
THE UNIVERSITY OF
WINNIPEG
Department of Applied
Computer Science
APPLIED
COMPUTER
SCIENCE
DIGITAL INNOVATION FOR
RESEARCH AND INDUSTRY
MARCH 2018
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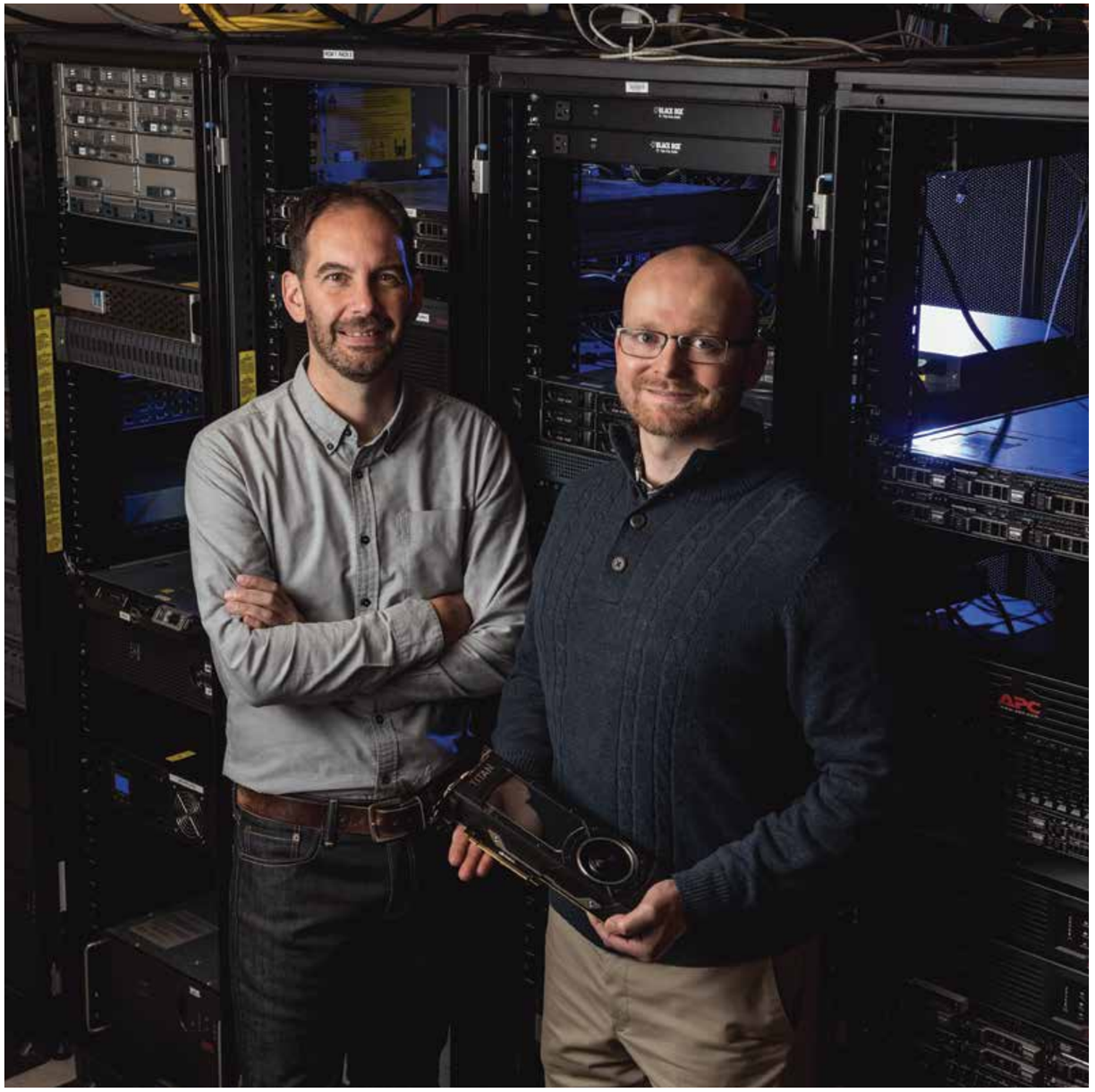


THE FUTURE IS NOW

Machine learning and artificial intelligence are impacting every industry and will continue to do so over the next decade. The University of Winnipeg's research team has significant expertise in this shifting landscape. It is a transformation with tremendous implications across all sectors, from health care and hospitality to agriculture and aerospace.

Investing in innovation and collaborative partnerships is critical to Canada's future economy. New approaches and ways of thinking will encourage researchers, governments, the community and the corporate sector to work together to solve complex problems and create new opportunities.

Big data is the new oil. Our challenge is to mine this rich and unlimited resource by effectively collecting, managing, sorting and analyzing enormous amounts of data to detect meaningful patterns. This deep learning is driving artificial intelligence breakthroughs and unleashing the robotics revolution.

Much of this new momentum is because of the availability of Graphic Processing Units (GPU) that make parallel processing faster, cheaper, and more powerful. In effect, this is desktop supercomputing. In spring 2018, UWinnipeg officially opens its new state-of-the-art GPU lab, on the third floor of Lockhart Hall.

UWinnipeg's department of Applied Computer Science has other unique strengths. Our program combines a deep understanding of technology with project management, communication and teamwork skills, and problem solving with clients — the "soft" skills that employers want.

Our students are also encouraged to take an interdisciplinary approach to their studies: they minor in math, statistics, business, e-commerce; with our new Scientific Computing stream, their minor can expose them to geography, chemistry, biology and physics.

We are educating students to meet the demands in critically important emerging areas: data mining, cyber security, gaming technologies and precision agriculture.

Left: UWinnipeg faculty members Dr. Christopher Bidinosti and Dr. Christopher Henry

WHAT WE OFFER

Our Applied Computer Science department offers a 4-year Bachelor of Science and a Masters of Science degree in Applied Computer Science and Society. We have approximately 300 undergraduate students and 35 Master's degree students studying with us annually. As graduates, they are in high demand.

The department has several award winning professors and fosters a collaborative educational environment. The department is housed in a new facility, on the third floor of Duckworth Centre, made possible by the generous combined gift of $1.5 million from the Power Corporation group of companies and the Winnipeg Foundation.

We prepare students for professional careers in applied computing and business and for further advanced education. Students develop analytical thinking, oral and written communication skills, and software design and development skills by blending theoretical and practical aspects of Computing and Information Systems.

Bachelor of Science

Students develop expertise in the following core areas: programming fundamentals (algorithms), information and data management, software engineering and project management, internet programming and security, and human computer interaction (graphic user interface, design and programming, intelligent systems, machine learning).

The 4-year major includes development of a team-based project for a "real world" organization.

- **Information Systems Stream** - aimed at students interested in focusing on information and business needs of the IT industry. Sample courses include: internet programming, database design and development, software requirements and design, telecommunications, business application systems and e-commerce.

- **Scientific Computing Stream** - designed to give students a strong mathematical and scientific foundation for their computing skills. Graduates of this stream will be able to apply their experience and knowledge of computer science to selected scientific disciplines.

Master of Science in Applied Computer Science and Society

Unique in North America, this program fosters critical reflection on how technology and society interact. It offers a pragmatic and applied curriculum, addressing globalization and cultural issues alongside technical instruction. The program attracts international students from around the globe, the majority of whom graduate into careers in Canada.

"My graduate thesis research focus was on Artificial Intelligence applications. That was a very good foundation for my career. There were two very important things I obtained at UWinnipeg. First, I got a chance to learn something I was really interested in; the second was I learned to always remain positive. Today I am working in Ottawa for Human Resource Systems Group as a machine learning data analyst. We are working on labor market analysis and human resource related consulting. My work is using machine learning and AI technology to analyze labor market data to support our web application."

Jiajie Yu came to UWinnipeg from China and graduated in April 2017 from the Master's degree program.

ACADEMIC OPPORTUNITIES AND COLLABORATIVE PARTNERSHIPS

Applied Parallel Computing and Collaborative Research Laboratory
Official Opening Spring 2018

With the assistance of a private $50,000 seed donation, UWinnipeg's new research lab fosters collaboration and innovation among students, researchers, and industry developing novel applications of parallel computing. Our focus is the use of graphics processing units (GPUs) to solve often computationally complex, scientific and industrial problems. GPUs can perform certain calculations in a fraction of the time that it takes regular processors. GPUs are also very compact which means the average user can now harness a computational power that was once only achieved by supercomputers. Our lab is training Canada's researchers, innovators, and workforce for the new world of highly accessible high-performance computing. This gives Canada an important competitive edge and is spawning beneficial new technology such as improved weather and natural disaster prediction, personalized medicine, and precision agriculture.

UWinnipeg's new state-of-the-art lab opens up new academic opportunities. New research opportunities include: hydrological modeling; medical imaging and image processing; remote sensing and geoanalytics; precision farming; machine learning; computational intelligence; computational biology, chemistry, and physics.

CORPORATE OPPORTUNITIES AND BENEFITS

Our lab eliminates barriers to innovation, such as the upfront investment in GPU technology. It allows for collaborative successes through guided experience, shared resources, code development, and hardware prototyping.

New government and corporate partnership opportunities that will strengthen and enhance research at the lab and digital innovation in Manitoba include:

- "Corporately-Named" Research Chair in Advanced Parallel Computing
- Industrial Collaboration Chair – an industry contribution that is cost-shared with matching funds from *Natural Sciences and Engineering Research Council of Canada* (NSERC), Canada's federal funding agency for university-based research
- "Named" Scholarships to support Highly Qualified Persons (Postdoctoral fellows and Graduate students who are qualified to supervise research teams)
- Financial support for fourth year and graduate students pursuing projects in the areas of: hydrological modeling; medical imaging and image processing; remote sensing and geoanalytics; precision farming; machine learning; computational intelligence; computational biology, chemistry, and physics

In conversation with thirty local and national companies through 2017, it is clear there is strong pent-up demand for parallel computing, spanning every sector. Notable Manitoba industries include hydro-electric, telecom, finance and insurance, agriculture (especially the burgeoning precision agriculture sector), animation and rendering.

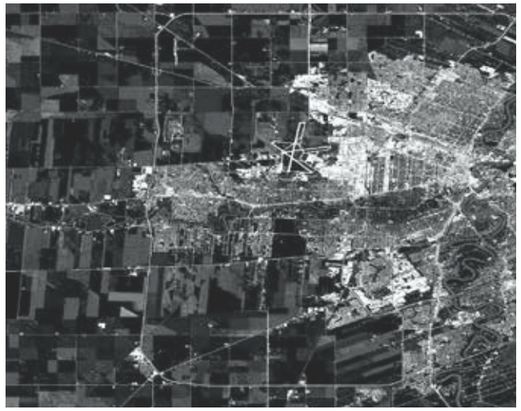
We actively seek collaboration with industrial partners who have computational problems that would greatly benefit from parallel computing with GPUs. The partners may or may not have computing skills. Our role is to connect industry with our academic talent in the creative atmosphere of the lab, and foster innovation. Industry partners may also have specific needs, such as the use of proprietary software and data security. We provide secure access to our equipment for prototyping, benchmarking, and testing. Industry is securely connecting to the hardware point-to-point, which guards against loss of intellectual property. Our lab has the ability to customize research and services to meet the needs of our partners.

TACKLING "REAL-WORLD" ISSUES — CASE STUDIES

MANITOBA HYDRO

Improved Hydrological Modeling

Timely and accurate predictions of watershed runoff and drainage are fundamental to Manitoba Hydro's business and crucial to its daily operations. Manitoba Hydro uses computer modeling to forecast water levels and flow rates to plan a wide range of river management activities such as flow regulation and the construction of generating stations and spillways. Manitoba Hydro also provides water level forecasts along the Winnipeg River during flood conditions for the Province of Manitoba. As a result, finding ways to significantly reduce the runtime of computer models and simulations is very important to Manitoba Hydro. The result of this work was the reduction of simulation runtime by over 60 times. The success of this project has many benefits to Canada.



GEO MANITOBA

Creating Better Maps Using Satellite Image Data

Maps created from satellite images are now vital for flood forecasting, urban and rural land-use planning, resource and disaster management. Producing these accurate and timely maps is becoming increasingly important around the globe. In this process, each pixel in a satellite image must be classified into a number of land-use classes (e.g. deciduous forest, marshland, fens, and water) using deep neural networks. We developed an automated system that can produce a land-use/land classification (LULC) map in just 9 minutes – with 88% accuracy – rather than the approximately 4,800 hours that used to be required. This allows technicians to focus on analysis of problems rather than repetitive pattern classification, tasks which people find tedious and are prone to human error.

NORTHSTAR ROBOTICS

Improving Agricultural Yields

The focus of this work is to develop machine learning methods that will enable precision agriculture, which lies at the intersection of artificial intelligence and machine learning, advanced low-cost sensors and robotics, and the culmination of 100s of years of modern agricultural practices. The aim is simple: Apply macro agricultural techniques at the individual plant level to reduce costs, prevent and alleviate harmful environmental side effects, and to increase yield. The benefits to Canada are tremendous. The precision farming expertise and techniques resulting from this work will allow farmers to reduce costs associated with producing corn and canola, thereby providing an advantage in the highly competitive food production industry. This work will play an important part in reducing environmental harm through the reduction of pesticides applied to Manitoban and Canadian fields. Lastly, the experience gained in this work can be applied to other plant species, and can also be applied to other jurisdictions across Canada, thereby positioning Manitoba and Canada as a world leader in precision agriculture.

"As a student, I was part of a project with Manitoba Hydro using GPU technology to develop and run tests that predict water levels in Manitoba 150 years into the future. We were able to run the tests 60 times faster and offer a more precise measurement of water behaviour. Hydro was quite happy with how the research progressed over the academic year. The best part for me about UWinnipeg was the small class sizes and hands-on research at the undergraduate level."

Daeyoun Kim came to UWinnipeg from South Korea and graduated in October 2016 with a Bachelor of Science (Honours). He currently works for a Winnipeg technology start-up as a software developer.

""We learned more about our Cloud environment because of these students. They had the technical acumen and also the desire to work through set-backs and be flexible. They built a system, tested it, coded and presented it. We brought the whole team in as interns and they continue to make great contributions to our business! We plan to engage with UWinnipeg in a student-project again."

Brock Huebner is Director of Data Governance at Investors Group and a graduate of the UWinnipeg computer program. He recently mentored a group of five UWinnipeg students, tasked with creating a sales portal that would work on mobile devices.

FACULTY EXPERTISE

JEFF BABB
Associate Professor, Mathematics and Statistics, Acting Applied Computer Science Department Chair

Jeff Babb has extensive statistical consulting experience with government, industry, and academia. His current research interests include multivariate analysis, spatial statistics, simulation, anthropology, climatology, demography, and the history of mathematics. Previously he served as the Biometrician for the Grain Research Laboratory of the Canadian Grain Commission.

DR. CHRISTOPHER BIDINOSTI
Associate Professor, Physics, Adjunct Professor, Applied Computer Science

Dr. Bidinosti's main research interest is the development of novel techniques of nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI). Applications range from medical imaging to fundamental physics. Current research includes high performance computing using graphics processing units, and with Dr. Henry, is founder of UWinnipeg's new GPU lab.

DR. SERGIO CAMORLINGA
Associate Professor, Applied Computer Science

Dr. Camorlinga has expertise in the analysis, design, implementation and management of computer science research and development with a focus on Health Informatics. His current research interests are in the areas of Systems and Complexity Sciences and its applications to Brain Systems and Distributed Systems design.

DR. YANGJUN CHEN
Professor, Applied Computer Science

Dr. Chen's research interests include: Federated Databases, Deductive Databases, Document Databases, Graph Databases, DNA Databases, as well as Big Data, Graph Algorithms and Combinatorics. Recently, he and his students have made some significant progress in string matching and set intersection algorithms which are very important for designing efficient search engines.

DR. CHRISTOPHER HENRY
Associate Professor, Applied Computer Science

Dr. Henry has many years of experience working in the area of reinforcement learning and working with theoretical frameworks for modeling human perception. Since 2013, Dr. Henry has been working on applications of deep learning neural networks. Dr. Henry is an expert in general purpose computing using GPUs, and with Dr. Bidinosti, is founder of UWinnipeg's new GPU lab.

DR. SIMON LIAO
Professor, Applied Computer Science

Dr. Liao's research interests include Computer vision, signal and image analysis and recognition, pattern recognition, and their applications to health systems, such as cardiovascular diseases detecting via pulse analysis and prediction of influenza-like illnesses in hospital emergency departments.

DR. RON MCFAYDEN
Assistant Professor, Applied Computer Science

Dr. McFadyen is interested in various way of modeling databases: entity-relationship, object role, and document modeling.

DR. SHEELA RAMANNA
Professor, Applied Computer Science

Dr. Ramanna is co-founder of the department's Master's degree program. Her focus is fundamental and applied research in machine learning and intelligent systems. Her current interests include: foundations of granular computing techniques with applications in social networks, text categorization and analysis of perception-based image and audio information; and exploration of hybrid methods for big data.

DR. CHRISTOPHER STORIE
Associate Professor, Geography; Adjunct Professor, Applied Computer Science; Chair, Board of Directors, Churchill Northern Studies Centre

Dr. Storie's research focuses on the analysis of big data within the field of remote sensing. He uses high performance computing to assist in the training and development of deep learning neural networks. His current research focuses on the semantic segmentation of satellite imagery into land use/land cover classes.

UNIQUE MANITOBA PARTNERSHIP

UWinnipeg faculty members are also founders in the newly developing **Manitoba Training and Research Consortium for High Performance Computing**, an initiative of researchers and users at The University of Winnipeg, the University of Manitoba, and Red River College, partnered with local industry. The goal is to train students to meet Manitoba's needs for the new digital economy, and to elevate the high performance computing capabilities of Manitoba researchers and companies through problem-specific training and guided experience. Training programs are being established at all three institutions tailored to the curricula, teaching, and research expertise of each institution.

Above: UWinnipeg faculty members Dr. Yangjun Chen, Dr. Sheela Ramanna, and Dr. Sergio Camorlinga

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The department of Applied Computer Science actively seeks industry, government and donor partners to support and champion digital innovation in Manitoba.

CONTACT US

JEFF BABB
Applied Computer Science Chair
204-786-9361
j.babb@uwinnipeg.ca

DR. CHRIS HENRY
Applied Parallel Computing
and Collaborative Research Laboratory
204-786-9378
ch.henry@uwinnipeg.ca

APPLIED AND COMPUTER SCIENCE
University of Winnipeg
Duckworth Centre, 3rd floor
400 Spence Street
Winnipeg, MB