CS 486/686
Introduction to Artificial Intelligence

Yuntian Deng

Lecture 1

Adapted from CS486/686 slides by  Alice Gao,  Blake VanBerlo, and  Wenhu Chen.

Upcoming: Distinguished Lecture

Prof. Kyunghyun Cho (NYU)

Tue May 26, 10:00–11:30 AM · DC 1302

kyunghyuncho.me

More on Prof. Cho later in this lecture.

Learning goals

- Meet me and your classmates.
- Get a map of the course.
- Spot AI in the wild.

Who am I?

Now	Assistant Professor, Waterloo CS · Associate, Harvard CS · Faculty Affiliate, Vector Institute
Research	Natural language processing & machine learning
Before	Postdoc at AI2 · PhD at Harvard (Rush, Shieber) · MS at CMU (Xing) · BE at Tsinghua (Zhou)

Who are the TAs?

- Liliana Hotsko (`lhotsko@`) — *Piazza*
- Bihui Jin (`b27jin@`)
- Larry Yinxi Li (`y3395li@`)
- Yuxuan Li (`y624li@`)
- Henry Lin (`h293lin@`)
- Hala Sheta (`hsheta@`)
- Dake Zhang (`d346zhan@`)

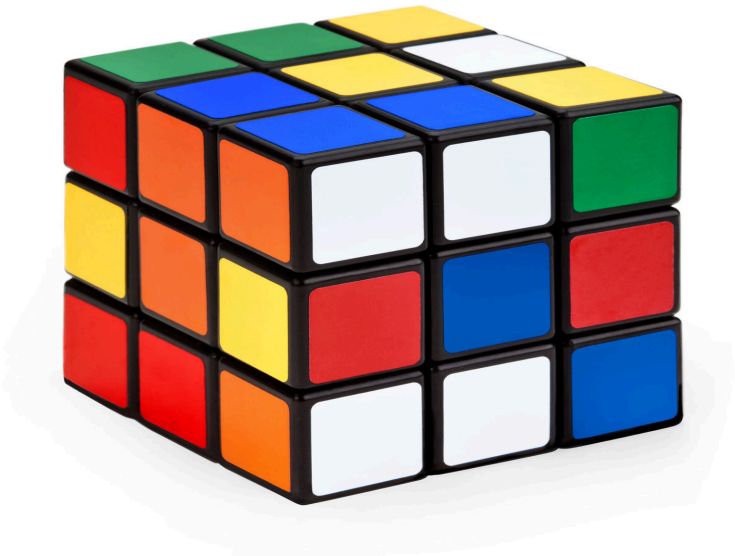
All emails end with `@uwaterloo.ca`.

Course roadmap

4 modules · 22 lectures

> ***Heads up:*** *this is classical AI. We do* ***not*** *cover LLMs, ChatGPT, or modern deep learning at scale. Full picture later in this lecture.*

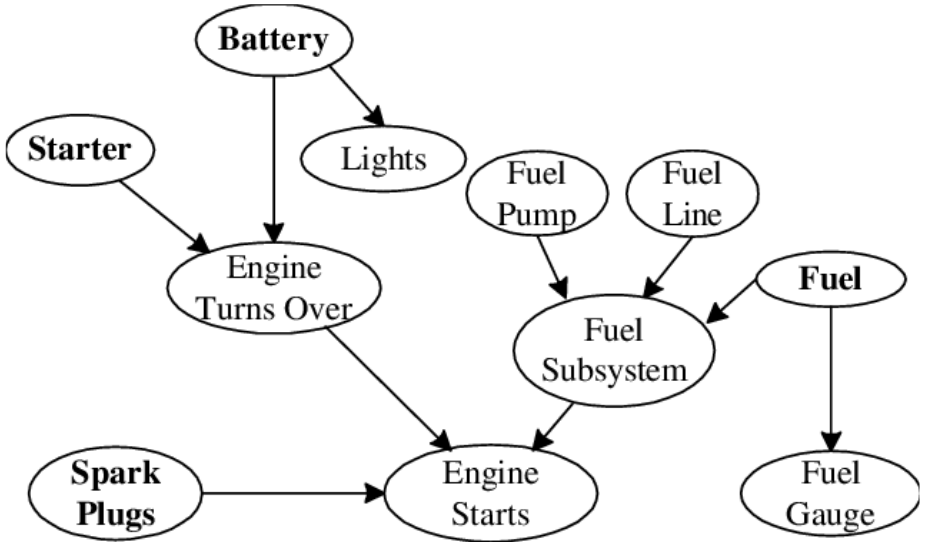
Module 1 — Search (L2–L5)



A classic search problem: 4.3×10^{19} states.

- Generic search algorithm + complexity / completeness
- Uninformed: DFS, BFS · Heuristic: A*
- Constraint satisfaction problems + arc consistency
- Local search: simulated annealing, genetic algorithms

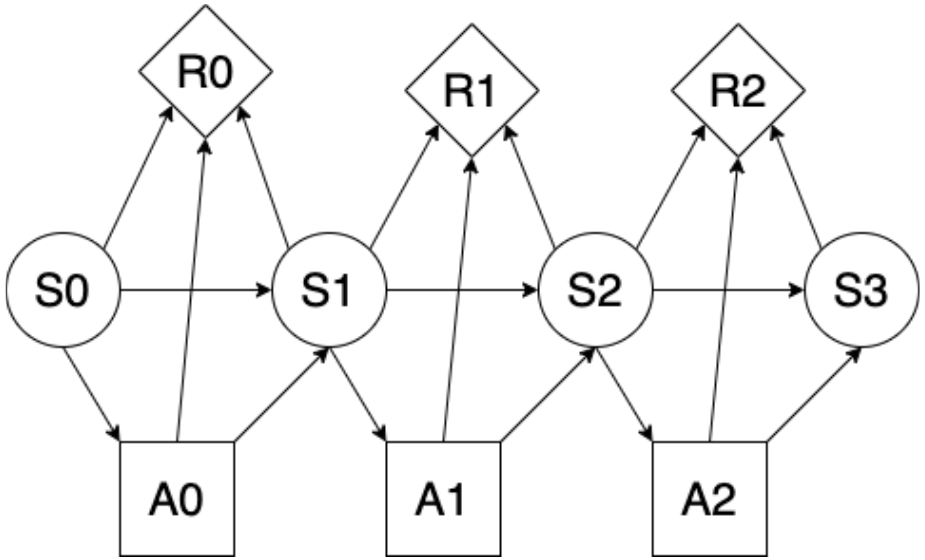
Module 2 — Reasoning under Uncertainty (L6–L11)



Car-diagnosis Bayesian network: infer hidden causes from observed evidence.

- Probability rules + independence + Bayes' rule
- Bayesian networks + D-separation
- Variable elimination for inference
- Hidden Markov Models + Forward–Backward

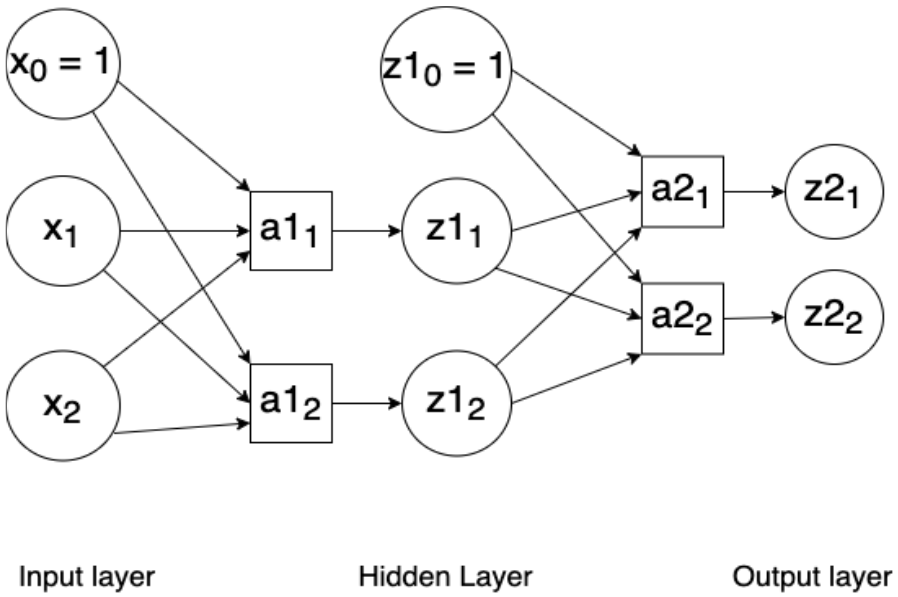
Module 3 — Decision Making (L12–L15)



States S, actions A, rewards R: a sequence of decisions under uncertainty.

- Decision theory: actions, utility, expected utility
- MDPs: making a sequence of decisions under uncertainty
- Value iteration for optimal policies
- Reinforcement learning: TD learning + Q-learning

Module 4 — Machine Learning and Deep Learning (L16–L21)



A 2-layer feedforward neural network.

- Supervised vs. unsupervised · bias–variance trade-off
- Unsupervised: k-means clustering
- Decision trees
- Neural networks + backpropagation

Course website

bit.ly/cs486

Bookmark it — everything lives here.

Getting help

- **Office hours** — 6 TAs across the week (see next slide).
- **Piazza** — public posts for course content, private posts for personal issues. We aim to reply within ~2 business days.
- **Email** — only for confidential matters.

Office hours

Start the week of May 18. Zoom links one-click on the course website.

Day	Time	TA	Where
Mon	1:00–2:00 PM	Larry Yinxi Li	Zoom
Mon	2:00–3:00 PM	Dake Zhang	Zoom
Mon	3:00–4:00 PM	Yuxuan Li	Zoom
Wed	1:00–2:00 PM	Hala Sheta	Zoom
Thu	10:00–11:00 AM	Henry Lin	Zoom
Fri	3:00–4:00 PM	Bihui Jin	DC 2555

Liliana Hotsko runs Piazza (no OH).

Assignments

- **3 assignments**, ~20 days each.
- Written + programming parts.
- Submit everything on **Learn**.

Chat assignments with Chrysalis

- **10 chats × 2% = 20%** of your grade.
- *Teach Chrysalis* what you learned each week by answering questions in a chat interface.
- Graded on **participation**: full marks for any genuine attempt; no penalty for wrong answers. Marks lost only for skipped or low-effort answers.
- Sign up at **andromeda-208.cs.uwaterloo.ca** with your WatIAM @uwaterloo.ca email. Full instructions on the course page.

Project

- **CS 686:** required (30% of grade).
- **CS 486:** optional (+10% bonus).
- Individual or groups up to 3.
- Topic open: RL, vision, NLP, biomedical, etc. — not a public-GitHub clone.
- Proposal mid-term; final report after the exam.

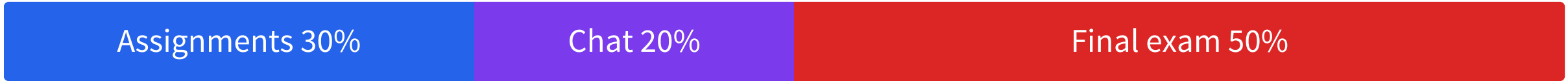
Free GPUs: Google Colab · Math Faculty Teaching GPU Cluster

Final exam

- 2.5 hours, date/time TBA.
- No makeup exam.
- CS 486 students must pass the exam to pass the course.
- Covers all course material.

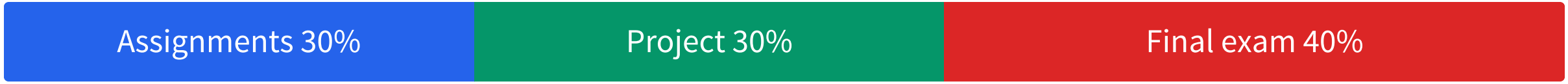
Score breakdown

CS 486



+ Optional project: **10% bonus**.

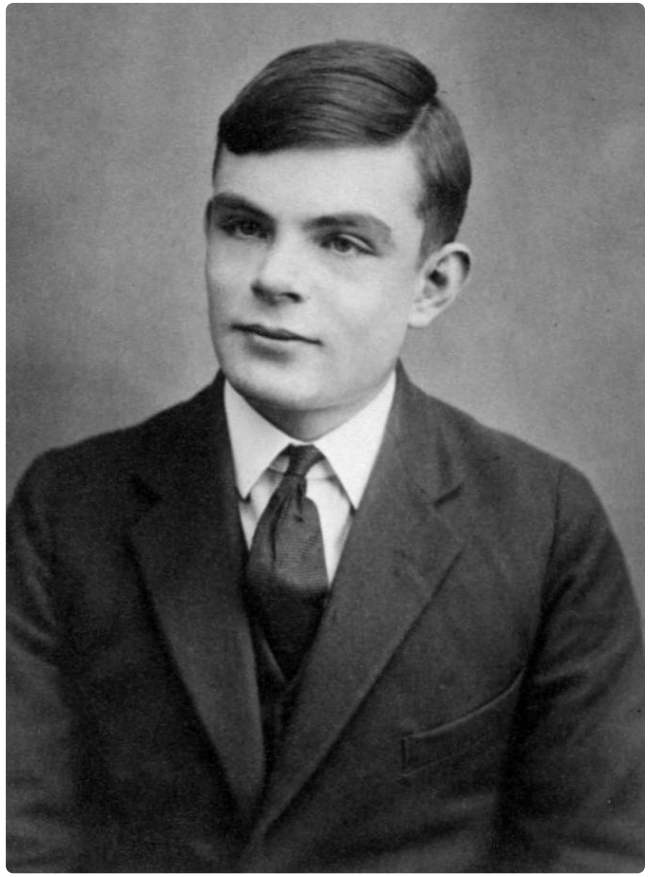
CS 686



The goal of AI

- Sense, comprehend, act, and learn.
- Use computation to solve hard problems.
- Not limited to biology-inspired methods.

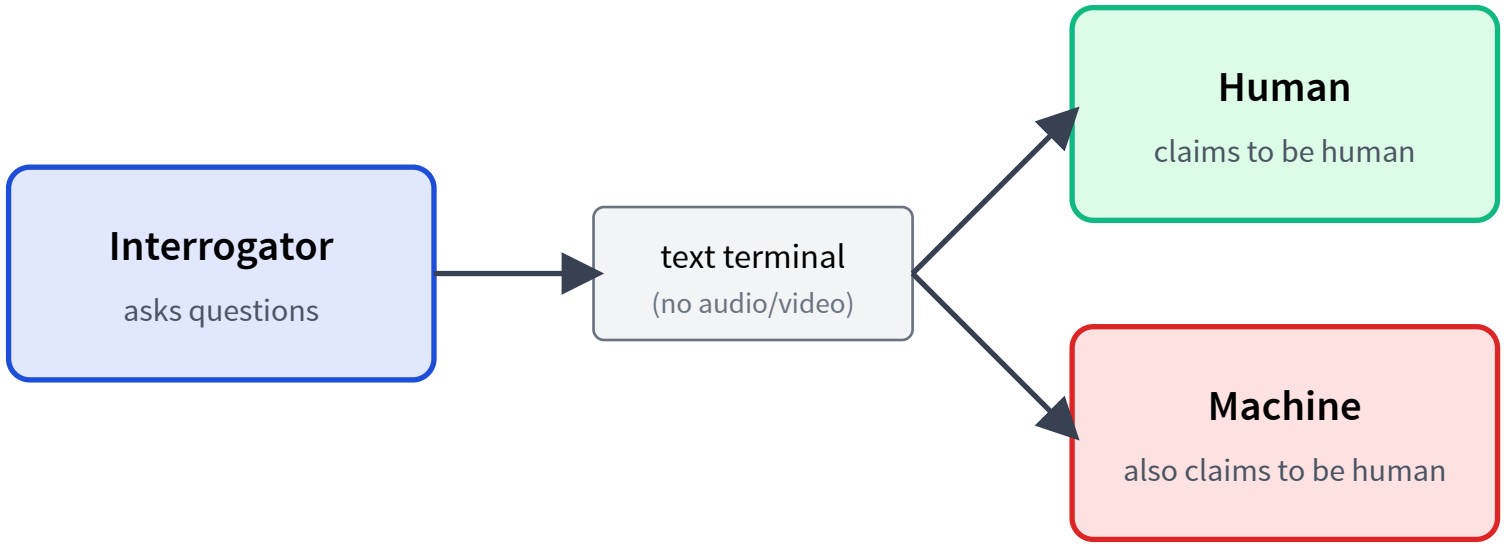
Birth of AI



Alan Turing, c. 1928

- **Alan Turing** (1912–1954): WW2 codebreaker; asked *"Can machines think?"*; proposed the imitation game.
- **Dartmouth, 1956:** John McCarthy coins the term *artificial intelligence*.
- McCarthy also invents **Lisp**.

The Turing Test



If the machine fools the interrogator, it "passes" the Turing Test.

ELIZA — pattern matching that "fooled" people (Weizenbaum, 1966)

```
ME: Hi
ELIZA: How do you do? What brings you to see me?
ME: I'm thinking of taking a course in artificial intelligence.
ELIZA: Why do you say that?
ME: I'm worried about it
ELIZA: Are you worried often?
ME: when I take AI courses
ELIZA: What happened when you take ai courses?
ME: I usually spend long nights doing assignments
ELIZA: Earlier you said you felt worried?
ME: about AI courses
ELIZA: Maybe your plans have something to do with this.
ME: no
ELIZA: Why not?
ME: because I think you are a computer
ELIZA: Is it because you think I am a computer that you came to me?
```

Loebner Prize — the Turing-Test competition, 1990–2019

- Annual Turing-style contest, launched by Hugh Loebner.
- Grand prizes ($25K text-only / $100K text + audio + video) **never awarded**.
- Replaced today by modern LLM evaluations.

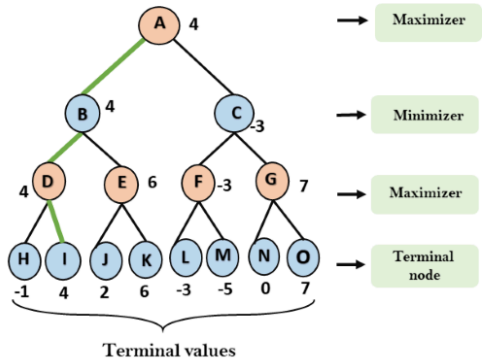
```
CONFEDERATE: Hello, my name is Sam and I am the human
JUDGE: Hi Sam, tell me which is larger, a TV screen or Belgium.
CONFEDERATE: Belgium is a little bit larger.
JUDGE: Wljso lwjejdo wleje elwjeo wjeol, isn't it?
CONFEDERATE: Is that Polish?
JUDGE: Which is further away from this apartment, Queens or the Queen of England?
CONFEDERATE: If the Queen is visiting Manhattan, she is closer.
```

SHRDLU — Winograd, 1968

- First system that linked language to a (virtual) physical world.
- Tiny domain: a "blocks world".

```
Pick up a big red block
OK
Grasp the pyramid
I DON'T UNDERSTAND WHICH PYRAMID YOU MEAN
What does the box contain?
THE BLUE PYRAMID AND THE BLUE BLOCK.
What is the pyramid supported by?
THE BOX.
How many blocks are not in the box?
FOUR OF THEM
```

Games as an AI testbed



- Min–max: one player maximizes, the other minimizes.
- **Game playing = search over states.**

Chess — Deep Blue, 1997

- ~10^{100} game-tree states.
- **1997:** IBM Deep Blue defeats Garry Kasparov, 3.5–2.5.
- Method: deep lookahead + handcrafted evaluation.

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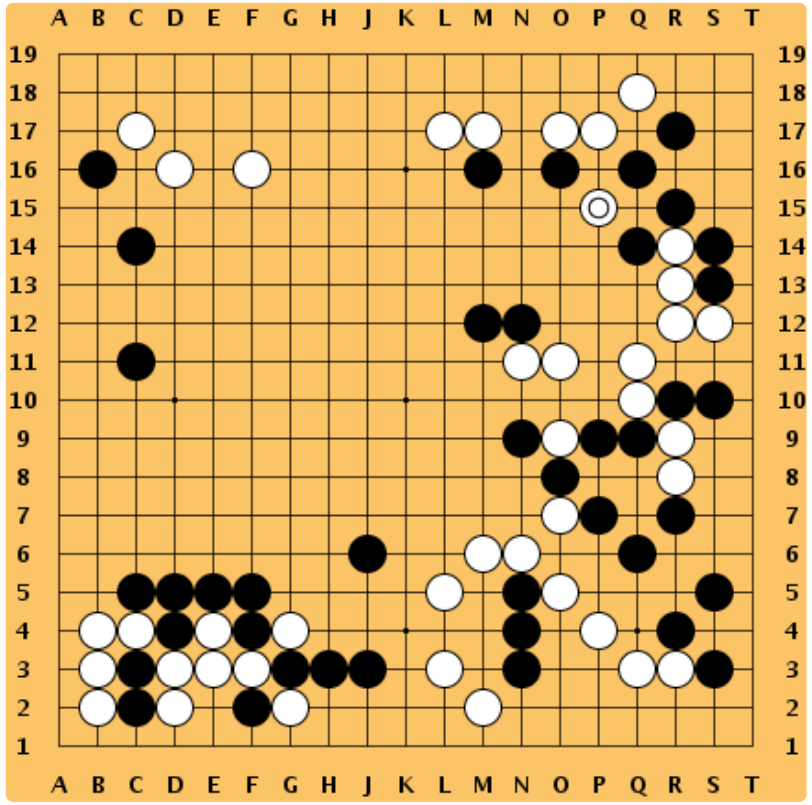
20 years after Deep Blue (Scientific American)

Go — AlphaGo, 2016



- ~10^{360} states — far beyond brute-force search.
- **2016:** AlphaGo (DeepMind) defeats Lee Sedol 4–1.
- Recipe: Monte-Carlo tree search + value net + policy net + self-play.

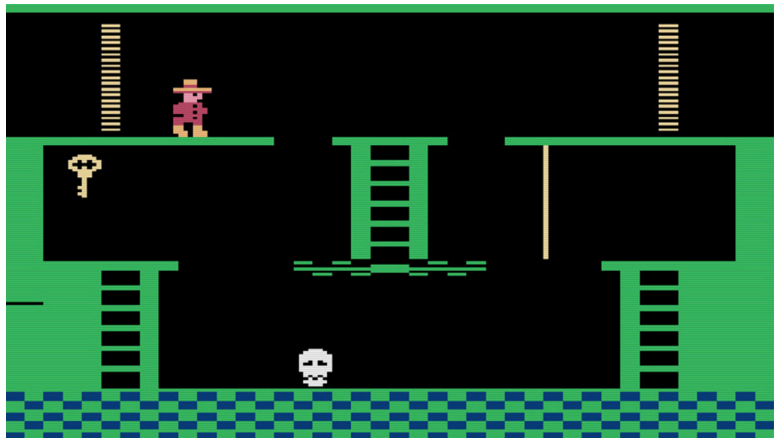
Silver et al., 2016 — Mastering the game of Go with deep neural networks and tree search (Nature 529).

Poker

- Hidden information + opponent modeling + long-term reward.
- **2015:** heads-up limit hold'em *solved*.
- **2019:** superhuman 6-player no-limit poker.

Bowling et al., 2015 (Science 347) · Brown & Sandholm, 2019 (Science 365).

Atari games



- End-to-end RL on raw pixels — CNN + Q-learning.
- Beat humans on 3 / 7 Atari 2600 games tested.
- The starting point for modern deep RL.

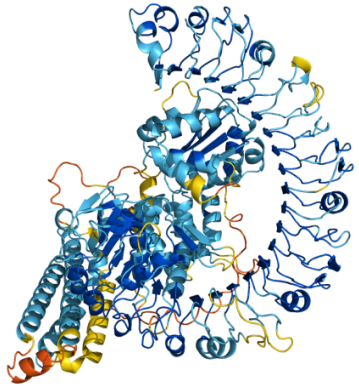
Mnih et al., 2013 — Playing Atari with Deep Reinforcement Learning.

StarCraft II — AlphaStar, 2019

- Multi-agent, imperfect information, huge action space.
- Grandmaster level via multi-agent RL + league self-play.

Vinyals et al., 2019 (Nature 575) · demo video.

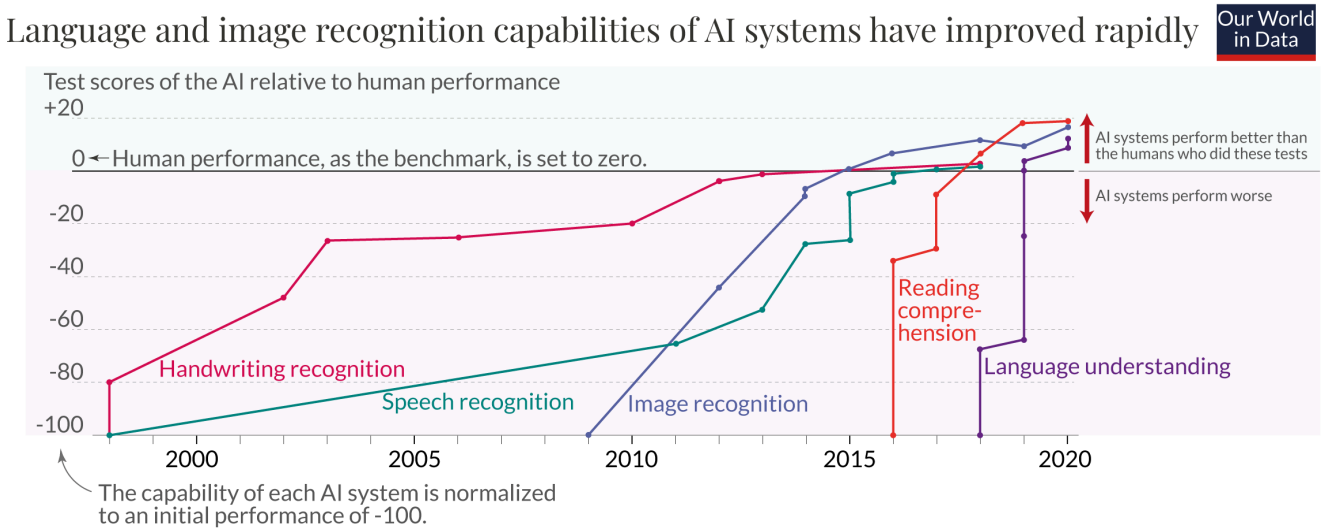
AlphaFold — protein structure



- Predicts 3D protein structure from sequence.
- EvoFormer architecture + Protein Data Bank training.
- Reduced months-to-years of lab work to minutes.

Jumper et al., 2021 — Highly accurate protein structure prediction with AlphaFold.

The deep learning era



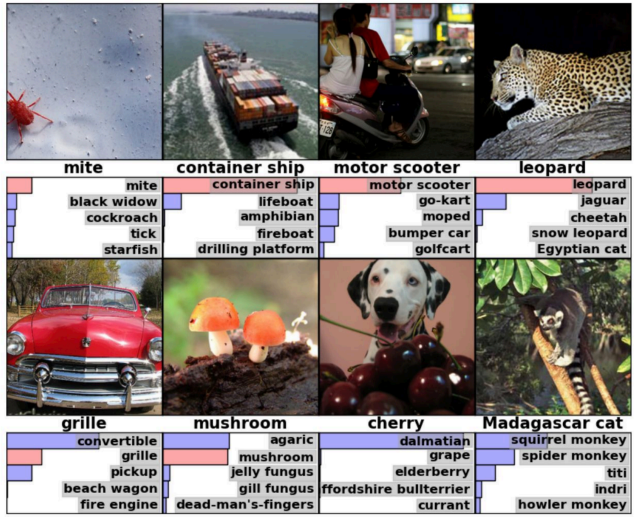
- Pre-2012: SVMs, decision trees, boosting.
- **2012:** AlexNet on ImageNet → deep learning takes off.
- AI has surpassed humans on classic benchmarks; harder ones (GPQA, SWE-bench, ARC-AGI) still rising fast.

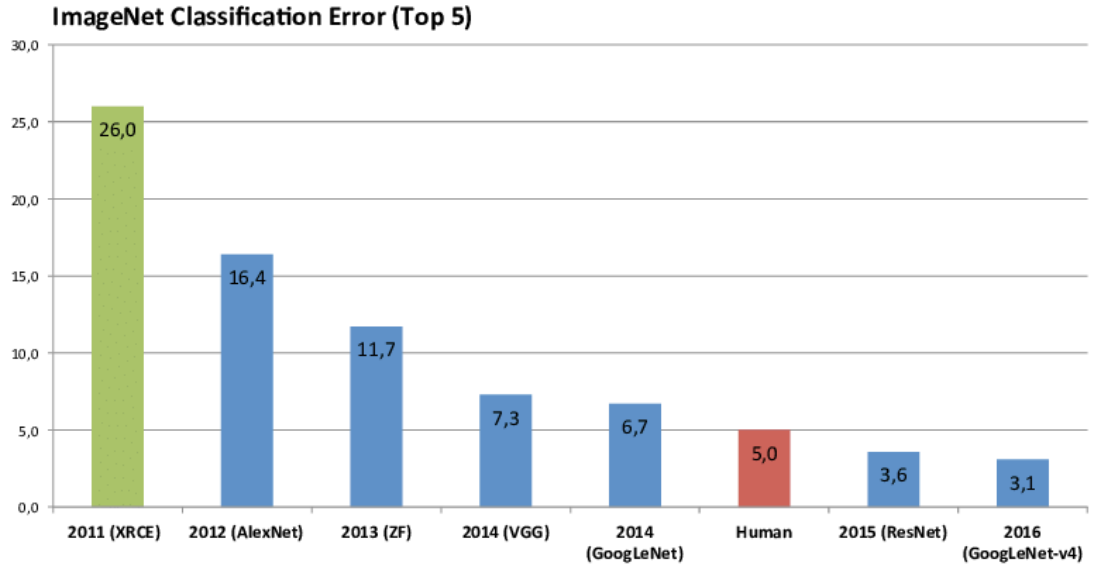
ImageNet — the spark

ImageNet Challenge

IMAGENET

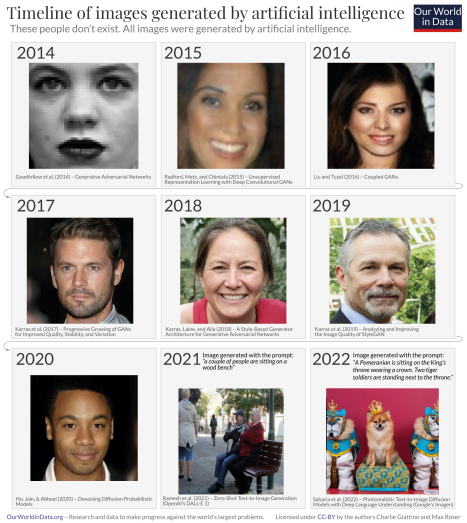
- 1,000 object classes (categories).
- Images:
  - 1.2 M train
  - 100k test.





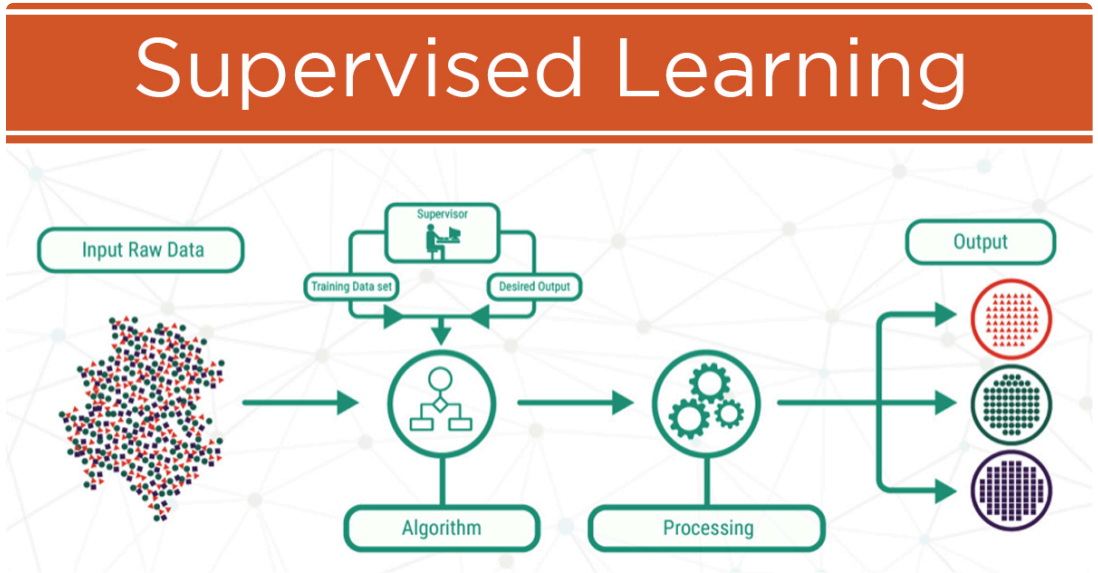
1000-class image classification. The curve was flat — then **AlexNet (2012)** arrived. Today: essentially solved.

Image generation

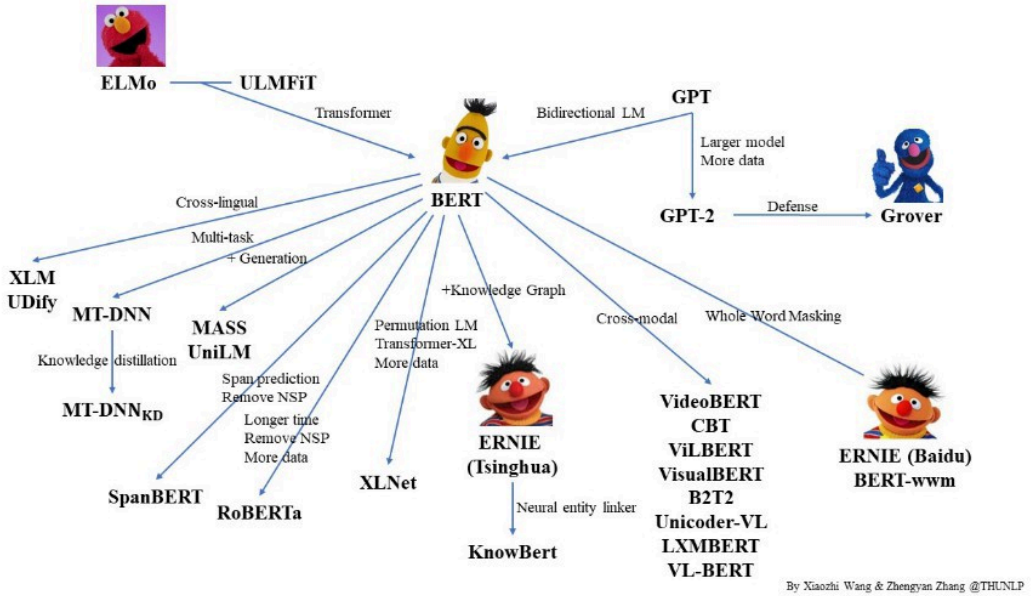


A decade of AI-generated faces.

Supervised vs. self-supervised



Supervised: humans label data.



Self-supervised: model predicts parts of unlabeled data.

Large language models — 2026 frontier

- From GPT-3 (2020) and ChatGPT (2022) to today's **GPT-5.5**, **Claude Opus 4.7**, **Gemini 3.1 Pro**.
- Strong open-weight competitors: **Llama 4**, **DeepSeek V4**, **Qwen 3.6**, **GLM-5.1**.
- Mixture-of-Experts is standard; closed labs no longer publish parameter counts.

Best AI Models, April 2026 (buildfastwithai.com)

What today's LLMs can do

Reasoning

"Thinking" models trade inference compute for hard math, science, coding (o-series, DeepSeek-R1).

Long context

1M+ token windows — whole codebases or books in a single prompt.

Multimodal

Text, images, audio, video in one model.

Agentic tool use

Calls tools, browses, executes code over long horizons (MCP, Claude Code, agent modes).

What this course IS (and is NOT)

IS — Classical AI (~1970s–2000s)

- Search (DFS, BFS, A*, CSPs, local search)
- Probabilistic reasoning (Bayes nets, HMMs, variable elimination)
- Decision-making under uncertainty (MDPs, value iteration, basic RL)
- Foundations of ML (decision trees, basic neural nets, backprop)

IS NOT — Modern AI

- Training / building LLMs (GPT, Claude, Gemini)
- Prompt engineering or agentic LLM applications
- Modern deep learning at scale (transformers, diffusion, foundation models)
- Production ML systems, GPU clusters, RAG, fine-tuning

Reality check: most empirical AI breakthroughs of the last 5 years came from *scale + deep learning*, not from the algorithms in this course. For modern AI, take **CS 480 / 680**, grad NLP/ML courses, or read recent ICLR/NeurIPS papers.

Keeping up with modern AI

Most of what's happening in AI isn't in textbook. Twitter/podcasts are where the field actually communicates.

Twitter / X

Frontier labs

@AnthropicAI · @OpenAI · @GoogleDeepMind · @thinkymachines

Researchers

@karpathy (Andrej Karpathy) · @srush_nlp (Sasha Rush) · @ylecun (Yann LeCun) · @dwarkesh_sp (Dwarkesh Patel)

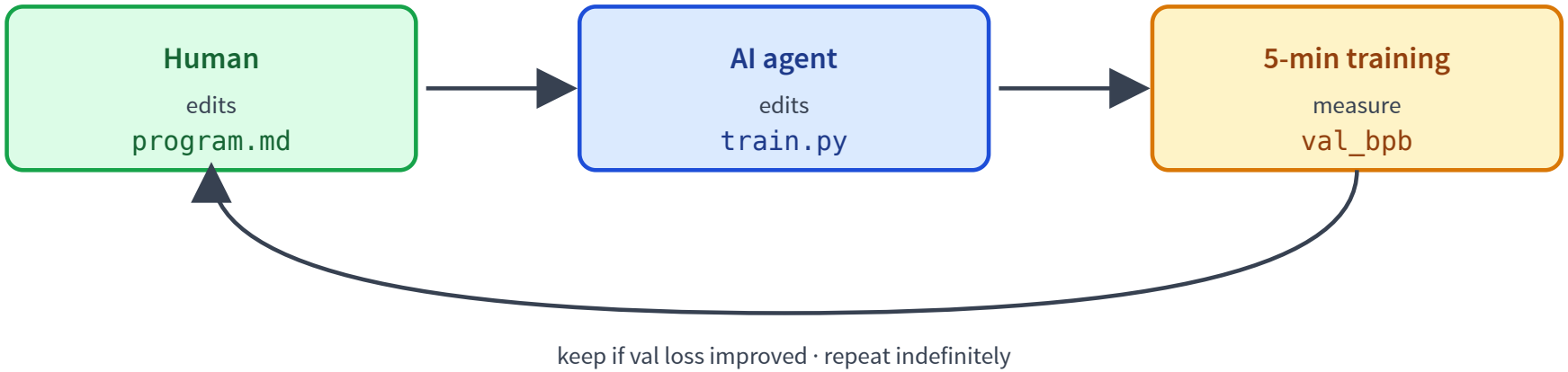
Podcasts and long-form

- Dwarkesh Podcast — long-form research interviews
- Latent Space — AI engineering and infra
- Andrej Karpathy on YouTube — "Neural Networks: Zero to Hero"

> **Or just ask the models themselves:** ChatGPT · Claude · Gemini — very good at explaining

This is how “search” is done in 2026

Karpathy's `autoresearch`, March 2026 — not the informed / uninformed search in our L2–L5 module.



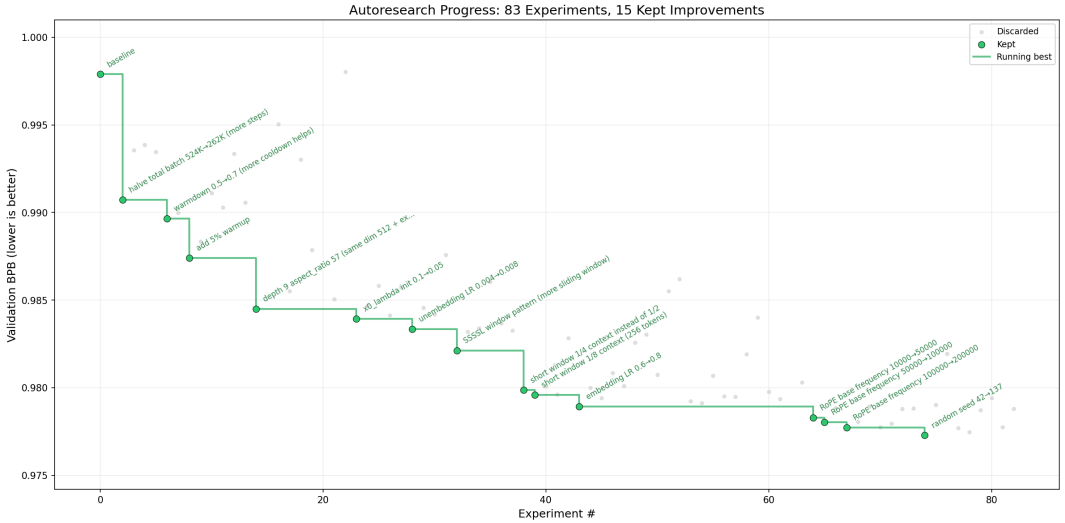
Karpathy stripped nanochat down to a single-GPU, ~630-line training repo. The agent edits `train.py`; the human only edits the prompt that drives the agent. Each training run is a fixed 5 minutes.

~12 experiments per hour. ~100 while you sleep. Winners are committed to a feature branch.

Andrej Karpathy. `autoresearch`, March 2026. Announcement: x.com/karpathy/status/2030371219518931079.

What an overnight autoresearch run looks like

Karpathy's published `progress.png` — 83 experiments, 15 kept (green). Lower validation BPB is better.

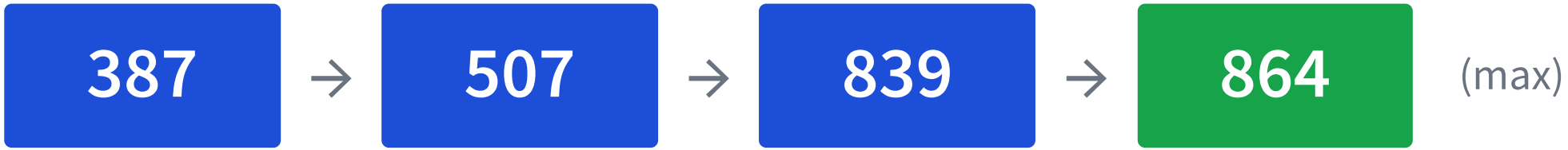


Gray dots: tried and discarded. Green dots: kept. The agent autonomously tuned batch size, warmup, warmdown, depth, window pattern, RoPE base frequency — and yes, even the random seed.

Andrej Karpathy, `autoresearch`, March 2026. Chart from the repo's `progress.png`.

My take: this is what replaces classical AI

Personal opinion. Not consensus.



Codex (OpenAI, May 2026) writes & iterates a pure-Python Breakout policy. No neural network trained.

Same recipe: MuJoCo Ant 6000+, HalfCheetah ~11,800 (Deep-RL range); Atari57 median ≈ PPO across 342 unattended runs.

> **My read:** LLM-driven code synthesis is what replaces the hand-derived classical algorithms in this course.

Jiayi Weng (OpenAI). "Learning Beyond Gradients", May 2026. Single blog post, not peer-reviewed. The framing is my personal opinion.

Distinguished Lecture: Prof. Kyunghyun Cho (NYU)

Photo: NYU Photo Bureau / Gallo

Professor of CS & Data Science at **NYU**; Co-Director of the Global Frontier AI Lab (with Yann LeCun).

Co-author of two foundational papers in modern NLP:

- The **GRU** recurrent unit (Cho et al., 2014).
- The seminal **attention mechanism** for translation (Bahdanau, Cho, Bengio, 2015) — direct ancestor of today's LLMs.

His work directly inspired my PhD.

Tue May 26, 10:00–11:30 AM · DC 1302 · kyunghyuncho.me

Learning goals (recap)

- Meet me and your classmates. ✓
- Get a map of the course. ✓
- Spot AI in the wild. ✓

Don't miss the Distinguished Lecture!

Prof. Kyunghyun Cho (NYU)

Co-inventor of attention (Bahdanau, Cho, Bengio, 2015) and the GRU

Tuesday, May 26, 2026

10:00–11:30 AM · DC 1302

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