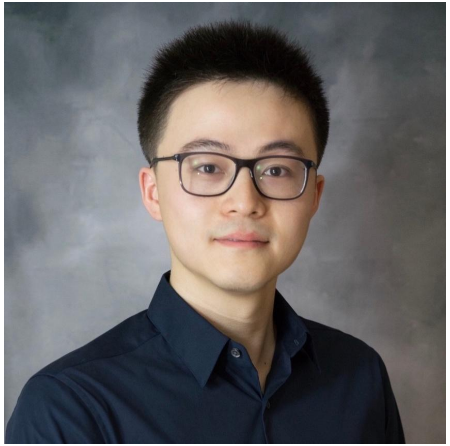
CS231n:
Deep Learning for Computer Vision

Lecture 1 - Overview

Instructors

Fei-Fei Li

Yunzhu Li



Ruohan Gao

Today's agenda

- A brief history of computer vision
- CS231n overview

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- A brief history of computer vision
- CS231n overview

CS231n overview

- Deep Learning Basics
- Perceiving and Understanding the Visual World
- Generative and Interactive Visual Intelligence
- Human-Centered Applications and Implications

Deep Learning Basics

- Image Classification: A core task in Computer Vision

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→ cat

Deep Learning Basics

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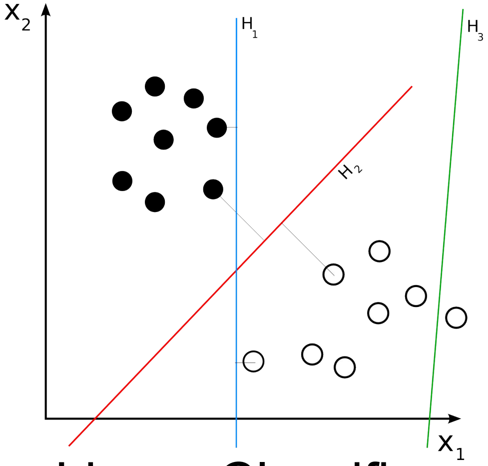
cat



Linear Classifier

Deep Learning Basics

- Image Classification: A core task in Computer Vision

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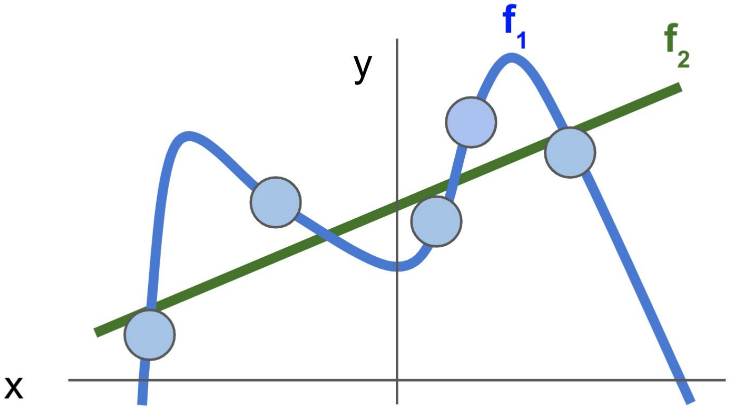

Regularization & Optimization

Deep Learning Basics

- Image Classification: A core task in Computer Vision

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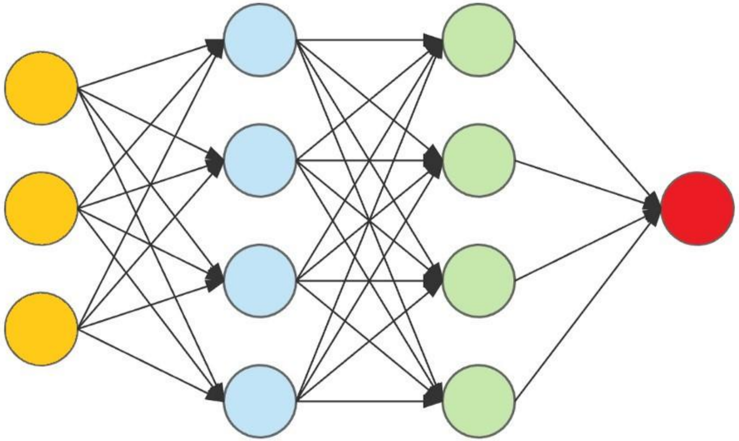

Neural Networks

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Perceiving and Understanding the Visual World

Tasks

Models

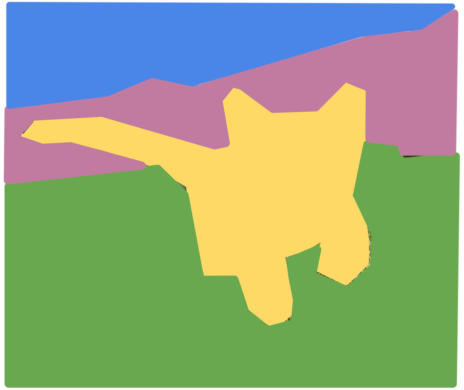
Tasks Beyond Image Classification

Classification

CAT

No spatial extent

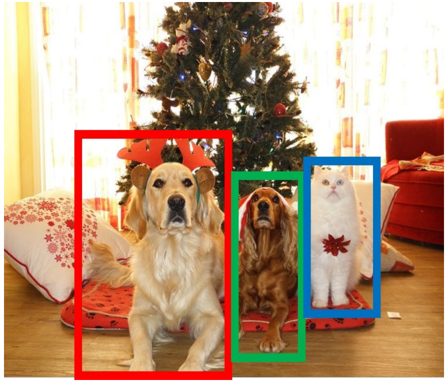
Semantic Segmentation



GRASS, CAT, TREE, SKY

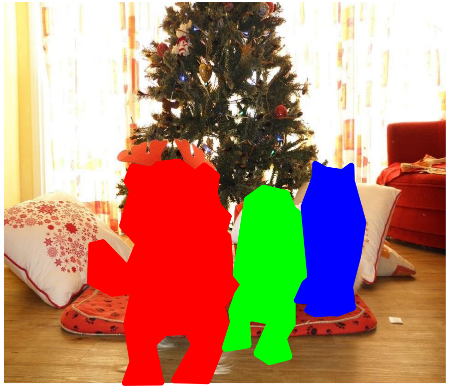
No objects, just pixels

Object Detection



DOG, DOG, CAT

Instance Segmentation



DOG, DOG, CAT

Multiple Object

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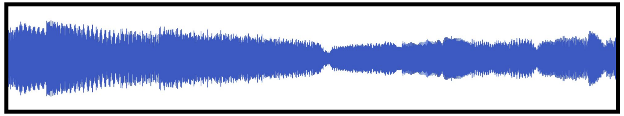
Tasks Beyond Image Classification

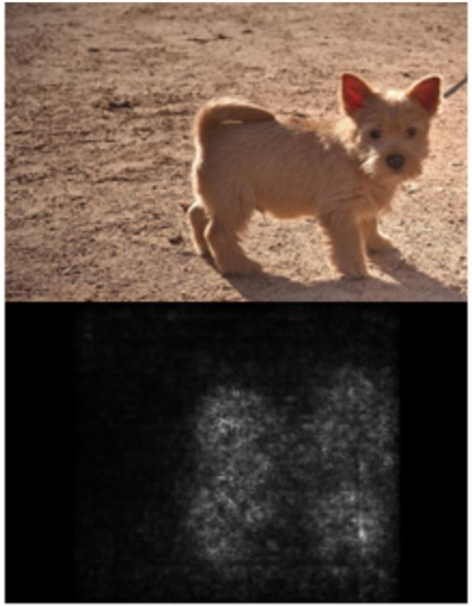
Video Classification

Running?
Jumping?

Multimodal Video Understanding



Visualization & Understanding



Models Beyond Multi-Layer Perceptron

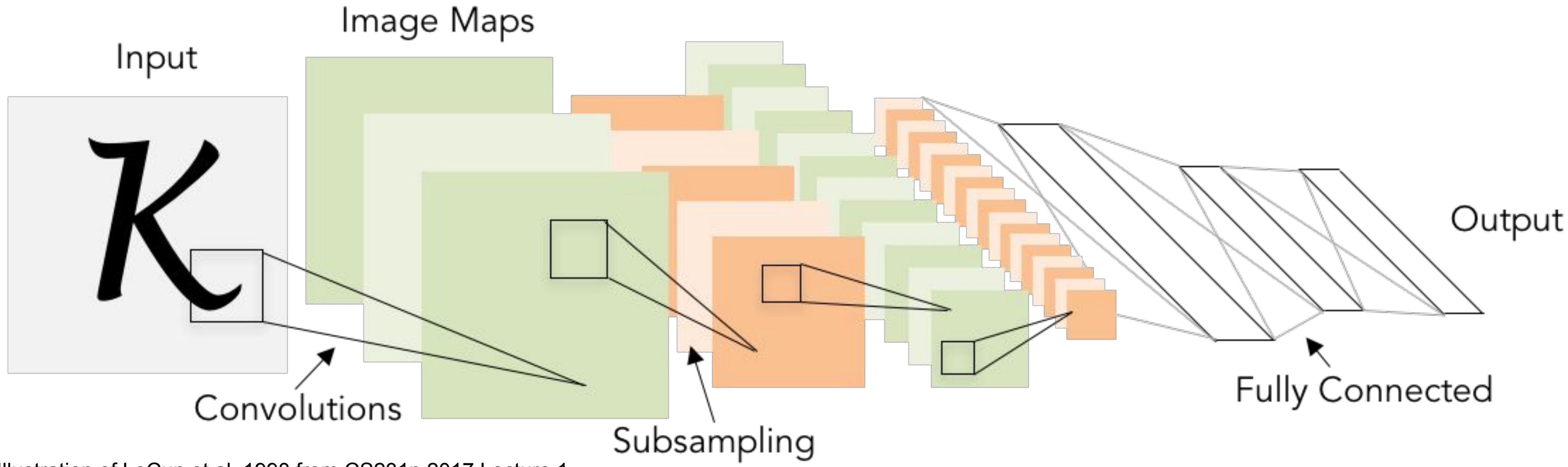
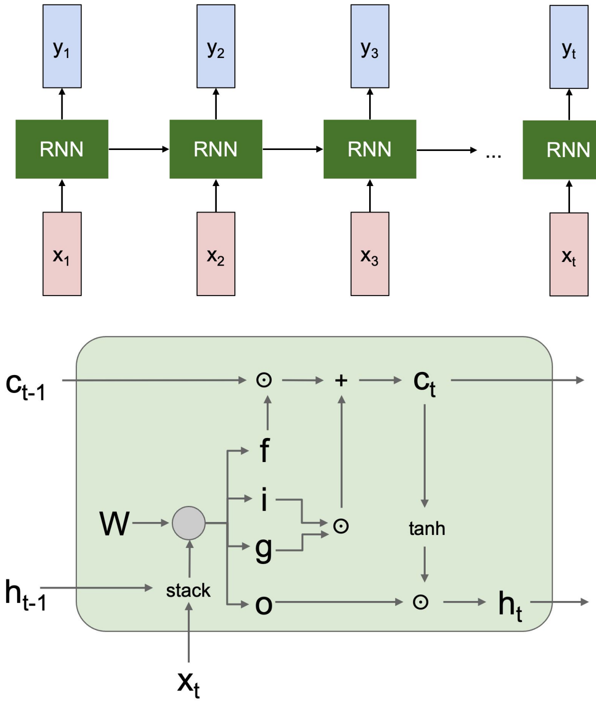


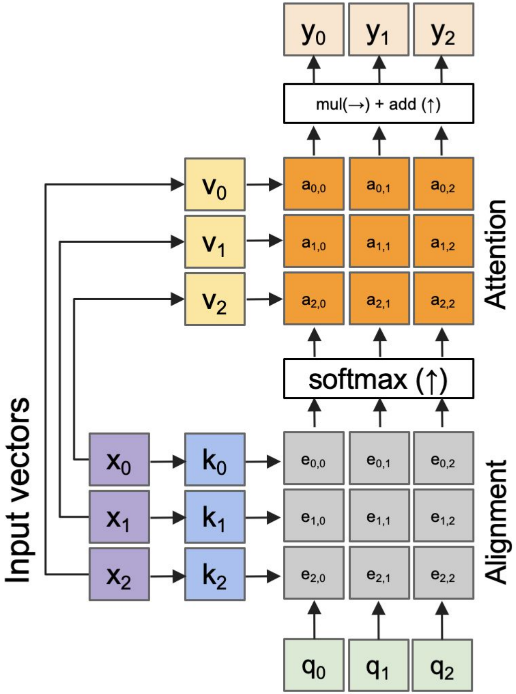
Illustration of LeCun et al. 1998 from CS231n 2017 Lecture 1

Convolutional neural network

Models Beyond Multi-Layer Perceptron



Recurrent neural network



Attention mechanism / Transformers

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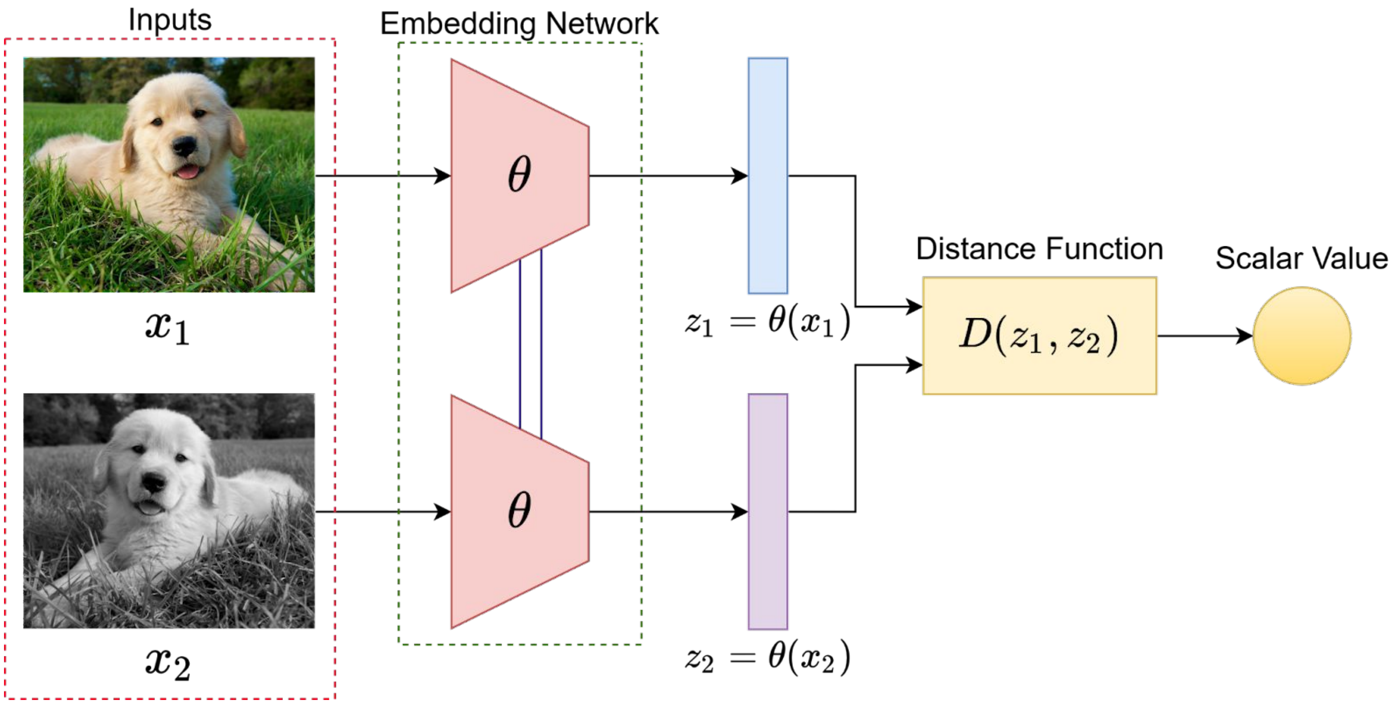
Beyond 2D Recognition

Beyond 2D Recognition: Self-supervised Learning



Beyond 2D Recognition: Generative Modeling

"Teddy bears working on new AI research underwater with 1990s technology"

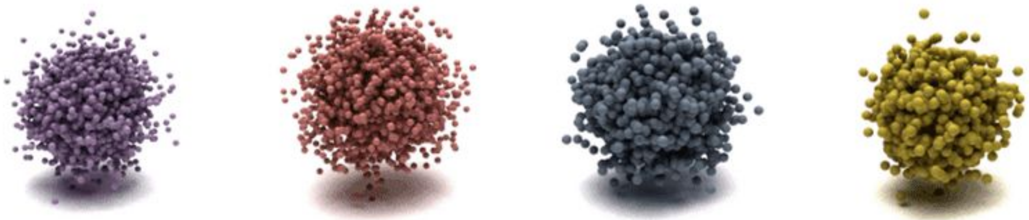
DALL-E 2

Beyond 2D Recognition: Generative Modeling

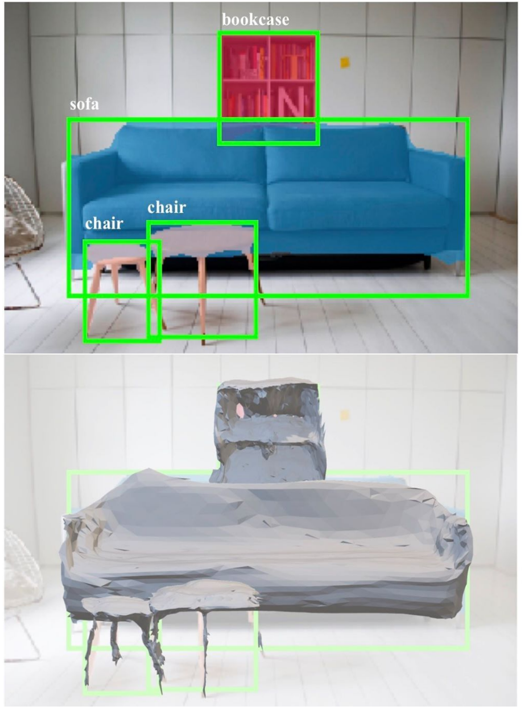
Style Transfer

Beyond 2D Recognition: 3D Vision

Choy et al., 3D-R2N2: Recurrent Reconstruction Neural Network (2016)



Zhou et al., 3D Shape Generation and Completion through Point-Voxel Diffusion (2021)



Gkioxari et al., “Mesh R-CNN”, ICCV 2019

Beyond 2D Recognition: Embodied Intelligence

Li et al., BEHAVIOR-1K: A Benchmark for Embodied AI with 1,000 Everyday Activities and Realistic Simulation (2022)

Mandlekar and Xu et al., Learning to Generalize Across Long-Horizon Tasks from Human Demonstrations (2020)

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2018 Turing Award for deep learning

most prestigious technical award, is given for major contributions of lasting importance to computing.

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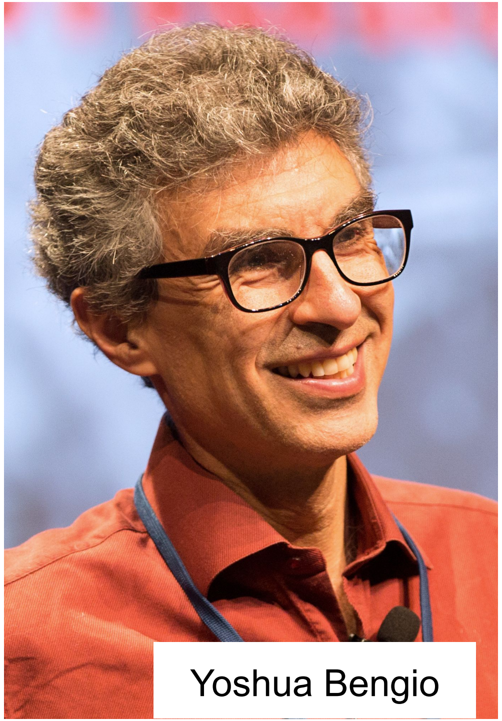

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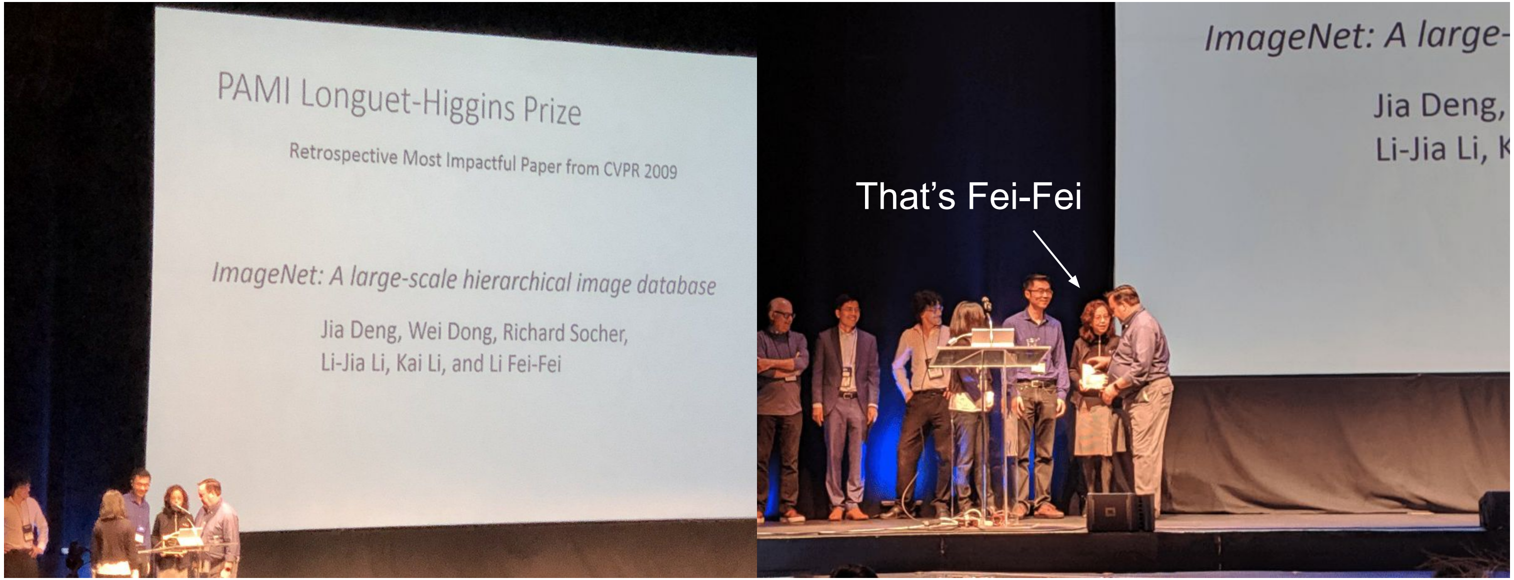
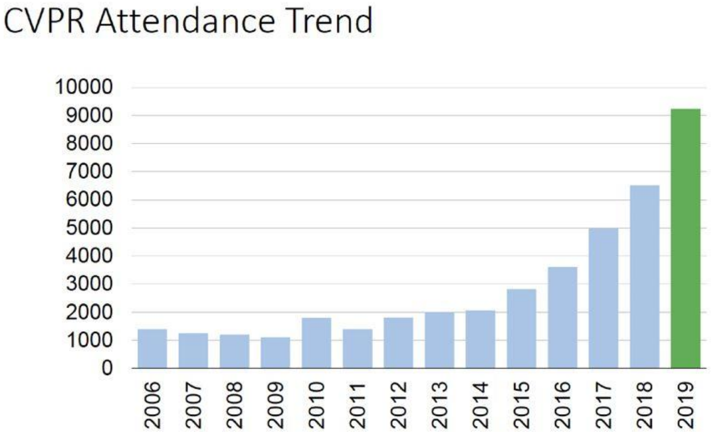
IEEE PAMI Longuet-Higgins Prize

Award recognizes ONE Computer Vision paper from **ten years ago** with **significant impact on computer vision** research.

At CVPR 2019, it was awarded to the 2009 original ImageNet paper





JUNE 18-22, 2023
CVPR
VANCOUVER, CANADA

>9k submissions, 2,360 accepted papers

Logistics

Instructors

Fei-Fei Li

Yunzhu Li

Ruohan Gao

Teaching Assistants

Ziang Liu
(Head TA)

Tanmay Agarwal

Samuel Clarke

Zane Durante

Yuan Gao

Jeff He

Hao Li

Manasi Sharma

Bokui (William) Shen

Haochen Shi

Manuka Stratta

Tiange Xiang

Course Manager

Amelie Byun

Lectures

- **Tuesdays** and **Thursdays** between **12:00 PM to 1:20 PM at NVIDIA Auditorium**
- **Lectures will not be streamed on Zoom** but will be broadcasted live via Panopto
- Slides will be posted on the course website shortly before each lecture
- All lectures will be recorded and uploaded to Canvas after the lecture under the "Panopto Course Videos" Tab.

Course website [http://cs231n.stanford.edu/] - Refresh!

CS231n Home | Course Notes | Coursework | Schedule | Office Hours | Lecture Videos | Ed

CS231n: Deep Learning for Computer Vision

Stanford - Spring 2023

Schedule

- **Lectures** will occur Tuesday/Thursday from 12:00-1:20pm Pacific Time at NVIDIA Auditorium.
- **Discussion** sections will (generally) occur on Fridays between 1:30-2:30pm Pacific Time, location TBD. Check Ed for any exceptions.

Updated lecture slides will be posted here shortly before each lecture. For ease of reading, we have color-coded the lecture category titles in blue, discussion sections (and final project poster session) in yellow, and the midterm exam in red. Note that the schedule is subject to change as the quarter progresses.

Date	Description	Course Materials	Events	Deadlines
04/04	**Lecture 1: Introduction** Computer vision overview Course overview Course logistics			
---	**Deep Learning Basics**			
04/06	**Lecture 2: Image Classification with Linear Classifiers** The data-driven approach K-nearest neighbor Linear Classifiers Algebraic / Visual / Geometric viewpoints SVM and Softmax loss	Image Classification Problem Linear Classification		
04/07	Python / Numpy Review Session	1:30-2:30pm PT	Assignment 1 out	
04/11	**Lecture 3: Regularization and Optimization** Regularization Stochastic Gradient Descent Momentum, AdaGrad, Adam Learning rate schedules	Optimization		

Friday Discussion Sections

6 Discussion sections **Fridays 1:30 PM - 2:20 PM at Thornton 102**

04/07	Python / Numpy Review Session
04/14	Backprop Review Session
04/21	Final Project Overview and Guidelines
04/28	PyTorch / TensorFlow Review Session
05/05	RNNs & Transformers
05/12	Midterm Review Session

Hands-on tutorials, with more practical details than the main lecture

Check canvas for the Zoom link of the discussion sessions!

This Friday: Python / numpy / Colab

Ed

For questions about assignments, final project, midterm, logistics, etc, use Ed!

Access: Canvas -> Deep Learning for Computer Vision -> Ed Discussion

SCPD students: Use your @stanford.edu address to register for Ed; contact scpd-customerservice@stanford.edu for help.

Office Hours

We'll be hosting both in-person and remote office hours. (starting week 2)

- Location
  - In-person: Huang basement, look for a CS231N sign
  - Remote: Zoom and QueueStatus to setup queues
    - Please see Canvas or Ed for the QueueStatus link
    - TAs will admit students to their Zoom meeting rooms for 1-1 conversations when it’s your turn using QueueStatus.
- Office hour schedule is on the course website

Overview on communication

Course Website: http://cs231n.stanford.edu/

- Syllabus, lecture slides, links to assignment downloads, etc

Ed:

- Use this for most communication with course staff
- Ask questions about homework, grading, logistics, etc
- Use private questions only if your post will violate honor code if you release publicly.

Mailing list

- cs231n-staff-spr23@cs.stanford.edu

Gradescope:

- For turning in homework and receiving grades

Canvas:

- For watching recorded lectures
- For watching recorded discussion sessions

Assignments

All assignments will be completed using Google Colab

Assignment 1: Will be out Friday 4/7, due 4/21 by 11:59 PM

- K-Nearest Neighbor
- Linear classifiers: SVM, Softmax
- Two-layer neural network
- Image features

Grading

All assignments, coding and written portions, will be submitted via Gradescope.

An **auto-grading system:**

- A consistent grading scheme
- Public tests:
  - Students see results of public tests immediately
- Private tests
  - Generalizations of the public tests to thoroughly test your implementation

Grading

3 Assignments: 10% + 20% + 15% = 45%

In-Class Midterm Exam: 20%

Course Project: 35%

- Project Proposal: 1%
- Milestone: 2%
- Final Project Report: 29%
- Poster & Poster Session: 3%

Participation Extra Credit: up to 3%

Late policy

- 4 free late days – use up to 2 late days per assignment
- Afterwards, 25% off per day late
- No late days for project report

AWS

We will have AWS Cloud credits available for projects

- Not for HWs (only for final projects)

We will be distributing credits to all enrolled students using your AWS account IDs

We will have a tutorial for walking through the AWS setup

Collaboration policy

We follow the Stanford Honor Code and the CS Department Honor Code – read them!

- **Rule 1**: Don't look at solutions or code that are not your own; everything you submit should be your own work
- **Rule 2**: Don't share your solution code with others; however discussing ideas or general strategies is fine and encouraged
- **Rule 3**: Indicate in your submissions anyone you worked with

Turning in something late / incomplete is better than violating the honor code

Prerequisites

Proficiency in Python

- All class assignments will be in Python (and use numpy)
- Later in the class, you will be using Pytorch and TensorFlow
- A Python tutorial available on course website

College Calculus, Linear Algebra

No longer need CS229 (Machine Learning)

Optional textbook resources

- *Deep Learning*
  - by Goodfellow, Bengio, and Courville
  - Here is a free version
- Mathematics of deep learning
  - Chapters 5, 6 7 are useful to understand vector calculus and continuous optimization
  - Free online version
- Dive into deep learning
  - An interactive deep learning book with code, math, and discussions, based on the NumPy interface.
  - Free online version

Learning objectives

Formalize computer vision applications into tasks

- Formalize inputs and outputs for vision-related problems
- Understand what data and computational requirements you need to train a model

Develop and train vision models

- Learn to code, debug, and train convolutional neural networks.
- Learn how to use software frameworks like PyTorch and TensorFlow

Gain an understanding of where the field is and where it is headed

- What new research has come out in the last 0-5 years?
- What are open research challenges?
- What ethical and societal considerations should we consider before deployment?

Why should you take this class?

Become a vision researcher (an incomplete list of conferences)

- Get involved with vision research at Stanford: apply using this form.
- CVPR 2022 conference
- ICCV 2021 conference

Become a vision engineer in industry (an incomplete list of industry teams)

- Perception team at Google AI, Vision at Google Cloud
- Vision at Meta AI
- Vision at Amazon AWS
- Nvidia, Tesla, Apple, Salesforce, ……

General interest

CS231n: Deep Learning for Computer Vision

- Deep Learning Basics (Lecture 2 – 4)
- Perceiving and Understanding the Visual World (Lecture 5 – 12)
- Reconstructing and Interacting with the Visual World (Lecture 13 – 16)
- Human-Centered Artificial Intelligence (Lecture 17 – 18)

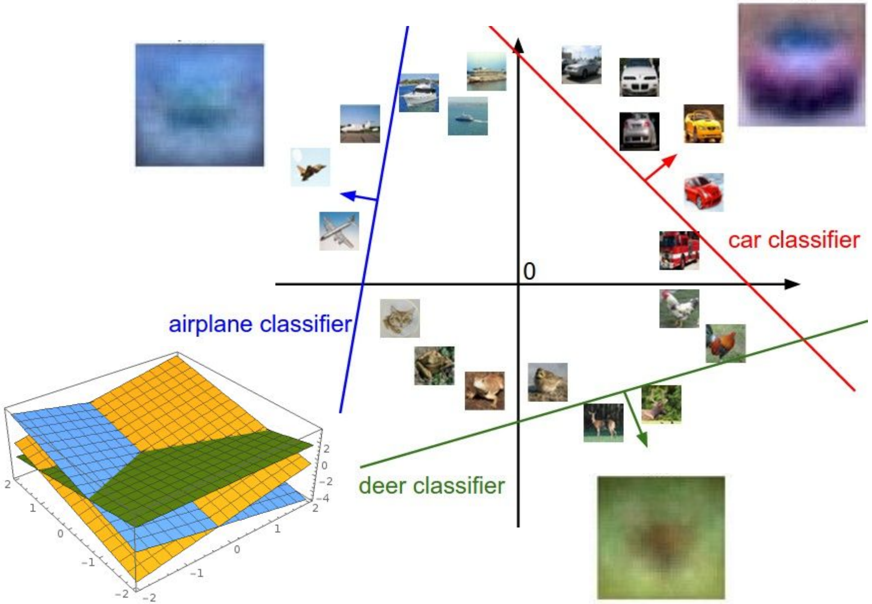
Syllabus

Deep Learning Basics	Convolutional Neural Networks	Computer Vision Applications
Data-driven learning	Convolutions	RNNs / Attention / Transformers
Linear classification & kNN	PyTorch / TensorFlow	Image captioning
Loss functions	Activation functions	Object detection and segmentation
Optimization	Batch normalization	Style transfer
Backpropagation	Transfer learning	Video understanding
Multi-layer perceptrons	Data augmentation	Generative models
Neural Networks	Momentum / RMSProp / Adam	Self-supervised learning
	Architecture design	3D vision
		Robot learning
		Human-centered AI
		Fairness & ethics

Next time: Image classification with Linear Classifiers

k- nearest neighbor

Linear classification



Plot created using [Wolfram Cloud]