented and Virtual Reality), co-organized SAVR (Software for Augmented and Virtual Reality), and worked on a Virtual Reality installation at the Royal BC Museum built by CDM students called BC Stories. The educational evaluation of this project was profiled in the VRAR Association’s Blog on Education. Dr. Coady is also the Chief Scientist and Co-founder of PurposeFive, a social enterprise working to promote diversity within executive and technical teams.

Publications
Faculty of Engineering Research Program Briefs

Assistive Robotics and Mechatronics Laboratory (ARMLab)
Associate Professor Daniela Constantinescu PhD, PEng
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
The research in the ARMLab aims to extend the human touch and manipulation abilities across geographical distance and into digital worlds. Force-based interactions in remote and digital environments benefit fields that demand the dexterity of one or multiple operators but need to dispense with the human presence because of scale constraints or environmental hazards, or because the interaction is in a digital world. Important applications include telesurgery and telerehabilitation, virtual reality-based surgical training, serious computer games, marine oil and gas field services, subsea and terrestrial explosive device mitigation, nuclear decommissioning. The ARMLab develops comprehensive modeling and control frameworks for single and multi-user force-based interactions in remote and digital environments. A key research goal is to render the control of the robotic systems that mediate users’ remote or digital interactions composable, in the sense that a system of systems will inherit stability, robustness and fidelity from its components. Composability will lead to simple and systematic control design strategies for force-based cooperation among humans, among humans and robots, and across computer networks, advancing the use of such cooperation in practical applications.

Significant Research Projects: Contributions and impact
Constantinescu’s scholarly work brought significant contributions in the areas of: (1) force-based interaction in slowly updated digital environments, by developing control and filtering strategies to passively connect users to digital worlds updated at slow and fixed rates, and to convey crisp transitions from free motion to simulated contact; and (2) force-based cooperation among multiple networked users, by developing force rendering methods that permit direct user-to-user interaction in addition to cooperative manipulations, and distributed controllers for cooperation among more than two users. Constantinescu also served on the Organizing Committee of the IEEE Haptic Symposium.

HQP training and impact
Over the past 6 years, Constantinescu graduated 2 PhD students, 1 MASc student, and 2 MEng students, and supervised 5 visiting MASc students and 4 visiting undergraduate students. Her graduate students published their work in IEEE and ASME journals and conferences in haptics, robotics and control. They have pursued academic positions in Canada, further graduate work in the US and Europe, or work for Canadian companies and Dutch start-ups.

Publications
Stochastic Energy Systems Modeling, Optimization and Operation
Dr. Curran Crawford, Sustainable Systems Design Lab (SSDL)
MECH/IESVic
Faculty of Engineering
University of Victoria

Research program summary
Our society is increasingly facing the consequences of climate change, providing impetus for economic, political and societal changes to reduce greenhouse gas emissions (GHGs). Our GHG footprint is in large part determined by the energy systems we use. My lab’s research program is aimed at developing and then employing models of these inter-connected energy systems to reduce GHG emissions. The models span the range of technical detail from energy capture devices (wind, wave, tidal, solar) through electrical and synthetic fuels pathways to end uses (transportation, heating). The models have a unique focus on capturing the stochastic nature of these systems, using a range of probabilistic modeling tools and multidisciplinary optimization approaches. My lab also works with researchers in psychology, business, economics and others to capture the effects of consumers in these models. As storage is a key element of moving to renewables-based energy systems, a specific focus is the use of demand response (DR) to control loads on the energy system in real-time, to act as virtual generators with no GHG impact.

Significant Research Projects: Contributions and impact
I led a 4-year project with SFU, UBC and BCIT to help BC in rolling-out plug-in vehicle infrastructure across BC, including projecting consumer adoption and grid loads, and helping to inform BC incentive policies. Recently, we have conducted modeling for multiple transit authorities, municipalities and utilities across Canada to determine the technical feasibility of adopting electric transit buses, as part of CUTRIC, a national consortium. Our stochastic grid modeling and demand response work is starting to achieve impacts through internal discussions with BC Hydro and Enbala (DR company). In the emerging realm of airborne wind energy, we are developing unsteady wind models and system upscaling models to contribute to the design of this nascent energy generation technology; we do this as part of the AWESCO EU project, and with various industrial partners. Our stochastic models of conventional wind turbine aerodynamics, and probabilistic composites used in wind turbine blades, are helping to enable the next generation of 10-20 MW machines that must implicitly include stochasticity in their design. We have developed a methodology for analysis of tidal turbine farms, to enable developers to optimize projects with more confidence and reduced risk.

HQP training and impact
My lab has trained over 40 HQP over the last 10 years, from undergraduate through to post-docs. These HQP have gone on to careers in a range of areas in the renewable energy sector, including: professors at UNB and Catholic University of Chile on clean energy; researcher at DTU (premier wind energy institute); engineer at Canadian wind turbine company; renewable energy consultants; UVic energy manager; engineers and researchers at TESLA, Ford and GM.
Professor Daniela Damian, PhD, PEng
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
In a synergetic partnership with local as well as large international software corporations, the research I lead aims to improve the quality and effectiveness of geographically distributed software development projects. The business of software, its stakeholder landscape as well as societal impact has become global, with an unprecedented international outreach. However, the ability to develop software across geographic, cultural and organizational distances has been challenged by the complexities of IT ecosystems involving diverse human and business interactions across organizational, functional as well as national, cultural and socio-economic boundaries. In SEGAL we employ a synergy of empirical methods, data mining and social network analysis techniques to understand these complex interactions as well as engage in ongoing technology transfer to develop methods, processes and tools to improve the effectiveness of communication and coordination in large, distributed software projects.

Significant Research Projects: Contributions and impact
Damian’s scholarly work brought significant contributions in the areas of: (1) Requirements Engineering, by bridging the gap and facilitating communication between the community of software developers and the community of software users so that the user needs are adequately expressed and captured, and made central to the development of software development processes and (2) Globally Distributed Software Engineering, by serving large international corporations to make effective use of communication and information technologies to support teams and organizations that collaborate closely without the need to be in the same location, as well as individuals to work for an organization without having to relocate there (particularly important for unique talent in certain geographical areas such as Vancouver Island or women having family whilst continuing employment). Damian’s work with a variety of major industry partners such as IBM, GM, Dell, and Siemens resulted in significant technology transfer at these organizations, as well as awards related to the impact in their development processes and employment education in these areas. Damian also serves on the major boards and editorial venues of scholarly work in Software Engineering.

HQP training and impact
Over the past 6 years Damian graduated 6 PhD students and 7 MSc students, and supervised 4 post-doctoral fellows and many undergraduate research assistants. Her graduate students and post-docs published their work in top IEEE journals and international conferences in the area of Software Engineering. Her students pursue academic positions in US, Europe and South America, or work for large software corporations such as IBM, Amazon, or Siemens.

Publications
Engineering Entrepreneurship
Professors Thomas (Ted) Darcie and Stephen Neville
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria

Research program summary
This is a broad and innovative program that we established in which teams of Master’s students work with business leaders from world-class high-tech incubator Wesley Clover, with financial support from the BCIC and others. Students with high entrepreneurial aspirations earn MASc degrees and ownership stakes in the company that is to be incorporated upon completion. A MASc thesis is defined from the development of the core technology. This model was received as an exciting and highly innovative opportunity for all players involved and has proceeded very well after a 2009 launch resulting in the creation of 6 new companies (one new company per year).

Significant Research Projects: Contributions and impact
Evidence of the power of our unique partnership model is that all of these new companies are flourishing, whereas the typical success rate for start-ups is < 1/10. Wesley Clover, BCIC, Western Diversification and the newly-created not-for-profit Alacrity Foundation committed ~$1M to UVic resulting in the creation of these companies: Referral SaaSquatch, Tutela, Pretio, Encepta, EchoSec and most recently, Certn. Our companies now employ roughly 180 engineers within the region with a market capitalization exceeding $30M. We received the 2016 Craigdarroch Research Award for Research Partnerships for this program.

HQP training and impact
Roughly 17 students successfully completed this program. Each has gone on to become a technology and business leader of their respective companies. Several awards (VIATec, BC Business) have been won for business leadership and teamwork. Most graduates remain in the region, whereas most would have gone to the US without this program.
Research Program Summary

We are focusing on computing and supporting architectures compatible with the post-Moore era where foreseeable device scaling limitations and power constraints do not allow performance scaling on general purpose architectures.

Most often, specialized architectures are targeting and are optimized for specific computations while new technologies, such as quantum computing among others, are emerging.

Our approach is two-prong. We are interested in studying and developing computational methods and eventually architectures targeting specific applications namely neural networks. Secondly, we are interested in studying the interaction of software and the underlying hardware in delivering performance under low power.

In terms of neural networks research, we are focusing in developing methods for training models that would generalize well. This is a particularly difficult problem when not enough examples are available to train the model. Unlike deep learning where data is abundant and the issue is the extraction of information/knowledge from the available data, in certain domains such as QSAR (quantitative structure activity relationship) examples are rare since the involvement of biological experimentation is exceedingly expensive. We have developed regularization methods that help our models generalize well under such adverse conditions. Our heuristics are computationally expensive since they rely in the training of many different models and the selection of the most fitting ones. In order to improve the computation time, we have experimented with quantum annealing techniques, successfully developed methodology and run our applications on D-Wave’s 2000Q system.

Another aspect of our neural network related research, is research in understanding the effects of disease on brain activity. Our hippocampus models have shown that “dead regions” such as the ones encountered in CTE (Chronic Traumatic Encephalopathy) or in Alzheimer’s patients tend to increase the base frequency of the theta rhythm.

In terms of processor power/performance modeling, we have developed models that can predict the power and performance of software running on GPUs based on analysis of the software itself and the resources available to the GPU running it. Similarly, we have developed models that predict stable phases and their power demand through training application-specific models on short duration training runs.

HQP Training

Four PhD students, one Masters student and an undergraduate honours student are at various stages of completing their degrees.

Publications

- S. Khoshbakht, N. Dimopoulos “Execution Phase Prediction Based on Phase Precursors and Locality” 5th International Workshop on Energy Efficient Supercomputing (E2SC), 2017
Research program summary
Our research program focuses on understanding energy systems and identifying feasible decarbonization pathways accounting for the links between the techno-socio-economics of the provision of energy services demanded by society and the energy sources provided by nature. The work encompasses: i) development of novel electricity systems operation through demand response schemes and smart grid technology to facilitate large scale penetration of renewable energy; ii) analysis of the potential for greenhouse gas reduction in the transportation sector via electrification and system integration of public transport and personal vehicles, including e-buses, electric cars and e-bikes; (iii) system modelling integrating water, energy and climate with application to long-term infrastructure planning to achieve concurrent development and sustainability objectives in Canada and in various regions/subcontinents. The main thrust of our system modelling and analysis work is to identify synergistic system integration and inform investment and policy decisions toward long-term sustainability.

Significant Research Projects: Contributions and impact
Examination of hydro-climatic change in the context of long-term electricity supply and demand in British Columbia has shown the crucial importance of embedding adaptation strategies due to the large contribution of hydropower resources to regional electricity supply. Using basin-scale hydrologic models driven by downscaled global climate data, we showed that the combined effect of seasonal streamflow and warmer temperatures could significantly impact long-term generation planning; the implication of climate uncertainties were systematically analysed to outline the required adaptive capacity in long-term planning. This work and the related sub-continental scale studies have led to collaboration with the renowned International Institute for Applied Systems Analysis to study the water-energy-climate nexus in Africa.

We have developed multiscale transactive control strategies that, when coupled to coordinated operation of neighbouring electricity jurisdictions, can significantly enhance renewable resource utilization and reduce costs. Estimates for the Western Electric Coordinating Council (WECC) that consists comprises BC, Alberta and 14 US states indicates that annual systems cost savings exceeding US$150B can be achieved by the year 2024. This work has been conducted in collaboration with the Pacific Northwest National Lab (Washington), Stanford’s SLAC Laboratory, and Tianjin University in China.

The transportation electrification work has spun off two collaborative projects, the first sponsored by CUTRIC (Canadian Urban Transit Research & Innovation Consortium) to develop strategies for the management of electric bus fleets operating with various transit authorities, including impacts on the electricity grid. The second is a local community project in partnership with the CRD (Capital Regional District) to explore strategies for reducing GHG emissions in the CRD fleet through development of a Smart Fleet analysis for fleet optimization, and field trial of fuel cell electric vehicles and cargo E-bikes.
Recent Awards include:
- Fellowship, Royal Society of Canada (2013)
- Honorary Professorship, Tianjin University, China (2013)
- Thompson-Reuters Highly Cited Researcher (2014)
- Jules Stachiewicz Medal, Canadian Society for Mechanical Engineering (2017)

HQP training and impact
Recent trainees from the program have gained technical and leadership skills with a broad understanding of the broad socio-economic aspects of energy systems combined with technical skills that enable them to perform design and analysis using state of the art concepts and methods informed by environmental, economic and social stewardship. Recent graduates have been recruited by Exro Technologies, SLAC (Stanford University), and Embala Power Networks Inc., and worked as Interns with CUTRIC and Ballard Power Systems.

Recent Awards to students include:
- Best paper to PhD student Simon Parkinson, South East European Conf. on Sustainable Development of Energy, Water & Environment Systems, Macedonia, June 2014
- Student paper Award to PhD Student Alireza Akhgar, CSME International Congress 2016, Kelowna, BC, June 2016.
- Finalist 2017 CAGS/UMI Distinguished Dissertation Awards, PhD student Simon Parkinson
- MITACS Accelerate Internship, MASc student Anaïssia Franca, 2017

Publications
Wireless Connectivity Fabric for Internet of Things
Professor Xiaodai Dong, Canada Research Chair Tier II (2205-2015)
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria

Research program summary
My research program develops a scalable, efficient, and secure wireless connectivity fabric for internet of things (IoT), where billions of physical devices are inter-networked and interacting with one another by collecting and exchanging data. IoT is expected to transform almost every vertical industry: transportation and logistics, healthcare, energy, agriculture, automobile, cities and infrastructure, public safety and security, consumer applications, etc. The research will provide both theoretical and practical guidance to commercial IoT product development, enhance existing and create new products and services in industries.

Significant Research Projects: Contributions and impact
- 5G Cellular User Equipment (UE) Design (cited in industry seminars, tweeters, news). Proposed distributed phased array multiple input multiple output (DPA-MIMO) for 5G UE. It has received 9000+ full text views in IEEE Xplore within three months.
- Cloud based mobile electrocardiogram (ECG) for long term heart monitoring. Developed a low cost, smartphone based ECG system for easy patient/user heart monitoring outside the hospital. Collaborating with cardiologists, occupational health professionals, and industry to commercialize the technology.
- Many other projects on hybrid beamforming design of 5G massive MIMO, energy harvesting, autonomous robotic aided wireless localization, smart intercom, AI for healthcare, etc.

HQP training and impact
Graduated 13 PhDs, 27 Master’s, 3 Postdoctoral Fellows, 1 Research Associate and numerous undergraduate students. Three Best (Student) Papers Awards. The diverse projects in different areas and collaborations with industry exposed students to interdisciplinary research and highly interactive environments. Almost every student, PhD and Master’s, has publications out of the research work under my supervision. Many joined the telecommunication, Internet and power industries such as Fortinet, Google, Qualcomm, SAP, Nokia, Amazon, Huawei, etc., afterwards.

Publications
Have over 150 refereed journal and conference publications. Sample publications are:
Green Transportation and Quantitative Intelligent Systems  
Professor Zuomin Dong, PhD, PEng, FCSME  
Department of Mechanical Engineering and Institute of Integrated Energy Systems  
Faculty of Engineering, University of Victoria

Research Program
Zuomin Dong joined UVic in 1989 and served as the Chair of Mechanical Engineering for over ten years. He is Professor of Mechanical Engineering, a member of the Institute for Integrated Energy Systems, a registered Professional Engineer, and a Fellow of CSME. His research program covers the following areas:

- modeling, design optimization and intelligent optimal control of next generation hybrid electric vehicles and marine vessels, including heavy-duty ships, mining vehicles, and fuel cell vehicles;
- advanced global optimization techniques for solving complex, multidisciplinary design problems;
- real-time optimal operation control of complex systems, including hybrid electric vehicles and ships, smart power distribution grids, and traffic systems;
- automated optimal 5-axis CNC tool path planning and generation for machining free-form surfaces.

These researches have been extensively published in scientific journals and conferences, and as industrial patents. Dr. Dong served as a member on the editorial boards of several international journals and organization committees of a number of key technical conferences of ASME, IEEE and CSME. He has been working closely with industry and served as director, consultant and collaborator of companies and government agencies. In addition to leading the UVic Green Transportation Research Team, he nurtured the UVic EcoCAR/Formula Hybrid program/teams and facilitated the establishment of the UVic Green Vehicle Research, Testing and Training Centre.

Research Contributions and Impact
Dr. Dong’s research combines advanced computer modeling, global optimization, and artificial intelligent system techniques to form key enabling technologies and innovative solutions for solving critical problems faced by the transportation and manufacturing industries. The research has successfully incorporated global optimization and intelligent system into the Model Based Design (MBD) practice for developing electrified vehicles (EVs), and extended the new Model Based Design and Optimization (MBDO) technology to marine and mining applications. The cutting-edge research has effectively secured continuous and significant government and industrial funding and supports; attracted a large number of high-caliber students and researchers at all levels; and instigated considerable attentions from the generic public and international research communities to UVic’s exciting program.

HQP Training and Impact
Over the years, the research program has produced a large number of academic and industrial leaders and specialists. They become successful academics in Canada and beyond, research engineers and leaders in top automotive, clean energy technology, and marine companies. The EcoCAR and Formula Hybrid student competition teams, initiated and advised by Dr. Dong, has received over 40 top awards in North America.

Publications
Sustainable drinking water and sanitation in Canada and abroad

Dr. Caetano C. Dorea, Public Health & Environmental Engineering (PH2E) Lab
Department of Civil Engineering, Faculty of Engineering, University of Victoria

Research program summary

My research is at the crossroads of environmental and public health engineering. This includes the development and evaluation of water and sanitation/wastewater technologies, field- and operator-appropriate water/wastewater/faecal sludge quality analytical methods, and functional ecology characterisation of biological treatment systems for safeguarding the health of the public and the environment. My activities are focused both on developing and industrialised countries with projects ranging from the development of methods for the online monitoring and control of disinfection by products in Canadian municipalities to the delivery of safe water and sanitation for humanitarian relief. This program can be divided in to three main areas. (1) Rational design based on the characterisation of the functional microbial ecology of biological treatment processes. This is done through a variety of methods ranging from carefully controlled microcosm experiments to next generation sequencing techniques to elucidate the underpinning (micro)biological processes of slow sand filters, biosand filters, septic tanks, and pit latrines. (2) Development and evaluation of humanitarian emergency water supply and sanitation technologies. Such endeavours include technologies such as the ClarKE (Clarifier Kit for Emergencies) currently being deployed in South Sudan. 3) Development and application of appropriate technologies for low resource contexts. This vein of research includes projects such as the low-cost estimation of DBPs through differential UV spectrophotometry (currently in Lévis in partnership with industrial partners) and assays for oxygen demand (organic strength) estimations of faecal sludge samples (to be piloted in Uganda and Malawi).

Significant Research Projects: Contributions and impact

The ClarKE water treatment kit for emergencies has recently been awarded the prestigious International Water Association Project Innovation Award-Development (Global Winner) for Applied Science. My contributions have also resulted in other indicators of esteem such as membership of editorial boards and technical working groups of funding donors. I closely collaborate with researchers across Canada and abroad (UK, USA, Brazil, Malawi, Switzerland and South Africa). The expertise generated through my research has also resulted in water quality consultancies with UNICEF.

HQP training and impact

Further to the conventional research skills, field-based activities with collaborating universities and world class laboratories, as well as partnerships with industry and relief agencies, give students invaluable field experience and attributes highly sought by potential future employers. In such circumstances, students are faced with open solution problems in often resource-limited contexts. This formatively develops a creative and resourceful problem solving heuristic based on sound science and engineering. Trained HQPs have NSERC and FRQNT scholarship laureates and have received numerous awards for best presentations and posters at the international conferences they attend.

Publications

- Craud, Vigneron, Fradette, Charrette, Rodriguez, Dorea & Culley (2017) Open the SterivexTM casing: An easy and effective way to improve DNA extraction yields. Limnology & Oceanography: Methods (accepted).
Growth of Semiconductor Bulk Single Crystals

Professor Sadik Dost
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
Almost all electronic and optoelectronic devices need semiconducting materials of single crystalline structure. These materials are called single crystals, and are produced by a solidification process called crystal growth. Today, most bulk semiconductor single crystals are grown from the liquid phase by the growth processes known as the melt/solution techniques. These growth techniques have evolved from artisanship, relying very much on experience and intuition. Even today, this is the case in most techniques if not in all. The production of the same crystal twice is still a challenge.

Dr. Dost’s research efforts have thus been focused on making these crystal growth techniques scientific so that the high quality crystals with desired sizes can be grown reproducibly. This is the main and long-term objective of the current research program focusing on:

- **Growth of Si$_x$Ge$_{1-x}$** (silicon germanium) single crystals from the germanium side by the Liquid Phase Diffusion (LPD) technique with uniform silicon compositions (concentrations),
- **Growth of CdZnTe$_x$ (CZT; cadmium zinc telluride) single crystals with uniform zinc (Zn) compositions** by two important techniques: namely, the solution growth technique of the Travelling Heater Method (THM) using tapered novel crucibles, and by the melt technique of Vertical Gradient Freezing (VGF). Each technique has its own advantages and for many applications they need to be considered in parallel for efficient yield and seed production,
- **Numerical Simulations:** Proposed experimental research will be supported by numerical simulations of the transport phenomena occurring in the melt/solution of these growth processes and the related application areas. This is essential to gain insight to these processes.

The objectives of the research program will be achieved through the development of well-designed experiments in terms of their thermal (applied thermal profiles, crucible materials, translation and rotations rates, etc.) and structural (materials and system design) characteristics. Experiments will be supported by numerical simulations for thermal, concentration, and flow velocity fields in the melt/solution, for crystal composition in the grown crystals, and for the stability of growth and dissolution/melt interfaces.

The proposed research program is innovative and original, and features strong fundamental research, leading edge technology, state-of-the-art unique facilities, and commercialization potential all of which will further enhance the training aspects of the current proposal and attract high quality students and researchers in this critical field. Due to the interdisciplinary nature of the proposed program, that includes thermofluids, semiconductor physics, materials science and engineering, and also sophisticated design engineering, students and research personnel involved in this research program will gain the required background to be able to work in a wide variety of work environments. Research results obtained from the proposed research program will not only contribute scientifically to the related field, but will also help the development of new crystal growth technologies in Canada.
Audio and radio signal processing
Professor Peter Driessen
Department of Electrical and Computer Engineering, University of Victoria,
www.driessen.ca

Research program summary
The research program is the area of extracting information from broadband sensors and arrays, both acoustic and electromagnetic. Of particular interest is the detection and classification of rare or unusual events (outliers). We focus on data from three types of sensors: (1) hydrophones in underwater cabled ocean observatory networks, (2) arbitrary microphone arrays made with smartphones, and (3) broadband radio antennas.

A key novelty of our approach is to expand upon our early success with hydrophone data to include other sensor types, and exploring the application of audio signal processing techniques to broadband radio signals. The research uses real-world measured data and is guided by interaction with end users. Applications range from surround sound recording and monitoring to marine biology to wireless communications to atmospheric conditions (water vapour and fire locations).

Significant Research Projects: Contributions and impact
An entirely new method of transmitting wireless signals was invented, using time compression and overlap-add techniques, suitable for software-defined radio implementation. This patented method was found to yield superior performance for infrastructure monitoring applications as well as radar target detection in the presence of jamming. New methods of detecting and classifying underwater acoustic signals from Ocean Networks Canada have yielded superior classification accuracy, and may be applied by Transport Canada to minimize conflicts between whales and vessels. New methods of tracking the statistics of motion of rigid bodies has been applied to psychological science to determine how hand motions are perturbed by external influences.

HQP training and impact
HQP have been successful, employed in government research labs, local companies and start-ups.

Publications
- S Harrison, PF Driessen, Spread spectrum method and apparatus, US Patent 9,479,216
- G Cipli, F Sattar, PF Driessen, Multiple classifiers fusion to classify acoustic events in ONC hydrophone data, Communications, Computers and Signal Processing (PACRIM), 2015.
Explaining and Architecting Intelligent, Connected Software Systems
Dr. Neil A. Ernst, Software Engineering
Department of Computer Science
Faculty of Engineering, University of Victoria

Research Program Summary
Software systems are becoming more intelligent, adding machine learning components that are difficult for humans to interpret. Software is becoming more connected, formed of interacting components. The promise of intelligent and connected systems is that they enable radical new functionality with much less human effort. Critically important systems—like autonomous vehicles and energy grids—will be intelligent and connected.

My research tackles two challenges with these systems. First, I seek to explain how a software system is fulfilling our intentions for it. This is important since emerging machine learning approaches to make software behavior hard to interpret. Second, I seek novel ways of designing intelligent connected systems to fulfill user intentions. Since they are composable and autonomous, new design approaches will be needed to constrain how these systems evolve. The impact of my research will be greater confidence in assembling these systems, and a better understanding of how to design them to support user intentions.

Significant Research Projects: Contributions and Impact
1. A large-scale qualitative investigation into how design decisions resulted in technical debt at three multinational software companies. Technical debt is the short-term focus on delivering functionality at the expense of long-term design quality. Software tooling is an important way to assess how well a system is designed, yet most tools focus on low-level code and implementation details. I demonstrated a way of prioritizing the rules in these tools so that they identified only design-level issues.

2. Good design is a collaborative and human-centric process. I have worked with large federal agencies and contractors to properly consider design decisions in software modernization. I extended that work by incorporating search algorithms for identifying the optimal set of decisions to enact. Stakeholders appreciate the fact this research showed that only a small number of decisions dominate all others.

3. Investigating the design defects caused by runtime dependencies (a dependency of A on B means B must exist for A to function correctly). An ongoing extension to this project is examining the use of untrusted components in the Robot Operating System (ROS). Working with stakeholders, we are constructing a validated set of indicators for key quality attribute concerns (such as the system's modularity and performance).

HQP Training and Impact
As a brand-new faculty member, my HQP training is just starting, but my research will develop skills in software engineering, qualitative research, and the ethical implications of technology.

Publications
Using computational methods to optimize energy use in buildings, districts and cities

Dr. Ralph Evins
Energy Systems and Sustainable Cities research group
Department of Civil Engineering
Faculty of Engineering
University of Victoria

Research program summary

Future holistic, integrated energy systems solutions span from buildings (which are now active players in energy markets) to district and city-level designs and national scale infrastructure. Simulation is the only way to explore the performance of new concepts, since all buildings are unique (there are no prototypes) and simulation can explore the influence of future contextual parameters (energy prices, warmer climates) on new designs.

The design space of possible systems and their performance is vast and intricate, making it impossible to discover the best solutions by trial-and-error or by exhaustive evaluation of all options. Computational design optimization (e.g. multi-objective genetic algorithms and mixed-integer linear programming formulations) are powerful tools for finding high-performing designs and exploring their sensitivity, robustness and resilience.

The next steps in achieving real progress in computational design aids will use machine learning and big data to solve problems more effectively. For example, statistical emulators use methods like neural networks to approximate detailed models that are too time-consuming to run directly.

Significant Research Projects: Contributions and impact

- PI on a $1.5M submission to NRCan with 20+ partners from industry and government.
- One of ten experts on a $5M CFI cyber-infrastructure submission regarding building data.
- Ongoing collaboration with Empa in Switzerland on the Swiss national low-carbon transition plan, building on lots of prior research ($2M+) applying these methods to that problem. NSERC-Engage SmartEMS project with local company SES Consulting, applying the techniques developed here for control applications in real buildings, including the UVic campus.
- Currently working with the City of Victoria on the best way to retrofit the building stock.

HQP training and impact

The research links to undergraduate teaching (building energy simulation) and graduate research. Domain-specific skills are low-energy building and district design and simulation, and multi-objective optimization and linear programming. Widely-applicable skills include Python programming, numerate problem-solving, big data analysis, and machine-learning techniques.

Publications

Network of Living Campuses
Professor Thomas Froese
Research group with Asst. Professor David Bristow, and Asst. Professor Ralph Evins
Department of Civil Engineering
Faculty of Engineering
University of Victoria

Research program summary
The building sector employs 1.2M, uses 40% of Canada's energy, and generates 33% of GHG emissions. Applications of Big Data hold great potential for improving the performance of the Built Environment, but a lack of a large building dataset and collaboration platform poses a significant barrier to research. Three UVic researchers—Froese, Bristow, and Evins—are participating with researchers at the University of British Columbia, the University of Alberta, Ryerson University, Carleton University, École de Technologie Supérieure, and the University of New Brunswick on the proposed Network of Living Campuses project. This three-year project will develop a national platform, housed at Compute Canada's Centre for Advanced Computing, to address this infrastructure gap. Researchers will use this platform to share, analyse, and visualize campus building performance data. A suite of simulation, predictive algorithm, and analytics applications will enhance this unique dataset and support research breakthroughs in building information management, user behavior and controls, maintenance, cybersecurity, resilience, and energy performance.

Significant Research Projects: Contributions and impact
This research will result in more sustainable, efficient, comfortable and resilient buildings, enabling significant improvements in building operational performance, supporting Canada's COP21 commitments. The capacity developed on this platform will enhance Canada's global reputation and leadership in research and development of efficient building technologies.

HQP training and impact
This project will involve direct project personnel of 6 FTE for 3 years including Team Lead, DevOps Engineer/System Administrator, and Database Administrator and a Development Team contributed by industry partner, FuseForward

Publications
Machine learning, Neuroscience and Computational Linguistics
Dr. Alona Fyshe, PhD
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
For most people, reading is nearly effortless. However, programming a computer to interpret language is immensely challenging. My first research focus is to improve how computers represent language meaning by studying how the brain represents meaning. Currently, this approach is hampered by the small amount of brain imaging data available. I propose we have participants record their own brain images, at home, over several sessions. With more data, we can build models of language that are truer to life. My second research focus is to understand how the brain constructs complex meaning from single words. Currently, we know very little about how our brains actually perform language comprehension. As a result, we do not understand disorders that affect language areas of the brain. I study how the brain represents language meaning, and how information travels through the brain. We can improve how we treat disorders and disease in language areas of the brain if we better understand how the brain processes language.

Significant Research Projects: Contributions and impact
Brain images to inform semantic models.
It can seem far-fetched that studying the brain would allow us to build better language models. The vast majority of semantic models are built using just text resources, and they perform well on multiple tasks. My research is the first example of a semantic model that uses both text data and brain images to create vector representations of word meaning (Fyshe et al. 2014). I showed that the inclusion of brain images resulted in marked improvement on several semantic tasks. This work is unique not only in the incorporation of brain imaging data, but also because of the formulation of the model allows the inclusion of text data even when brain images are not available for a particular word. This work was presented at the Society for the Neurobiology of Language Annual meeting in 2013.

I recently released a new collection of brain image datasets in a simple software package (BrainBench, Xu 2016) that allows researchers to compare their computer models against how the brain actually processes language. With BrainBench, I am inviting a whole community of talented language researchers to contribute to our understanding of the brain. I believe this large-scale collaboration will increase the speed at which we can acquire knowledge about how the brain is organized.

Interpretability in Semantic Models
I have developed semantic models that continue to perform well on a variety of semantic tasks, while maintaining interpretability (Fyshe et al. 2014, Fyshe et al. 2015). In contrast, many popular techniques (e.g. neural networks or singular value decomposition) produce semantic models that are hard to interpret: it is difficult to say why a learned parameter is high or low for a particular word’s representation. This lack of interpretability makes it hard to “debug” the cases where a model ails, and thus it is difficult to improve the model. Interpretability is also important if we use a semantic model to study the brain. It is not enough to know that a brain area is more active when a person reads a particular word – we must be able to say why it is more active in relation to semantic model parameters.
Resource Management in Next-Generation Networks

Dr. Sudhakar Ganti
Department of Computer Science
Faculty of Engineering
University of Victoria

Research program summary

IT virtualization along with cloud-based services is transforming the industry of hosted services by providing flexibility and agility. Software Defined Networking (SDN) is a programmable paradigm that provides network services in these hosted virtual environments. Currently many network functions (e.g., firewalls, security appliances and load balancers) use hardware devices that are located outside of the virtual environment. Instead, it is natural to use compute resources within the virtual environment to deploy these hardware functions, which is known as Network Function Virtualization (NFV). This is a key emerging area that results in unprecedented agility to deploy new network services and functions.

The main goals of our research are to investigate and develop methods, algorithms and techniques to provide scalable and efficient network infrastructure support for the next generation Internet services based on virtualization, especially on the following topics: 1) Investigate methods on how to decompose and execute network functions that are traditionally implemented in dedicated hardware appliances across several NFV software elements; Investigate methods to allocate network and cloud resources for NFV deployment; Develop mechanisms to ensure reliable services and service level guarantees for such NFV based service architectures; 2) Data centre network (DCN) architectures: Investigate methods and architectures to provide isolation and guarantee network bandwidth resources to efficiently deploy NFV based services with service guarantees in data centers; 3) Develop methods to detect traffic and service anomalies.

Significant Research Projects: Contributions and impact

- Developed efficient Cloud Resource management algorithms for Virtual Machine migration
- Developed traffic anomaly detection methods based on self-organizing maps
- Developed large packet network transports and optical bypass techniques for large network volumes

HQP training and impact

Currently I supervise/co-supervise four Ph.D students and four M.Sc students. My former students have either been employed in industry (e.g., Telus, Ericsson, Fortient., BC Government) or continued with academia (e.g., UBC, U of T and Stanford).

Publications

Models with latent structure
Another theme of my research is learning latent representations. I have developed several new methods for learning latent pattern dictionaries from text data, brain data or the combination of both (Fyshe et al. 2012, Fyshe et al. 2014, Fyshe et al. 2015). These latent representations increase the signal to noise ratio and/or reduce the dimension of our data, which allows us to build efficient and effective models.

Semantic Composition in the Brain
I recently explored semantic composition in adjective noun phrases (Fyshe 2015). For example, when you read the phrase “tasty tomato” or “rotten tomato” how is the neural representation of the phrase different? And how do phrasal semantics change as a function of the individual words? My research produced several novel findings for semantic composition in the human brain. Previous work had identified the brain areas used during composition: the left anterior temporal lobe (LATL) and the inferior frontal gyrus (IFG). My research showed that, though they are involved in composition, these brain areas are not the areas that represent the semantics of the composed phrase. I also showed that the semantic signature of the adjective is active in the brain even while the noun is being read, and that phrasal semantics are detectable much later than would have been suggested by previous studies.

Additional Information on Contributions
Conferences are the premier venues for publishing research in my field, and have acceptance rates around 25%. In my field, the first author is typically the main contributor to the work, and authors are listed in descending contribution order, save for the last author who is typically the supervising author.

HQP training and impact
I currently am supervising 6 MSc students and 1 PhD (one MSc is co-supervised). I have supervised or co-supervised 3 NSERC USRA students in the past 2 years.

Publications
• A. Fyshe, P. Pratim Talukdar, B. Murphy and T. Mitchell. Interpretable Semantic Vectors from a Joint Model of Brain- and Text- Based Meaning. The 52nd Annual Meeting of the Association for Computational Linguistics (ACL), Baltimore, Maryland. 2014
• E.E. Papalexakis, A. Fyshe, N. Sidiropoulos, P. Pratim Talukdar, T. Mitchell, C. Faloutsos. Good-Enough Brain Model: Challenges, Algorithms and Discoveries in Multi-Subject Experiments. ACM Special Interest Group on Knowledge Discovery and Data Mining (SIGKDD), New York, USA. 2014
Cryptography & Telecommunications Research

Professor Fayez Gebali
The Gebali Lab, Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary

My research team is interdisciplinary spanning several areas of computer science, computer engineering and electrical engineering as outlined below.

Significant Research Projects: Contributions and impact

Computer Arithmetic: I am interested in developing algorithms and hardware accelerators for modulo arithmetic in several types of Galois fields including GF(p), GF(2m), and GF(3m). We are also trying to find the multiplicative index of a field element.

Telecommunications: In this work I am doing performance analysis of hybrid free-space optical (FSO) communications and radio frequency (RF) systems. These systems are used in infrastructure networks or in disaster recovery. I am also studying performance analysis of networks-on-chips (NoC) where the chips could be standard two-dimensional chips or the next-generation three-dimensional chips. Different routing algorithms are being developed and their performance is being investigated.

Algorithms: In this field, I am trying to perform design-space exploration of different algorithms. These algorithms I am studying are found in the fields of machine learning and in cryptography. Some of these algorithms show inherent parallelism while others are more general in their data dependences. For the latter, I am developing dataflow computing paradigm and developing the associated hardware.

HQP training and impact

My HQP training plan exposes students to cutting-edge research in embedded multicore systems, parallel algorithms, parallel computing, and cryptographic hardware design. My HQP are in very high demand in academia and industry. I currently supervise 10 PhD, 8 MASc, 3 MEng students and 1 undergraduate student. Two fundamental dimensions of my research are implementation of cryptographic algorithms on parallel computers as systolic array accelerators or dataflow computing on embedded multicore SoC. Another major research direction is deep learning using context-aware complex event processing and clustering hardware accelerator for big data. HQP typically work on more than one research objective to benefit from cross-fertilization. All HQP work on industrial-strength CPS applications, collaborate with industry, and present their research in top venues.

Publications

Free and Open Source Software (FOSS)
Professor Daniel M. German
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
My work is focused on understanding how Free and Open Source Software (FOSS) is being developed and reused, and how FOSS is affecting software engineering in industry. It can be divided into four main topics:
1. Learning from FOSS engineering;
2. Legal issues in software engineering development;
3. Provenance of FOSS artifacts; and
4. Mining Software Repositories for Software analytics.

Significant Research Projects: Contributions and impact
My research has been published primarily in software engineering venues. In total, I have published more than 100 papers, including:
- 29 journal papers. This includes 16 in the top two journals in Software Engineering: 11 in the Journal of Empirical Software Engineering and 2 in IEEE Transactions of Software Engineering
- 5 full research papers at ICSE—the International Conference in Software Engineering, the top conference in the field.
According to Google Scholar my H-index is 36.

HQP training and impact
I have supervised 15 MSc students and 3 PhD students.

Publications
- Google Citations: https://scholar.google.com/citations?user=hpxl9PEAAAAJ
- DBLP: http://dblp.uni-trier.de/pers/hd/q/German=aacute=n:Daniel_M=
- Papers are freely downloadable: http://github.com/dmg/
Faculty of Engineering Research Program Briefs

Development of Biomechanical Understanding and Mechatronic Devices to Improve Orthopaedic Training, Assessment and Surgery

Dr. Joshua W Giles
Department of Mechanical Engineering
Faculty of Engineering
University of Victoria

Research program summary

Emerging low-cost wearable sensor technologies and biomechanical modelling techniques can produce insights into joint function outside of research labs. My research focuses on developing and integrating these technologies, and improving biomechanical understanding in order that orthopaedic devices can be produced that improve clinician training, patient assessment, and surgery. One critical application of this research is the development of personalized orthopaedic surgical planning technologies that can aid non-specialist orthopaedic surgeons who often do not have the required level of expertise. This research will enable all surgeons to optimally plan their procedures based on patient expectation, function, and anatomy.

This multi-disciplinary research program includes aspects of basic biomechanical experimentation, computational modelling, and mechatronic device development (a combination of mechanical design, electronics, and software). This research will produce new biomechanical understanding and foundational technologies useful to the musculoskeletal biomechanics research community and that can lead to novel clinical technologies. This will in turn benefit the Canadian economy through industrial partnerships, through cost savings associated with improved healthcare technologies, and by improving patient outcomes.

Significant Research Projects: Contributions and impact

My research has produced several important benefits to the research community and end users. I developed the world’s most advanced hybrid cadaveric-robot shoulder testing system (1) which produced insights into shoulder biomechanics and clinical questions. This led to my collaboration on a $3.1M (CAD) US NIH grant to a University of Utah professor seeking to replicate my system. Furthermore, this system impacted knowledge users (i.e. clinicians) by changing their clinical practice. In particular, one paper was cited as one of the most important of its year (2) while another (3) was cited as the reason a leading clinical group changed their practice. I have also recently developed novel technologies and techniques that, for the first time, enable minimally invasive shoulder replacement surgery. This work yielded a patent (GB1504122.1), a clinical trial to begin soon, licensing negotiations with an orthopaedic manufacturer, and was recently awarded the Best Paper prize at the 2017 meeting of the International Society for Computer Assisted Orthopaedic Surgery.

Publications

Groundwater Science and Sustainability research group
Professor Tom Gleeson (research group leader)
Department of Civil Engineering (cross-appointed with School of Earth and Ocean Sciences and
Academic Advisor to Polis Water Sustainability Project)

Research program summary
Groundwater (the water beneath your feet in rocks and soils) is earth’s largest freshwater resource yet
the sustainability of groundwater is under threat from overuse, contamination and climate change.
Groundwater is usually studied in small local areas, but the Groundwater Science and Sustainability
research group goes big, real big, to study groundwater across the globe asking questions like:
How much groundwater is there in the world? How does groundwater flow in different parts
of the world? Can we use groundwater sustainably? We are a world-leading research group using
spatial data and mathematical models to answer these pressing scientific, social and environmental
questions. Our research is used by water managers and policy makers nationally and internationally, and
is critical in British Columbia currently because of the recent Water Sustainability Act, which is regulating
groundwater use for the first time. We are also leaders in data sharing, open science, innovative teaching,
and media outreach as highlighted on our group website.

Significant Research Projects: Contributions and impact
Gleeson was recognized with the AGU Hydrology Early Career Award as “one of the rising stars of international hydrology” and
Discover Magazine “Top 100 Science Stories of 2012” for
research contributions like the first map of groundwater stress
across the world as shown in the map of blues and reds on the
right. We have also developed the first global maps of permeability (the ease of groundwater flow) that
are being used by hundreds of scientists in dozens of countries. We have given prestigious invited lectures
/MIT, Columbia, ETH Zurich, National Academies of Science, Harvard University), held research
fellowships (William Dawson Scholar, McGill University and Global Scholar, CIFAR), co-edited a book,
started the EGU/AGU ‘Water Underground’ blog, and been interviewed in a number of print, online and
radio articles as evidenced by high alt-metric scores.

HQP training and impact
The research group has a strong record of HQP training, as can be seen
in the graphic on the right with all HQP publishing peer-reviewed
manuscripts and a number going on to faculty positions, NSERC
fellowships and being leaders – at one point three HQP were on the
executive the Canadian Water Network Student and Young Professional
committee.

Publications
In the last six years, we have co-authored over 50 papers including ten Nature
publications, highlighted in the graphic on the right. Two examples:
- Gleeson et al. (2012) Sustainable water balance of global aquifers revealed
- Gleeson et al. (2015) The global volume and distribution of modern
  groundwater. Nature Geoscience 9: 161-167. Recommended by the editors
  as an article that could help ‘change the world, one article at a time’.
Nanoplasmonics Research Group

Advancing Technology Based on Light at the Nanometer Scale

Professor Reuven Gordon
Canada Research Chair in Nanoplasmonics
ECE, Faculty of Engineering
University of Victoria

Research program summary

We are widely acknowledged as world-leaders in the area of light-matter interaction at the nanometer scale (e.g., 2015 plenary lecture at SPIE Optics and Photonics – 5000 person conference). Our work aims at advancing technologies that use light at the nanometer scale. These include: devices for detecting cancer at early stages; methods for analyzing single proteins and their interactions with potential drugs; devices for efficient THz radiation generation; improved energy conversion technologies. We have collaborations with companies including Vertex Pharmaceuticals, Biomark Technologies, Lumerical, TeTechS.

Significant Research Projects: Contributions and impact

We have licensed our technology for protein analysis to Vertex Pharmaceuticals. We have a patent with Biomark Technologies. We have internships and collaborations with Lumerical and TeTechS. I am also Director of the Materials for Enhanced Energy Technologies CREATE program.

HQP training and impact

HQP in my group have won numerous awards and scholarships/fellowships (e.g., NSF Postdoctoral Fellowship, Best Poster Awards). They also go on to Faculty positions (e.g., recently to University of Central Florida), postdoctoral fellowships (e.g., recently U. Michigan, U. Alberta) and positions in industry (e.g., recently Intel, Microsemi, Fortinet).

Publications

Faculty of Engineering Research Program Briefs

Intelligent Communication Networks
Professor T. Aaron Gulliver, Canada Research Chair in Advanced Wireless Communications
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
The impact of wireless systems and devices on our social and economic future cannot be understated. The demand for better services, faster, cheaper, with assured quality-of-service (QoS) and enhanced security, requires the development of communication systems with better spectrum efficiency and higher capacity. Wireless networks must evolve in order to address these challenges and expectations. New and efficient ways of using the wireless medium, particularly at higher frequencies, must be developed. This research program will develop intelligent communication networks with virtualized resource allocation, self-optimization capabilities, and guaranteed information security. They will be intelligent entities that can adjust to the environment and system requirements and make decisions based on the available data using artificial intelligence (AI) and big data analytics. These networks will be the supporting platforms for the internet of things (IoT) and smart cities. The IoT is an intelligent network infrastructure that can support a variety of services and applications. The ITU estimates that by 2020 there will be 30 billion IoT devices. A smart city integrates information and communication technology and IoT technology in a secure fashion to manage information systems, transportation systems, hospitals, power plants, water supply and waste management, and other community services. This allows for real-time interaction with people and infrastructure to monitor and adapt to changing conditions and provide a better quality of life. Intelligent sensors integrated with real-time monitoring systems collect data from people and devices that can be analyzed to develop solutions for clean energy, e-health and smart transportation. Smart grid and vehicular networks are key components, and AI, machine learning (ML) and big data are essential to process the substantial volumes of data that will be generated.

People need to interact and participate in communities, and wireless devices allow a level of connectivity that was unimaginable even a decade ago. People expect very high speed real-time wireless services wherever they are. According to Statistics Canada, more than 90% of the population use these devices to shop, study and stay in touch with family and friends. There are now over 27 million mobile wireless subscribers in Canada, and in 2015 data traffic over cellular networks increased by 44%. Thus, one of the key problems to be addressed is how the growing number of IoT devices can be integrated to coexist with people so as to not disrupt their services. The Canadian Wireless Telecommunications Association (CWTA) reports that the wireless industry generates revenue of over $65 billion annually with an employment impact of more than 300,000, and these numbers are projected to increase substantially. Thus, this research program considers key enabling technologies for future wireless communications systems. The long-term objective is to accelerate the development of future wireless communications standards. To achieve this goal, ultra-wideband (UWB) communications, cognitive radio (CR), green energy for communications, machine-to-machine (M2M) communications, and data mining for wireless applications, are being investigated, as well as wireless networks and protocols incorporating scheduling, resource management and QOS, and cooperative diversity, multiple access, and mobility management.
Innovative Materials and Infrastructure Management
Professor Rishi Gupta
Department of Civil Engineering
Faculty of Engineering, University of Victoria

Dr. Gupta’s research focusses on: Development of innovative cement-based mortars with improved bond properties for masonry structures - mortars with high volume fly-ash, admixtures and fiber reinforcement; shrinkage of concrete and development of ‘crack-free’ cement composites for base slabs; advanced materials for structures - Hybrid Fiber Reinforced Concrete, use of supplementing cementing materials in concrete; structural performance of insulated wall systems; health monitoring of structures and Non Destructive Testing; durability and corrosion studies of reinforced concrete.

Research program summary
Canada’s aging infrastructure is deteriorating at an alarming rate, a problem worsened by the staggering costs of addressing it properly. Just the cost of fixing all bridges in need of repair is estimated at $8-10 billion. Moreover, recent collapses of bridges in Canada and the US have increased the need for new technological solutions to manage and assess the condition of infrastructure like bridges, buildings, roads, water mains, and sewers to predict their safe remaining service life. Dr. Gupta’s research is based out of the Facility for Innovative Materials and Infrastructure Monitoring (FIMIM) at the University of Victoria’s Faculty of Engineering. At FIMIM, Dr. Rishi Gupta is working on developing Nanoscale Hybrid Fiber Reinforced Cement Composites (NHyFRCC) using hybrid combinations of low dosage Carbon Nanotubes (CNTs) and micro carbon fibers. Plastic and drying shrinkage tests—including a technique developed by the candidate and UBC’s Dr. Nemkumar Banthia—will help characterize the behavior of NHyFRCC required to develop “crack-free” composites. Using a novel technique the candidate co-invented with Kryton International, the constitutive properties and flexural toughness of NHyFRCC will be determined and the self-sealing ability of cracked NHyFRCC will be quantified. Lab-scale sensors will be developed and their piezoelectric behavior under cyclical loading will be determined. NHyFRCC and a control mix will be placed as a thin overlay on a test bench spanning 16 feet and simulating a bridge deck exposed to real environmental conditions. Already located in the candidate’s existing lab space, the test bench allows for long-term, in-situ performance of materials. The performance of the overlays will be monitored using state-of-the-art non-contact Laser Scanning Vibrometry (LSV) equipment. Data from the LSV will be used to determine dynamic modulus of the material and compared to findings from alternate sensors such as mounted wireless accelerometers. Long-term goals include developing algorithms to perform condition assessments of other infrastructure, including bridges. Various Non-Destructive Evaluation (NDE) techniques, such as resistivity measurements and Ground Penetrating Radar (GPR) scans, will help study the durability of NHyFRCC and any debonding from the test bench surface. A high-capacity computer server is being used to store data from the test-bench sensors and is now being used as a repository with high computing capacity for Structural Health Monitoring (SHM) of infrastructure in Canada.

Benefits to Canadians: Dr. Gupta’s proposed research aims at developing sustainable infrastructure in Canada. ‘Crack-free’, ‘self-sealing’ and ‘self-sensing’ durable NHyFRCC will help extend the life of infrastructure in Canada. Self-sensing materials combined with NDE techniques and new algorithms will assist in predicting the remaining life of infrastructure in Canada, preventing premature decommissioning of structures and potentially saving billions of tax dollars. A National repository collecting real-time data from various structures will assist in potentially detecting early failure and potentially saving lives.
Significant Research Projects: Contributions and impact

Since joining UVic in July 2013, I have made major accomplishments in my field and secured close to $900,000 in research funding. This funding has allowed me to engage in high impact research and emerge as an expert in the area of sustainable construction technologies. The funding has already allowed me to train a large number of HQP. I have filed two patents (1 approved in 2015) in the last 5 years; both expected to have a major impact on the construction industry. Projects completed with Minaen International and Metro Testing were NSERC funded. As a PI I have completed projects with Cement Association of Canada, Masonry Institute of BC, and Real Estate Board of BC. I also have ongoing joint projects with colleagues at UVic and Dr. Banthia at UBC.

I am leading two major international projects as a PI and have been recently honored as a “Fellow” of Engineers Canada for my several years of contribution to the profession.

HQP training and impact

The applicant’s current research team of 15+ members includes 5 PhD students. The applicant has a strong history of training HQP and has supervised more than 45 personnel in the past six years (including current grad students). The applicant has trained numerous undergraduate students also with highly sought after skills by industry. These students have greatly benefited from the applicant’s industrial partnerships and have landed positions in industry with key engineering portfolios. Select examples of these students are: M. Furumori: Engineer at BC Hydro, A. Pham: Project Coordinator at Deramore Construction, A. Deaconu: Project Coordinator at Southwest Contracting, M. Qian: Designer EIT at MMM Group, and M. Jaimes: EIT at Kiewit. Some HQP like S. Gavrilovic and A. Basra are now pursuing PhD and Masters programs at UBC and H. Rathod has returned to pursue his PhD under the applicant’s supervision. Several of these students have also had the opportunity to publish as a coauthor with the applicant. Select examples include: A. Kailey, L. Simandl, H. Rathod, A. Deaconu, A. El-Newihy, A. Kim and A. Basra.

Publications

UVic’s Advanced Microscopy Facility
Professor Rodney Herring
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
The Advanced Microscopy Facility (AMF) of the University of Victoria [1] has numerous types of imaging devices used for a broad range of research studies. The AMF includes numerous types of microscopes including the Scanning Transmission Electron Holography Microscope (STEHM), a unique confocal microscope and a unique acoustic medical imager. The AMF’s STEHM is a one-of-a-kind microscope considered to be the most powerful microscope in the world between 2011 – 2015 winning the McRae Award of Microscopy & Microanalysis (2012) [2], the highest level of technological improvement in the field of microscopes and microscopy. Although numerous research studies with high-impact outcomes are being conducted using the AMF, two recent projects have achieved notoriety. They include the developed of a means to measure strain in crystals three-dimensionally (3D) and the development of nanocrystals to clean water, prevent disease transfer on surfaces and offer a new means to treat cancer.

The STEHM has been used to create a method to measure the 3D strain profile in crystals, the first and still only means available to scientists and engineers. This method applied a unique method of electron holography to the highest resolution method of measuring strain in crystals extending the method from a 2D measurement to a 3D measurement [3, 4]. Knowing the strain in crystals is important for numerous reasons as it affects the crystal’s physical, electronic, photonic, magnetic and electrical properties. Of note is strain-bandgap engineering, which has produced our current fast computers, by using germanium (Ge) doped silicon (Si). Ge is a larger atom than Si. It’s incorporation into the Si crystal of 2% – 4% speeds up the electrons by ~700 times. Increasing Ge in Si to 20% - 30% will enable the next generation computers to be produced based on strain-bandgap engineering to produce quantum computers being heavily invested by IBM and other companies. Critical for this development is the knowledge of the 3D strain profile within the crystal. This project impacts every person using an electronic device.

Ultra-high-resolution STEHM images of nanocrystals was used to create nanoparticles that clean wastewater. These crystals increased the degradation of pollutants in wastewater using visible-light activated photocatalysts from 2% to 98% [5, 6]. These crystals clean 100% of the organics and 100% of the ammonia from the wastewater offering a significant improvement over bioreactors, UV treatments and other means. I have high confidence they are able to also clean the fire retardants, pharmaceuticals and hormones from water. Additionally, they have been used to kill germs such as E-coli and staph on surfaces using ambient light (normal room lighting). They are now being targeted to prevent the formation of mildew on surfaces, as well as, provide a new means to treat cancer using their oxygenating radicals, the most powerful radicals possible, offering a different approach than the currently used gold nanocrystals, which use surface plasmon heating. Impacts include reducing the acidification of our rivers, lakes and oceans, reduction of red tides, reduced transfer of disease via surfaces, keeping marine surfaces clean of barnacles, treatment of cancer.

The Diffuse Acoustic Confocal Imager
The diffuse acoustic confocal imager (DACI) [7, 8] is a medical imaging device evolved from an acoustic holography imager that accurately measured the speed of sound of breast cancer tissue (1534 m/s) [9]. DACI combines several unique optical concepts including the use of the thermal diffuse scattered (TDS) intensity (discarded from Ultrasound imaging) produced within the imaged object as a virtual source [10], the confocal 3D imaging concept [11, 12] and a software defined radio wave imaging concept [13] that
enables speed of sound images to be obtained for imaging, diagnostic and treatment purposes of diseased tissue. These three imaging concepts combined make DACI unique from all other medical imagers. Although DACI is applicable to the entire body including brain tumors and pancreatic cancer, its current targets are providing a means for routine prostate and ovaries examinations, capabilities not provided by any means. If disease is found, DACI can safely non-intrusively diagnose the type and state of the development of the disease, immediately treat the disease by ablation or histotripsy and monitor the treatment process using the change in speed of sound of the diseased tissue. Impact is helping to save lives.

The SDR Earth Atmosphere Imager

The software defined radio (SDR) Earth Atmosphere Imager [13] is a unique device now being constructed at UVic and the Dominion Radio Astrophysical Observatory (DRAO), Penticton, BC. This device images the Earth’s atmosphere using radio waves reflected from Earth’s ionization layer. It promises to be able to measure the power, energy, and place, as well as, the direction of movement of atmosphere disturbing events such as earthquakes, large storms, lightning strikes, forest fires, etc., as well as, monitor Earth’s climate change, pollution in cities and better predict daily weather possible by measuring the 3D temperature, pressure and composition of Earth’s atmosphere. Three devices could monitor British Columbia and 10 devices could monitor Canada. Its impacts are many including a better understanding of Earth.

References

1.  https://www.uvic.ca/research/advancedmicroscopy/
Computational and Logical Foundations of Security
Professor Bruce Kapron
Computer Science Department
Faculty of Engineering
University of Victoria

Research program summary
Security plays a fundamental role in almost every aspect of modern computing and communication systems. Increasing connectivity between systems, devices and users brings increased risk of malicious attacks, with significant financial, personal and even political impact. At the same time, advances in cryptographic techniques allow innovations such as secure cloud computation and distributed ledger (blockchain) applications. My research addresses the design, evaluation and testing of secure systems, including the development of cryptographic tools that support advanced functionalities, foundational systems for the verification of cryptographic protocols, and automated systems for the evaluation of anti-malware programs.

Significant Research Projects: Contributions and impact
I recently collaborated with researchers from Intel on a project titled “Anti-virus evaluation via malware mutation”. One outcome of this project was a system for automating the testing the effectiveness of anti-virus software against thousands of newly generated variants of known malware. We used this platform to expose weaknesses commercial anti-virus products. Another recent project involved the design of a powerful cryptographic tool known as circular encryption, which is an important component in systems that compute on encrypted data. A major outcome of this project was the identification of general conditions under which circular encryption is possible.

HQP training and impact
Much of the work on circular encryption described above was done with my former Ph.D. student, Mohammad Hajiabadi. This work was published in the top conferences for cryptographic research, including Eurocrypt and Crypto. Since graduating, Dr. Hajiabadi was a postdoctoral fellow in CS at University College London and is now a post doc at UC Berkeley, one of the top CS departments in the world. The malware project was done with my M.Sc. student Erkan Ersan. Mr. Ersan worked closely with researchers at Intel during the project, and presented his work at the Symposium on Foundations and Practice of Security. He is now an analyst at Ocean Networks Canada. In the past three years I have graduated four M.Sc. two Ph.D. students. All continue to do related work.

Publications
Infrastructure for a Low Carbon Planet
Professor Chris Kennedy
Department of Civil Engineering
Faculty of Engineering, University of Victoria

Research program summary
I apply principles of Industrial Ecology to challenges of developing sustainable cities and global infrastructure systems. The overarching objective of my new research program is to understand how evolution to a low carbon world will impact the development of fossil fuel conveying infrastructure – in particular railways and marine ports. There are deep, substantial implications for the planning, development or reuse of these infrastructure systems, which has received little attention. In short, if by mid-century, the world no longer needs to burn fossil fuels, then it no longer needs to transport them either, nor construct new infrastructure for doing so.

Significant Research Projects: Contributions and impact
• Inaugural Chair of UVic’s new ‘green’ Civil Engineering department.
• Seconded to OECD, 2011-12, to support Working Party on Climate, Investment and Development
• President International Society for Industrial Ecology, 2015-16 (~500 members in 30+ countries)
• Keynote Speaker at 6 conferences (since 2011)

HQP training and impact
The research training is situated in a confluence of industrial ecology and civil engineering. The field of industrial ecology is ideal for encouraging students to conduct quantitative (engineering) research on sustainable development in an interdisciplinary and policy relevant context. Half of my PhD students now hold faculty positions.

Publications
Algorithm design for very large graphs and distributed networks
Professor Valerie King
Department of Computer Science
Faculty of Engineering
University of Victoria

Research program summary
Distributed computing studies how agents may interact to achieve a common goal or alternatively, to coordinate shared resources. As networks have grown increasingly large and with the advent of armies of malicious computers controlled by a single mind (the adversary) and hidden in this network, the problem of malicious (or Byzantine) fault tolerant computing has become more important, while all-to-all communication has become infeasible.

Today, a common goal in industrial applications, is to implement a distributed ledger, an agreement among a large number of distributed agents about the history of the transactions among them. This has been used for applications such as digital currency (bitcoin), supply-chain management, and voting.

Dr. King and her colleagues have developed techniques which ensure agreement in a worst case environment, where the adversary may eavesdrop and successfully decode messages between other agents, thus giving the strongest guarantees of security known. See "Byzantine Agreement in Polynomial Time" Journal of the ACM 2016. She is currently working with her students on making these techniques efficient and practical.

Graphs are an abstract model of nodes and edges (links) between nodes and are used to model connections in mobile networks, biological networks, links in the Web, or social relationships. Often we are considering not just a one-time graph problem, but a situation where the input to the problem is incrementally changing. The goal of dynamic graph algorithms is to save computation time by organizing information from previous computations so as to enable the problem solution to be maintained quickly, as updates to the input are made. Dr. King, her student and colleague, work on these problems. Most notably they gave a breakthrough paper "Dynamic Graph Connectivity in Polylogarithmic Worst Case Update Time" SODA 2013 (winner of best paper prize).
H.L. Kwok  
Department of ECE  
Faculty of Engineering  
University of Victoria

Research program summary

We were one of the first research groups examining negative capacitance effect in organics back in 2003 [1]. Since then, many more researchers joined the field and have applied the same (or similar) techniques to prototype devices and integrated circuits which would offset the physical limits associated with “scaling” – the means to shrink device size and increase packing density.

In both science and engineering, thermoelectric effect is known to be the prime candidate used in the conversion of heat into electricity which is illustrated in the retrieval of exhaust heat in automobiles. This form of renewable energy is of interest to environmentalists because of the lack of carbon emission. We are one of the first research groups to publish papers on thermoelectrics using disordered organics that are both inexpensive and non-toxic (when compared to heavy metal materials).

Significant Research Projects: Contributions and impact

Recently, we reported a new device structure capable of operating with enhanced current-voltage characteristics in the kilohertz frequency range and the objective is to develop improved structures capable of increasing the operational frequency to the hundreds of kilohertz range and lowering the thermal limitation [2]. Attempts will be made to shorten the time delay through modifying charge transport through states associated with trapping.

Our current project centers on exploiting non-uniform heat transfer to enhance the heat conversion efficiency which (at least in theory) should result in converters with unsurpassed performance. We will also investigate means to enhance the localization length of carriers which affects charge hopping and mobility [3].

Thermoelectrics are also used in solid-state cooling and refrigeration with the elimination of toxic coolants. It is well recognized that the sole reason why microprocessors and lap-top computers cannot work faster has to do with a lack of temperature control and the use of negative capacitance devices coupled with the inclusion of thermoelectric cooling should significantly reduce heat dissipation and enhance performance in integrated circuits design.

HQP training and impact

I have 1 Master’s student working on IC design. The lack of resources and funding did not allow us to expand.

Publications


Mining and analyzing personal behaviour using hardware accelerators
Professor Kin Fun Li
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
Our long-term goal is to develop and establish advanced infrastructures and tools to support
behaviour mining and analysis for innovative applications, such as web search, learning, and
information security systems. By utilizing data analytics algorithms in searching and matching
relevant and similar information, both human mental and physical behaviour can be captured,
alysed, and modelled. To be of practical use in this era of big data and personalized devices, the
real-time response and portability requirements are of concern. Many personalized applications will
be used in small embedded devices such as mobile phones, assistive technology apparatus, and
information security instruments. Part of the program is to design and develop hardware
accelerators to enhance performance and portability.

Significant Research Projects: Contributions and impact
- Past research contributions and practical applications:
  - Motion tracking and learning in telehabilitation applications
  - Mining business intelligence for the telecommunication industry: consumer sentiment, on-line
gaming user behaviour, network device classification
  - Reconfigurable hardware accelerators for mobile and embedded applications

HQP training and impact
Past and current HQP: one doctoral graduate is an assistant professor at an US university; two
master’s graduates and two Canadian postdocs are working in industry; five international postdocs
and visiting scholars are continuing our collaboration. Currently, one postdoc, three doctoral and
two master’s students in our research group are working in the said program projects.

Publications
- D.G. Perera and K.F. Li, “A Design Methodology for Mobile and Embedded Applications on FPGA-Based
- A. Xiao, K.F. Li, and Y. Zhao, “Human Motion Retrieval based on Feedback Learning,” International
  Symposium on Computational Intelligence and Design, December 2017.
- D. Arora, K.F. Li, and A. Loffler, “Big Data Analytics for Classification of Network Enabled Devices,”
- J. Yang, K. Huang, H. Rong, and K.F. Li, “A Compression Approach to Reducing Power Consumption of
- D. Arora, K.F. Li, and S.W. Neville, “Consumers’ Sentiment Analysis of Popular Phone Brands and Operating
  System Preference Using Twitter Data: A Feasibility Study,” IEEE International Conference on Advanced
  International Journal of Space-Based and Situated Computing 3(3) 2013.
Evaluation of scour susceptibility of infrastructures and recycling of Slurried Wastes
Cheng Lin, PhD, PE
Department of Civil Engineering
Faculty of Engineering
University of Victoria

Research program summary
Our research has been focused on three domains in geotechnical engineering: scour related risks to infrastructures, behavior and recycling of slurried wastes, and innovative solution for sustainable road construction.

Scour is a process of soil erosion caused by currents and waves and is a major cause of infrastructure failure in river and coastal areas. The effects of scouring are exacerbated by sea level rise, storm surge, flood and hurricane; events that are expected to be more severe with the global climate change. By the 2020s, annual economic damage to Canada's coast from sea-level rise and storm surge is estimated to be $2.6 to 5.4 billion. Our research focuses on developing a new integrated analysis method that will provide a more accurate and cost effective way to assess scour susceptibility of structures, and monitor at risk structures. This research will benefit Canadians by improving infrastructure life–cycle performance and combating risks due to extreme weather events.

Slurried wastes are mainly referred to as dredged materials, mine tailings, tunneling grouts, etc. Their annual production worldwide is estimated at over one billion m$^3$. Safe management and treatment of these wastes represents a major challenge in Canada. Our group is to develop a new testing apparatus to evaluate fundamental behavior of slurried wastes and develop a novel solidification/stabilization technique to turn them into useful construction materials. The benefit to Canada from this research will be a new treatment of waste materials to make them usable as construction materials, thereby greatly reducing the construction cost and carbon footprint.

Sustainable road construction is researched by utilizing the novel three-dimensional geosynthetics made from nano polymeric alloy (NPA), called NPA geocell to reinforce the roadways in cold climatic regions. This material is placed in bases or subbases of roads to improve the performance of the roadways, reduce the construction cost, and lower emission of CO2. It is especially promising for roadway construction in rural communities in Canada.

HQP training and impact
Our research group has one Master’s student and has graduated one undergraduate Coop. It is expected to have two more Ph.D. students in early 2018. All the students are involved in the research topics mentioned previously. So far a spreadsheet based program for evaluation of pile capacity under scour conditions has been developed by the students and one journal paper has been submitted for review.

Publications
Dr. Lin has published over 30 papers including 24 journal papers and 15 conference papers. The full list of the publications can be found at Google scholars:
https://scholar.google.com/citations?user=QHxNWfsAAAAJ&hl=en
Nanospectroscopy Using Integrated Ultrahigh Quality Factor Microcavities
Researcher and/or Research Group: Tao Lu/Bio-nano-photonics
Department of ECE
Faculty of Engineering
University of Victoria

Research program summary

The nature of our research is to investigate ultra-high quality factor microcavities integrated on a single silicon photonic chip for spectrally discerning individual nanoparticles and biomolecules, discovering their chemical compositions in high spectral resolution and observing their mutual interactions, with the incorporation of advanced machine learning techniques. The research program will result in the development of lab-on-a-chip nanospectrometers that can be used to interrogate nano-objects and their interactions at individual level, in vitro, of super high spectral resolution and in real time.

Significant Research Projects: Contributions and impact

The rapid advancement of nanotechnologies demands devices of sensing, sizing and distinguishing the nanoscale objects. The proposed research targets to fill the needs. The successful completion of the research will be of interest to drug development engineers who are constantly searching for portable devices that can detect and distinguish single protein molecules as well as monitor their interactions with drugs at molecular levels. Physicists, microbiologists, and nanotechnologists will also find this work valuable in observing photon, nanospecimen, and protein interactions at individual particle levels. The anticipated outcomes of the research include the development of an integrated nanosensing and single-molecule nanospectroscopic lab-on-a-chip device.

HQP training and impact

Our lab, which includes a class-100 cleanroom and complete infrastructure for both nano devices fabrication and characterization, provides excellent training environment for HQPs. Through the extensive training, skills of nano-fabrication, -modelling and –characterization will be developed. As an example, one of our PhD students has developed ground breaking cavity optomechanical sensing scheme and achieved a record sensitivity for single molecules detection on whispering gallery platform. His work has published in Nature Communications. He was also selected as top 5 finalists among 643 participants worldwide in 2015 Maiman Outstanding Student Paper Competition at CLEO 2015, one of the most prestigious conferences in photonics. In Mogoth’s CROWN challenge 2017 to use machine learning predicting chemical spectrum, our team finished 12th position worldwide in the first round (2nd in North America).

Publications

Analysis and design of digital filters for image processing

Dr. Wu-Sheng Lu
Department of Electrical and Computer Engineering Faculty of Engineering
University of Victoria, BC, V8P 5C2, Canada

Research program summary

The importance of data analysis and processing in science and engineering is now well understood. His work in this field is largely model-based, using numerical optimization and other analytical tools for analysis and processing. Over the past thirty years of teaching and research at UVic, His research focuses are shifting as time goes by to catch the current of knowledge discovery. These include adaptive control of industrial robots, analysis and design of digital filters for image processing, sparse signal processing for compressive sensing and noise removal, and real-time handwritten digits recognition by machine learning methods. A current research program is algorithmic development for automatic parsing, detecting, and classifying/labeling electrocardiogram (ECG) signals of varying volume from various devices via various media to reveal information about the patient’s heart health.

Significant Research Projects: Contributions and impact

Dr. Lu has more than thirty years of teaching and research experiences in signal processing, optimization, and machine learning. His research has been supported by NSERC in the form of operating and discovery grants since 1987. Under Micronet, a Centre of Excellence program in micro-electronics sponsored by NSERC from 2000 to 2006, Dr. Lu conducted long-term research collaborations with PMC-Sierra in Vancouver concerning peak-to-average power-ratio reduction for wireless and xDSL communication systems and multiuser detectors for CDMA channels. As of Nov. 2017, the Google Scholar reported a total of 6,165 citations with an h-index 40 for his books and scholarly papers. Dr. Lu is a registered engineer in BC and is a Life Fellow of the IEEE.

HQP training and impact

Supervised and co-supervised 17 Ph.D., 16 M.ASc., and 3 MEng. theses since 1992. Most of the theses have led to multiple journal and conference publications. Three graduates received best paper awards, one graduate became IEEE Fellow, one graduate became senior manager in charge of standard affairs for Qualcomm, one graduate is now serving as department head at Hong Kong Chinese University.

Publications

Signal Processing Algorithms
Dr. Michael McGuire, Associate Professor
Digital Signal Processing Group, Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research Program Summary
This research program develops new signal processing algorithms for high data rate, secure, private, and ubiquitous communications at low power and cost. For many decades, improvements to the data rate, security, and flexibility of communications devices has come at the cost of more computation so that modern radio receivers need sophisticated computing processors consuming large amounts of power. As a result, the power consumption of computation in radio receivers is becoming comparable to the radio transmission power. This research program develops signal processing algorithms which use parallel and low-precision calculations to provide power-efficient processing with low cost hardware.

Significant Research Contributions
Algorithms for Joint Channel Estimation and Data Detection in Wireless Channels
My research group has developed algorithms for efficiently estimated the radio channels for fast fading radio channels using an iterative technique that provides performance near that to when ideal channel state information is available. Capacity calculations for iterative channel estimation have been developed which show that ideally this technique can provide performance near that of communication with blind channel estimation at a much lower computational cost.

Faster-than-Nyquist (FTN) Signalling for Multiple-Input/Multiple Output (MIMO) Communications
A FTN signal has too low a bandwidth to be received without inter-symbol-interference but, if properly designed, has nearly the same error performance as a full bandwidth signal. My group developed a FTN technique for multiple antenna radio systems with low cost detection and highly flexible frequency usage.

Wireless Physical Layer Security
My group has developed wireless secret key generation techniques which allow secure, private communications between terminals without prior distribution of secret keys. Refined bounds on secret key lengths for practical network deployments have been developed.

HQP Training and Impact
I have trained many Masters and PhD students who are now mostly employed in telecommunications companies in Canada and the United States included MaxLinear, Verizon Labs, and Cisco. One of my former PhD students, Dr. Alireza Movahedian is currently a Professor at Imam Reza International University.

Significant Recent Publications
New algorithms for representation learning and lifelong learning

Dr. Nishant A. Mehta
Department of Computer Science, Faculty of Engineering, University of Victoria

Research program summary
My research is on the theoretical foundations of machine learning (ML). In particular, I focus on two rapidly-evolving areas: developing new understanding and algorithms for deep learning, and developing optimal algorithms for lifelong learning.

I now describe both these aspects of my work in turn. The success of ML algorithms hinges on which numerical features are used to represent data. We are now in an era where “deep” ML methods learn useful representations of data automatically. These deep learning methods are becoming vital to many other fields, including drug design and computer graphics. Despite great empirical successes, our understanding for why these methods work well and how to best train deep models is lacking. Part of my research is to develop new theory to understand how well a deep model will perform when it makes predictions about new data. My strategy to obtain better performance guarantees is to use theory that leverages specific properties of the actual data an algorithm sees and specific properties of the algorithm itself. By considering both of these important aspects of training, I expect to achieve success for deep learning models as well. The quest of obtaining practical error bounds for deep learning methods is now at the forefront of ML. Progress in this area can lead to new insights into how to design better learning algorithms for deep models, and any better algorithms can support scientific applications and feed into many existing and future industrial applications. Insights from this work may lead to guidance on how to design the layout of deep models, a very difficult problem.

One of the greatest advancements the field of ML can make is to shift from learning each new thing in isolation to reusing what has been learned in the past when learning new tasks. This continual transfer when learning an endless sequence of tasks is known as lifelong learning. While some research has begun in this important area, the mathematical theory for how well algorithms can perform lifelong learning is scant, especially with regards to adaptive algorithms that transfer more from their past experiences when they encounter tasks that are highly similar to past tasks. My research extends to developing algorithms for lifelong learning along with error guarantees. I aim to answer questions like the following: If a learning agent encounters a series of slowly changing learning tasks, can we pool the data from previous tasks in order to learn new tasks using much less data? Adaptive lifelong learning algorithms that more efficiently transfer information learned from previously encountered tasks to new tasks can lead to massive savings in the amount of data needed to learn well. For instance, an agent in the world that is learning to classify objects sequentially may need much less data to learn a later object than it does for earlier objects. This work can bring us closer to truly intelligent systems that learn faster using less data.

Selected research contributions and impact

Learning sparse representations: Sparse representations of data using sparse codes were adopted by the ML community over two decades ago. Recently, researchers have formed models which learn sparse codes from data and then linearly combine the sparse codes to make predictions for classification and regression. In (Mehta and Gray, 2013), I presented the first error bounds for this model. A key result of this work is a numerical stability result for the lasso, an optimization problem for sparse regression that has seen widespread use since the 1990’s. Technical results from this work have been reused by other researchers studying sparse representations, with transfer learning being one application.
Understanding when learning can be fast: Much of my work (Mehta and Williamson, 2014; Van Erven et al., 2015; Reid et al., 2015; Mehta, 2017) has focused on identifying situations where learning algorithms can achieve a desired level of error using much less data than is possible for worst-case problems. Put another way, with respect to the size of the training sample, the error decays at a fast rate. These works have been with collaborators spanning multiple institutions across the Netherlands, Australia, and the US. The conditions we have studied describe what types of learning problems are "easy" (meaning a departure from worst-case scenarios), and the conditions apply to problems in statistical learning problems and sequential prediction problems. These works are important because the conditions are both simple and mild, being able to hold in practical situations, and when the conditions hold it is possible for practitioners to enjoy massive reductions in the amount of data needed to train learning models.

Publications

Materials and Technologies for Next Generation Green Buildings

Dr. Phalguni Mukhopadhyaya — Building Science Research Program
Department of Civil Engineering, Faculty of Engineering, University of Victoria

Research Program Summary

Buildings consume about 40% of our national energy demand and National Energy Code for Buildings (NECB) aims to improve energy efficiency of Canadian buildings and, thereby, reduce greenhouse gas emissions by providing minimum requirements for the design and construction of energy-efficient buildings in Canada. The most recent updates of our national and provincial building codes have more stringent energy efficiency requirements than the previous editions and align with the internationally recognized building energy codes and are complemented by green building practices such as LEED and Net-Zero. These requirements have provided a fresh impetus for the development of green building materials and technologies, and assess their impacts on the long-term performance and sustainability of next generation green buildings. This research program focuses on the development and performance assessment of next generation green building materials and technologies. The outputs from this research program will help to produce affordable, sustainable and comfortable/healthy next generation green buildings for all Canadians, including indigenous and remote northern communities.

Significant Research Projects: Contributions and impact

This is a relatively new UVic research program, established in 2015. However, the research program has already received a number of external research grants (NSERC, CFI, BCKDF, Provincial Govt., Federal Govt., Industry etc.) to support graduate students and build the building science research laboratory. The building science research laboratory has already procured/developed a number of critical pieces of laboratory equipment and can be considered one of a kind in North American universities. All these pieces of equipment are invariably linked with externally funded research projects.

The lead researcher of this research program has contributed to the development of national and international moisture design guidelines for exterior building envelopes (walls and roofs), materials test standards (ASTM (www.astm.org); ISO (www.iso.org); ULC (www.canada.ul.com)), and International Energy Agency (IEA (www.iea.org)) Annex reports on high performance thermal insulations. At present this research group is leading (nominated and elected global convenor) the development of an ISO standard for Vacuum Insulation Panel (VIP), which has about 10 times thermal insulating capacity than traditional thermal insulations, for building envelope applications.

HQP Training and Impact

We established a healthy research group of 10+ research students who are working on various green building design and construction issues using laboratory/field based investigations, analytical techniques and numerical modelling tools. Graduating HQP are routinely absorbed by the Canadian construction industry. One of my PhD students has recently received an NSERC Industrial Postgraduate Scholarship award, which is supported by an industrial partner.

Publications

Software Engineering for Intelligent Cyber Physical Systems

Professor Hausi A. Müller PhD PEng FCAE Google Citations
Associate Dean Research Faculty of Engineering hausi@uvic.ca
Vice President IEEE Computer Society Technical and Conferences Activities Board
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary

Cyber physical systems (CPS) are orchestrations of computers, machines and people working together in cyber physical environments to achieve goals using computation, communications and control (CCC) technologies. CPS have risen from the field of embedded systems to the realm of digital ecosystems and are becoming increasingly smart and intelligent due to analytics and machine learning capabilities readily available in clouds and accessible over networks. The advances in the interconnected capabilities of CPS affect virtually every engineered system and will enable adaptability, scalability, resiliency, safety, security, and usability in future CPS that will far exceed the system capabilities of today. The number of cyber components in CPS has grown gradually to the point where CPS are now software-intensive systems. In today’s CPS, software dominates all aspects of connecting the physical and cyber worlds by orchestrating the CCCs in CPS applications. Consequently, the engineering of high-confidence CPS has also evolved. The resulting process is neither an extension of traditional engineering nor a straightforward application of software engineering, but rather a new systems engineering science.

Significant Research Projects: Contributions and impact

CPS technologies are becoming the key enablers for building smarter infrastructures for industrial applications. Thus, the technologies and applications emerging from combining the cyber and physical worlds will provide an innovation and incubation engine for a broad range of industries—creating entirely new markets and platforms for years to come. Our modern societies and economies increasingly depend on integrated, software-intensive CPS. My research program is funded by NSERC and industry.

- 2011–16 NSERC Strategic Networks Grant on Smart Applications on Virtual Infrastructure (SAVI)
- 2016-21 NSERC Discovery Grant on Software Engineering for Cyber Physical Systems
- 2017–20 NSERC/IBM Strategic Grant on Middleware Framework and Infrastructure for IoT Services
- 2017–20 IBM Cognitive IoT Recipe Maven, IBM CAS Research Project

HQP training and impact

My research program trains HQP with highly desired skills in cutting-edge research in CPS, IoT, adaptive systems, context awareness as well as models and assurance at runtime. Applications include energy management, situation-aware applications for elderly care, food supply chains and flight control. Students with expertise and skills in these areas are in high demand in academia and industry.

Publications

Mathematical modeling of complex materials
Professor Ben Nadler
Department of Mechanical
Faculty of Engineering
University of Victoria

Research program summary
Computational mechanics have become a very useful approach to study complex mechanical systems. Computational tools can provide fast, cost-effective results and physical insights that cannot be obtained by experiments alone. This requires the development of accurate and efficient mathematical models to describe these physics problems. My research focuses on mathematical modeling of complex materials with evolving microstructure. In particular I am interested in developing models for anisotropic inelastic materials such as non-spherical granular materials, biological materials, biological cells and ballistic fabrics. Over the past two years I have developed models for anisotropic grains. Grains show complex phenomena, such as orientational order and self-organization. Mathematical modeling of these complex granular material will provide fundamental insight into their physical behaviour as well as tools to improve and optimise their transportation and sorting used in the agriculture, food processing and pharmaceutical industries.

Significant Research Projects: Contributions and impact
We have developed complex models to study the thermomechanics of biological cells comprised of a peripheral membrane enclosing cytoplasm fluid. Our study provided new information, unobtainable from experimental data alone, on the stress distribution, contact, perforation and adhesion properties of cells. The results our work is used to determine the mechanical properties of biological cells form indentation and micropipette aspiration experiments and to improve medical procedures involving microinjection.

HQP training and impact
Working under my supervision provides my students with deep knowledge of mathematical modeling and computational methods and trains them to use computational tools to analysis a wide range of engineering problems. The results of their work are published in high quality international journals. In today's world with increasing use of computational tools, having the knowledge and experience in mathematical modeling and computational methods obtained during their academic training, the HQP will be well-qualified to pursue both academic and industrial careers.

Publications
Cyber-security, Privacy and High-tech Entrepreneurship
Dr. Stephen W. Neville, PhD, PEng (BC), Associate Professor (Software Engineering)
Department of Electrical and Computer Engineering, University of Victoria

Research program summary
My applied research focuses on the following areas: i) data analytics, ii) cyber-security and privacy, iii) quality of service and operational management of large-scale software systems, and iv) high-tech entrepreneurship. The common theme underlying these areas is the need to identify and address theory-to-practice gaps that arise in the engineering of operational, real-world scale systems such that they behave predictably and reliably, provide sufficiently security and privacy protections.

Statistical and Large-scale Data Analytics. Modern societies’ shift to information age economies is generating vast and ever-increasing volumes of data. Deriving value from this data requires that it is converted into correct actionable knowledge, which is the purview of data analytics. Although many tools and techniques exist, spanning classical statistical analysis and pattern recognition methods, through to modern high-profile neural network, machine learning, deep learning, and artificial intelligence methods, no silver bullet solution exist. Instead, the best methods and techniques are problem specific and must be selected and tailored to the problem hand and the questions being of the data. My work focuses on applied data analysis for larger-scale industry- or government-held operational data sets, i.e., those spanning Gigabytes to Terabytes. This work has spanned a variety of industries from telecommunications, health care, cyber-security, content marketing, mining, etc. This work builds on my more than 25 years of combined industry and academic backgrounds in: statistical data analysis, statistical signal processing, pattern recognition, machine learning, neural networks, and artificial intelligence technologies.

Large-scale Software Systems (Quality of Service and Operational Management). As we move into a future of Smart Cities, Grids, Vehicular networks, as facilitated through Internet-of-Things (IoT) and Cyber-Physical Systems (CPS) technologies, their control and management will fall into the purview of large-scale, complex software systems encompassing strong human and environmental health and safety requirements. This raises new engineering concerns to ensure these systems: behave predictably under all expected operational conditions, remain controllable, safe, reliable, efficient, sufficiently secure. My research focuses on better understanding the interplays between software systems and dynamical systems concerns, as these underlie system predictability and controllability.

Cyber-security and Privacy. Large-scale software systems are also increasingly subject to cyber-attacks enacted by intelligent well-resourced adversaries. How to secure such systems and assure sufficient privacy protections are challenging research problems. My work focuses on developing better understandings for constructing systems with bounded privacy and security risks even when exposed to intelligent, motivated, and capable adversaries. This work builds on my extensive years’ experience in cyber-security research and as a co-founding member of the NSERC Strategic Network on Internetworked Systems Security Network (ISSNet) [2007-2014].

High-tech Entrepreneurship. Dr. Thomas Darcie and I manage UVic’s Entrepreneurship@UVic program, which focuses on transforming and nurturing top-tier STEM bachelor degree holders into BC’s next generation of skilled, knowledgeable, and capable high-tech entrepreneurs. Founded in 2009 as a unique collaboration between UVic, Wesley Clover International, and the Alacrity Foundation, this program has been instrumental in the co-founding of six new, rapidly growing, globally-focused high-tech ventures that now combined employ over 170 personnel while possessing a vetted market value exceeding $30M. In 2016 we received UVic’s Craigdarroch Research Award for Research Partnerships for our successes in this program.

Publications and HQP Training
Publications: 1 book chapter, 9 journal papers, 75 conference papers, 2 awarded patents, 4 submitted patent applications, 4 provisional patent filings, 28 technical reports. HQP training: 4 PhD, 15 MASc. Startups: co-founding 5 rapidly growing BC high-tech companies.
Fluid-Structure Interactions and Flow-Induced Noise
Professor Peter Oshkai (poshkai@uvic.ca)
Department of Mechanical Engineering, Institute for Integrated Energy Systems (IESVic)
Faculty of Engineering, University of Victoria

Research program summary

*Mitigation of acoustic noise pollution due to marine transportation.* With intensified commercial shipping activity and increased public awareness of its impact on the environment, acoustic noise pollution from vessels is emerging as a major concern for the marine industry, certification organizations and the general public. Our research group works to address a recognized need in the international marine research and regulations community to increase the fidelity of the methods used for prediction of acoustic emissions from vessels by developing state-of-the-art simulation tools.

*Safety of pipeline systems.* Pipelines are commonly used for transporting fluids in a variety of engineering systems. Turbulent, separated flows that form in pipelines can couple with the acoustic waves, and the resulting resonant pressure oscillations can lead to noise, vibrations and ultimately fatigue failure of the pipeline. My research program looks into the fluid-structure interactions and prediction of the dispersion of hazardous gas clouds in the vicinity of a leak from a pipeline. In particular, hazard assessment of CO₂ pipelines is a necessary and integral part of the Carbon Capture and Storage (CCS) processes.

Significant Research Projects: Contributions and impact

Our research group developed a semi-empirical approach based on laser-based flow imaging and numerical simulation of the acoustic field, which provides a foundation for effective techniques for controlling the flow-induced vibrations and noise. This technique was applied, for the first time, in our laboratory. Since then, several research groups in Canada and abroad have been successful in applying variations of this method to acoustically-coupled flows. The international impact of my research is evidenced by collaborations with prominent universities: Trinity College Dublin (Ireland), Moscow State University (Russia), Karlsruhe Institute of Technology (Germany), Politecnico di Milano (Italy), Kanazawa University (Japan).

HQP training and impact

The internationally recognized level of our research contributions, the dynamic, collaborative environment, and timely, industrially relevant research directions have attracted graduate students with outstanding academic aptitude. For example, many of my students and postdoctoral fellows have held NSERC scholarships. Our former group members have been recruited by industry (AFCC, Ballard Power Systems, RWDI, Robert Allan Ltd., Combustion Solutions Inc., Babcock Marine, Neurostream Technologies, Baylis Medical Company Inc.), government (The Standards Council of Canada, BC government, CEA (France)) and academia (University of Ulster, Ireland).

Publications

Research program summary

Nanoscale science and technology involves controlling the size and shape of materials at the nanometre (nm) scale such that their properties can be tailored for specific applications in ways not possible at larger scales. Nanofabrication underpins and enables the application of nanoscale materials and seeks to construct structures using a variety of unique approaches and tools, which is the topic of this research program. A novel combination of nanofabrication techniques is used in conjunction with high-resolution microscopy and precise electrical measurements to produce nanostructured films and coatings with feature sizes down to 1-2 nm and properties that can be engineered for applications in electronics and energy. Nanofabrication provides the potential for improved performance and new functionality while reducing costs that will enhance existing technology and lead to further growth in the fields of electronics and green energy production and storage that can strongly benefit Canada strategically.

Significant Research Projects: Contributions and impact

Molecular Electronic Networks: Developed and demonstrated self-assembled metal-molecular electronic networks via fabrication, electronic transport and simulation studies. These results demonstrate a potential avenue for the creation of molecular integrated circuits for logic or memory applications and were featured in Advanced Science News (June 21, 2017).

Bottom-up Nanofabrication: My group made several advances in the area of nanoscale self-assembly and patterning. Patterning of thin films via colloidal lithography showed low-cost and high-throughput assembly of nanostructures into well-defined superstructures that are advantageous for developing applications in electronics, photonics and biosensors.

Top-down Nanofabrication: Advanced nanoscale grinding as a unique approach to nanoparticle thin film synthesis. Nanogrinding can directly produce large amounts of nanoscale particles without the use of complex chemical or physical processing. Thin films created via nanogrinding possess unique physical properties, which can be used for advanced materials and devices.

HQP training and impact

The training environment provided for HQP in my laboratory involved interdisciplinary research with a range of knowledge transfer opportunities: HQP learned nanofabrication, microscopy, spectroscopy and electronic/optical material and device characterization. 90% of my HQP outcomes over the last six years have been positions in industry or further research studies.

Publications

Portable Platforms for Telecommunication, Security, and Biomedical Applications
Daler Rakhmatov, PhD (Arizona), PEng (BC)
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
Our research aims to advance green embedded computing technologies for computation-intensive applications executed on battery-powered portable platforms. We pursue three interdependent lines of inquiry: (1) configurable hardware/software architectures to enable energy-efficient and flexible application execution, (2) predictive analytical models of platform energy supply-demand dynamics to enable battery-aware optimizations, and (3) model-driven platform management algorithms that maximize service quality, subject to battery-imposed energy constraints during application execution. Our work is of value to a broad community of researchers and practitioners in the area of mobile computing systems and communication protocols.

Research project example
We have proposed a novel specialized elliptic-curve cryptographic processor, combining performance, security, and flexibility features within a single computing architecture. To enhance performance, our processor exploits parallelism by pipelining modular arithmetic computations and associated input/output data transfers. To enhance security, modular arithmetic computations and associated data transfers are grouped into atomically executed computational blocks. The flexibility of our processor is achieved through the software-controlled hardware programmability, which allows for different scenarios of computing atomic block sequences.

HQP training and impact
Our trainees are exposed to the broad and diverse research agenda, while gaining solid knowledge and desired skills across several technical disciplines, such as digital signal processing, biomedical imaging, applied cryptography, wireless communication, system-on-chip architectures, algorithm design, and partial differential equations. Among our HQP graduates are a research associate at the National Research Council Canada, an internet technology entrepreneur in Nigeria, and a Deputy Director of the National Center for Cybersecurity Technology in Saudi Arabia.

Selected publications
Energy Conversion and Thermal Systems
Dr. Andrew Rowe PEng
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
Global demand for thermal services includes space cooling, refrigeration, gas liquefaction, and thermal storage; these services are responsible for approximately 40-50% of global energy consumption. Research in thermal systems is aimed at the development of new technologies with higher efficiency, lower cost, and less environmental impact. One area of activity is the development of devices using solid substances as working materials – generally known as caloric materials. A specific focus is the use of magnetocaloric materials for advanced heat pumps; magnetocaloric materials respond to changes in magnetic field with a reversible change in temperature. Other research activities related to thermal design include enhanced heat transfer structures such as heat pipes, the use of solid carbon dioxide for storage and transport of frozen foods, and thermal optimization of systems for algal growth and energy storage.

Significant Research Projects: Contributions and impact
Collaborative research on magnetocaloric refrigeration with BASF New Business, Germany, has led to a number of joint patents, papers, and training of graduate students. The work performed at UVic enabled the demonstration of a magnetocaloric device at the 2015 Consumer Electronics Show in Las Vegas.

Undergraduate and graduate students have analyzed and designed a passive, mobile, cold storage system using solid CO2 for a local start-up company, Cryologistics Limited. Based on our work, a prototype was constructed which led to an initial round of seed funding. The collaboration is continuing with the development of a thermal control system for a larger, pallet-scale system.

Optimal thermal designs are being developed for improved operation of photobioreactors produced by Industrial Plankton, a Victoria company. Research at UVic has identified new heat transfer structures that reduce cost and increase algal growth rates.

HQP training and impact
Students receive advanced training in thermal design, energy conversion, heat transfer, experimentation, and modeling. Students have developed joint patents with industry partners. Undergraduate and graduate students are applying their research to help local companies develop new technologies for food transport and improved photobioreactors for algal growth.

Publications
Research results are communicated and archived via technical reports, conference and journal papers, theses, patents, and presentations. Please contact Andrew Rowe for more information.
Energy Systems: The 2060 Project
Dr. Andrew Rowe PEng
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
A key strategy for long-term, deep decarbonisation is the development of a sustainable electrical system. In the future, clean electricity substitutes directly and indirectly for fossil fuel use across all sectors of the economy. This strategy leverages the existing system in British Columbia and presents new opportunities and challenges. The 2060 Project explores the intersection of technology, policy, and economics on the decarbonisation of Canada’s energy system.

Significant Research Projects: Contributions and impact
Policy-related findings include optimal electrical intertie capacity between the Canadian provinces of British Columbia and Alberta. The value of residual forest biomass has been assessed as an energy supply for hydrogen production, synthetic fuel, and for refiring of stranded coal power plants. The impacts of carbon regulation on electrical system evolution in Alberta were quantified. BC relevant studies examined the potential for wave energy on Vancouver Island and the impacts of increased intertie capacity on hydroelectric operations. The value of nuclear power to mitigate emission risk, and the relative greenhouse gas reduction values of wind power versus deployment of district energy were analyzed for the province of Ontario.

HQP training and impact
Students interact and work closely with partners in utilities, government, and electricity market administrators giving regular presentations on their research. The research is interdisciplinary; an example being a PhD student in Environmental Studies working with engineering students. In contrast, an undergraduate co-op student analyzed the value of cogeneration to reduce greenhouse gas emissions in the Alberta oilsands. The work was published in Energy Policy with the student as the first author. She is now working with an engineering consulting firm on energy infrastructure. Graduate students have been hired as electricity system planners with utilities, demand management consultants, and energy efficiency analysts.

Publications
A comprehensive communication strategy is used to engage as broadly as possible. In addition to journal articles, presentations, and conference papers, research results are disseminated through Opinion Editorials, website blogs, white papers, and social media. These different modes provide effective ways to digest findings and to educate various audiences on the complexities and challenges of energy system decarbonisation. Please contact Andrew Rowe for more information.
Combinatorial Algorithms
Professor Frank Ruskey
Department of Computer Science
Faculty of Engineering
University of Victoria

Research program summary
A key aspect of mathematical discovery is the elucidation of patterns, and the computer is our able assistant in this endeavor. A major part of my research is dedicated to developing algorithms and software for efficiently and exhaustively listing mathematical structures of various types, particularly those with symmetry. Amongst these are familiar structures such as Venn diagrams, Tatami mat layouts, and lace patterns; but also esoteric structures, such as basic words of antimatroids, and primitive polynomials over finite fields. I am a strong believer in the importance of doing non-important research, being curious about something and then following whatever path it leads to.

Significant research projects
My recently graduated PhD student, Veronika Irvine, has revolutionized a centuries old area of human enquiry, namely the fiber art form known as bobbin lace. She did this, for the first time, by determining a precise mathematical model to describe legal thread layouts, both the topological and the geometric aspects. She then used this model to write a program to enumerate all legal patterns, discovering along the way some new patterns that had never been discovered before. She has received much acclaim for this work, both mathematical and artistic; for example, interviewed by CBC, work exhibited at the joint AMS/MAA mathematics meetings, invited plenary speaker at Bridges (premier conference on Mathematics and the Arts).

HQP training and impact
My former graduate students have faculty positions at Simons Rock, Guelph, VIU, UNB, and UofA. Others are working in industry, including Google, Cooperleaf, and Citibank. One of my PhD students co-founded Freshbooks, which now has 250 employees.

Representative Publications
• V. Irvine and F. Ruskey: Developing a Mathematical Model for Bobbin Lace, Journal of Mathematics and the Arts 8:95–110 (2014). — This paper was selected as the best paper published in the journal in the last two years.
New algorithms for representation learning and lifelong learning

Dr. Nishant A. Mehta
Department of Computer Science, Faculty of Engineering, University of Victoria

Research program summary

My research is on the theoretical foundations of machine learning (ML). In particular, I focus on two rapidly-evolving areas: developing new understanding and algorithms for deep learning, and developing optimal algorithms for lifelong learning.

I now describe both these aspects of my work in turn. The success of ML algorithms hinges on which numerical features are used to represent data. We are now in an era where “deep” ML methods learn useful representations of data automatically. These deep learning methods are becoming vital to many other fields, including drug design and computer graphics. Despite great empirical successes, our understanding for why these methods work well and how to best train deep models is lacking. Part of my research is to develop new theory to understand how well a deep model will perform when it makes predictions about new data. My strategy to obtain better performance guarantees is to use theory that leverages specific properties of the actual data an algorithm sees and specific properties of the algorithm itself. By considering both of these important aspects of training, I expect to achieve success for deep learning models as well. The quest of obtaining practical error bounds for deep learning methods is now at the forefront of ML. Progress in this area can lead to new insights into how to design better learning algorithms for deep models, and any better algorithms can support scientific applications and feed into many existing and future industrial applications. Insights from this work may lead to guidance on how to design the layout of deep models, a very difficult problem.

One of the greatest advancements the field of ML can make is to shift from learning each new thing in isolation to reusing what has been learned in the past when learning new tasks. This continual transfer when learning an endless sequence of tasks is known as lifelong learning. While some research has begun in this important area, the mathematical theory for how well algorithms can perform lifelong learning is scant, especially with regards to adaptive algorithms that transfer more from their past experiences when they encounter tasks that are highly similar to past tasks. My research extends to developing algorithms for lifelong learning along with error guarantees. I aim to answer questions like the following: If a learning agent encounters a series of slowly changing learning tasks, can we pool the data from previous tasks in order to learn new tasks using much less data? Adaptive lifelong learning algorithms that more efficiently transfer information learned from previously encountered tasks to new tasks can lead to massive savings in the amount of data needed to learn well. For instance, an agent in the world that is learning to classify objects sequentially may need much less data to learn a later object than it does for earlier objects. This work can bring us closer to truly intelligent systems that learn faster using less data.

Selected research contributions and impact

Learning sparse representations: Sparse representations of data using sparse codes were adopted by the ML community over two decades ago. Recently, researchers have formed models which learn sparse codes from data and then linearly combine the sparse codes to make predictions for classification and regression. In (Mehta and Gray, 2013), I presented the first error bounds for this model. A key result of this work is a numerical stability result for the lasso, an optimization problem for sparse regression that has seen widespread use since the 1990’s. Technical results from this work have been reused by other researchers studying sparse representations, with transfer learning being one application.
Understanding when learning can be fast: Much of my work (Mehta and Williamson, 2014; Van Erven et al., 2015; Reid et al., 2015; Mehta, 2017) has focused on identifying situations where learning algorithms can achieve a desired level of error using much less data than is possible for worst-case problems. Put another way, with respect to the size of the training sample, the error decays at a fast rate. These works have been with collaborators spanning multiple institutions across the Netherlands, Australia, and the US. The conditions we have studied describe what types of learning problems are “easy” (meaning a departure from worst-case scenarios), and the conditions apply to problems in statistical learning problems and sequential prediction problems. These works are important because the conditions are both simple and mild, being able to hold in practical situations, and when the conditions hold it is possible for practitioners to enjoy massive reductions in the amount of data needed to train learning models.

Publications

Combimotarial Algorithms
Professor Frank Ruskey
Department of Computer Science
Faculty of Engineering
University of Victoria

Research program summary
A key aspect of mathematical discovery is the elucidation of patterns, and the computer is our able assistant in this endeavor. A major part of my research is dedicated to developing algorithms and software for efficiently and exhaustively listing mathematical structures of various types, particularly those with symmetry. Amongst these are familiar structures such as Venn diagrams, Tatami mat layouts, and lace patterns; but also esoteric structures, such as basic words of antimatroids, and primitive polynomials over finite fields. I am a strong believer in the importance of doing non-important research, being curious about something and then following whatever path it leads to.

Significant research projects
My recently graduated PhD student, Veronika Irvine, has revolutionized a centuries old area of human enquiry, namely the fiber art form known as bobbin lace. She did this, for the first time, by determining a precise mathematical model to describe legal thread layouts, both the topological and the geometric aspects. She then used this model to write a program to enumerate all legal patterns, discovering along the way some new patterns that had never been discovered before. She has received much acclaim for this work, both mathematical and artistic; for example, interviewed by CBC, work exhibited at the joint AMS/MAA mathematics meetings, invited plenary speaker at Bridges (premier conference on Mathematics and the Arts).

HQP training and impact
My former graduate students have faculty positions at Simons Rock, Guelph, VIU, UNB, and UofA. Others are working in industry, including Google, Cooperleaf, and Citibank. One of my PhD students co-founded Freshbooks, which now has 250 employees.

Representative Publications
- V. Irvine and F. Ruskey: Developing a Mathematical Model for Bobbin Lace, Journal of Mathematics and the Arts 8:95–110 (2014). — This paper was selected as the best paper published in the journal in the last two years.
Faculty of Engineering Research Program Briefs

Advanced Control for Intelligent Cyber-Physical Systems
Professor Yang Shi
Faculty of Engineering, University of Victoria

Research program summary
This research program aims to develop technologies for the design, analysis, and control synthesis of intelligent cyber-physical systems with a variety of application areas. “There is Nothing More Practical Than A Good Theory”. Therefore, our program is essentially developed and built on solid fundamental research including model predictive control, optimal control, stochastic control, system identification, cooperative control, learning-based intelligent control. The application areas include robotics and mechatronics, autonomous vehicles, vehicles and transportation systems, energy systems, industrial automation.

Significant Research: Contributions and impact
Professor Shi is an internationally leading scholar in control and automation, with influential work in networked control systems, multi-agent systems, model predictive control, mechatronics, autonomous vehicles, control and optimization of energy systems. He has developed a unified practical framework for the analysis and synthesis of networked control systems, and has proposed pioneering solutions to robust model predictive control for networked and distributed dynamic systems. These results have led the way on how to control plants remotely via an internet link. Professor Shi and his team have developed advanced real-time control methods and successfully applied them to several sectors such as aerospace, underwater vehicles, robotics, combined cooling, heating and power plants, and smart grid. He has published 120 journal papers and 2 research monographs. Recognizing his pioneering work, Thomson Reuters named him one of the top 200 worldwide Highly Cited Researchers in 2014, 2015, and 2016, based on the high impact of his research (h-index: 44). Professor Shi was the recipient of the 2017 IEEE Transactions on Fuzzy Systems Outstanding Paper Award, the Craigdarroch Silver Medal for Excellence in Research at the University of Victoria in 2015. He is Co-Editor-in-Chief of IEEE Transactions on Industrial Electronics. Professor Shi is an IEEE Fellow, ASME Fellow and CSME Fellow, recognized for his accomplishments in networked and distributed control systems.

HQP training and impact
Over the years Professor Shi has provided first-class training to a large number of graduate students and research personnel. The training of HQPs is enriched through exposure to fundamental research in the area of advanced control and its practical applications. The unique HQP training, with good balance of theory and applications, has launched the careers of many gifted engineers and scholars in industry, research and academia.

Publications
Laboratory of Reconfigurable Computing Engineering — http://recoeng.ece.uvic.ca

Mihai Sima, PhD
Associate Professor
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria
Phone: (250) 721-8680
E-mail: msima@ece.uvic.ca
Web: http://www.ece.uvic.ca/~msima

Research program summary
The Laboratory of Reconfigurable Computing Engineering (ReCoEng) focuses on the architecture, design, development, implementation, testing, and evaluation of Field-Programmable Gate Arrays (FPGA), which are hardware platforms configured under software control. These devices have led to the paradigm of Reconfigurable Computing (RC), in which customized computing units are designed and dynamically swapped onto programmable hardware. This way, a virtually infinite amount of hardware is emulated.

Significant Research Projects: Contributions and impact
Being programmable, FPGAs can be used in a large class of applications ranging from software defined radios and wireless communications to image processing and cryptography. However, the programmability feature comes at the penalties of increased silicon area and power consumption. The research performed in the ReCoEng Laboratory investigates the use of coarse-grained units in FPGAs, with the main goal of mitigating those penalties. Specifically, our research aims to balance the power consumption into a constant value, which in turn will increase the robustness to side channel attacks against FPGA-mapped cryptosystems. Our research also aims to lower the silicon area of these devices, which in turn will make the use of FPGA in mobile terminals viable for the current level of technology. It is emphasized that our research is application centred, as secured wireless communications is an emerging area in the industry.

HQP training and impact
As of 2017 three doctoral and two Master's students are affiliated with the ReCoEng Laboratory. We provide training in the emerging area of programmable arrays, which faces high demand on the labour market. Our alumni have obtained prestigious positions in academia (such as Qassim University, Saudi Arabia) as assistant professors and industry (such as Cadence UK and Apple California) as design and test engineers.

Publications
Multiscale Heterogeneous Computational Electromagnetics

Dr. Poman So — Computational Electromagnetic Research Laboratory (CERL)
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria

Research program summary
The main objective of CERL’s research program is to develop efficient computational algorithms for solving grand challenge multiscale electromagnetic engineering problems. Computer aided design and engineering (CAD/CAE) tools enabled with these algorithms can take advantage of the evolving heterogeneous computing hardware consists of multiple graphics processing units (GPUs) and multicore central processing units (CPUs). CAD/CAE tools adopting heterogeneous computing paradigms can run hundreds to thousands of time faster than traditional implementations and thus can boost the design capability of the electromagnetic industry.

Significant Research Projects: Contributions and impact
Heterogeneous electromagnetic modeling algorithms, object-oriented electromagnetic components, modeling of metamaterials, and computer-aided microwave circuit analysis and synthesis. These algorithms are published in high impact conference proceedings and engineering journals as well as implemented in our in-house electromagnetic field modeling software. Many of these published algorithms are employed in a CAD tool, MEFiSTo, by Faustus Scientific Corporation.

HQP training and impact
Graduate students are trained to use electromagnetic software packages such as CST Microwave Studio, ANSYS HFSS, and Faustus MEFiSTo which are established CAD/CAE tools for the high frequency RF/wireless/microwave/millimeterwave industry. Students are also trained to develop specialized computational components for integration into CERL’s in house modeling tools. Upon completion of their training, students are equipped to tackle multiscale computational issues in the high frequency electromagnetic industry.

Publications
Foundations of Data Analytics
Professor Venkatesh Srinivasan
Department of Computer Science
Faculty of Engineering
University of Victoria

Research program summary
Today, we are surrounded by a deluge of complex information coming from diverse sources such as the public web, scientific data systems, digital libraries, biological data management, and business intelligence. To extract knowledge from such information, there is an urgent need to analyze data which is massive, partially structured and evolving. The knowledge gained through such analysis will aid us in making important decisions in application domains such as health, defense and the environment. Graphs are a natural choice to represent complex data with partial structural information. For example, social network data is naturally represented as a graph in which the nodes represent individuals or organizations and the edges correspond to interdependency such as friendship, common interests, or common beliefs. My research program identifies challenges in three core areas of large graph analytics, data credibility, diversity, and privacy, and tackles fundamental problems in each of them.

Significant Research Projects: Contributions and impact
To ensure the reliability of information, we need techniques to detect, limit the spread of or even completely eliminate information that is not credible. Our research has proposed a mechanism that combines statistical and semantic analysis, for detecting hidden paid posters in news websites. This work was covered by MIT Technology Review, ACM TechNews, Slashdot, Times Colonist and others. We have also explored the notion of diversity in the context of recommender systems and social networks. Our research, published in a top-tier ACM conference, uses the idea of edge conflicts to introduce a new generalization of a well-known graph matching problem. It presents efficient algorithms for this problem and shows its applications in creating diverse recommendation lists. Finally, our work on data privacy has shown many interesting results for the notion of data anonymization.

HQP training and impact
In the past six years, I have supervised 5 PhD students and 7 Masters students. All my students have been very successful in their career after graduation. Among the five PhD students, one is now an Assistant Professor, two are postdoctoral researchers at prestigious universities and two have joined as software engineers in the IT industry.

Publications
- C. Chen, L. Zheng, V. Srinivasan, A. Thomo, K. Wu and A. Sukow, "Conflict-Aware Weighted Bipartite Matching and its Applications to E-commerce", IEEE Transactions on Knowledge and Data Engineering (TKDE), 28(6), 2016, pages 1475-1488.
Human Problem Solving in the Cognitive Era
Dr. Ulrike Stege, Associate Professor
Department of Computer Science, Faculty of Engineering, University of Victoria

Research program summary
Many IoT devices and apps augment human capabilities, ranging from support for experts to everyday activities. We are in the era of cognitive computing, where advanced data-centric computing models and open innovation approaches allow technology to augment decision-making capabilities for business and government. Research on this topic is commonly referred to as human problem solving (HPS). I focus on the study of human performance and strategies when tackling computational problems especially computationally hard problems. What problems can people solve successfully? Which ones cannot be solved? What are the properties of the ones that people are interested in solving? What are successful solving strategies? To characterize cognitive functions, we draw on methods in classical and parameterized complexity, the development of exact algorithms, as well as empirical studies and their analyses. An improved understanding of HPS impacts many different application areas including improved user engagement. When designing games and puzzles, methods for identifying properties of the cognitive functions used when playing games or puzzles that many people are intrigued by, while having a satisfactory playing experience, will provide the industry with strategies and tools to create new games involving these properties. Another example are context-aware software systems. When designing for example self-driving cars, it is beneficial to understand how humans make decisions on the road. Furthermore, the knowledge gained is useful in education, for educators at all levels, including teaching problem solving skills.

Significant Research Projects: Contributions and impact
HPS, a fundamental aspect of understanding human cognition, investigates the mental mechanisms that underlay the cognitive ability of problem solving. Fundamental to characterizing cognitive functions and to support human decision making and problem solving effectively, one needs to understand what problems people can solve, as well as how and under which conditions. We investigated the question of how humans cope with complexity from a computational complexity perspective—what problems can humans solve. When designing experiments, we need to ensure that the question posed is indeed a question people actually tackle. Our human performance studies indicate that people do not solve the problem presented when tasked with computationally hard optimization problems—these optimization problems are ill-defined goals. Using optimization and search versions of problems, we recognized that differences in performance between these versions are due to differences in how problem solvers encode the goal of a given task. Thus, the investigation of human performance on NP-hard problems shows that asking people to answer the optimization version of a problem may not be informative. This sheds a new light on the vast majority of prior published human problem solving research that was based solely on studies that investigated optimization versions.

HQP training and impact
Highly qualified personnel trained in my group acquire an interdisciplinary education based on solid foundations in theoretical computer science, and learn how to conduct empirical studies. These HQP are highly sought after by industry. I am very proud of my former graduate students and postdocs: The first start-up of two of my former postdocs was bought out by Google; their second company is employing an impressive team, including a number of UVic alumni. Three of my former PhD students work in academia.

Publications
Human and Social Aspects of Software Engineering

Dr. Margaret-Anne Storey, Professor and Director, Software Engineering Program
Canada Research Chair in Human and Social Aspects of Software Engineering
University of Victoria Department of Computer Science, Faculty of Engineering

Research program summary

Dr. Storey's main research goal is to understand how technology can help people explore, understand, and share complex information and knowledge. She evaluates and applies techniques from social software, data science and visual interface design to applications such as collaborative software development, program comprehension, cybersecurity, and biomedical ontology development. Her work has had direct impact on the tools and processes used in companies such as IBM, Microsoft, Thales Canada, the World Health Organization and the Canadian Research Department of National Defense.

Significant Research Projects: Contributions and impact

*Social media has had a transformative influence on distributed software engineering projects,* impacting how developers learn, share knowledge and connect with others. This research captures how social media and other tools such as software bots, enable a sophisticated participatory development culture in software engineering, but also cause challenges, e.g., information overload and interruptions.

*How visualization can enhance comprehension and navigation in software development:* Dr. Storey, along with her students and collaborators, have designed, developed and evaluated several visualization frameworks to address software engineering and security problems.

*Ontologies and knowledge modelling techniques are often used to integrate and share disparate information sources.* Dr. Storey investigated the requirements for and developed a Web-based visualization tool that has been integrated within the BioPortal ontology portal for the National Center for Biomedical Ontology in the US.

HQP training and impact

Dr. Storey leads a large and vibrant research group and her lab is known internationally as an innovative and supportive environment that attracts world-class students and researchers. Her collaborations have provided students with opportunities to visit other labs and enter industrial internships. Her past students are now professors or hold research or professional positions in a variety of local and international companies.

Publications

Non-equilibrium Thermodynamics and Kinetic Theory of Gases
Professor Henning Struchtrup
Department of Mechanical Engineering
Faculty of Engineering
University of Victoria

Research program summary
The general interest of my research program is the development of mathematical models for the description of transport processes in strong non-equilibrium situations, in particular those in micro and nano devices. Under the conditions of interest, the classical laws of thermodynamics and fluid dynamics break down, and must be extended in order to capture effects that do not occur on traditional macroscopic length scales. I am also interested in the modelling of non-equilibrium processes in energy conversion systems, such as pressure retarded osmosis power plants.

Significant Research Projects: Contributions and impact
Gas flows in micro and nano devices exhibit transport processes due to gas rarefaction, that do not occur on normal length scales. While microscopic simulators, which describe a gas as a large number of individual particles, can be used to describe these flows, these require significantly more computational power than the classical macroscopic transport laws, which describe the gas as a continuum. Our Regularized 13 Moment Equations (R13) provide an extended set of macroscopic equations that reproduces all important rarefaction effects in sufficient accuracy.

HQP training and impact
My graduate students are trained to solve challenging multi-facetted problems from beginning to end, from outline to presentation, using analytical and numerical methods. Recent students found jobs in local industry and government.
A real highlight was mentoring of recent undergraduate student Devesh Bharadwaj, with whom I studied Pressure Regarded Osmosis Power Plants in his co-op terms and honours thesis: he now has a start-up company, supported in part by UVic (https://www.uvic.ca/Devesh).

Publications
Our papers appear in leading journals, e.g., J. Fluid Mechanics, Physics of Fluids, Physical Review Letters, Physical Review E, and are well cited, and also lead to invitation o international conferences and institutions. Full list available on Google Scholar. Most recent papers:


Moreover, I authored a monography on macroscopic modelling of gas flows (Springer 2017) and a textbook on thermodynamics for my undergraduate teaching (Springer 2014).
Faculty of Engineering Research Program Briefs

Center for Aerospace Research
Unmanned Air Systems and Related Technologies
Professor Afzal Suleman, Director
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
The aerospace industry is facing several challenges of contradictory nature: the demand for speed and capacity increase while simultaneously minimizing the environmental impact caused by air travel. The Unmanned Air Systems research program is a relatively low cost approach to design and test novel aircraft configurations. The design, development and manufacturing of the proposed experimental flight demonstrators are performed as an integral part of the aircraft design and validation process. Novel aircraft configurations enable improved aircraft efficiencies, aerodynamic performance, reduced structural loads and lighter weight structures.

Significant Research Projects: Contributions and impact
The Centre for Aerospace Research (CFAR) has developed a unique expertise through several industrial collaboration initiatives and funding from the Federal and Provincial Governments that include: Western Economic Diversification ($2M) [2011-2017]; a partnership with the Composites Research Network (CRN) spearheaded by the University of B.C. with funding from Western Economic Diversification ($9.8M) [2013-2020]; funding from CFI for the design and development of UAS; partnership with NSERC and Bombardier Aerospace on design, build, test and fly of novel aircraft configurations, more specifically on Multidisciplinary Design Optimization of Flexible Wing Aircraft and a partnership in the development of a novel BWB business jet; experimental and computational flight testing in the framework of the Sensorcraft Program funded by the Air Force Research Labs (USAF) and Boeing USA. More recently, UVic-CfAR has partnered with NSERC, DRDC, CAE and University of Waterloo on the evaluation of magnetic anomaly detection sensors on UAS. Currently, UVic-CfAR is actively collaborating with the University of Lisbon (Portugal) on MDO and with Sabanci University (Turkey) on Advanced Composites.

HQP training and impact
Annually, the CfAR research group has typically consisted of 2 PDFs, 4 PhD, 6 MSc graduate students, and 8 undergraduate co-op students, and additionally it may include research associates and/or research visitors. Students acquire skills across a broad range of interdisciplinary technologies, including computational design and modeling, fluid mechanics, structural mechanics, composite materials, multidisciplinary optimization and experimental methods and techniques. Through the thematic programs and related collaborations, students also learn about aerospace systems such as novel air vehicles configurations and unmanned air vehicles, energy systems (fuel cell design modeling and optimization, hybrid propulsion, energy harvesting), and advanced composite structures and materials. CfAR has hosted visiting students from Portugal, Germany, Italy, Malaysia, Mexico, Turkey and Brazil.

Publications
Design of Durable and High-Performance Steel Structures
Dr. Min Sun
Department of Civil Engineering
Faculty of Engineering, University of Victoria

Research program summary
Infrastructure is central to every aspect of life in Canada. The research is motivated by an increasing number of reports on poor in-service performance and even hazardous collapse of some exposed steel structures across North America. Solutions will be developed to improve the structural performance and extend the service lives of bridges, highway and parking structures, industrial plants and transmission towers. Structures composed of high-performance materials have obvious advantages in economical, environment protection and energy-saving aspects. The research will also generate design tools for engineers to fully utilize the structural and architectural advantages of the “new-generation” structural steel material. The long-term goal is to facilitate design, fabrication, construction and maintenance of durable and high-performance infrastructure in Canada.

Significant Research Projects: Contributions and impact
Dr. Min Sun has extensive experience in performing experimental, numerical and analytical research on steel structures, including marine structures. Dr. Sun is actively involved in research projects sponsored by both the Canadian Institute of Steel Construction (CISC) and the American Institute of Steel Construction (AISC). In 2016, Dr. Sun received the CISC University Research Grant. The CISC, representing the Canadian steel industry, is committed to supporting research programs at leading Canadian universities as part of its mandate to support the development of expertise, knowledge and innovation in steel design and construction. Dr. Sun’s research is also supported by fundings from the Natural Sciences and Engineering Research Council of Canada (NSERC) and his industrial collaborators across the country. Dr. Sun has published his research in top scientific journals including the ASCE Journal of Structural Engineering, AISC Engineering Journal, Journal of Constructional Steel Research, and Engineering Structures.

HQP training and impact
Dr. Sun joined the University of Victoria in 2016. His research team consists of one PDF, two PhDs, two MAScs and one undergraduate student.

Publications
Real-Time Modeling and Tracking of Dynamic Geometry
Professor Andrea Tagliasacchi, Visual Computing Group
Department of Computer Science
Faculty of Engineering, University of Victoria

Research Program Summary
We investigate ways to represent geometry that are different from what is typically adopted by the computer graphics and vision communities. This representation, a particular variant of the so-called sphere-meshes, is used today by 3D artists to efficiently design the coarse articulated structure of digital content. Their mathematical properties make them ideal for VR/AR applications, as geometric queries essential to real-time registration algorithms (i.e. tracking) can be answered with extreme efficiency. These models can also be easily adapted to changes in geometry, thus making them suitable to represent our ever-changing world. My research team approaches this investigation from three different angles. We are (1) studying how to reverse engineer sphere-mesh surfaces from acquired data; (2) investigating their use in real-time consumer applications; and (3) developing a cost-effective omnidirectional 3D acquisition system.

Significant Research Projects: Contributions and impact
My group has been a world leader in the realm of real-time tracking since our pioneering project [Tagliasacchi et al. 2015]. We then extended this work by introducing Sphere-Meshes as geometric representations for tracking, which allow efficient calibration of tracking templates to users [Tkach et al. 2016, Tkach et al. 2017]. These algorithms have captured the attention of Intel RealSense and Google Daydream amongst others, and resulted in my appointment as FENG “Industrial Research Chair in 3D Sensing” in conjunction with the submission of an NSERC CRD. Currently, I am a visiting faculty at Google/Waterloo, with the goal of transferring my research to commercial products.

HQP training and impact
I am currently supervising 3x PhD students, 4x MSc students, and 1x postdoctoral fellow. My oldest PhD student is about to graduate after only three years, and has already secured a researcher position in Google. While completing their degrees, my students have participated in research internships at Microsoft Research, Frostbite Research (EA), and Google, while my postdoc has been awarded a MITACS Elevate fellowship.

Publications
Sensible Analytics for Massive Interlinked Data and Social Networks
Professor Alex Thomo
Databases and Data Mining Group
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
Dr. Thomo’s research group strives to make possible sensible and scalable data analytics on massive complex datasets. Data is generated at an exponential rate from millions of people around the world, large-scale open-data movements, scientific experiments, business information systems, social media, and so on. This data is often represented as a web of facts that link entities (people, organizations, and objects) to each other. The unifying theme and novelty of our research is in addressing simultaneously the real life challenges of volume, uncertainty, and impreciseness of data links and social connections. Some of the questions we strive to answer are: How to extract insightful, high-confidence patterns from large databases under uncertainty and impreciseness? How to find influential individuals and communities in large social networks under uncertain influence patterns and competitive information providers? How to limit the spread of "bad" information and accelerate the spread of "good" information? How to make use of modern systems for massive computing to solve computational challenges in analyzing very large graphs of interlinked data and social networks? Our research has the potential for great impact in a multitude of data analysis activities in many diverse areas of science, engineering, and business.

HQP training and impact
47 graduate students supervised/co-supervised (completed or in progress).
32 of the above students have completed their studies (7 Doctoral, 25 Master’s)
These HQP work in high-profile positions at well-known companies such as Microsoft, Intel, IBM, Scotiabank, as university faculty

Publications
- Sean Chester, Alex Thomo, S. Venkatesh, Sue Whitesides: Computing k-Regret Minimizing Sets. PVLDB 7(5): 389-400 (2014)
Epitaxial Semiconductor Thin Film Growth for Optical Devices
Professor Tom Tiedje, PEng, FRSC, FCAE
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research Program Summary
In our lab we grow epitaxial semiconductor films by molecular beam epitaxy (MBE) for electronic and optical device applications. MBE is a high vacuum vapour deposition method that is used in research and industrial production of high purity compound semiconductors, especially III-V compounds in which the group V element is arsenic (eg GaAs) or nitrogen (eg GaN). These materials are useful for making high-speed devices such as transistors and photoconductive switches for terahertz generation, as well as for optical and x-ray detectors and solar cells. MBE is an attractive tool for research on film growth because the growth surface can be monitored in-situ by light scattering and electron diffraction. Our goal is to find new semiconductor materials with new and useful properties that aren’t available in existing materials.

Significant Research Projects and Contributions
The materials we are currently working on include environmentally benign and earth abundant semiconductors in the II\textsubscript{3}V\textsubscript{2} family including Zn\textsubscript{3}N\textsubscript{2} and Mg\textsubscript{3}N\textsubscript{2}. We are also world leaders in the growth and properties of the bismuth-containing semiconductor alloy GaAsBi and have grown GaAs and GaAsBi with short charge carrier lifetimes for applications in photoconductive switches in collaboration with the Nanoplasmonics Research Group. We are currently applying our optical and electrical measurement expertise to bulk CdZnTe crystals in a collaboration with Redlen Technologies. In 2016 TT was awarded the MBE Innovator Award at the North American MBE Conference.

HQP Training
Graduates have gone on to successful careers at large companies including IBM, Intel, Apple Computer, and Honeywell; to a variety of small and medium size BC companies including their own successful startups; to faculty positions in Canada, USA and Europe, including Johns Hopkins University, U. Lethbridge, and the Technical University of Berlin; and to government labs including the Paul Drude Institute, the National Research Council of Canada and Lawrence Livermore National Lab.

Publications
- P. Wu, T. Tiedje, H. Alimohammedi, V. Bahrami-Yekta, M. Masnadi-Shirazi, Cong Wang, “MBE growth and optical properties of single crystal Zn\textsubscript{3}N\textsubscript{2} films” Semicond. Sci. Technol. 31, 10LT01 (2016)
Detection and Response for Emerging Cybersecurity Threats
Research Group: Information Security and Object Technology (ISOT) Lab
Professor Issa Traore, PhD, PEng http://www.isot.ece.uvic.ca
Department of Electrical and Computer Engineering
Faculty of Engineering, University of Victoria

Research program summary
A few months ago, the Edmonton-based McEwan University was defrauded $11.08 million in online phishing scam. Phishing, delivered predominantly by email or short messages, is currently one of the most pervasive attack methods currently available. Ransomware is another very disruptive form of security threats severely felt currently around the world.
Our research focuses on developing new algorithms, processes, techniques, and tools to protect software applications, conventional computer networks, IOT (Internet of Things) Networks, Cloud Computing Networks, and Mobile devices, against the aforementioned security threats and other lesser known but equally dangerous security threats, using machine learning and heuristics models.

Significant Research Projects: Contributions and impact
The most significant contribution of the ISOT Lab is the pioneering work on continuous user authentication using biometrics, with the invention of a new software-based biometric that allows identifying computer users based on their mouse movements. This has opened the door to a new field of research which has been growing steadily. Several journal and conference papers were published based on this work, and led (cumulatively) to over 800 citations.
Our work on software-based biometrics led to the creation of a spin-off company named Plurilock Security Solutions Inc. (www.plurilock.com), founded in October 2008 which has been growing steadily, with customers in the defense, banking, and insurance sectors, located in the USA, Canada, and Brazil. The flagship product of Plurilock, named BioTracker, was one of the winners of the second call issued by the Canadian Innovation Commercial Program (CICP). The CICP is a very selective and highly competitive federal procurement program allowing the federal government to purchase cutting-edge Canadian innovations. Plurilock is currently run by Mr. Ian Paterson (CEO) and Mr. Barry Carlson (Executive Chairman), a successful serial entrepreneur and investor in computer security ventures, and has on its board of directors Admiral Mike McConnell, former Director of National Intelligence (DNI) and of the National Security Agency (NSA) in the USA.

HQP training and impact
Dr. Traore has supervised and graduated 4 postdoctoral fellows, and 32 graduate students, including 12 PhD students, and 20 Master’s students. He is currently supervising 19 graduate students including 8 PhD and 11 Master’s students. Several of the PhD graduates are working as Assistant and Associate Professors in Universities in Canada, the USA, and the Middle East.

Publications
Dr. Traore has co-authored and been granted 3 patents, 4 books and over 150 papers in cybersecurity journals and conferences. Below are a few selected papers:
Computer Analysis of Audio and Music
Professor George Tzanetakis, Canada Research Chair (Tier II)
Department of Computer Science
Cross-listed with School of Music, Electrical and Computer Engineering
University of Victoria

Research program summary
Dr. Tzanetakis conducts research in the analysis of music and audio using computers. His pioneering work has been instrumental in establishing the research field of Music Information Retrieval. Many of the content-analysis algorithms that he has proposed are now part of music streaming platforms such as Apple Music, Spotify, Pandora, and Google Music. As an example, he contributed to the mobile audio fingerprinting algorithm used in most current Android phones, and worked on the content identification algorithms utilized on every YouTube video while doing a study leave at Google Research in 2011. His research deals with all stages of audio content analysis such as feature extraction, segmentation, classification, tagging, tempo estimation, music visualization, and music robotics. He is currently exploring how augmented and virtual reality can be used for computer-assisted pedagogy, finalizing the fastest and most expressive robotic drummer in the world, and designing new programming language paradigms for expressing time and probabilities.

Significant Research Projects: Contributions and Impact
The pioneering work of Dr. Tzanetakis on musical genre classification is frequently cited (2730 citations, Google Scholar Nov 2017) and received an IEEE Signal Processing Society Young Author Award in 2004. Marsyas is an open source software framework that Dr. Tzanetakis designed and is the main developer that has been in active development for over 20 years. It has been used in a wide variety of projects in academia and industry (http://marsyas.info) and has been very influential in MIR research. The Orche (http://archive.cs.uvic.ca) is one of the largest archives of bioacoustic recordings consisting of Orca vocalizations recorded at OrcaLab over a period of 30 years and has been used for pioneering research in automatic classification and understanding of these vocalizations. The research work of Dr. Tzanetakis has had significant impact as evidenced by citations (7923 citations, Google Scholar Nov 2017) and by awards such as a Canada Research Chair Award in 2010 (renewed in 2015), and receiving the Craigdarroch Award of Excellence in Artistic Expression in 2011.

HQP training and impact
Dr. Tzanetakis has supervised 5 post-doctoral fellows and graduated 3 PhD students, and 8 Masters students. These students have obtained competitive internships in prestigious universities such as the National University of Singapore, and companies such as Google. Students that graduated from Dr. Tzanetakis’s group have taken positions in local industry (MediaCore, IVL Inc), started companies (Madrona Labs), and are academic faculty (California Institute of the Arts, Ontario College of Art and Design).

Recent Publications
- T. Li, M. Oghihara, G. Tzanetakis (Eds). Music data mining. CRC Press (2011)
Environmental Informatics
Professor Caterina Valeo
Department of Mechanical Engineering
Faculty of Engineering, University of Victoria

Research program summary
Dr. Caterina Valeo's research program develops environmental informatics tools for application to urban water resources engineering. Environmental information systems (EIS) research involves the creation, collection, storage, processing, modelling, interpretation, display and dissemination of data and information in environmental engineering. My EIS research targets the hydrosphere of the global environment. My EIS research program involves both stochastic and deterministic approaches and is multi-scale. It is multi-scale because I research processes at the sub micrometer scale and the kilometer scale. The application of my research includes sustainable urban engineering, forestry, river engineering, environmental hydraulics, phytoremediation, climate change analysis and geomatics engineering (remote sensing and geographic information systems) for environmental engineering decision making. My EIS research has led to new, innovative low impact development options for urban infrastructure design that treat water quantity and quality in Canadian climates - such as permeable pavements and bioretention cells (rain gardens). My Biofilm Research Laboratory and the HAL (Hybrid Absorbable Landscapes project with Dr. Rishi Gupta of Civil Engineering) field site in Parking Lot 6 of the University of Victoria support research collaborations with Biologists, Civil Engineers and Mechanical engineers to determine the processes behind treating water in the field and developing practical tools and instruments to monitor and assess that treatment. My EIS research program is also being used to understand the nearshore ocean water quality around the Capital Regional District in order to develop a more efficient, less expensive monitoring program based on the response of bacterial levels to environmental data. This is based on ongoing research into water quality processes in freshwater lakes, rivers and well water in Canada.

Significant Research Projects: Contributions and impact with publications
EIS in support of urban sustainable infrastructure design: Examples of my research impact is seen in efforts made by the City of Calgary and other municipalities to incorporate my work into their stormwater management guidelines; I have been interviewed for my work on flooding and am a Subject Matter Expert for the City of Calgary's River flood Mitigation Program; I was invited to be a member of a prestigious panel at the University of Victoria on the necessity of Community Engagement in Research and Teaching (University of Victoria, March, 13 2014) and finally I was nominated by my peers and selected to become a member of the NSERC Discovery Grant Review Committee for Civil and Industrial Engineering (2017-2020) because of my EIS research in this area.

EIS research on the impacts of disturbances in forested and urban regions: In 2014 I received the Award of Distinguished Scientist from the International Society of Environmental Information Sciences for my body of work in the use of environmental informatics to deal with a variety of issues. An example of a publication in this area involves: McAllister, D. and Valeo, C. 2009. “Error and Quality Assessment for Remotely Sensed Estimates of Leaf Area Index.” Canadian Journal of Remote Sensing, 35(2): 141-151, which received the 2nd Best Paper of 2009 for this journal. In addition, the following publication merges stochastic and deterministic methods to analyze environmental data in order to better understand and model processes: Valeo, C., Checkley, S., He, J and Neumann, N. 2016. Rainfall and Microbial Contamination in Alberta Well Water.” Journal of Environmental Engineering and Science, 11(1):18-28. DOI: 10.1680/jenes.15.00022. It is currently the second most downloaded paper for this journal.
Software Engineering for Medical Systems

Professors Jens H. Weber and Morgan Price, LEAD lab
Department of Computer Science, Faculty of Engineering, University of Victoria

Research program summary

Software-intensive systems play an increasingly important and mission-critical role in modern health care delivery. The range of software-intensive medical systems spans from computer-controlled medical devices up to large-scale health information exchange networks and computer-based clinical decision support systems. These systems are increasingly connected into ultra-large scale “systems of systems” and subject to mission-critical safety, security, privacy and usability concerns. A large number of highly publicized failures of software-intensive medical systems (including Vancouver Island Health Authority’s own iHealth project) have highlighted the engineering challenges involved with constructing and evolving dependable and effective solutions in the health care space.

LEAD lab is an interdisciplinary research laboratory, co-directed by Profs. Weber (PEng, Software Engineering) and Price (MD, PhD, Health Informatics, UBC/UVic Island Medical Program). LEAD lab’s research focuses on new methods for engineering dependable, safe and secure socio-technical software-intensive systems, particularly but not exclusively in the medical domain. This includes research on legacy system modernization, system quality certification, and the integration of innovative system functionality such as computer-based genomic decision support, wearable sensors and health IoT technologies.

Significant Research Projects: Contributions and impact

LEAD lab has been involved in applied research in collaboration with private industry, public partners and policy makers. Collaboration examples include a Health Canada funded contract on exploring the potential and risks related to Personal Health Records, two Privacy Commissioner of Canada funded projects related to privacy risks related to Electronic Health Records, an ongoing collaboration with OSCAR EMR (healthcare software vendor) on software quality assurance, an ongoing collaboration with the Health Data Coalition of British Columbia on health data analytics, and an ongoing project with the Vancouver Island Health Authority on the integration of electronic patient outcome reporting for seniors. The lab’s current funding includes:

- 2015-20 NSERC Discovery Grant on Quality Assurance of Mission-Critical Information Systems
- 2016-19 CIHR eHIPP Grant on Integrating Electronic Patient Outcome Reporting (ePRO)
- 2017-18 Two NSERC Engage Grants related to Medical Software Evolution and Data Analytics
- 2018-19 CIHR Project Grant on Patient-centric software support for pain management

HQP training and impact

LEAD lab students are trained in a highly interdisciplinary environment at the intersection of software engineering and health informatics. LEAD lab graduates are equipped with knowledge and skills that are in high demand in industry. Alumni have moved on to leading positions in software companies and health care organizations, such as Vancouver Island Health and the Ministry of Health.

Publications

Sensors for Extreme Environments
Professor Peter Wild
Department of Mechanical Engineering
Faculty of Engineering
University of Victoria

Research program summary
The long term objective of this Research Program is to develop sensors for measurements in extreme environments that inform scientific inquiry, enable environmental monitoring and enhance industrial processes. My research team investigates a range of applications including novel sensors for challenging applications in fuel cells, medicine, forest products and environmental monitoring.

Significant Research Projects: Contributions and impact
a. For in situ diagnostics of proton exchange membrane fuel cells, we developed sensors to measure temperature, relative humidity, the presence of water and hydrogen peroxide.

b. For in process control of mechanical wood pulp refiners, force sensors have been developed and validated through trials in laboratory, pilot and mill-scale refiners.

c. To measure hydrostatic pressures in the esophagus during swallowing, we created a sensor system that offers superior pressure resolution, higher spatial resolution (i.e. closer spacing of sensors) and reduced patient discomfort, relative to existing esophageal manometry techniques.

d. To monitor CO$_2$ injection sites in the deep ocean, we developed fiber tip refractometers to detect and distinguish between liquid/supercritical CO$_2$ and liquid CH$_4$ droplets in high pressure aqueous environments.

HQP training and impact
Since 2011, ten MASc and PhD students have worked on this research program. In addition to the technical aspects of their graduate work, all students interacted with industry partners to ensure thorough understanding of the intended operating environment for the sensor systems that are developed through this research. These students have all gone on to academic (University of Alberta) or to industry positions, four within the local technology sector in Victoria.

Publications


The Willerth Lab: Bioprinting Neural Tissue
Dr. Stephanie Willerth Researcher and/or Research Group
Department of Mechanical Engineering
Faculty of Engineering
University of Victoria

Research program summary
The Willerth lab biprints neural tissue using human induced pluripotent stem cells (hiPSCs) as these cells can form any cell type found in the body, including the cells found in the brain and spinal cord. This project will determine the optimal printing process for generating functional neural tissues using our novel bioink in combination with Aspect Biosystem's novel Lab-on-a-Printer system. The composition of these printed tissues will be analyzed to assess if these bioprinted tissues replicate the electrical and chemical signals that occur in vivo. Next, we will print tissues using hiPSCs derived from patients suffering from Alzheimer's disease provided by Dr. Nygaard at the University of British Columbia and then confirm these tissues exhibit the hallmark features of this disease. For both the healthy and diseased tissues, we will validate these tissues as a tool for drug screening applications using compounds possessing known toxicity to neural cells.

Significant Research Projects: Contributions and impact
Once validated as a tool for drug screening, we will license these engineered neural tissues to pharmaceutical companies. Dr. Willerth and Aspect Biosystems have a collaborative research agreement in place to facilitate this process. This project will generate novel intellectual property in collaboration with a Vancouver based biotechnology company. It will also contribute to improving treatments for Canadians suffering from Alzheimer's disease, resulting in a decreased healthcare burden and improved quality of life.

HQP training and impact
Dr. Willerth's innovative interdisciplinary research program attracts top tier trainees. She has trained 56 highly qualified personnel (HQP), including 2 Ph.D. students, 6 masters, 46 undergraduates (co-op, work study, directed study, honors thesis), 1 technician, and 1 visiting scholar from diverse backgrounds, including biochemistry, biology, biomedical engineering, chemistry, mechanical engineering, neuroscience and software engineering over the past six years.

Publications
Network Science
Prof. Kui Wu
Department of Computer Science
Faculty of Engineering, University of Victoria

Research program summary
My research focuses on network science, which is "the study of network representations of physical, biological, and social phenomena leading to predictive models of these phenomena." Analyzing big data from a networked environment, my work applies theories and techniques of network science, including graph theory, machine learning, statistical inference, and data mining, to solve real-world problems. My most significant contributions can be grouped into the following themes: (1) online social network analytics and e-business, (2) computational sustainability, (3) Quality of Service (QoS) for cloud computing and content delivery networks (CDN), (4) computer security, and (5) theoretical foundation of computer networks.

Significant Research Projects: Contributions and impact
My research covers both theory and practice and is driven by social and industrial demands. Our research on social network analytics has attracted much attention and has been reported broadly by MIT technology review, ACM TechNews, slashdot, Time Colonist, Discovery News, and more. Our research on reliability of enterprise power networks has led to two approved US patents, and our research on datacenter energy monitoring has led to a US patent pending. Our fast service provisioning solution, called VMThunder, has been tested and is currently used in a super computing center (name omitted due to non-disclosure agreement). Our research on teleco cloud and CDN is supported by Ericsson, which sponsors only top researchers from the open competition all over the world. Finally, my research has been published in highly competitive conferences (mostly with acceptance rate below or around 20%) and prestigious ACM/IEEE journals.

HQP training and impact
In the past 6 years, I have completed supervising 10 PhD students, 11 thesis-based Master’s students, 1 project-based Master’s student, 7 undergraduate students for intern/USRA/work terms, and 4 Research Associates. All my students graduated in the past 6 years have a successful career after graduation, including 5 faculty members at universities, 1 department manager in Black Duck Research, 2 research scientists, 1 founder of a start-up, and 13 software engineers/data analysts.

Currently, I am supervising 5 PhD students, 4 thesis-based Master’s students, 2 project-based Master’s students, 1 undergraduate (USRA), and 2 Research Associates.

Publications
Paradigms for Intelligent 3D Models
Professor Brian Wyvill, Department of Computer Science, Faculty of Engineering, University of Victoria

Research program summary

In a world where both virtual and real objects reside, it is important that not just the appearance, but also the behaviour of a digital model should be able to imitate real objects, react realistically to its surroundings or be programmable to behave as we desire. This research combines our expertise in computer graphics and computer vision to generate virtual objects that will fit perfectly into a real environment and behave accordingly. We aim to explore methods for augmented reality, suitable for a wide variety of applications. With improvements in VR devices, advances in modelling are fundamental to the wide adoption of VR for entertainment, and many other fields of human endeavor. Applications are widely ranging such as collaborative model building in distant locations, from the simulation of forest fires, to the design of reactive models for virtual surgery. Such advances are vital to help Canada’s high-tech industries gain a prominent position as a provider of VR/AR technology.

Significant Research Projects: Contributions and impact

Modelling contributions. We elevated the use of implicit models to be a practical alternative to the usual triangle meshes. An implicit model is represented as a contour surface in a scalar field, enclosing a volume. Our 2013 ACM SIGGRAPH publication offered fundamental solutions to efficiency and other issues that had made implicit modelling previously impractical for VR/AR. This was followed up by an application to a basic process of computer animation that is putting a skin around the skeleton of a virtual human, implicit skinning takes advantage of fast contact detection to produce realistic skin deformations in motion. This work led to two SIGGRAPH papers and is receiving interest from the games industry. An industrial project is underway with our international partners at Joseph Fourier University in Toulouse. With our French partners and Andrea Tagliasacchi, we published another fundamental breakthrough in 2017 ACM SIGGRAPH, introducing a new technique for obtaining blends between virtual objects and applying the design to similar junctions throughout a complex model. Current research projects include animation, games and 3D printing.

HQP training and impact

We have a lively group of about 12 students plus postdocs and share a lab with Andrea Tagliaacchi and Kwang Moo Yi. Over the last four years four PhD students have graduated from my group. One was a co-tutelle student with Joseph Fourier University, Toulouse, France. Three of the four are working in industry, one in industrial research. The fourth, Li Ji, is currently a postdoc in our lab and, under a MITACS grant, working 50% of the time at a local research company, LLamazoo, investigating new methods for displaying physiological models for training veterinary surgeons.

Publications

Advanced Wireless Communications

Prof. Hong-Chuan Yang PhD, PEng
Department of Electrical and Computer Engineering
Faculty of Engineering
University of Victoria

Research program summary
The wireless industry is facing new and more severe challenges. The radio spectrum available for wireless services is increasingly scarce. Wireless systems become the largest contributor of CO₂ emission in the ICT sector. There is a growing concern about information security of wireless transmission. The objective of this research program is to develop novel technical solutions that can effectively i) improve the spectrum utilization efficiency; ii) reduce the environmental impact; and iii) enhance the security of wireless transmission, of wireless communication systems. The long-term goal of the program is to facilitate an efficient, green, and secure wireless ecosystem.

Significant Research Projects: Contributions and impact
1. Development of advanced diversity combining techniques: Diversity techniques can effectively improve the performance of wireless systems. Together with international collaborators from Korea, Qatar, and Saudi Arabia, we developed several novel advanced combining schemes for future wireless communication systems;
2. Application of advanced order statistics to wireless system analysis: Suitable mathematical tools play critical roles in wireless system analysis. We pioneered the full exploration of order statistics in the analysis of advanced wireless transmission technologies. Order statistics new becomes an indispensable tool for wireless system analysis.
3. Published two books on wireless communications: Our research findings have engendered Order Statistics in Wireless Communications by Cambridge University Press and Introduction to Digital Wireless Communications by IET.

HQP training and impact
Five PhD student and fourteen Master students have graduated from the program. With strong analytical skills and critical thinking skills developed through the program, these graduates all found suitable academic and industrial positions, including Huawei, Intel, Qualcomm, and Google.

Publications
Innovative Lateral Load Resisting Systems for Mid- and High-Rise Timber Buildings

Lina Zhou, PhD, Assistant Professor
Department of Civil Engineering, University of Victoria
linazhou@uvic.ca T: 250-4725846 C: 250-2080752

Research program summary
Timber is a green, natural, renewable and environmentally friendly material. Rethinking the use of wood in mid- and high-rise construction has become a trend. Since 2009, various provincial and federal jurisdictions in Canada have amended their respective building codes to increase the storey limit of residential wood frame buildings from 4 to 6 storeys. Recently, an 18-storey mass timber residential building has been built on the campus of University of British Columbia and is currently the tallest timber structure of its style in the world. Increases in height have raised the demand for a stronger shear wall system to resist higher gravity and lateral loads. The main aim of this research program is to develop a stronger shear wall system that can be used for construction of mid- and high-rise timber buildings. This wall system is expected to possess comparable ductility and energy dissipation capacity to the traditional ones, which is desirable for construction located in high seismic zones.

This research will promote the use of timber in mid- and high-rise buildings, which will eventually benefit the Canadian forestry industry, as well as the community as forestry is a vital part of Canadian economy. The success of this program will propel Canada into a leading position internationally for technologies and application in next-generation green building construction.

Significant Research Projects: Contributions and impact
During my doctoral thesis project, I investigated the seismic performance of mid-rise hybrid building systems consisting of a light wood frame structure and a reinforced masonry core. Empirical equations for calculating the seismic force modification factors of hybrid buildings were proposed based on the properties of the two sub-systems and their inter-connections.

My PhD research project belongs to a 5-year program, commonly known as NEWBuildS — NSERC Strategic Research Network on Innovative Wood Products and Building Systems. This program has played a key part in contributing to the amendment of building codes that the construction of mid-rise wood buildings has been allowed in the National Building Code of Canada 2015 edition.

HQP training and impact
I worked as a post-doctoral fellow at the Wood Science and Technology Centre at UNB in Jun. 2015-Dec. 2016 before joined UVic. in Jan. 2017. During that period, I co-supervised a research assistant, a technician and a PhD student in a few research projects. At the end of these projects, the technician and the research assistant had mastered the skills of testing insulated timber joints and shear walls under both monotonic and reversed cyclic loads. The PhD student learned the skills to develop numerical models for wood shear walls with finite element software ABAQUS.

Publications
Understanding the environment through Computer Vision and Deep Learning
Kwang Moo Yi, Visual Computing Group
Department of CSC
Faculty of Engineering
University of Victoria

Research program summary
Geometry, the task of understanding the scene structure, in computer vision is one of the core enablers for Autonomous Vehicles (AV) such as self-driving cars and delivery drones, that allows them to understand the environment, automatically navigate and interact with the world. Beyond AVs, it is also the core technology behind Augmented Reality (AR) and Mixed Reality (MR). However, despite its importance, existing methods are not accurate enough to be deployed in the wild.

At our group, we focus on developing machine learning based methods that can provide significant advancements compared to existing methods for geometry with computer vision. We combine traditional mathematical means with recent deep learning based methods, to obtain more robust methods. Our new techniques will bring applications such as autonomous driving, delivery drones, domestic robots, augmented reality, and mixed reality to our daily lives.

Significant Research Projects: Contributions and impact
Towards this end, we have been working on the foundations on which modern computer vision is built on. The local features. Local features are a way of describing images in a compact and robust way. Until recently, the computer vision community has been relying on decade-old handcrafted methods to do so. However, our recent work on learned local features, LIFT [1], has drastically changed the landscape, demonstrating that one can do significantly better when deep learning is properly applied. The computer vision community has shown much interest, demonstrated by the many citations, and being featured in the Computer Vision News magazine.

HQP training and impact
Though this project has just started, an engineer from Sony has was trained as a scientific collaborator. He has been trained to use our learned local features in different contexts, and collaborated in follow-up work, which is expected to be published soon.

This research is expected to support four M.Sc. Students and three Ph.D. students, as well as contributing to the training of undergraduate interns.

Publications
2017
Faculty of Engineering
University of Victoria

Vision
The Faculty of Engineering strives to be recognized as one of the top engineering and computing science schools in Canada. We value academic excellence and aim to be both welcoming and inclusive. Through knowledge of science and technology, and experience with their application to creative problem solving, our graduates support the economic and cultural development of society and help protect the natural environment.

Mission
Create diverse career opportunities for our students and economic, social and environmental benefits for our community through engineering and computing science.

Team Member Jackie Dong explains EcoCar2’s inner workings.
Photograph By DARREN STONE, TIMES COLONIST