Foundations of Applied Deep Learning (Fall)

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TA: TBA (TBA)

Description

Introduction to the foundations of data-driven modeling through artificial neural networks, emphasizing applications involving signal, image, sequence, and structured data. Students explore linear/logistic regression, multi-layer perceptrons (MLPs), convolutional neural networks (CNNs), recurrent neural networks (RNNs), and encoder-decoder architectures. Core training algorithms, including stochastic gradient descent, Adam and techniques such as initialization, regularization, and data augmentation strategies are examined in depth. Hands-on assignments use real-world datasets from scientific, engineering, and financial domains, through which students can understand and evaluate model behavior, training techniques, performance trade-offs between models.

Learning goals

Understand fundamentals of artificial neural networks (ANN) and their underlying principles making them generic computing frameworks.

Build computational skills for training such networks by understanding and working with algorithms such as stochastic gradient descent, Adam, Dropout, initialization etc.

Survey ANN models that are foundational to modern deep learning methods to learn their strength, limitations and apply them to a variety of real-world applications.

Topics covered (Tentative)

Neural network fundamentals and feed-forward networks

(W1) Model and Data / Neural Network Fundamentals
(W2) Logistic Regression / Training NNs with Back-propagation and Gradient Descent
(W3) Techniques for Deep Learning Optimizations

Convolutional neural network models

(W4) Introduction to Convolutional Neural Networks
(W5) Residual Convolutional Neural Networks

Sequence models

(W6) Introduction to Recurrent Neural Networks
(W7) LSTM and GRU
(W8) Encoder – Decoder RNNs and Attention

Advanced techniques

(W9) Techniques for Hyperparameter Tunings

Final project

(W10) Project week (TG break)
(W11) Project presentation (Project codebase)

Class format (Tentative)

The class will meet every week where the class time will be divided into **Lectures** (Theoretical concepts) and **Lab** (Practice aspects). More information will follow on canvas.

Requirements

Theoretical aspects
Basic understanding in Multi-variable Calculus, Linear Algebra, Statistics and Probability Theory.

Practical aspects
Basic knowledge of computer science and Python programming skills.

Grading (Tentative)

Fundamental concepts (Canvas Quiz – individual, weekly): **20%**

Hands-on practice (Lab Assignment – individual, weekly): **40%**

Real-world application (Group Project – Team): **40%**

Course Materials

Theory
Lecture slides
Canvas quiz

Practice
Lab slides
Example jupyter notebook

Assignment
Lab report template jupyter notebook
