NS4002: A MATHEMATICAL INTRODUCTION TO NEURAL NETWORKS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
A Mathematical Introduction to Neural Networks

Subject Code
NS - Neuroscience
Course Number
4002

Academic Unit
Neuroscience (NS)

College/School
College of Biomedicine (BD)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course introduces the principles and applications of neural networks and machine learning, with a focus on their relevance to neuroscience and biological systems. Students will learn about various neural network architectures, training algorithms, and their biological inspirations. The course covers fundamental concepts of machine learning, deep learning, and their applications in analyzing neurological data, modeling neural systems, and solving biological problems. Emphasis will be placed on understanding the parallels between artificial neural networks and biological neural systems.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Demonstrate advanced understanding of neural network concepts and their relationship to biological neural systems	20	x	x	
2	Apply sophisticated machine learning, deep learning, and numerical methods to analyze neurological data and model complex neural systems	30	x	x	x
3	Implement and optimize advanced neural network models using programming tools and numerical techniques	25	x	x	x
4	Critically evaluate and compare the potential and limitations of neural networks and numerical methods in neuroscience research and applications	15	x	x	
5	Design and conduct original research projects applying neural networks and numerical methods to solve cutting-edge neuroscience problems	10	x	x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Advanced presentation of neural network concepts, architectures, numerical methods, and their biological inspirations	1, 2, 4	

2	Laboratory Sessions	Hands-on experience with implementing and optimizing neural networks using Python, relevant libraries, and numerical algorithms	2, 3, 5	In or after classes
3	Case Studies	In-depth analysis of state-of-the-art applications of neural networks and numerical methods in neuroscience research	2, 4	
4	Research Projects	Individual and group work on applying neural networks and numerical methods to solve complex neuroscience-related problems	1, 2, 3, 4, 5	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Midterm Exam	1, 2	25	-	No
2	Programming Assignments	2, 3, 5	25	GenAI will be allowed for computer programming	Yes
3	Research Project and Presentation	2, 4, 5	25	GenAI will be allowed for computer programming	Yes

Continuous Assessment (%)

75

Examination (%)

25

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

Programming Assignments

Criterion

Based on the submitted programming codes and reports to evaluate whether the students can apply neural network concepts and implement models to address neuroscience-related problems.

Excellent (A+, A, A-)

The student is able to implement neural network models without assistance, demonstrating a deep understanding of the concepts and their applications in neuroscience. The code is well-documented and efficient, and the accompanying report is clear and insightful.

Good (B+, B, B-)

The student is able to implement neural network models with minimal assistance, showing a good understanding of the concepts and their applications. The code is functional and mostly well-documented, with a clear accompanying report.

Fair (C+, C, C-)

The student is able to implement basic neural network models with some assistance, demonstrating an adequate understanding of the concepts. The code functions with minor issues, and the report covers the main points.

Marginal (D)

The student is able to implement only parts of the neural network models and submits a basic report with some gaps in understanding.

Failure (F)

The student fails to implement functioning neural network models and is unable to produce a coherent report.

Assessment Task

Research Project and Presentation

Criterion

Based on the submitted written report and oral presentation to evaluate whether the students can understand the concepts of the models and skills they learned in lessons.

Excellent (A+, A, A-)

The student submits the clearly written report and presents the results without any error.

Good (B+, B, B-)

The student submits the clearly written report and presents the results with minor errors.

Fair (C+, C, C-)

The student submits the report and presents the results without significant errors.

Marginal (D)

The student submits a partially finished assignment without significant error.

Failure (F)

The student fails to submit the report and present the results. Or the student submits a partially finished report with significant errors.

Assessment Task

Midterm and Final Examinations

Criterion

Able to show the understanding of concepts and applications of numerical methods and models.

Excellent (A+, A, A-)

Students achieve a 86% or greater on the examination

Good (B+, B, B-)

Students achieve a 65% or greater on the examination

Fair (C+, C, C-)

Students achieve a 50% or greater on the examination

Marginal (D)

Students achieve between 40% to 50% on the examination

Failure (F)

Students achieve less than 40% on the examination

Part III Other Information

Keyword Syllabus

Artificial neural networks; Deep learning; Biological neural systems; Supervised and unsupervised learning; Convolutional neural networks; Recurrent neural networks; Neurological data analysis; Computational neuroscience

Reading List

Additional Readings

	Title
1	Grokking Deep Learning by Andrew W. Trask (2019)
2	Neural Networks and Deep Learning: A Textbook by Charu C. Aggarwal (2018)
3	Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems by Peter Dayan and L. F. Abbott (2001)
4	Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, Drug Discovery, and More by Bharath Ramsundar, Peter Eastman, Patrick Walters, and Vijay Pande (2019)