ARTIFICIAL INTELLIGENCE

The Collaborative Specialization in Artificial Intelligence (AI) provides thesis-based masters students in Computer Science, Engineering, Mathematics and Statistics, and Bioinformatics with a diverse and comprehensive knowledge base in AI. Students wishing to undertake graduate studies at the masters level with emphasis on artificial intelligence will be admitted by a participating department and will register in both the participating department and in the collaborative specialization.

Students will learn from a multidisciplinary team of faculty with expertise in fundamental and applied deep learning and machine learning, while conducting AI-related research guided by a faculty advisor. By the end of this program, graduates will have comprehensive understanding of leading-edge AI techniques and will be able to apply this knowledge to solve real-world problems.

Administrative Staff

Graduate Program Coordinator
Dr. Graham Taylor (3515 Thornbrough, Ext. 53644)
gwtaylor@uoguelph.ca
TBD
Graduate Program Assistant (, Ext. )

Graduate Faculty

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

Hussein A. Abdullah
B.Sc. Univ. of Technology, M.Sc., PhD Glasgow, P.Eng. - Professor Graduate Faculty

R. Ayesha Ali
B.Sc. Western Ontario, M.Sc. Toronto, PhD Washington - Associate Professor Graduate Faculty

Daniel A. Ashlock
B.Sc. Kansas, PhD CalTech - Professor Graduate Faculty

Christine Baes
B.Sc. Guelph, M.Sc. Hohenheim, PhD Christian-Albrechts - Associate Professor Graduate Faculty

Mohammad Biglarbegan
B.Sc. Tehran, MA Toronto, PhD Waterloo, P.Eng. - Associate Professor Graduate Faculty

Scott Brandon
B.Sc. Western, M.Sc., PhD Queen's, P.Eng - Assistant Professor Graduate Faculty

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

Lorna Deeth
B.Sc., M.Sc., PhD Guelph - Assistant Professor Graduate Faculty

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

Bob Dony
B.A.Sc., M.A.Sc. Waterloo, PhD McMaster, P.Eng., FIET, FEC - Associate Professor Graduate Faculty

Zeny Feng
B.Sc. York, MMath., PhD Waterloo - Professor Graduate Faculty

David Flata
B.Sc., M.Sc., PhD Saskatchewan - Associate Professor Graduate Faculty

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

Karen D. Gordon
B.Sc. Guelph, PhD Western Ontario, PEng - Associate Professor and Associate Dean (Academic), College of Engineering and Physical Science Graduate Faculty

Gary Gréwal
B.Sc. Brock, M.Sc., PhD Guelph - Associate Professor Graduate Faculty

Julie Horrocks
B.Sc. Mount Allison, BFA Nova Scotia College of Art & Design, MMath, PhD Waterloo - Professor Graduate Faculty

Hadis Karimipour
B.Sc. Ferdowi, M.Sc. Shahrood, PhD Alberta, PEng - Assistant Professor Graduate Faculty

Lei Lei
BS, PhD Beijing - Assistant Professor Graduate Faculty

William David Lubitz
B.Sc., M.Sc., PhD California, P.Eng - Associate Professor Graduate Faculty

Pascal Matsakis
B.Sc., M.Sc., PhD Paul Sabatier (France) - Professor Graduate Faculty

Edward McBean
B.A.Sc, British Columbia, S.M., C.E., PhD MIT, P.Eng - Professor Graduate Faculty

Medhat A. Moussa
B.Sc. American, M.A.Sc. Moncton, PhD Waterloo, PEng - Professor Graduate Faculty

Khurram Nadeem
B.Sc., M.Sc. Karachi, PhD Alberta - Assistant Professor Graduate Faculty

Mihai Nica
B.Math., Waterloo, PhD Courant Institute NYU - Assistant Professor Graduate Faculty
MSc/MASc Collaborative Specialization

Admission Requirements

Masters students in the Collaborative Specialization in Artificial Intelligence must meet the admission requirements of the participating department in which they are enrolled. The application process has two stages. First, prospective students will apply to their primary program of interest, identifying interest in the collaborative specialization as a focus. If the student is admitted to the primary program as a thesis student, the second stage is then admission to the collaborative specialization. All applications to participate in the Collaborative Specialization in Artificial Intelligence will be vetted by the specialization's Graduate Program Coordinator.

Program Requirements

Masters students in the collaborative specialization in artificial intelligence must complete:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIV*6080</td>
<td>Computational Thinking for Artificial Intelligence</td>
<td>0.25</td>
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<tr>
<td>UNIV*6090</td>
<td>Artificial Intelligence Applications and Society</td>
<td>0.50</td>
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Select one of the following Elective Core courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS*6200</td>
<td>Artificial Intelligence</td>
<td>0.50</td>
</tr>
<tr>
<td>ENGG*6500</td>
<td>Introduction to Machine Learning</td>
<td>0.50</td>
</tr>
<tr>
<td>STAT*6801</td>
<td>Statistical Learning</td>
<td>0.50</td>
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Select two of the following Complementary AI-related courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BINF*6970</td>
<td>Statistical Bioinformatics</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*6050</td>
<td>Neural Networks</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*6060</td>
<td>Bioinformatics</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*6070</td>
<td>Discrete Optimization</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*6080</td>
<td>Genetic Algorithms</td>
<td>0.50</td>
</tr>
<tr>
<td>CIS*6100</td>
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<td>0.50</td>
</tr>
</tbody>
</table>

And an acceptable AI-related thesis.

Requirements of this collaborative specialization may also serve as core and/or elective requirements in the student's home program.
ELECTIVE Core

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

ENGG*6500 Introduction to Machine Learning Unspecified [0.50]
The aim of this course is to provide students with an introduction to algorithms and techniques of machine learning particularly in engineering applications. The emphasis will be on the fundamentals and not specific approach or software tool. Class discussions will cover and compare all current major approaches and their applicability to various engineering problems, while assignments and project will provide hands-on experience with some of the tools.

Department(s): School of Engineering
Location(s): Guelph

STAT*6801 Statistical Learning Unspecified [0.50]
Topics include: nonparametric and semiparametric regression; kernel methods; regression splines; local polynomial models; generalized additive models; classification and regression trees; neural networks. This course deals with both the methodology and its application with appropriate software. Areas of application include biology, economics, engineering and medicine.

Department(s): Department of Mathematics and Statistics
Location(s): Guelph

COMPLEMENTARY AI-related

BINF*6970 Statistical Bioinformatics Winter Only [0.50]
This course presents a selection of advanced approaches for the statistical analysis of data that arise in bioinformatics, especially genomic data. A central theme to this course is the modelling of complex, often high-dimensional, data structures.

Restriction(s): Restricted to students in Bioinformatics programs.

Department(s): Dean's Office, College of Biological 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*6120 Uncertainty Reasoning in Knowledge Representation Unspecified [0.50]
Representation of uncertainty, Dempster-Schafer theory, fuzzy logic, Bayesian belief networks, decision networks, dynamic networks, probabilistic models, utility theory.

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*6320 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*6420 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

ENGG*6100 Machine Vision Unspecified [0.50]
Computer vision studies how computers can analyze and perceive the world using input from imaging devices. Topics covered include image pre-processing, segmentation, shape analysis, object recognition, image understanding, 3D vision, motion and stereo analysis, as well as case studies.

Department(s): School of Engineering
Location(s): Guelph

ENGG*6140 Optimization Techniques for Engineering Unspecified [0.50]
This course serves as a graduate introduction into combinatorics and optimization. Optimization is the main pillar of Engineering and the performance of most systems can be improved through intelligent use of optimization algorithms. Topics to be covered: Complexity theory, Linear/Integer Programming techniques, Constrained/Unconstrained optimization and Nonlinear programming, Heuristic Search Techniques such as Tabu Search, Genetic Algorithms, Simulated Annealing and GRASP.

Department(s): School of Engineering
Location(s): Guelph
ENGG*6570  Advanced Soft Computing  Unspecified  [0.50]
Neural dynamics and computation from a single neuron to a neural network architecture. Advanced neural networks and applications. Soft computing approaches to uncertainty representation, multi-agents and optimization.
Prerequisite(s): ENGG*4430
Department(s): School of Engineering
Location(s): Guelph

MATH*6020  Scientific Computing  Unspecified  [0.50]
This course covers the fundamentals of algorithms and computer programming. This may include computer arithmetic, complexity, error analysis, linear and nonlinear equations, least squares, interpolation, numerical differentiation and integration, optimization, random number generators, Monte Carlo simulation; case studies will be undertaken using modern software.
Department(s): Department of Mathematics and Statistics
Location(s): Guelph

MATH*6021  Optimization I  Unspecified  [0.50]
A study of the basic concepts in: linear programming, convex programming, non-convex programming, geometric programming and related numerical methods.
Department(s): Department of Mathematics and Statistics
Location(s): Guelph

MATH*6051  Mathematical Modelling  Unspecified  [0.50]
The process of phenomena and systems model development, techniques of model analysis, model verification, and interpretation of results are presented. The examples of continuous or discrete, deterministic or probabilistic models may include differential equations, difference equations, cellular automata, agent based models, network models, stochastic processes.
Department(s): Department of Mathematics and Statistics
Location(s): Guelph

PHIL*6760  Science and Ethics  Unspecified  [0.50]
A consideration of the problems which arise in the conjunction of science and ethics.
Department(s): Department of Philosophy
Location(s): Guelph

STAT*6841  Computational Statistical Inference  Unspecified  [0.50]
This course covers Bayesian and likelihood methods, large sample theory, nuisance parameters, profile, conditional and marginal likelihoods, EM algorithms and other optimization methods, estimating functions, Monte Carlo methods for exploring posterior distributions and likelihoods, data augmentation, importance sampling and MCMC methods.
Department(s): Department of Mathematics and Statistics
Location(s): Guelph

Undergraduate Complementary AI-related Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENGG*4460</td>
<td>Robotic Systems</td>
<td>0.50</td>
</tr>
<tr>
<td>STAT*4000</td>
<td>Statistical Computing</td>
<td>0.50</td>
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