THE UNIVERSITY OF WINNIPEG

APPLIED COMPUTER SCIENCE

Course Number: **GACS-7401-600**
Course Name: **Current Topics in Computing (Directed Readin**gs): Deep learning in Neurodegeneration Radiogenomics

Instructor Information

Instructor: Qian Liu
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Meeting Time: Mondays/Wednesdays 8:30 - 10:00am 3C08B

Important Dates

1. First Class: Monday, May 6, 2024
2. Last Class: Monday, July 29, 2024
3. Final Withdrawal Date w/o academic penalty*: Friday, July 12, 2024
4. University closures: Victoria Day Monday, May 20, 2024
   Canada Day Monday, July 1, 2024

*A minimum of 20% of the work on which the final grade is based will be evaluated and available to the student before the voluntary withdrawal date.

Course Objectives / Learning Outcomes

Neurodegeneration, prevalent in aged populations, leads to severe disorders like Alzheimer's, Parkinson's, and Huntington's disease, all lacking effective treatments. These conditions are characterized by mitochondrial dysfunction, telomere shortening, genomic instability, and protein aggregate accumulation, driven by a complex interplay of genetic, molecular, and environmental factors. Advances in neuroimaging techniques like MRI and FDG-PET have provided insights into the structural and metabolic changes underlying these diseases. Additionally, genetic studies have identified risk variants, while 'omics' approaches have revealed deregulated pathways and potential biomarkers in neurodegeneration. Radiogenomics combines medical imaging with genomic information to offer less invasive insights into neurodegenerative diseases, aiding in understanding genotype-phenotype correlations and guiding personalized therapies. Vision Transformers (ViT) and attention mechanisms, especially with Cross-Modal

Attention (CMA), have emerged as powerful tools in radiogenomic analysis, facilitating the integration of multi-modal data.

Students involved in this course will review the literatures published in the multi-modal data integration field of neurodegenerative disease. They will review and summary the data resources, and machine learning/deep learning methods in this field. They will also learn scientific writing, oral presentations. Students may have chance to submit their work. Here are the course objectives and learning outcomes for a course on neurodegeneration, focusing on multi-modal data integration, neuroimaging, and machine learning approaches:

- Understand the Fundamentals of Neurodegenerative Diseases: Gain a comprehensive understanding of the biological and molecular mechanisms underlying neurodegenerative diseases, including Alzheimer's, Parkinson's, and Huntington's disease, with a focus on mitochondrial dysfunction, telomere shortening, genomic instability, and protein aggregation.
- Explore Advanced Neuroimaging Techniques: Delve into the latest advances in neuroimaging techniques such as MRI and FDG-PET, and their role in identifying structural and metabolic changes in neurodegenerative diseases.
- Grasp the Essentials of Genetic Studies and 'Omics' Approaches: Learn about the identification of risk variants through genetic studies and the insights gained from 'omics' approaches, including genomics, proteomics, and metabolomics, in uncovering deregulated pathways and potential biomarkers in neurodegeneration.
- Understand Radiogenomics: Explore the emerging field of radiogenomics and its contribution to less invasive insights into neurodegenerative diseases, facilitating the understanding of genotype-phenotype correlations and guiding personalized therapies.
- Discover Machine Learning and Deep Learning in Neurodegeneration: Investigate the application of machine learning and deep learning techniques, including ViT and attention mechanisms, particularly CMA, in the analysis of neurodegenerative diseases using multi-modal data.
- Develop Scientific Writing and Presentation Skills: Enhance scientific writing and oral presentation skills, with opportunities to review, summarize, and present findings from the literature in the field of neurodegenerative disease and multi-modal data integration.

This course is designed to equip students with a thorough understanding of neurodegenerative diseases from a multi-disciplinary perspective, integrating biological insights with advanced computational analysis techniques.

Evaluation Criteria

- Weekly progress report (20%)
  - Students need to attend weekly meeting to report their research progress.
  - A written report is needed to submit to the instructor at least one day before the meeting. The report should include what the students have done in the last week, what they are plan for next week, what are the difficulties they met.

- Department presentation (10%)
  - Students are required to prepare a 25-minutes presentation regarding their research work to the faculties in the Department of Applied Computer Science and address the questions/comments from faculties.

- Final report (65%)
  - GOAL:
    - The final report should critically review the current state of research in neurodegenerative diseases, with a particular focus on the application of multi-modal data integration, neuroimaging, genetic studies, 'omics' approaches, and machine learning/deep learning techniques. The paper should explore the complex interplay of genetic, molecular, and environmental factors in neurodegeneration, and how advanced computer science technologies and methodologies are contributing to our understanding and management of these diseases.
  - CONTENT:
    - **Abstract** (250 words maximum): Provide a concise summary of the review's scope, key findings from the literature, and major conclusions.
    - **Introduction**:
      - Present an overview of neurodegenerative diseases focused on, such as Alzheimer's, Parkinson's, and Huntington's disease. Discuss the significance of understanding the underlying biological and molecular mechanisms.
      - Introduce the role of advanced computer science technologies and methodologies in research on neurodegeneration.
    - **Biological and multi-omics basis of neurodegeneration:**
      - Discuss the genetic and environmental factors influencing neurodegeneration. Summarize key genetic risk variants identified and their implications. Review insights from genomics, proteomics, metabolomics, etc., into deregulated pathways and biomarkers.
    - **Medical image and radiomics of neurodegeneration:**
      - Review the application of MRI, FDG-PET, and other neuroimaging techniques in detecting and understanding neurodegenerative diseases.
      - Highlight significant findings and how radiomics contribute to our knowledge of neurodegeneration.
    - **Radiogenomics of neurodegeneration:**
      - Discuss the integration of medical imaging with genomic data (radiogenomics) and its potential in guiding personalized therapies.
      - Review the use of machine learning and deep learning in analyzing neurodegenerative diseases, focusing on multi-modal data integration.
    - **Discussion:**
      - Analyze the implications of reviewed studies for the future of neurodegeneration research.
      - Discuss challenges, limitations, and potential areas for further investigation.
    - **Conclusion**:

    - Summarize the main findings from the literature, the current state of research, and future directions.
  - **Formatting Requirements:**
    - Length: 20-30 pages, including references.
    - Figures and Tables: Appropriately labeled and referenced in the text.
    - Ensure the report is original, with all sources properly cited to avoid plagiarism.
    - The deadline for submission is August 2, 2024.
- EVALUATION CRITERIA:
  - Students will be evaluated on the organization, content, overall presentation of the underlined items in the Goal Section.

Students should contact the instructor as soon as possible if extenuating circumstances require missing a lab, assignment, test or examination. A medical certificate from a practicing physician may be required before any adjustments are considered.

Students with documented disabilities, temporary or chronic medical conditions, requiring academic accommodations for tests/exams (e.g., private space) or during lectures/laboratories (e.g., note-takers) are encouraged to contact Accessibility Services (AS) at 204-786-9771 or accessibilityservices@uwinnipeg.ca to discuss appropriate options. All information about a student's disability or medical condition remains confidential.
https://www.uwinnipeg.ca/accessibility-services.

Students may choose not to attend classes or write examinations on holy days of their religion, but they must notify their instructors at least two weeks in advance. Instructors will then provide opportunity for students to make up work examinations without penalty. A list of religious holidays can be found in the 2019-20 Undergraduate Academic Calendar online at http://uwinnipeg.ca/academics/calendar/docs/important-notes.pdf

Final Letter Grade Assignment

Historically, numerical percentages have been converted to letter grades using the following scale. However, instructors can deviate from these values based on pedagogical nuances of a particular class, and final grades are subject to approval by the Department Review Committee.

A+	90 – 100%	B+	75 – 79%	C	60 – 64%
A	85 – 89 %	B	70 – 74%	D	50 – 59%
A-	80 – 84%	C+	65 – 69%	F	below 50%

Required Text Book

There is no textbook for the course. The instructor will provide reading material in the form of journal papers, theses, and/or tutorials.

Prerequisite and Restriction Information

Consent of the Department Graduate Program Committee Chair or Instructor.

Regulations, Policies, and Academic Integrity

Students are encouraged to familiarize themselves with the Academic Regulations and Policies found in the University Academic Calendar at:
https://uwinnipeg.ca/academics/calendar/docs/regulationsandpolicies.pdf
Particular attention should be given to subsections 8 (Student Discipline), 9 (Senate Appeals) and 10 (Grade Appeals).

Avoiding Academic Misconduct: Academic dishonesty is a very serious offense and will be dealt in accordance with the University's policies.

Detailed information can be found at the following:

- Academic Misconduct Policy and Procedures: https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-policy.pdf and https://www.uwinnipeg.ca/institutional-analysis/docs/policies/academic-misconduct-procedures.pdf
- About Academic Integrity and Misconduct, Resources and FAQs: https://library.uwinnipeg.ca/use-the-library/help-with-research/academic-integrity.html

Uploading essays and other assignments to essay vendor or trader sites (filesharing sites that are known providers of essays for use by others who submit them to instructors as their own work) involves "aiding and abetting" plagiarism. Students who do this can be charged with Academic Misconduct.

Academic Integrity and AI Text-generating Tools: Students must follow principles of academic integrity (e.g., honesty, respect, fairness, and responsibility) in their use of material obtained through AI text-generating tools (e.g., ChatGPT, Bing, Notion AI). If an instructor prohibits the use of AI tools in a course, students may face an allegation of academic misconduct if using them to do assignments. If AI tools are permitted, students must cite them. According to the MLA (https://style.mla.org/citing-generative-ai/), writers should

- cite a generative AI tool whenever you paraphrase, quote, or incorporate into your own work any content (whether text, image, data, or other) that was created by it
- acknowledge all functional uses of the tool (like editing your prose or translating words) in a note, your text, or another suitable location
- take care to vet the secondary sources it cites

If students are not sure whether or not they can use AI tools, they should ask their professors.

Non-academic misconduct: Students are expected to conduct themselves in a respectful manner on campus and in the learning environment irrespective of platform being used.

Behaviour, communication, or acts that are inconsistent with a number of UW policies could be considered "non-academic" misconduct. More detailed information can be found here:

- Respectful Working and Learning Environment Policy https://www.uwinnipeg.ca/respect/respect-policy.html,
- Acceptable Use of Information Technology Policy https://www.uwinnipeg.ca/institutional-analysis/docs/policies/acceptable-use-of-information-technology-policy.pdf
- Non-Academic Misconduct Policy and Procedures: https://www.uwinnipeg.ca/institutional-analysis/docs/student-non-academic-misconduct-policy.pdf and https://www.uwinnipeg.ca/institutional-analysis/docs/student-non-academic-misconduct-procedures.pdf.

Copyright and Intellectual Property: Course materials are the property of the instructor who developed them. Examples of such materials are course outlines, assignment descriptions, lecture notes, test questions, and presentation slides—irrespective of format. Students who upload these materials to filesharing sites, or in any other way share these materials with others outside the class without prior permission of the instructor/presenter, are in violation of copyright law and University policy. Students must also seek prior permission of the instructor/presenter before, for example, photographing, recording, or taking screenshots of slides, presentations, lectures, and notes on the board. Students found to be in violation of an instructor's intellectual property rights could face serious consequences pursuant to the Academic Misconduct or Non-Academic Misconduct Policy; such consequences could possibly involve legal sanction under the Copyright Policy:
https://copyright.uwinnipeg.ca/basics/copyright-policy.html

Privacy

Students have rights in relation of the collecting of personal data the University of Winnipeg

- Student Privacy: https://www.uwinnipeg.ca/privacy/admissions-privacy-notice.html
- Zoom Privacy: https://www.uwinnipeg.ca/privacy/zoom-privacy-notice.html

Class Cancellation, Correspondence with Students and Withdrawing from Course

When it is necessary to cancel a class due to exceptional circumstances, the course instructor will make every effort to inform students via uwinnipeg email and Nexus.

Students are reminded that they have a responsibility to regularly check their uwinnipeg e-mail addresses to ensure timely receipt of correspondence from the University and/or the course instructor.

Please let course instructor know if you plan on withdrawing from the course. Note that withdrawing before the VW date does not necessarily result in a fee refund.

Topics to be covered (tentative)

- Deep learning
- Machine learning
- Radiomics
- Multi-genomics
- Radiogenomics
- Multi-modal data integration
- Neurodegenerative disease

Note that all topics listed may not be covered and can be offered in a different time order.