Western Science

Research Theme

The Computational Sciences

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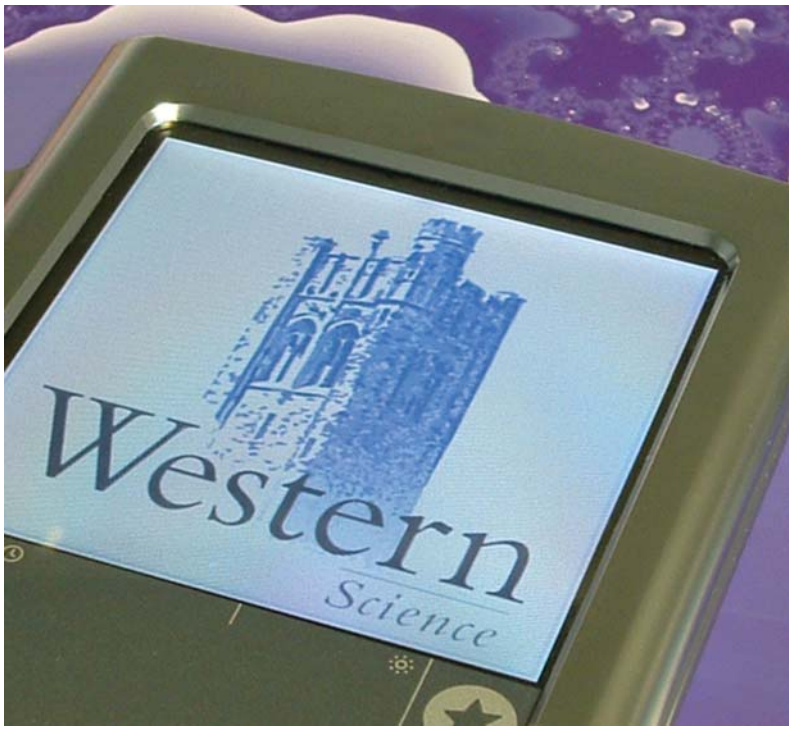


The Computational Sciences. Research activities range from the theoretical foundations of mathematics and computing, through software systems, to the application of mathematical and computational techniques across science. They include mathematics, formal language theory, software systems, mathematical and statistical computation, computer algebra, data visualization, stochastic modeling and bioinformatics. The teaching mission of the computational sciences includes almost every student in the University, and for this reason, a major Science fundraising priority includes an endowed modern information technology fund for computational hardware and software.

The computational sciences are undergoing explosive growth worldwide, against which we have recruited some of the best junior scientists. Their retention is a crucial issue for us and is being addressed through a range of solutions, including spousal arrangements, research chairs, and competitive salaries. Outstanding faculty appointments have been possible in many areas including compilers and computer algebra, computational chemistry, computational geodynamics, bioinformatics, financial mathematics, and computational materials physics. Research and teaching in the computational sciences have attracted substantial governmental and private-sector financial support, including Canada Research Chairs, PREA awards, Institutional and New Opportunities CFI-ORF and ORF grants, and the very large, multi-Faculty, multi-University, high performance SHARCNET computer grid. This facility is housed in the Western Science Centre and was recently awarded $50 M for infrastructure expansion. There are also numerous research and financial-support arrangements with private-sector companies and government organizations.

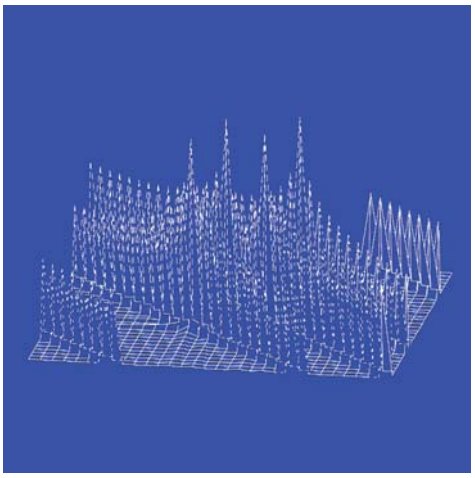
Although most of this research is performed in four departments: Applied Mathematics, Computer Science, Mathematics, and Statistical & Actuarial Sciences, large-scale computational

research is also performed in Physics & Astronomy, Chemistry and Earth Sciences. For example, Applied Mathematics has a strong presence in non-linear dynamics, theoretical physics, computational materials physics, computer algebra, mathematical biology (L. Wahl, Tier 2 CRC), and financial mathematics. Computer Science is also one of the centers recognized worldwide for strength in bioinformatics, finite automata and formal languages, image analysis, and distributed systems management. Mathematics has developed a strong profile in algebra, analysis and homotopy theory. Researchers in Statistical & Actuarial Sciences study stochastic modeling and data analysis problems, including models and methods used in actuarial science, finance, risk theory, forestry, bioinformatics, health management and the medical sciences.

SHARCNET™

Research activities in the computational sciences are increasingly multidisciplinary. Such activities include strong research collaborations among the four mathematical sciences departments, and between the Mathematical Sciences departments and other units including Medicine & Dentistry, Biochemistry, Electrical & Computer Engineering, Law, Information and Media Studies, Psychology, Economics, The Ivey School of Business, Robarts Research Institute and the Faculty of Education. This integrated approach is exemplified by Western's Science-led participation in the Fields Institute for Mathematical Research as a Principal Sponsoring University. This participation involves 40 researchers, five Science departments, the Ontario Research

Centre for Computer Algebra (ORCCA), SHARCNET, the Faculties of Education and Graduate Studies, and the VP (Research).
It is increasingly important to be expert in more than one discipline to make significant advances in computational science. Western Science makes every effort to foster such groups. We have outstanding interdisciplinary research teams, including ORCCA (in which the search for a Tier 2 CRC has begun). Other excellent research teams include the computer vision group in Computer Science and the internationally-recognized algebra and homotopy theory group in Mathematics, led by a Tier 1 CRC, J.F. Jardine; his work underlies areas such as cryptography, and network and language design.
We are committed to a significant presence in mathematical biology with emphasis on bioinformatics, genomics, proteomics, and mathematical models of experimental evolution. We are building a research program in collaboration with Medicine & Dentistry that extends the existing university strength in molecular biology, and have significant applications in the medical and health sciences.

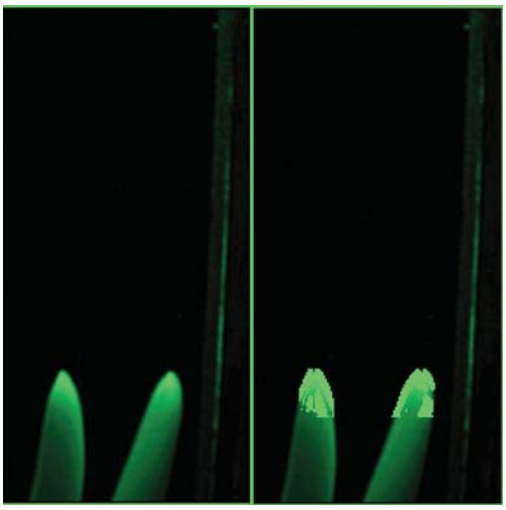


The past decade has witnessed the development of financial mathematics into a major interdisciplinary subject. Many PhD level mathematicians and physicists are now employed in the financial sector. A financial mathematics group in the Departments of Applied Mathematics and Statistical & Actuarial Sciences has grown to have a major presence in this area and has attracted researchers from other faculties including the Ivey School of Business. A Tier 2 CRC has been allocated to strengthen this area and a strong candidate is being nominated.

There is substantial overlap between computational science and Western's strong presence in theoretical physics. Theoretical physics crosses departmental lines, including active particle physics groups within Applied Mathematics and Physics & Astronomy, and an interdepartmental theoretical physics PhD program. Mathematics

seeks to develop a viable group in mathematical physics. Theoretical physicists at Western have forged strong links with Perimeter Institute for Theoretical Physics, which currently includes a jointly funded Associate position (A. Buchel) and four Affiliate positions.

Researchers in Computer Science embrace two related sets of problems. The first set advances core areas of computing and explores its limits. For example, we address questions concerning the fundamental limits in the complexity of computational models, and explore alternative models (e.g., DNA computing and quantum computing). L. Kari has received a Tier 2 CRC in Biocomputing to study DNA computing. We also study emergent phenomena in large-scale software systems, novel software engineering approaches and mechanisms to control their complexity. With increasingly pervasive computing, questions in the area of distributed computing, network quality, mobile computing, and data security are very important. Advances in computation over the next four years will require significant infrastructure. Hardware resources are one component of this infrastructure, but software infrastructure is increasingly important. Research in software systems requires diversely configurable software platforms upon which experiments can be conducted. Software infrastructure development is labour-intensive, and as expensive as laboratory infrastructure in the physical sciences. We are building on Western's position as a site for resource-intensive research to expand our research activities in software systems, both by development of university consortia and by through private-sector partnerships.



The second set of problems recognizes that computation is increasingly important to all disciplines. We note four areas of importance: (i) The computational side of bioinformatics addresses algorithms for analyzing genetic and protein sequences. This is a critically important area for significant collaboration between the computational and basic medical sciences. Together with the Faculty of Medicine & Dentistry, Science has developed a bioinformatics program and a Tier 2 CRC is in place (B. Ma, Chair in Bioinformatics). (ii) In the area of computing and the law, we have already seen a deepening interest in intellectual property and licensing considerations. However, the larger issue of the interplay between legal and software architectures is mostly unexplored and will have central impact on the way software is built and deployed. This is already the cornerstone of e-commerce, and will have increasing impact on distributed systems and legal implications of computing. (iii) The entertainment field has undergone a revolution with greater reliance on digital data and advance processing techniques. Future advances in this area will depend on individuals with computing expertise as well as talents in art, music and design. (iv) Enormous quantities of data and information are being generated in many areas, particularly sequences of digital images. As a result, extensive interdisciplinary research activity has arisen among medicine, computer science, statistics, engineering and environmental science, all in aid of the development of analysis and data mining techniques.