SDSC4008: DEEP LEARNING

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Deep Learning

Subject Code
SDSC - Data Science
Course Number
4008

Academic Unit
Data Science (DS)

College/School
College of Computing (CC)

Course Duration
One Semester

Credit Units
3

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

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
SDSC3006 Fundamentals of Machine Learning I

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract
This course provides students with an extensive exposure to deep learning. Topics include shallow and deep neural networks, activation functions and rectified linear unit, construction of deep neural networks and matrix representations

including deep convolutional neural networks and deep recursive neural networks, computational issues including backpropagation, automatic differentiation, and stochastic gradient descent, complexity analysis, approximation analysis including universality of approximation, design of deep neural network architectures and programming according to various applications.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand the basic ingredients of deep learning and constructing deep neural networks by matrix representations	20	x		
2	State clearly application domains and the properties of deep neural networks with various architecture	20	x	x	
3	Conduct complexity analysis and approximation analysis of deep learning methods	30	x	x	x
4	Apply deep learning algorithms to typical datasets, design new algorithms from theoretical understanding of complexity and approximation, and solve some practical problems in data science by deep learning algorithms	30	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	Learning through teaching is primarily based on lectures.	1, 2, 3, 4	39 hours in total
2	Take-home assignments	Learning through take-home assignments is primarily based on interactive problem solving and hand-on computer exercises allowing instant feedback.	2, 3, 4	after class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Test	1, 2, 3, 4	15	Questions are designed for the first part of constructing deep neural networks and computing with backpropagation to see how well the students have learned the basic ingredients of deep learning and applications of deep learning algorithms to some typical datasets. (0-30%)
2	Hand-in assignments	3, 4	15	These are skills based assessment to enable students to demonstrate the basic concepts, methods and algorithms of deep learning, and applications of deep learning algorithms in some applications. (0-30%)
3	Projects	2, 3, 4	30	The projects provide students chances to demonstrate their achievements on deep learning methods learned in this course.

Continuous Assessment (%)

60

Examination (%)

40

Examination Duration (Hours)

2

Additional Information for ATs

Note: To pass the course, apart from obtaining a minimum of 40% in the overall mark, a student must also obtain a minimum mark of 30% in both continuous assessment and examination components.

Assessment Rubrics (AR)

Assessment Task

Test

Criterion

Ability to understand the basic ingredients of deep learning and apply deep learning algorithms.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Hand-in assignments

Criterion
Ability to learn the basic concepts, apply methods and algorithms of deep learning, and develop applications of deep learning algorithms.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Formative take-home assignments

Criterion
Ability to grasp basic principles of deep learning, understand deep neural network structures, and apply deep learning algorithms to some practical data sets.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
Ability to solve learning tasks using deep learning algorithms.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- Review of neural networks: activation functions, sigmoidal functions and rectified linear unit.
- Construction of deep neural networks and matrix representations: fully connected networks represented by full matrices, deep convolutional neural networks represented by convolutional matrices, deep recursive neural networks represented by structured matrices, and pooling.
- Computational issues: backpropagation and automatic differentiation, overfitting and the role of rectified linear unit in deep learning, non-convex optimization and saddle problems in training deep neural networks.underfitting, gradient vanishing
- Complexity analysis: regularization for deep learning, learning ability in terms of the number of hidden neurons and depth of the deep neural networks.
- Approximation analysis: universality of approximation of functions, better approximation by deeper layers.
- Generative Models: VAE, GAN, Flow-based Models and Diffusion Models
- Network Architectures: CNN, ResNet, Transformer
- Adversarial Robustness: Adversarial Attacks, Adversarial Defense
- Design of deep neural network architectures and programming according to various applications of deep learning.

Reading List

Compulsory Readings

	Title
1	Lecture slides and other related material
2	Neural Networks and Deep Learning: a Textbook by Charu C. Aggarwal. Springer. 2018

Additional Readings

	Title
1	Neural Networks and Deep Learning: a Textbook by Charu C. Aggarwal. Springer. 2018