Topic 0: Course Introduction

Machine Learning or Computer Vision?

Machine Learning (ML):

- Theory: Sample Complexity, VC Dimension and PAC learnability
- Models: k-Nearest Neighbors, Decision Trees, Support Vector Machines, Neural Networks
- 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 (CV):

- 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 design and implementation of deep learning (DL), and how it helped solve CV problems.

Organization:

- Topic 1: Learning with 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, Adversarial ML) – 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)

This course does not cover advanced state-of-the-art architectures, although they are very effective to solve computer vision problems.

(e.g. Vision Transformers, ConvNeXt)

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**, **Amazon's SageMaker Studio Lab**, and/or our own **Foundry**. 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

Instructor Office Hours and GTA Information

Instructor Office Hours:

- **Location:** CS 313 (Tentative)
- **Time:** Wednesday 1pm - 2pm

GTA Office Hours:

- **Location:** TBD
- **Time:** Friday TBD