**Course Description**

Prerequisite: Machine learning, probability, calculus, linear algebra, and statistics

**Deep Learning:**
This course provides an in-depth exploration of Deep Learning, focusing on key algorithms and computational frameworks that enable complex data representation. Students will study essential architectures like Feedforward and Convolutional Neural Networks, along with advanced techniques such as Diffusion Models, Variational Models, and Generative Adversarial Networks (GANs). The course also covers attention mechanisms and Large Language Models (LLMs), with applications in Natural Language Processing (NLP), Computer Vision, Bioinformatics, and more. By the end of the course, students would be equipped with a strong understanding of modern Deep Learning methods, preparing them for advanced research and practical implementations.

**Tentative Topics:**

- **Feedforward Deep Networks**
    - Basic architecture and training techniques for deep neural networks.
- **Optimization and Regularization for Training Deep Models**
    - Techniques to optimize training, including gradient descent, learning rate scheduling, and regularization methods like dropout and weight decay.
- **Convolutional Neural Networks (CNNs)**
    - Architectures for image and spatial data processing, including convolution, pooling, and fully connected layers.
- **Recurrent Neural Networks (RNNs)**
    - Models for sequential data, including RNNs, Long Short-Term Memory (LSTM), and Gated Recurrent Units (GRU).
- **Seq2Seq Models**
    - Sequence-to-sequence models for tasks like machine translation, using encoder-decoder architectures.
- **Autoencoders and Variational Autoencoders**
    - Models for dimensionality reduction and feature learning, including basic autoencoders and Variational Autoencoders (VAEs).
- **Deep Generative Models**
    - **Moment Matching Networks**: Techniques for matching moments between data distributions.
    - **Generative Adversarial Networks (GANs)**: Models that generate data by training a generator and discriminator in opposition.

    - **Diffusion Models**: Models that generate data by learning to reverse a diffusion process, commonly used in tasks like image generation.

- **Attention Mechanisms and Self-Attention**
    - Techniques to focus on relevant parts of input data, including the self-attention mechanism used in transformers.
- **Transformers and Performers**
    - Transformer architectures for sequence processing and Performer variants for scaling attention mechanisms.
- **Large Language Models (LLMs)**
    - **BERT, GPT**: Pre-trained models for Natural Language Processing (NLP), focusing on bidirectional and autoregressive techniques.
    - **Alignment Techniques**: Including Reinforcement Learning from Human Feedback (RLHF) for aligning model outputs with human preferences.
- **Deep Reinforcement Learning (Optional, if time allows)**
    - Techniques for training agents using deep learning in reinforcement learning environments, focusing on decision-making and policy optimization.
- **Graph Neural Networks (GNNs)**
    - Architectures for processing graph-structured data, including node embeddings and graph convolutions.

**Grade Breakdown**

| **Activities and Assignments** | **Weigh** |
|---|---|
| Assignments (2 at 15% each) | 30% |
| Wiki Contributions for Lectures | 10% |
| Paper Presentation | 10% |
| Wiki Contributions for Paper Presentation | 10% |
| Final Project (Report) | 40% |

**WikiCourseNote Contributions (WCN):**

**Wiki Contributions for Lectures:**
Students are required to collaboratively build a comprehensive course note by **scribing at least 10 lectures** over the term. Contributions must be completed **within one week after each lecture**. This

collective effort ensures all students remain engaged and enhances understanding in the asynchronous, online course format.

**Wiki Contributions for Paper Presentations:**
The course includes **group paper presentations**. Students who are **not presenting** must contribute by **scribing papers presented by their peers**. Each student is required to contribute to **at least half of the presented papers**. Contributions must be completed **until the last class**. Contributions to the paper a student presents are not counted. This ensures continuous engagement and a shared understanding of the presented materials. See details in **Activities and Assessments**.

**Tracking and Evaluation:**
The wiki platform records all contributions, and this history will be used for grading. Contributions will be assessed for quality, completeness, and consistency. This process is designed to encourage active participation and reinforce collaborative learning in the asynchronous environment.

**Important Notice:**

You may not incorporate portions of pre-existing thesis work into your final course project. Additionally, projects previously submitted for other courses are not eligible for re-use as your final project in this course.

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**Materials and Resources**

**Textbook**
**Required**
No textbook is required for this course.

**Recommended**
*Deep Learning* by Ian Goodfellow, Yoshua Bengio and Aaron Courville
The book is online https://www.deeplearningbook.org/

**Communication**

All communication should occur on the Piazza discussion board. Piazza allows you to discuss course materials and ask questions publicly, learn from others' questions, and receive announcements and clarifications. Regular reading of Piazza is expected.

**Piazza Guidelines**

- **Public Posts**: Everything you post on Piazza is visible to all course members. Do not share assignment solutions; this can be considered cheating. For detailed questions, use the "private post" option to instructors/TAs.
- **Post Guidelines**: Keep posts relevant, concise, and avoid wasting readers' time. Use meaningful subject headings and appropriate tags.
- **Search First**: Before posting, use Piazza's search function to find existing answers. Avoid posting duplicate questions.

- **Complaints**: Direct complaints to the instructor privately, not on Piazza. Piazza is for course-related discussions, not for grievances.
- **Grades**: Grades and announcements will be handled through Learn. Regularly check Piazza and Learn to stay informed.

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**Contact Us**

- **Instructor: Ali Ghodsi**
    - **For**: Course content and personal questions
- **TA: Hao Quan**
    - **For**: Assignments, technical issues (Piazza/Kaggle), deadlines
    - **Note**: Post course-related questions on Piazza for the benefit of all students.

For personal questions, contact the instructor directly.

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**Technical Support**

**Technical problems with Waterloo LEARN**
**learnhelp@uwaterloo.ca**
Include your full name, WatIAM user ID, student number, and course name and number.
Technical support is available during regular business hours, Monday to Friday, 8:30 AM to 4:30 PM (Eastern Time).
LEARN Help Student Documentation

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**Student Resources**

Student Resources

- Academic advice
- Student success
- WatCards
- Library services and more

Turnitin or other plagiarism detection will be used to verify the originality of your submissions. Please note that submissions to Turnitin are stored on a U.S. server. If you have concerns regarding privacy and/or security, please inform the instructor within the first week of the course. Communication should be made via email with the subject line: "Opting Out of Turnitin for STAT 940."

**Resources**

- Library COVID-19: Updates on library services and operations.

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**University Policies**

- **Academic integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect, and responsibility. [Check the Office of Academic Integrity for more information.]
- When utilizing ideas, charts, text, or any other intellectual property created by someone else, proper citation of the original source is mandatory.
- If you directly copy text—be it a sentence or a paragraph—from another's work, you must not only cite the source but also enclose the copied material within quotation marks.
- Please note that evidence of plagiarism in final project reports, codes, or any other submitted materials will result in a failing grade for the course. All reports, codes, etc., will be checked by plagiarism detection software.
- **Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.
- **Discipline:** A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.
- **Appeals:** A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals.
- **Note for students with disabilities:** AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require