METU - Department of Computer Engineering

# CNG 403 – Introduction to Deep Learning

## 2024-2025 Spring

**Web & Forum**: ODTUclass page of the course.

**Instructor**: Sinan Kalkan, skalkan@metu.edu.tr (Office hours: by appointment)

**Teaching Assistant**: Bedrettin Çetinkaya, bckaya@metu.edu.tr

**Lectures**: Video recordings shared on Monday and Thursday on ODTUclass. Q&A Session on Tuesdays at 10:40am online at https://meet.google.com/oqc-vmqa-nhk

**Credits**: METU: 3 Theoretical, 0 Laboratory; ECTS: 8.0

**Catalog Description**: Fundamental concepts in machine learning; history of artificial neuron models; perceptron learning; gradient descent and its alternatives; multi-layer perceptrons; convolutional neural networks; recurrent neural networks.

**Textbook**: Zhang, Lipton, Li, Smola, "Dive into Deep Learning", Cambridge University Press, 2023. https://d2l.ai/ The following can also be useful: Chollet, "Deep Learning with Python", Manning Publications, 2017.

**Grading**:

| | |
|---|---|
| **Attendance to the Q&A Sessions** | 5% |
| **Quizzes** | 10% |
| **Assignments with Exams (x 2)** | 30% |
| **Midterm Exam** | 20% |
| **Final Exam** | 35% |

**Warnings**

(1) Participating in the final exam is subject to the following conditions: (i) Attending 60% of the quizzes and 60% of the Q&A sessions. (ii) Completing half of the given assignments. (iii) Participating in the Midterm Exam. Not satisfying them will result NA as the grade, implying being ineligible for a resit exam from the course.

(2) The use of Generative AI tools is strictly forbidden (see also the next page).

**Tentative Schedule**:

| Week | & Date | Topic |
|---|---|---|
| 1 | 17 Feb | **Mathematical foundations for deep learning** [Linear algebra, differentiation, probability/statistics] |
| 2 | 24 Feb | **Fundamental concepts in machine learning** [Supervised, unsupervised, self-supervised, reinforcement, continual, meta learning. Classification vs. regression. Issues in machine learning: Hypothesis space, bias/variance tradeoff, overfitting, generalization] |
| 3 | 3 Mar | **Introduction to neuron models** [History of artificial neuron models; perceptron learning; linear classification/regression] |
| 4 | 10 Mar | **Gradient descent and its alternatives** |
| 5 | 17 Mar | **Multi-layer perceptrons (MLPs)** [Activation functions; model architecture; forward pass] |
| 6 | 24 Mar | **Multi-layer perceptrons (MLPs)** [Backpropagation] |
| 7 | 31 Mar | **Multi-layer perceptrons (MLPs)** [Weight initialization, input preprocessing, batch normalization, convergence, representational capacity] |
| 8 | 7 April | *Midterm Exam [Tentative]* |
| 9 | 14 Apr | **Convolutional neural networks (CNNs)** [Problems with MLPs and motivation for CNNs. Different operations in CNNs. Designing a CNN architecture] |
| 10 | 21 Apr | **Convolutional neural networks (CNNs)** [Types of convolution (shared/unshared, deformable, separable, group). Backpropagation in CNNs] |
| 11 | 28 Apr | **Convolutional neural networks (CNNs)** [Popular CNN architectures: LeNet, AlexNet, GoogleNet, VGG, ResNet, ResNext, DenseNet, ConvNext. Visualizing and understanding CNNs] |
| 12 | 5 May | **Recurrent neural networks (RNNs)** [Time-series/sequence modeling. Unfolding feedback connections. Backpropagation through time] |
| 13 | 12 May | **Recurrent neural networks (RNNs)** [Vanishing & exploding gradients. Long Short Term Memory and its variations] |
| 14 | 19 May | **Recent Advances** [Self-attention, transformers, foundation models] |
| 15 | 26 May | **Recent Advances** [Self-attention, transformers, foundation models] |

**Professionalism and Ethics**

Students are expected to complete the assignments/exams on their own. Sharing your work with others, uploading the assignment/exam questions to the online websites for seeking solutions, and/or presenting someone else's work/solution as your own work will be considered cheating. In addition, using generative AI tools to generate solutions and/or presenting generative AI solutions as one's original work will also be considered cheating. For a comprehensive cheating definition, please refer to: https://ncc.metu.edu.tr/res/academic-code-of-ethics

When a breach of the code of ethics occurs (cheating, plagiarism, deception, etc.), the student will be added to the BLACK list, and the instructor can apply one of the following:

1. Perform an oral or written test for the students to confirm their knowledge and assess their grades. If the follow-up exam (oral/written) results in failure, the instructor can apply one of the other items below.
2. Give a "zero" grade directly for the relevant exam/assignment,
3. Give a "zero" grade for a larger part or all of the assignments,
4. Give a failing letter grade for the course,
5. Forward the case to the discipline committee.

**Makeup Exam Policy**

There will be no makeup exams unless the student has a valid medical leave approved by the METU NCC Health Center. Students who provide a valid medical leave approved by the METU NCC Health Center will be eligible for a makeup examination, subject to the following regulations:

1. There will be a single makeup exam.
2. The makeup examination will be conducted after the final exams at the end of the semester.
3. The makeup examination will be comprehensive and can cover all topics addressed throughout the semester, regardless of the specific exam missed (e.g., quizzes, midterm, final).
4. The grade obtained in the comprehensive makeup examination will replace the grade of the missed assessment.
5. In the unlikely cases where a student missed multiple exams with valid medical documentation, the grade of the makeup exam will replace
   the grades of all the missed elements.