# UNIVERSITY of GUELPH

# ENGG*6600 Special Topics in Engineering Systems and Computing

## ST: Deep Learning

Summer 2023

Section(s): C01

School of Engineering

Credit Weight: 0.50

Version 1.00 - May 01, 2023

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# 1 Course Details

## 1.1 Calendar Description

A course of directed study involving selected readings and analyses in developing knowledge areas of Engineering Systems and Computing.

## 1.2 Course Description

This course focuses on various topics in deep learning, covering topics from fundamental concepts in neural networks to state-of-the-art deep learning. We start with feed-forward nets, backpropagation, convolutional nets, and regularization techniques such as batch normalization and dropout. Then, we cover sequence modeling (useful for NLP and speech processing) including RNN, LSTM, attention, transformers, BERT, and GPT. Next, generative models are covered including variational models, generative moment matching nets, GAN, and diffusion models. The other covered topics are Boltzmann machines, graph neural nets, deep reinforcement learning, meta-learning, network compression, federated learning, explainable AI, and self-supervised learning. Some applications of deep learning, including usage in computer vision, image processing, and NLP, are introduced. If time allows, the theory of optimization in networks is also discussed.

## 1.3 Timetable

Lecture time: Tuesdays, 7:00 - 9:50 PM

Lecture room: MCLN 107

Starting class: May 16, 2023

## 1.4 Final Exam

No final Exam. Also, a presentation and a final project will be used instead. Instructor will post the exact date and time on CourseLink. Moreover, the course has a midterm exam.

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# 2 Instructional Support

## 2.1 Instructional Support Team

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|---|---|
| **Instructor:** | Benyamin Ghojogh |
| **Email:** | bghojogh@uoguelph.ca |
| **Office Hours:** | By appointment and/or via Teams/Zoom. |

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# 3 Learning Resources

## 3.1 Required Resources

**CourseLink (Website)**
https://courselink.uoguelph.ca/
Course materials, news, announcements, and grades will be regularly posted to the ENGG*6600 (section 1) Courselink site. You are responsible for checking the site regularly.

**Required Reading (Article)**

1. Lecture notes (which are provided to students).
2. Some tutorial papers, which will be referred to in the lecture notes.

## 3.2 Recommended Resources

**Recommended Readings (Textbook)**

1. Benyamin Ghojogh, Mark Crowley, Fakhri Karray, Ali Ghodsi, "Elements of Dimensionality Reduction and Manifold Learning", Springer, 2023, https://link.springer.com/book/10.1007/978-3-031-10602-6
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep learning, MIT press, 2016, https://www.deeplearningbook.org/
3. Simon J.D. Prince, Understanding Deep Learning, to be published by MIT press, https://udlbook.github.io/udlbook/
4. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006, https://link.springer.com/book/9780387310732

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# 4 Learning Outcomes

## 4.1 Course Learning Outcomes

By the end of this course, you should be able to:
1. Learn the fundamentals of deep learning
2. Implement and code deep learning algorithms
3. Understand the theory and reasoning behind deep learning algorithms and techniques
4. Perform group projects in deep learning, useful for both academia and industry

## 4.2 School of Engineering - Graduate Degree Learning Outcomes

Successfully completing this course will contribute to the following:

| # | Outcome | Learning Outcome |
|---|---------|------------------|
| 1 | Literacy | 1, 2, 3 |
| 1.1 | Information Literacy | 1, 3 |
| 1.3 | Technological Literacy | 1, 2, 3 |
| 2 | Global Understanding | 1 |
| 2.1 | Global Understanding | 1 |
| 2.2 | Sense of Historical Development | 1 |
| 3 | Communication Skills | 4 |
| 3.1 | Oral Communication | 4 |
| 3.2 | Written Communication | 4 |
| 4 | Professional and Ethical Behaviour | 3, 4 |
| 4.1 | Teamwork | 4 |
| 4.3 | Leadership | 4 |
| 4.5 | Intellectual Independence | 3 |
| 5 | Critical and Creative Thinking | 2, 4 |
| 5.2 | Problem Solving | 2, 4 |
| 5.3 | Creativity | 2, 4 |

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# 5 Teaching and Learning Activities

Disclaimer: the schedule of weeks is tentative and is subject to some changes during the

semester.

## 5.1 Lecture

**Week 1**

| | |
|---|---|
| **Topics:** | Preliminaries (probability and expectation, the learning model, overfitting, etc), logistic regression, feedforward neural network (perceptron, backpropagation, feed-forward neural network, stochastic gradient descent) |

**Week 2**

| | |
|---|---|
| **Topics:** | Regularization techniques (overfitting/underfitting, cross validation, weight decay, dataset augmentation, adding noise, early stopping, parameter tying and parameter sharing, bagging, dropout, batch normalization) |

**Week 3**

| | |
|---|---|
| **Topics:** | Convolutional Networks (CNN, its philosophy, and variants like ResNet, UNet, DenseNet, AlexNet, etc), Deep metric learning, Self-supervised learning, Deep Learning Tuning (choosing the model architecture, choosing the optimizer, and hyper-parameter tuning in networks, e.g., batch size, learning rate, early stopping parameters, etc) |

**Week 4**

| | |
|---|---|
| **Topics:** | Sequence Modeling (introduction to NLP, RNN, LSTM, GRU, ELMo, etc), Attention mechanism (attention, transformers, BERT, GPT), introduction to Large Language Models (LLM) |

**Week 5**

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|---|---|
| **Topics:** | Network Compression (knowledge distillation, etc), Restricted Boltzmann Machine (RBM) and deep belief network |

**Week 6**

| | |
|---|---|
| **Topics:** | Generative Models (variational models, generative moment matching, adversarial learning, GAN, diffusion models) |

**Week 7**

| | |
|---|---|
| **Topics:** | Midterm exam |

**Week 8**

    **Topics:**                    Graph Neural Networks (convolution on graphs, GNN vanilla spectral GCN, ChebNet, GCNs, Graph Attention Networks), Few-shot Learning (meta-learning)

**Week 9**

    **Topics:**                    Deep Reinforcement Learning

**Week 9**

    **Topics:**                    Federated learning, Adversarial attacks

**Week 10**

    **Topics:**                    Explainable AI (including shortcut learning and saliency maps)

**Week 11**

    **Topics:**                    Theory of neural networks (SAM optimization, optimization landscape, probability bounds, information bottleneck, etc)

## 5.2 Seminar

**Week 12**

    **Topics:**                    Group presentations of projects

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# 6 Assessments

## 6.1 Assessment Details

**Assignments (20%)**

**Midterm exam (30%)**

**Group project (40%)**

**Group presentation of projects (10%)**

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# 7 School of Engineering Statements

## 7.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

## 7.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

## 7.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

# 8 University Statements

## 8.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

## 8.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

## 8.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

## 8.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

## 8.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

## 8.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

## 8.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

## 8.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

## 8.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website

(https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

## 8.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

## 8.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.

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