COMPUTER SCIENCE

The School of Computer Science offers an MSc degree in Computer Science.

The program emphasizes both academic and applied research that can contribute to further research, academic studies, industry partnerships, and government programs. The MSc degree encompasses professors at the cutting edge of their fields, course offerings covering a wide range of computer science areas, and competitive financial incentives to eligible students.

There are four main fields that students can study in. However, interaction with other disciplines is encouraged and many of our professors work in collaboration with both industry partners and other Schools/Departments at the University of Guelph. The fields are:

- **Applied Modelling (AM):** Students working in this field will engage in research on topics such as graph theory and algorithms, formal specifications, hardware-software co-design, and interdisciplinary work in environmental modeling and disease spread modeling.

- **Artificial Intelligence (AI):** Students working in this field will engage in research on topics such as Bayesian techniques, artificial neural networks, evolutionary computation, fuzzy systems, data mining, pattern recognition, and, intelligent agents.

- **Distributed Computing (DC):** Students working in this field will engage in research on topics such as parallel computing, distributed systems, embedded systems, multi-agent systems, mobile computing, wireless networks, and ad hoc networks.

- **Human Computer Interaction (HCI):** Students working in this field will engage in research on topics such as context-aware systems, usability, interface design, and mobile and ubiquitous computing.

The School of Computer Science also offers an Interdisciplinary PhD degree in Computational Sciences. More information on can be found at: Computational Sciences (calendar.uoguelph.ca/graduate-calendar/graduate-programs/computational-sciences/)

### Administrative Staff

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### Graduate Faculty

This list may include Regular Graduate Faculty, Associated Graduate Faculty and/or Graduate Faculty from other universities.

**Luiza Antoine**
B.Sc. Politehnica Bucharest (Romania), M.Sc. Alberta, PhD Alberta - Associate Professor
Graduate Faculty

**Neil Bruce**
B.Sc. Guelph, M.A.Sc., Waterloo, PhD York - Associate Professor

**David A. Calvert**
BA, M.Sc. Guelph, PhD Waterloo - Associate Professor
Graduate Faculty

**Ritu Chaturvedi**
PhD Windsor - Assistant Professor
Associated Graduate Faculty

**Rozita Dara**
B.Sc. Shahid Teheshti, M.Sc. Guelph, PhD Waterloo - Associate Professor
Graduate Faculty

**Ali Dehghantanha**
BSc Azad, M.Sc., PhD Putra Malaysia - Assistant Professor
Graduate Faculty

**David Flata**
B.Sc., M.Sc., PhD Guelph - Associate Professor
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**Dan Gillis**
B.Sc., M.Sc., PhD Guelph - Associate Professor
Graduate Faculty

**Minglun Gong**
B.Eng. Harbin Engineering, M.Sc. Tsinghua, PhD Alberta - Professor
Graduate Faculty

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B.Sc. NUST, M.Sc. Southern California, PhD Waterloo - Assistant Professor
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**Stefan C. Kremer**
B.Sc. Guelph, PhD Alberta - Professor
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**Xiaodong Lin**
BASc Nanjing, M.Sc. East China Normal, PhD Beijing, PhD Waterloo - Professor
Graduate Faculty

**Pascal Matsakis**
B.Sc., M.Sc., PhD Paul Sabatier (France) - Professor
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**Judi R. McCuaig**
B.Ed., B.Sc., MS, PhD Saskatchewan - Associate Professor
Graduate Faculty

**Denis Nikitenko**
B.Sc. Ryerson, M.Sc., PhD Guelph - Contractually Limited Faculty, Computer Science, University of Guelph
Associated Graduate Faculty

**Charlie F. Obimbo**
M.Sc. Kiev, PhD New Brunswick - Professor
Graduate Faculty

**Joseph Sawada**
MSc Program

The MSc is offered in the fields of:

1. applied modelling;
2. artificial intelligence;
3. distributed computing; and
4. human computer interaction.

Admission Requirements

Most spaces are filled in March for entry the following September, and in October for entry the following January. Prospective students should check the School of Computer Science website http://www.socs.uoguelph.ca/ for admission procedures and deadlines.

General Requirements

To be considered for admission, applicants must have a four-year honours degree in computer science, or a four-year honours degree in another discipline with a minor in computer science. Applicants must meet the minimum admission requirements of both the university and the School of Computer Science, including at least a 75% average during the previous two years of full-time university study for a degree.

In addition to the university and School of Computer Science requirements, applicants must also submit:

i. a current CV and
ii. a statement of research that would normally include the following sections:

- Specific research interest with justification.
- Academic and/or practical research experience.

Course Requirement

Entrants who have a four-year honours degree in another discipline and a minor (or equivalent) in computer science must have taken at least 12 courses as described below. University of Guelph equivalents are given for comparison as appropriate.

A. Seven prescribed courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS*1500</td>
<td>Introduction to Programming</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*2500</td>
<td>Intermediate Programming</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*2430</td>
<td>Object Oriented Programming</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*2750</td>
<td>Software Systems Development and Integration</td>
<td>0.75</td>
</tr>
<tr>
<td>CIS*2520</td>
<td>Data Structures</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*1910</td>
<td>Discrete Structures in Computing I</td>
<td>0.50</td>
</tr>
<tr>
<td>or CIS*2910</td>
<td>Discrete Structures in Computing II</td>
<td></td>
</tr>
<tr>
<td>MATH*1200</td>
<td>Calculus I</td>
<td>0.50</td>
</tr>
</tbody>
</table>

B. Three core courses at the second-year or higher level selected from the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS*2030</td>
<td>Structure and Application of Microcomputers</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*3120</td>
<td>Digital Systems I</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*2460</td>
<td>Modelling of Computer Systems</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*3530</td>
<td>Data Base Systems and Concepts</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*3110</td>
<td>Operating Systems I</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*3490</td>
<td>The Analysis and Design of Computer Algorithms</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*3150</td>
<td>Theory of Computation</td>
<td>0.50</td>
</tr>
<tr>
<td>STAT*2040</td>
<td>Statistics I</td>
<td>0.50</td>
</tr>
</tbody>
</table>

C. Two elective courses at the third-year or higher level:

- These courses should be related to the applicant's proposed research area. They can be from a discipline other than computer science if deemed relevant by the proposed supervisor.

Applicants who meet requirements (A) and (C) but who do not meet requirement (B) may be granted provisional admission, i.e., they may be granted admission with the provision that they take specified courses within a specified time and achieve grades above a specified threshold.

English Proficiency

A test of English proficiency is required of all applicants whose first language is not English. Please refer to the University of Guelph Admission Requirements (calendar.uoguelph.ca/graduate-calendar/general-regulations/admission/admission-requirements/)

Program Requirements

Once a student has been admitted to the MSc program, the following components are required for the successful completion of the MSc degree:

- Completion of CIS*6890 Technical Communication and Research Methodology and at least four other graduate courses
Completion of the seminar requirement.
An accepted thesis.

Duration of the Program
The MSc degree is a two-year program during which students complete five courses, give a public seminar and complete and successfully defend a thesis. Heavy emphasis is placed on the thesis, which usually requires at least two semesters. Students should plan on spending at least four full-time semesters (16 months) in the program assuming adequate preparation for graduate work.

Course Requirement
An MSc student is required to take CIS*6890 Technical Communication and Research Methodology and at least four other CIS graduate courses. Of these four courses, at least two should be outside of the student’s thesis topic area. This area and the courses which fall outside of this area are identified by the student’s advisor. With approval from the Graduate Program Committee, a CIS graduate course requirement may also be met by a non-CIS graduate course or by a 4000-level course. At most one reading course (CIS*6660 Topics in Computer Science II) and at most one 4000-level course can count towards the course requirement.

Seminar Requirement
An MSc student must give one publicly announced research seminar on their MSc thesis research. The student will be allocated times and dates for the seminar. It must be attended by the student’s advisor and at least one other member of the student’s Advisory Committee. The quality of the presentation is graded on a pass/fail basis. The MSc seminar requirement is intended for students to practice presentation and communication skills and to participate in the process of knowledge dissemination as part of the academic life.

Thesis Defence
Arrangements for the MSc thesis defence should be made at least four weeks prior to the anticipated date of the defence, and the student must submit their MSc thesis to the Examination Committee at least two weeks prior to the defence. The examination consists of an oral presentation by the student followed by questions from the Examination Committee.

Collaborative Specializations
Artificial Intelligence
The School of Computer Science participates in the collaborative specialization in Artificial Intelligence. MSc students wishing to undertake thesis research with an emphasis on artificial intelligence are eligible to apply to register concurrently in Computer Science and the collaborative specialization. Students should consult the Artificial Intelligence (calendar.uoguelph.ca/graduate-calendars/collaborative-specializations/artificial-intelligence/) listing for more information.

One Health
The School of Computer Science participates in the collaborative specialization in One Health. Master’s and Doctoral students wishing to undertake thesis research or their major research paper/project with an emphasis on one health are eligible to apply to register concurrently in Computer Science and the collaborative specialization. Students should consult the One Health (calendar.uoguelph.ca/graduate-calendars/collaborative-specializations/one-health/) listing for more information.

Courses
The core graduate courses are designed to be accessible to any student with an appropriate background in Computer Science and will provide enough introduction for those unfamiliar with the specific area to allow them to keep up with the advanced material.

The advanced graduate courses are taught with the assumption that the student has sufficient background in the research area to understand the advanced concepts and research ideas. Students who intend to take a course for which they have insufficient background should consult with the instructor prior to enrollment in the course.

CIS*6000 Distributed Systems Unspecified [0.50]
Department(s): School of Computer Science
Location(s): Guelph

CIS*6020 Artificial Intelligence Unspecified [0.50]
An examination of Artificial Intelligence principles and techniques such as: logic and rule based systems; forward and backward chaining; frames, scripts, semantic nets and the object-oriented approach; the evaluation of intelligent systems and knowledge acquisition. A sizeable project is required and applications in other areas are encouraged.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6030 Information Systems Unspecified [0.50]
Relational and other database systems, web information concurrency protocols, data integrity, transaction management, distributed databases, remote access, data warehousing, data mining.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6050 Neural Networks Unspecified [0.50]
Department(s): School of Computer Science
Location(s): Guelph

CIS*6060 Bioinformatics Unspecified [0.50]
Data mining and bioinformatics, molecular biology databases, taxonomic groupings, sequences, feature extraction, Bayesian inference, cluster analysis, information theory, machine learning, feature selection.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6070 Discrete Optimization Unspecified [0.50]
This course will discuss problems where optimization is required and describes the most common techniques for discrete optimization such as: the use of linear programming, constraint satisfaction methods, and genetic algorithms.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6080 Genetic Algorithms Unspecified [0.50]
This course introduces the student to basic genetic algorithms, which are based on the process of natural evolution. It is explored in terms of its mathematical foundation and applications to optimization in various domains.
Department(s): School of Computer Science
Location(s): Guelph
CIS*6090  Hardware/Software Co-Design of Embedded Systems Unspecified [0.50]
Specification and design of embedded systems, system-on-a-chip paradigm, specification languages, hardware/software co-design, performance estimation, co-simulation and validation, processes architectures and software synthesis, retargetable code generation and optimization.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6100  Parallel Processing Architectures Unspecified [0.50]
Parallelism in uniprocessor systems, parallel architectures, memory structures, pipelined architectures, performance issues, multiprocessor architectures.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6110  Image Processing Algorithms and Applications Unspecified [0.50]
Brightness transformation, image smoothing, image enhancement, thresholding, segmentation, morphology, texture analysis, shape analysis, applications in medicine and biology.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6140  Object-Oriented Modeling, Design and Programming Unspecified [0.50]
Objects, modeling, program design, object-oriented methodology, UML, CORBA, database.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6150  Scalable and Massively Parallel Processing Architectures Unspecified [0.50]
Scalable and massively parallel processing architectures with focus on a diverse set of architectures, ranging from simple, high-end workstations, to supercomputers.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6160  Multiagent Systems Unspecified [0.50]
Intelligent systems consisting of multiple autonomous and interacting subsystems with emphasis on distributed reasoning and decision making. Deductive reasoning agents, practical reasoning agents, probabilistic reasoning agents, reactive and hybrid agents, negotiation and agreement, cooperation and coordination, multiagent search, distributed MDP, game theory, and modal logics.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6170  Software Engineering Unspecified [0.50]
This course will discuss problems where optimization is required and describes the most common techniques for discrete optimization such as the use of linear programming, constraint satisfaction methods, and meta-heuristics.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6180  Design Automation in Digital Systems Unspecified [0.50]
Techniques and software tools for design of digital systems. Material covered includes high-level synthesis, design for testability, and FPGAs in design and prototyping.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6190  Advanced Penetration Testing and Exploit Development Winter Only [0.50]
This course provides an in-depth understanding of techniques for detecting, responding to, and defeating Advanced Persistent Threats (APT) and malware campaigns using artificial intelligence and data mining techniques. Students will identify, extract, and leverage intelligence from different types of cyber threat actors.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6200  Analysis and Design of Computer Algorithms Unspecified [0.25]
The design and analysis of efficient computer algorithms: standard methodologies, asymptotic behaviour, optimality, lower bounds, implementation considerations, graph algorithms, matrix computations (e.g. Strassen’s method), NP-completeness.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6210  Intelligent Systems Unspecified [0.50]
Intelligent systems consisting of multiple autonomous and interacting subsystems with emphasis on distributed reasoning and decision making. Deductive reasoning agents, practical reasoning agents, probabilistic reasoning agents, reactive and hybrid agents, negotiation and agreement, cooperation and coordination, multiagent search, distributed MDP, game theory, and modal logics.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6220  Advanced Digital Forensics and Incident Response Fall Only [0.50]
This course provides an in-depth understanding of theoretical concepts and practical issues in the field of digital forensics and incident response. Students will develop necessary skills, methodologies, and processes to detect cyber incidents and conduct in-depth computer and network investigation.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6230  Cyber Threat Intelligence and Adversarial Risk Analysis Winter Only [0.50]
This course provides an in-depth understanding of techniques for detecting, responding to, and defeating Advanced Persistent Threats (APT) and malware campaigns using artificial intelligence and data mining techniques. Students will identify, extract, and leverage intelligence from different types of cyber threat actors.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6240  Soft Computing Unspecified [0.50]
Neural networks, artificial intelligence, connectionist model, back propagation, resonance theory, sequence processing, software engineering concepts.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6490  Analysis and Design of Computer Algorithms Unspecified [0.25]
The design and analysis of efficient computer algorithms: standard methodologies, asymptotic behaviour, optimality, lower bounds, implementation considerations, graph algorithms, matrix computations (e.g. Strassen’s method), NP-completeness.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6500  Soft Computing in Cybersecurity Unspecified [0.50]
Neural networks, artificial intelligence, connectionist model, back propagation, resonance theory, sequence processing, software engineering concepts.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6510  Cybersecurity and Defense in Depth Fall Only [0.50]
This course provides an overview of concepts and technical measures that are employed to enforce security policies and protect networks and systems from malicious activities. Students will learn how to engineer a secure system and how to secure networks in an ethical manner.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6520  Advanced Digital Forensics and Incident Response Fall Only [0.50]
This course provides an in-depth understanding of theoretical concepts and practical issues in the field of digital forensics and incident response. Students will develop necessary skills, methodologies, and processes to detect cyber incidents and conduct in-depth computer and network investigation.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6530  Cyber Threat Intelligence and Adversarial Risk Analysis Winter Only [0.50]
This course provides an in-depth understanding of techniques for detecting, responding to, and defeating Advanced Persistent Threats (APT) and malware campaigns using artificial intelligence and data mining techniques. Students will identify, extract, and leverage intelligence from different types of cyber threat actors.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6540  Advanced Penetration Testing and Exploit Development Winter Only [0.50]
This course provides an in-depth understanding of techniques for detecting, responding to, and defeating Advanced Persistent Threats (APT) and malware campaigns using artificial intelligence and data mining techniques. Students will identify, extract, and leverage intelligence from different types of cyber threat actors.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6550  Advanced Penetration Testing and Exploit Development Winter Only [0.50]
This course provides an in-depth understanding of techniques for detecting, responding to, and defeating Advanced Persistent Threats (APT) and malware campaigns using artificial intelligence and data mining techniques. Students will identify, extract, and leverage intelligence from different types of cyber threat actors.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph
CIS*6550 Privacy, Compliance, and Human Aspects of Cybersecurity Unspecified [0.50]
This course provides an in-depth view of the privacy, regulatory, and ethical issues surrounding cybersecurity. It covers methods of mitigating/treating privacy risks associated with emerging technologies that collect, manage, and analyse data. This course also examines data protection regulations and compliance strategies.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6560 Cybersecurity and Threat Intelligence Project Winter and Summer Reg Required [1.00]
Students plan, develop, and write an industry- or faculty-led report and produce required tools, services, and software. Projects should advance knowledge or practice, and address an emerging challenge in cybersecurity, cyber threat intelligence, digital forensics and incident response, cyber threat hunting, or a closely related field.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6570 Advanced Cryptography and Cryptanalysis Unspecified [0.50]
This course provides an in-depth understanding of modern cryptography, with emphasis on practical applications. Topics covered include classical systems, information theory, symmetrical cryptosystems, block ciphers, stream ciphers, DES, AES, asymmetric cryptosystems, ECC, provable security, key exchange and management, and authentication and digital signatures, among others.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6580 Security Monitoring and Cyber Threat Hunting Unspecified [0.50]
This course provides a comprehensive review of tools, techniques, and procedures for monitoring network events and assets to build a secure network architecture. It trains students in methods for hunting attackers that could bypass designed network defense mechanisms in an enterprise.
Restriction(s): Student registered in the MCTI program.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6590 Professional Seminar in Cybersecurity Fall and Winter Reg Required [0.50]
This two-semester course offers a multidisciplinary forum for discussion of topics related to cybersecurity. The seminar fosters professional skills development (academic and industry), promotes collaboration between industry experts and graduate students, facilitates mentoring and project development, and contributes to the transfer of knowledge between industry and academia.
Location(s): Guelph

CIS*6600 Topics in Computer Science I Unspecified [0.50]
This special topics course examines selected, advanced topics in computer science that are not covered by existing courses. The topic(s) will vary depending on the need and the instructor.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6660 Topics in Computer Science II Unspecified [0.50]
This is a reading course. Its aim is to provide background knowledge to students who need to get a head-start in their thesis research fields early during their program while no suitable regular graduate courses are offered. Admission is under the discretion of the instructor.
Restriction(s): Instructor consent required.
Department(s): School of Computer Science
Location(s): Guelph

CIS*6670 Special Topics in Cybersecurity Unspecified [0.50]
This course provides an in-depth view of a variety of advanced topics within cybersecurity. Subject areas discussed in any particular semester will depend upon the interests of both the students and the instructor. Students should check with the School of Computer Science to determine what topics will be offered during specific semesters.
Location(s): Guelph

CIS*6890 Technical Communication and Research Methodology Unspecified [0.50]
This course aims to develop students’ ability in technical communication and general research methodology. Each student is expected to present a short talk, give a mini lecture, review a conference paper, write a literature survey and critique fellow students’ talks and lectures.
Department(s): School of Computer Science
Location(s): Guelph