Topic 0: Course Introduction

Machine Learning or Computer Vision?

Machine Learning:

- Theory: Sample Complexity, VC Dimension and PAC learnability
- Frameworks: k-Nearest Neighbors, Decision Trees, Support Vector Machines, Neural Networks and their Architectures
- Regularization: L1-penalty, L2-penalty, Dropout, Batch Normalization
- Optimization: Gradient Descent, Momentum-based Acceleration, Adaptive Momentum (AdaM)
- Computation: Tensor Operations, Computational Graphs, Synchronous vs. Asynchronous Computation

Computer Vision:

- Transformation, Image Processing Filters
- Alignment and Homography Warping
- Segmentation
- Object Detection, Localization and Tracking
- Reconstruction
- Rendering
- Stereo Matching (3D modeling)
- Feature Detection/Matching (Edges, Lines)

What is this course about?

This course focuses on theory and implementation of deep learning (DL), and how it helped solve computer vision problems.

Organization:

- Topic 1: Fundamentals of Learning (Special Focus: Neural Networks) – 10 lect.
- Topic 2: Efficient Computation – 5 lect.
- Topic 3: Deep Learning in Computer Vision Problems – 10 lect.
- Topic 4: Trustworthy AI (Fairness, Explainability) – 5 lect.

Course Website: Click this link

Programming Language: **Python** (with PyTorch and Tensorflow)

Note: Course offered in-person as well as in distance-mode. However, students registered for in-person lectures are expected to attend the class physically.

What is this course not about?

This course is not about traditional machine learning (ML) techniques.

(e.g. Decision Trees, Support Vector Machines, typically found in Scikit-Learn)

This course is not about traditional computer vision (CV) techniques.

(e.g. image-processing based filters provided by OpenCV, ITK, SimpleITK packages)

This course is not about neural network architectures that are not frequently used to computer vision problems.

(e.g. Recurrent Neural Networks, LSTMs, Attention)

Necessary Prerequisites

Strong background in

- Probability Theory (Graduate level)
- Linear Algebra
- Machine Learning

Beneficial, if you also have background in

- Real and Functional Analysis
- Convex Optimization
- Introduction to Deep Learning
- Introduction to Computer Vision

Assignments and Grading

One assignment per topic: Mix of theoretical and practical questions

- Each homework can be compared to a project-like effort (3-4 weeks of effort)
- Please start working on them from the first day with diligence.
- All assignments to be submitted via Gitlab.
- You may need to use **Google Colaboratory** and/or **Amazon's SageMaker Studio Lab**. Open an account today!

Reading assignments:

- There is no one textbook. Relevant reference books and peer-reviewed papers will be provided via course website.
- DRM-free electronic copies will be made available on the course website, and links to relevant/important papers will also be provided.

Grading Policy:

Assignment 1:	25% of total grade
Assignment 2:	25% of total grade
Assignment 3:	25% of total grade
Assignment 4:	25% of total grade
Final Grade:	$[85-100]$: A, $[70-85)$: B, $[55-70)$: C, <55: F

Office Hours and Contingency Plan

Office Hours:

- **Location:** CS 325
- **Time:** Friday 3pm - 4pm

COVID-19 Contingency Plan:

- In-person attendees are strongly encouraged to attend with a face covering
- Maintain as much distancing as possible. We have a large classroom.
- Distance students are strongly encouraged to turn-on videos for better class participation.
- Kindly get vaccinated against COVID-19 (Do not forget your booster shot).
- If the student/instructor exhibits symptoms, they will attend the class online. All others should attend the class in-person.
- In case of campus lock-down, we will switch the entire class to distance-mode.