

## **Vision**

The Queen's School of Computing (QSC) aims to be an international leader in promoting learning and discovery to address global challenges in computing and information technology.

## **Mission**

To educate computer scientists of the highest caliber, and to discover and disseminate new findings from rigorous research that advances and improves the overall quality of life.

## **Strategic Objectives**

### **Education**

Deliver exceptional discovery-based experiential learning to students to ensure that they are successful computer scientists and professionals with a well-balanced educational experience. Develop innovative strategies to educate our undergraduate students with limited faculty. Address opportunities in our graduate programs at the masters and doctoral levels to attract outstanding students, who will be trained to serve in industry, at research centres, in the public sector, and at the very best institutions as tenure track faculty.

### **Research**

Provide impactful solutions to societal challenges through emphasizing a balance of traditional and frontier areas in computer science.

### **Service**

Provide service to Queen's, the Kingston community at large, and Canadians in general. Provide leadership and service to our technical societies for the benefit of the profession and computing education.

## **Strategic Plan**

The Queen's School of Computing (QSC) strategic plan centres on the following four goals.

- 1) Become a global leader in research and training for Intelligent Systems
- 2) Establish world-class research, scholarship, innovation, and creative work
- 3) Offer an excellent graduate and undergraduate diversified education experience
- 4) Create an inclusive, diverse and welcoming environment for our trainees and employees

For each of the goals, we highlight below our current achievements and progress towards the overall strategic plan.

## 1) Become a global leader in research and training for Intelligent Systems

### 5-year goal:

Ranked in top two Computing Departments in Canada in research and training for the area of applied Machine Learning (ML) and intelligent systems, as well as being the de facto resource and leader in applied ML across Queen's and the Kingston\Ottawa region with an extensive network of industry and government collaborations.

### Overview:

The Data Science (DS) field is rapidly evolving into an interdisciplinary field that integrates approaches from Statistics, Data Mining, ML, AI and Predictive Analytics with datasets from a variety of domains, including scientific, economic, social, and the Internet of Things (IoT) [1]. The deep connection between DS and Computer Science is acknowledged by many. For instance, Forbes notes that “[Data Science is] the story of the coupling of the mature discipline of statistics with a very young one—computer science.” [2]).

QSC is in a unique position to become a world leader in the area of Intelligent Systems – an area which captures the next evolution of the DS revolution. Intelligent Systems integrate DS innovations throughout computing, ensuring that such innovations touch the lives of billions in a practical and sensible manner. There is a well-documented need for trainees in Intelligent Systems and AI, as noted in recent reports by Gartner [3] and Burtch Works [4]. Intelligent Systems is also of great relevance to Queen's institutional plans and strategies. AI features prominently in Theme 6 of the Strategic Research Plan 2018-23. Subtheme Analytics & Digital Technologies makes specific mention of strategic analytics, cognitive computing and AI technologies as areas of specific research focus, while subtheme Human Machine Interactions, Machine Learning, Software Analytics & Smart Infrastructure makes specific mention of machine learning and AI. The Queen's Comprehensive International Plan 2015-19 emphasizes the aim of advancing research globally through international collaborations and gaining increased access to global funding and commercialization opportunities. AI is a topic of significance across the globe, with the AI market worldwide estimated to grow from US \$4B in 2018 to US \$60B by 2025. It is thus imperative for Queen's to invest to establish a world-class reputation in this field. In addition, as discussed above, strengthened focus on AI will meet growing demand for graduates in the field, thus contributing to enrolment growth and target metrics including graduate employment rates outlined in the Strategic Mandate Agreement 2017-20.

### Achievements and current progress:

QSC has two CRCs in the general area of intelligent systems: a CRC tier 1 in the area of Surgical Analytics (Fichtinger) and a CRC tier 2 in the area of Software Analytics (Hassan). QSC is home to one of only two Steacie Fellows (Hassan), Canada's highest accolade for academic research, ever recognized in the DS area. QSC also has another CRC in Security and Secure Software. Over two decades ago, QSC pioneered the concept of intelligent operation rooms in hospitals and our work on intelligent data centres is well recognized worldwide (e.g., QSC held Canada's first CREATE in the area of software and systems). We also pioneered the concept of intelligent communication systems that are now used in oil field and large industrial sites. Today, we continue our leadership position (e.g., we are currently leading a cross-Canada CREATE proposal titled “Training Software Engineers for a Data Science Future” partnering with the University of Waterloo, the University of Alberta, the University of Victoria and Concordia University). QSC is also playing a leading role in the establishment of Queen's-wide initiative on DS – the Queen's Institute of Analytics and Artificial Intelligence (QIAAI).

At the undergraduate level, demand for our Data Analytics (DA) and AI initiatives is very high (DA and AI are at the centre of Queen's Strategic Research Plan). We introduced 3 new courses and modified 2

others to have strong offerings in DA. At the graduate level, we introduced Canada's first AI service graduate course and introduced a graduate Field of Study in AI designed to align with the Vector Institute 1000 AI Masters initiative. Our new Biomedical Informatics graduate program is Canada's only cost-recovery program in the application of DS innovations in the biomedical field. The program is already a success with 10 students enrolled in its first offering (May 2018) and with enrolment expected to double in 2019. This cost-recovery program is one of many of our strategic initiatives to integrate DS innovations across the traditional Computing curriculum and builds on our already well-recognized strengths.

QSC will focus on expanding our leading role in intelligent systems along the following directions (based on recommendations from reports by NSF [8] and the European Union [9]): (1) intelligent devices (e.g., IoT); (2) intelligent fintech (e.g., blockchain and security [5]); (3) intelligent physical and virtual (e.g., data centre) infrastructure; (4) intelligent cyber security systems (e.g., servicing our local military and correctional services stakeholders), and (5) social and legal implications of intelligent systems. These directions will complement our recent hires (two in data analytics and one in robotics and machine learning).

### **Action plan:**

- a. Improve the infrastructure of student AI laboratories to incorporate leading-edge technology to enable novel applications of smart spaces, to develop and evaluate innovative approaches and solutions to existing and emerging challenges involving machine learning, robotics, autonomous systems and human robot interactions.
- b. Establish multidisciplinary research on the ethical and societal aspect of AI and how AI can be used for the betterment of Canadian society.
- c. Securing a high-profile hire in the area of intelligent systems (possibly CRC-1).
- d. Hire young faculty in AI, ML, DA, security and blockchain, Internet of Things and human robot interaction.

## 2) Establish world-class research, scholarship, innovation, and creative work

### 5-year goal:

Ranked in top five Computing Departments in Canada in research and innovation. Specifically through increasing:

- h-indexes for all full and associate professors by 20%.
- number and scope of research partnerships with private sector companies.
- dollar value of funding from NSERC, CIHR, OCE and other sources by 20%.

### Overview:

Based on an August 2017 analysis [6], QSC is the smallest Computing department across all Medical Doctoral and Comprehensive Universities in Canada (primarily due to a decade-long hiring freeze). Yet QSC has been slowly and surprisingly improving its QS World Ranking from 201-250 in 2015 to 151-250 in 2018 [7], a great achievement especially when put in the greater context with Queen's overall ranking dropping from as high as 175 to 239. Today, QSC ranks 7th in Canada after the Computing departments of UofT, UW, UBC, McGill, UofM, and UofA (in order). This quite notable when considering that these top six schools have been on hiring sprees while we are just starting hiring after a 10--year freeze in growth with considerable shrinkage. QSC is confident that with a stronger emphasis on recruiting top and strategic talents that we can at least bypass UofM and UofA (the smallest departments in the top six – though considerably larger than us). Our goal is to be the top small to medium-size department in Canada, with a longer-term goal of being in the top 3 Computing departments in Canada.

### Achievements and current progress:

QSC is a world leader in Biomedical Computing and Software Engineering, and enjoys considerable visibility in Human-Computer Interaction, Data Management, Computer Networks, Theoretical Computer Science, and Unconventional Computation. QSC has 3 IEEE Fellows (Ellis, Fichtinger and Hassanein), 2 inductees in the Royal Society of Canada (Mousavi and Hassan) and an IBM Research Fellow (Cordy). We collaborate across disciplinary boundaries to advance knowledge through teaching and research, and to collaborate with external stakeholders such as alumni, private industry and government agencies in order to strengthen our research and teaching. QSC also endeavors to explore new horizons in Computer Science and establish itself as a trailblazer in shaping the future of the discipline.

As recently as five years ago, QSC had the largest graduate program at Queen's. However, with actual and planned retirements of many faculty, some are no longer accepting graduate students (such that we have had a drastic drop in PhD intake). This has thus affected our research productivity as well. For instance, five years ago, QSC had the largest median NSERC funding by faculty member across all of Canada's Computing departments. We still remain competitive but are far from the head of the pack

### Action Plan:

- a. Support research-career development at all levels, but specifically to nurture the most talented early career researchers and members of under-represented groups.
- b. Raise the School's profile through: publications in the most prestigious venues, leadership of large grants, editorial roles in the top journals and conferences, representation on key committees and advisory boards.
- c. Enhance internal communication among research groups through departmental seminars and research meetings focused on key societal challenges or emerging topics of interest.
- d. Continue to nominate faculty to leadership positions in NSERC, IEEE, ACM, and others.
- e. Encourage faculty to deliver invited and distinguished talks and seminars.
- f. Host major computing conferences at Queen's.
- g. Aggressive graduate student recruitment, especially at the PhD level.

### 3) Offer an excellent graduate and undergraduate diversified education experience

#### 5-year goal:

Ranked in top 5 Computing Departments in Canada in 5 years (across all areas). Ranked in top 3 Computing Departments worldwide in 2 areas. Top medium-size Computing Department in Canada.

It is of the utmost importance that QSC maintains a leading position in national (e.g. Maclean's) and international (e.g., QS) rankings while ensuring that we produce topnotch trainees that are well sought after nationally and internationally. Such top rankings will ensure that we can recruit the best worldwide.

Increasing the faculty complement and number of students in Computing programs are key for QSC to climb back up the ranking.

#### Overview:

We are very confident that our graduates will be in strong demand for many years to come. The Information and Communication Technology Council (ICTC) notes that even though the output of ICT graduates has increased by ~25% since 2010, it is still insufficient to satisfy labour market needs [11,12]. ICTC projects that the hiring requirements of the Canadian ICT sector will reach 182,000 individuals by 2019. ICTC projects 88%, 44%, 21.4%, 16.7% ICT employment growth by 2020 in Ontario, Quebec, BC, and Alberta respectively.

#### Achievements and current progress:

The QSC undergraduate program is very popular. Our undergraduate numbers well exceed our capacity and demand is growing (30%+ annually). In 2018, if capacity permitted, we could have admitted over 300 undergraduates (with a 90+% average). We are on track to surpass 8,000 undergraduates across our 2018/2019 offerings – such that we had to hire term adjuncts for 20 sections. Several hires are needed to cover this existing demand.

We are keeping pace with the latest trends in computing with regards to intelligent systems and smart and secure infrastructures. We have introduced three new courses in DA, two courses in AI and one in security. We are working with ASC on a DA certificate and with ASC and Mathematics to refocus the Computing and Mathematics program towards DA. We are in the final stages of revising our undergraduate offerings to include a major and 6 streams that include DA, AI, Biomedical Computing and Gaming (requiring 4 new courses in DA and AI). A stream in Security and blockchain is planned for 2020 (requiring additional courses). These programs will contribute to enrolment growth and target metrics including graduate employment rates outlined in the Strategic Mandate Agreement 2017-20.

#### Action plan:

- a. Put stronger emphasis on work-integrated learning by expanding our internship programs. ICTC notes in their 2021 labour market outlook the growing need for work-integrated learning opportunities [10].
- b. Attract and retain excellent students to computing programs, and expand these programs.
- c. Secure appropriate lab and social and professional interaction space enhancing the experience of computing students.
- d. Hire new faculty to cover the teaching needs and increased demand of our programs in foundations of computer science, systems, security, networks, and high-performance computing.
- e. Work with alumni group on student mentoring, development, and enhancing diversity.
- f. Educate students on sustainability, ethics, and soft skills (presentation and writing skills).

**4) Create an inclusive, diverse and welcome environment for our trainees and employees**

**5-year goal:**

Maintain our leadership as the most diverse Computing Department in Canada at the undergraduate level. Be in the top 3 Computing Departments in terms of diversity at the graduate level.

**Overview:**

Women have been making notable advances in university participation in many fields, but STEM remains male-dominated. Among women who choose to pursue a STEM degree, most do so in biology or related science, resulting in even fewer women in computer science, engineering and mathematics. These choices have consequences, as fields of study such as computer science lead, on average, to better outcomes in terms of employment, job match and earnings.

Although women are a particular focus of Canadian efforts to encourage the study of computer science and related disciplines, other underrepresented groups in the field include Indigenous persons, Black persons and persons with disabilities.

**Achievements and current progress:**

QSC currently stands second in all Computing departments in Canada in its ratio of female/male faculty (19%) [7]. We are also second in mid-career female faculty who are essential role models to students and junior faculty, at 33%, just after UofT at 41%, with a median of 11%. 75% of QSC assistant professors are female (the median is 13%). We are also above or at median for non-Caucasian professors at all levels and overall.

Nevertheless, we acknowledge that there is still work to be done. QSC is committed to diversity and equity. Removing systemic bias from our processes – from recruiting to promotion to day-to-day activities – ensures that QSC can foster inclusion and equity. Changing the wording of a job description to be gender neutral, building a diverse selection committee, setting evaluation criteria in advance, and sourcing a diverse range of candidates increase the likelihood that assessment of a candidate's merit is based on skills and ability rather than gender, race, or ethnicity. In the past few years, we have been proactive in our recruiting efforts in the rare cases in which we have had an opportunity to recruit. 50% of faculty hires in the School of Computing in last 2 years have been females who are also members of visible minorities. We continue with our efforts to ensure a more balanced diversity in our department and at Queen's.

As we rebuild our faculty complement, we are already putting a strong emphasis on the recruitment of members of the most severely underrepresented groups at Queen's (i.e., Black and Indigenous Peoples) [PICRDI Recommendation #12]. More specifically, the School has already taken an active role in seeking such individuals as evident in our last hiring cycle. We ensured that candidates who are members of underrepresented groups were hired as long as other candidates were not substantially better. In addition, an Equity Task Force was established within our last Hiring Committee. The Task Force focused on actively seeking applications from racialized individuals (in particular Black) and Indigenous People from across the globe. The group shortlisted five candidates to whom we reached out with personalized invitations, and we were successful in hiring one of these candidates.

These new hires will form the backbone of a School-wide initiative to grow Queen's most severely underrepresented groups in our student population. The initiative will build on our very successful decade-long efforts in increasing our female population and will be co-led by Ms. Wendy Powley, a world leader in such efforts. Specifically once QSC is able to deliver on the enormous demand for our basic programs, we expect that some of the new hires will receive reduced teaching loads so they can focus on the implementation of a School-wide peer mentoring program for marginalized students [PICRDI Recommendation #5], and on the implementation of a transitional year program to allow greater support

for students with non-traditional academic and social backgrounds to excel at the School of Computing [PICRDI Recommendation #18]. Finally, the School also plans to actively participate in the annual ACM Richard Tapia Celebration of Diversity in Computing (<http://tapiaconference.org/>), as part of a concerted effort to connect with individuals from underrepresented groups at Queen's. We expect that our new hires as well as current faculty members will play a key role in such plans.

### **Action Plan:**

- a. To push the boundaries of CS application through links with a diverse set of other Queen's departments and other institutions, for example by encouraging QSC faculty members to collaborate on major research funding proposals with collaborators in other more diverse disciplines within and beyond Queen's and Canada
- b. To promote flexibility in our working approach allowing us to benefit from new, non-traditional opportunities, challenges and collaborations with a diverse group of stakeholders.
- c. Create a committee to study and make recommendations on how best to increase diversity and develop templates and resources that can be used in support of this goal e.g. recommendation to approach speakers from varied backgrounds to visit for departmental seminars, developing a broader set of qualifications to be used in job postings such as interest in interdisciplinary research or involvement in outreach activities.
- d. Expand our offering in professional, certificate and/or distance education courses and market them to members of underrepresented groups who may face challenges in attending a traditional program (e.g. individuals with disabilities, stay-at-home parents looking to transition back to the workplace).

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