CRC I Theme: Imaging and Artificial Intelligence: Unlocking the Potential of Imaging Data

Imaging is one of the most powerful tools scientists, engineers, and physicians have to collect data and make discoveries and decisions about information too minute or complex to be examined by the human eye. Imaging technologies range from simple photography to highly complex synchrotron-based facilities. Computing technologies have revolutionized imaging in the past, leading to sophisticated capacity to capture very detailed, complex images. These images represent a rich source of data for researchers in a multitude of fields, but unlocking these data requires an equally sophisticated capacity to compile, analyze, learn from them, and engineer technologies to use the information to improve the lives of Canadians.

Artificial Intelligence (AI) is a field of computer engineering and computer science that harnesses the power of techniques like machine learning and deep learning to solve problems by analysing and learning from vast datasets at speeds and capacities not possible for humans alone. In imaging, this can include technologies such as computer vision, object detection and classification, image segmentation, object content quantification, and scene interpretation. In medicine, it is a powerful tool to identify significant information in imaging data that may go unobserved by human eyes. Combined with other types of sensors, it can improve the sophistication and performance of machinery such as robotics and autonomous vehicles. As a whole, AI has the potential to unlock the information contained in millions of scans generated from various sources every day.

Many industries and fields of practice such as mining, agriculture, transportation, and medicine are seeking to harness the power of AI to improve safety, increase efficiency, adopt automation, and make new discoveries. However, there are challenges for these industries in adopting AI. New approaches are needed in AI, machine learning, and deep learning research to facilitate adoption of AI-based technologies and to unlock the significant wealth of information available in various sources of imaging across multiple disciplines. Potential areas of application include:

- Quality control: AI algorithms designed to recognize poor image quality as data are captured in real time, allowing technologists to correct for it and reducing the need to repeat expensive data collection or recall patients for additional scans
- Image triage: image capture technologies programmed to highlight areas of interest that may not be the focus of the current scan
- Big data analysis: this applies to many fields, especially medicine, but is of emerging interest in agriculture and mining as well. Image data analysis is an increasingly important tool in crop development and precision agriculture. In mining, it could have significant impacts on safety and operational efficiency.
- Multi-Disciplinary Image Integration: Integrating images from multiple disciplines (e.g., images from veterinary and human medicine, which has implications for One Health)
- Human-machine interaction: systems to enable machine automation while protecting human safety (e.g., autonomous vehicles, mining and farm equipment, drones, etc.)

- Decision support systems: these allow experts to use information more effectively
- Future developments may be possible in synchrotron applications such as chemical and materials characterization used in nano technologies, pharmaceuticals, biomaterials, and other chemical and material engineering.

All of these applications can positively impact the quality of life of Canadians by enabling new discoveries in a wide range of fields; improving efficiency in medical diagnostics, leading to reduced wait times and improved quality of medical care; enhancing safety of autonomous vehicles, machinery and industrial operations; developing new pharmaceuticals, chemicals, and materials; and improving the quality, quantity, and efficient production of Canadian agricultural products.

Enhancement of Performance and Collaboration

As the College of Engineering engages with partners in industry and across campus, it is increasingly clear that AI is an area of strategic importance, not just for the College, but for the university and for our partners and stakeholders. Because of its increasingly important role in many fields of application, and because of increasing demand for highly-qualified graduates, this area has been identified as a target for growth and development in the College of Engineering. Key partners such as the Health Sciences, College of Medicine, Western College of Veterinary Medicine, the Global Institute for Food Security (P_2IRC program), and the Global Institute for Water Security (Global Water Futures), and the Canadian mining industry (represented by the International Minerals Innovation Institute) have expressed a need for research and development in AI applications relevant to their future business and research and development environments. The College of Engineering has existing expertise and collaborations, which will support, and be supported by, the proposed CRC I:

- Computing and deep learning (Dr. Seokbum Ko, collaborating with P_2IRC), machine vision and image processing (Dr. Khan Wahid, Dr. Fang X. Wu), AI and fuzzy logic (Dr. Francis Bui, Prof. Emeritus Dr. Madan Gupta, a pioneer in fuzzy logic); and others including Drs. Chris Zhang (Engineering), Drs. Ian Staveness and Mark Eramian (Computer Science)
- Medical Imaging/Magnetic Resonance and Computer Tomographic Imaging with biomedical applications: Drs. Emily McWalter and JD Johnston (Engineering), with established collaborations (Drs. David Cooper, Stephen Machtaler, Saija Kontulainen, William Dust, Haron Obaid, and others); Dr. Gordon Sarty (Psychology)
- Tissue Engineering group: Drs. Daniel Chen and Don Bergstrom from Engineering; Drs. Brian Eames and Michael Kelly from Medicine)
- Western College of Veterinary Medicine: Dr. Khan Wahid (Engineering), Drs. Julia Montgomery and Joe Bracamonte (WCVM); WCVM Imaging Centre
- P_2IRC (Global Institute for Food Security): Drs. Scott Noble, Reza Fotouhi, in addition to Seokbum Ko (Engineering), Dr. Ian Staveness (Computer Science), Drs. Dean Chapman and Chithra Karunakaran (Canadian Light Source), and others. Imaging has been identified by Global Institute for Food Security and P_2IRC as critical to achieving their

missions, and there is a commitment from Dr. Leon Kochian, Canada Excellence Research Chair in Global Food Security, to support this CRC I.

- Synchrotron Sciences: Adjunct professors in Engineering from Canadian Light Source include Drs. Dean Chapman, Chithra Karunakaran, and Ning Zhu
- International Minerals Innovation Institute: Representing the major mining companies in Canada, IMII is supporting an industry-led initiative to adopt digital technologies throughout the mining sector. Automation and human-machine interaction are two key pillars of the necessary research and development, and imaging, image processing, and machine learning will play a critical roll in achieving the industry's digitalization and automation goals.

Many of these collaborations represent a source of data and expertise to support a CRC in Imaging and Artificial Intelligence. Of particular importance will be the opportunity to establish closer relationships with clinician-scientists working in medical and veterinary imaging. These groups on campus will be especially important partners in this proposed CRC program. There is a distinct need, nationally, to move forward on AI applications to medical imaging, as evidenced by the national ReImagining Healthcare (RIH) consortium of which the U of S is a member. The RIH consortium aggregates the expertise of 22 foundations, granting agencies, and NGOs, 9 universities, 31 healthcare institutions, 17 industrial partners, and the 4 artificial intelligence institutes from 9 provinces. The goal is to deploy a unique AI discovery platform and join forces across the country to align around a common mission – to improve healthcare through the implementation of AI. We expect this CRC to play an important role in this consortium.

Longer-term, as Health Sciences, programs like P_2IRC, partners like IMII and the Canadian Light Source accumulate increasing sources of imaging data, the CRC will help position the University of Saskatchewan broadly as a leader in Imaging and AI.

Potential to recruit an excellent candidate from the four designated groups (FDGs) – Women, Visible Minorities, Persons with Disabilities, and Indigenous Peoples

The focus will be on finding a candidate with interest in developing AI engineering techniques to be applied to imaging in the multi-diciplinary context outlined herein. A review of top citations in AI on InCites yielded some potential for candidate recruitment at a CRC I level. Additionally, several of the top researchers internationally in areas of AI have their research programs based in Canada, so there is good potential for both recruitment and future multi-institutional collaboration. The potential to work with imaging-related technologies and expertise at the Canadian Light Source is likely to be attractive, as will the opportunity to work with top experts in the Global Insitute for Water Security and the Global Institute for Food Security, College of Medicine (Department of Medical Imaging), and Western College of Veterinary Medicine (WCVM Imaging Centre).