

Neural Networks: Foundations to Generative AI

Course Logistics and Introduction

Today's Agenda

1. COURSE LOGISTICS

- Website, schedule, grading and evaluation criteria.
- Course textbook, lecture format, etc.

2. INTERESTING USE CASES

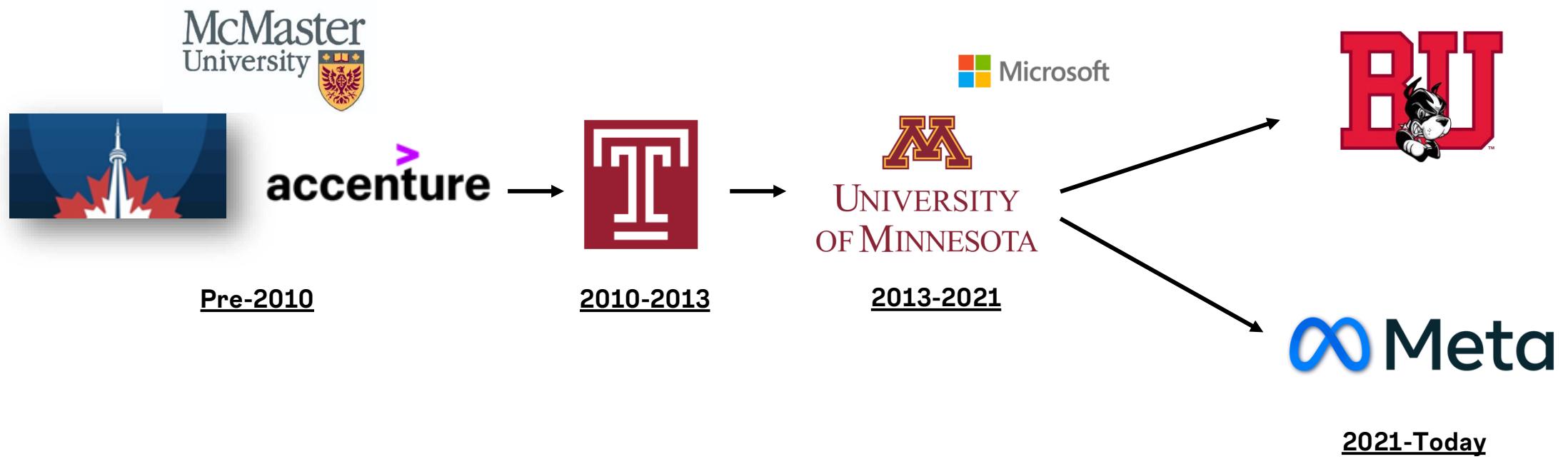
- Frivolous, academic, and practically useful.
- A recent failure, and societal concerns.

3. QUICK INTRODUCTION

- What is a neural network?
- How does it work?



My Background



TAKE CAUTION IN USING LLMs AS HUMAN SURROGATES: SCYLLA EX MACHINA*

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This Version: Jan 23th, 2025[†]

ABSTRACT

Recent studies suggest large language models (LLMs) can exhibit human-like reasoning, aligning with human behavior in economic experiments, surveys, and political discourse. This has led many to propose that LLMs can be used as surrogates or simulations for humans in social science research. However, LLMs differ fundamentally from humans, relying on probabilistic patterns, absent the embodied experiences or survival objectives that shape human cognition. We assess the reasoning depth of LLMs using the 11-20 money request game. Nearly all advanced approaches fail to replicate human behavior distributions across many models. Causes of failure are diverse and unpredictable, relating to input language, roles, and safeguarding. These results advise caution when using LLMs to study human behavior or as surrogates or simulations.

'She has twelve misshapen feet, and six necks of the most prodigious length;
 and at the end of each neck she has a frightful head with three rows of teeth in each'
 — Homer, *Odyssey* (Describing Scylla)

Introduction

Recent studies report that Large Language Models (LLMs) can exhibit human-like cognitive abilities. These studies demonstrate that LLMs show behaviors that align closely with those of human subjects in seminal experiments from behavioral economics, and responses comparable to those of humans in

[†]Previous Version: Aug 28, Oct 24, and Nov 13th 2024

*We thank seminar participants at the BU, Wharton (Sep 2024), USC, UC Irvine, and Meta. All errors are the author's own.

My Research

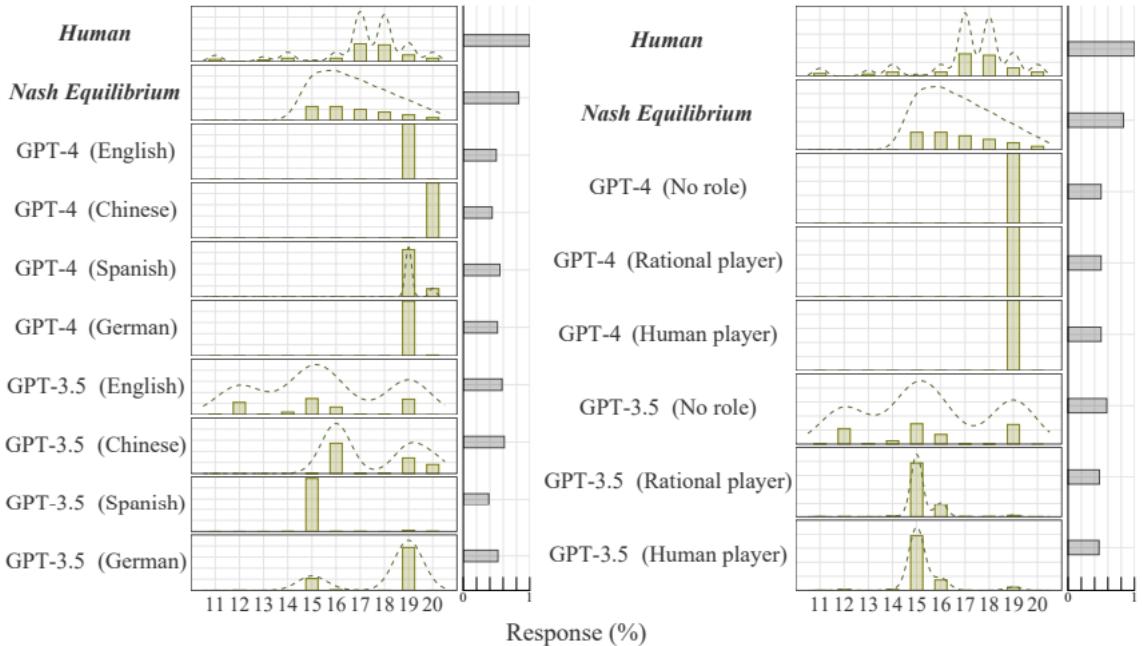
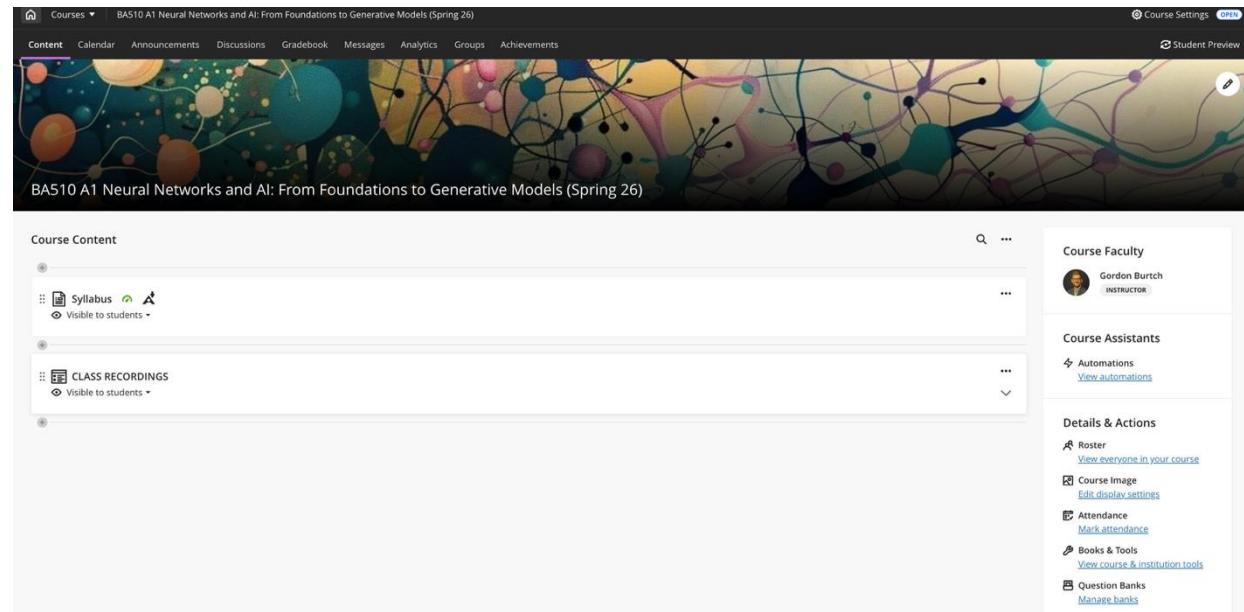


Figure 2: Prompt Brittleness: Roles and Languages. The bar chart on the right shows the similarity between the distribution of different subjects and human subjects, measured by Jensen-Shannon divergence scores. Density plots are omitted for subjects with over 98% of the data concentrated in a single choice to avoid potential misinterpretation.

Course Materials

COURSE WEBSITE

- The course website is on Blackboard – please let me know if you cannot see the site!
- You will submit all assignments and receive relevant course announcements via that site.
- I will post lecture materials and in-class exercises / examples via the GitHub Repository linked on Blackboard.



GOOGLE COLAB

- All homework and exercises in this course are to be implemented in Python. You should work in Google Colab because I cannot provide technical support if you run into issues with your local instance. For your project and individual assignment, you'll need to submit the .ipynb files that you produce in Colab.

Grading and Evaluation

PARTICIPATION / ATTENDANCE

- Regular attendance and participation will be worth 20% of your final grade.

INDIVIDUAL ASSIGNMENTS

- One individual assignment worth 15% of your final grade
- Due by 11:59pm on the date indicated in the course schedule – submit your Jupyter (Colab) Notebook file via Blackboard (submit the actual file with code, *not* a link to your notebook).
- Late submissions will result in grade deductions, per the syllabus.

CASE WRITE-UP

- We will discuss two HBS cases in class, and your submitted individual responses to case questions will be worth 15% of your final grade.

QUIZZES

- We will have 5 in-class, timed, paper and pencil, closed book / closed note quizzes. collectively worth 25% of your final grade.

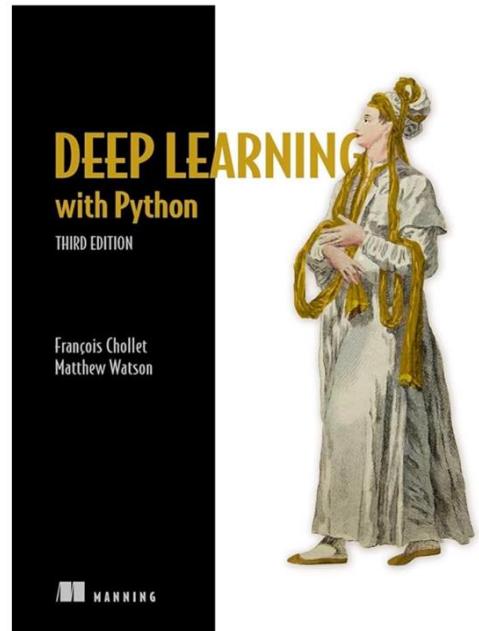
FINAL PROJECT

- The final project (worth 25% of your final grade) is a hands-on implementation driven by you.
- You will work in pairs or individually to implement a neural network-based predictive model that addresses a practical problem of interest to you! You need to identify and motivate the prediction problem (explain why it's meaningful, who it would be of value to), and then implement your model.
- Deliverables include a project proposal, a mandatory mid-point check-in meeting with me to ensure you are on track, submission of final code and slides, and a final presentation during the last week of class.

GRADE BREAKDOWN

(1) Participation	20%
(2) Individual Assignments (x1)	15%
(3) Case Write-up (x1)	15%
(4) Quizzes (x5)	25%
(5) Final Project	25%
TOTAL:	100%

Course Textbook



Chollet, François. (2025). *Deep Learning with Python (3rd Edition)*.
Manning Publications Co. **ISBN-13: 978-1633436589**.
<https://deeplearningwithpython.io>

Required Software

- You can access Google Colab at <https://colab.research.google.com>. You will want to use your BU Google account credentials!

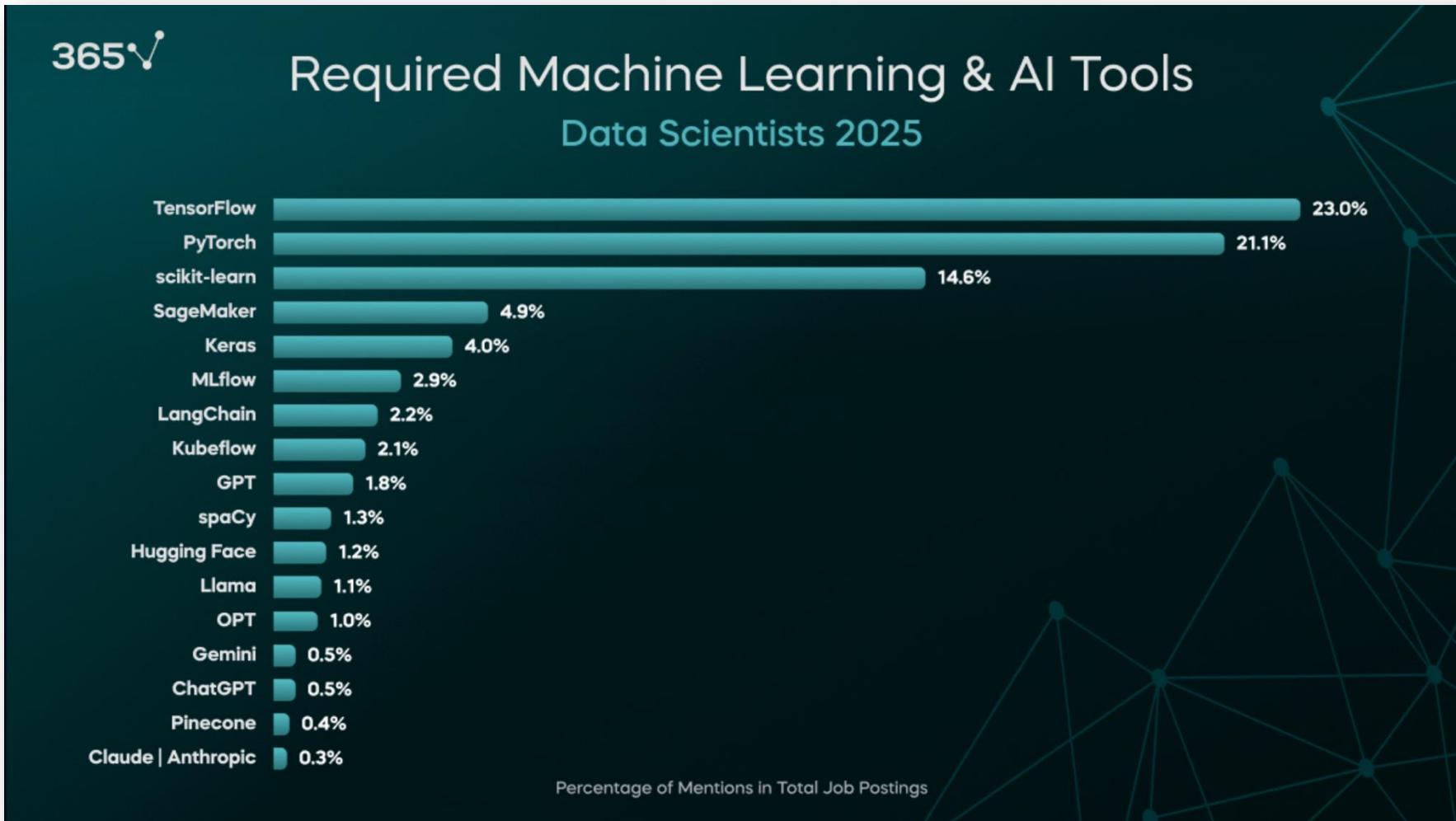
The screenshot shows the Google Colab pricing page. At the top, it says "Choose the Colab plan that's right for you". It explains that Colab is free but offers paid options for more computing power. Below this, there are four plans:

- Pay As You Go**: \$9.99 for 100 Compute Units or \$49.99 for 500 Compute Units. It notes that you currently have 300 units and they expire after 90 days. It includes a checkbox for "No subscription required" and a note about faster GPUs.
- Colab Pro**: \$9.99 per month. This plan is highlighted with an orange border. It includes a "Current plan" button and a "Colab Pro for Education" section with a "No cost for students and educators" button. It lists benefits: 100 compute units per month (expiring after 90 days), faster GPUs (upgrade to more powerful GPUs), and more memory (access to highest memory machines).
- Colab Pro+**: \$49.99 per month. It lists additional benefits: an additional 500 compute units per month (totaling 600), faster GPUs (priority access to more powerful premium GPUs), and background execution (notebooks continue running for up to 24hrs even if browser closed).
- Colab Enterprise**: Pay for what you use. It lists benefits: integrated with Google Cloud services like BigQuery and Vertex AI, enterprise notebook storage (replacing Google Drive notebooks), and productivity features (Generative AI powered code completion and generation).



A large red 'X' is drawn over the PyTorch logo, indicating that PyTorch is not a required software for this course.

Why Keras?



Google Colab

The screenshot shows the Google Colab interface. At the top, there's a navigation bar with the title "Making the Most of your Colab Subscription" and a "PRO" badge. The menu bar includes File, Edit, View, Insert, Runtime, Tools, Help, and a search bar with filters for Commands, Code, Text, Run all, and Copy to Drive. On the right, there are Share, Connect, and profile icons.

The main content area displays a notebook titled "Making the Most of your Colab Subscription". It contains several sections:

- A section titled "Google Colab is available in VS Code!" featuring icons for Colab, a heart, and VS Code.
- A note about the Google Colab extension for VS Code, with instructions to install it via the Extensions view or select kernel in VS Code.
- A section titled "Access Popular LLMs via Google-Colab-AI Without an API Key" which includes a code snippet for generating text using the google-colab-ai library.
- A section titled "Faster GPUs" which likely discusses GPU acceleration options.

At the bottom left, there's a copyright notice: "© Gordon Burtch, 2026".

Course Timeline

AGENDA

- We will start with the basic math concepts.
- We will then get into neural networks for simple prediction problems with structured data (e.g., a spreadsheet).
- Then, we will explore prediction tasks where inputs are unstructured data (e.g., images, audio, and/or text).
- Finally, we will learn about generative neural networks and agentic models.

NOTE TIMING OF DELIVERABLES

- First quiz will take place on 2/10.
- Individual homework assignment will be due 2/27.
- I will announce sign-ups for the first project proposal check-in meeting that will take place on 3/3.

Week	Dates	Topic	Assignments	Readings
1	Jan 20 & 22	Course Intro	--	Chapter 1
2	Jan 27 & 29	Review of Concepts	--	Chapters 5 and 6
3	Feb 3 & 5	Multilayer Perceptron (MLP)	--	Chapter 2
4	Feb 10 & 12	First NN & Model Tuning	Quiz 1 & Ind. Assignment Posted	Chapter 4
5	Feb 17 & 19	Intro to Image Models	--	Chapter 8
6	Feb 24 & 26	Image Models (cont.)	Quiz 2 & Ind. Assignment Due (Friday 11:59pm)	Chapters 9 and 10
7	Mar 3 & 5	Project Check-ins & Transfer Learning	Proposal Due (Friday 11:59pm)	Chapters 11 and 12 (Optional)
SPRING RECESS				
8	Mar 17 & 19	Intro to Text Models	Quiz 3	Chapter 14
9	Mar 24 & 26	Text Embeddings, Attention & Project Work	--	Chapter 15
10	Mar 31 & Apr 2	Generative Text Models	Quiz 4	Chapter 16
11	Apr 7 & 9	Generative Image Models & Project Work / Q&A	--	Chapter 17
12	Apr 14 & 16	Agentic AI, Other Concepts & JPMC Case	Quiz 5	JPMC Case
13	Apr 21 & 23	AI Wars Case & Project Work / Q&A	Case Responses Due (Friday at 11:59pm)	AI Wars Case
14	Apr 28 & 30	Project Presentations	Project Deliverables Due (Friday at 11:59pm)	

Course

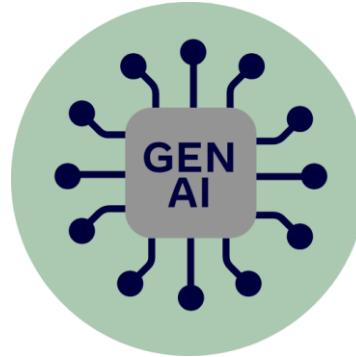


LECTURES

- We will meet twice weekly for ~75 mins each session. The Tuesday session will typically focus on lecture / concepts / explanation.

HANDS-ON EXAMPLES

- During the second session each week, we will walk through hands-on examples and demonstrations in Colab notebooks. I will provide these Colab Notebooks and data-sets (typically via GitHub).
- You are encouraged to ask questions as we progress! Make it interactive!
- Note that the quizzes, the individual assignment, and the exam will be based on the in-class material. I will not test you on things that were not discussed in class.



Policy

YOU CAN USE IT TO HELP YOU LEARN AND PERFORM BASIC TASKS

I expect you to use these tools, but the way you use them matters. Some valid use cases include i) implementing data munging tasks that you already understand based on past coursework, e.g., pre-processing text, or ii) automatic generation of code comments or documentation.

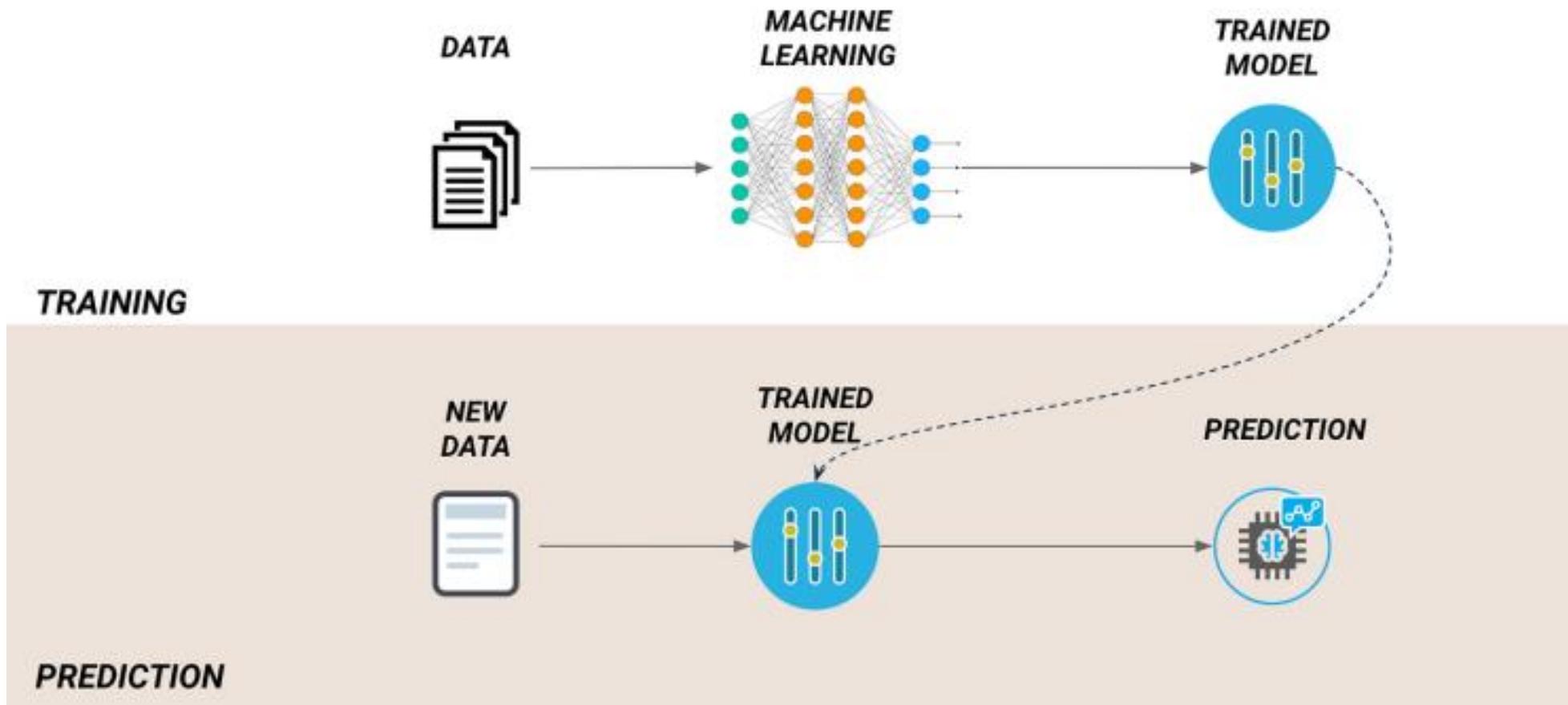
YOU SHOULD NOT GENERATE SOLUTIONS FROM SCRATCH

If you use these tools as a shortcut to avoid understanding the course material, you will not do well in the class. If I see you using functions and libraries that were not taught in the course (e.g., PyTorch), you may be asked to explain your code to me, verbally. If you are unable to explain what the code is doing, points will be deducted from your deliverable grade.

Pre-Survey: Your Interests & Background



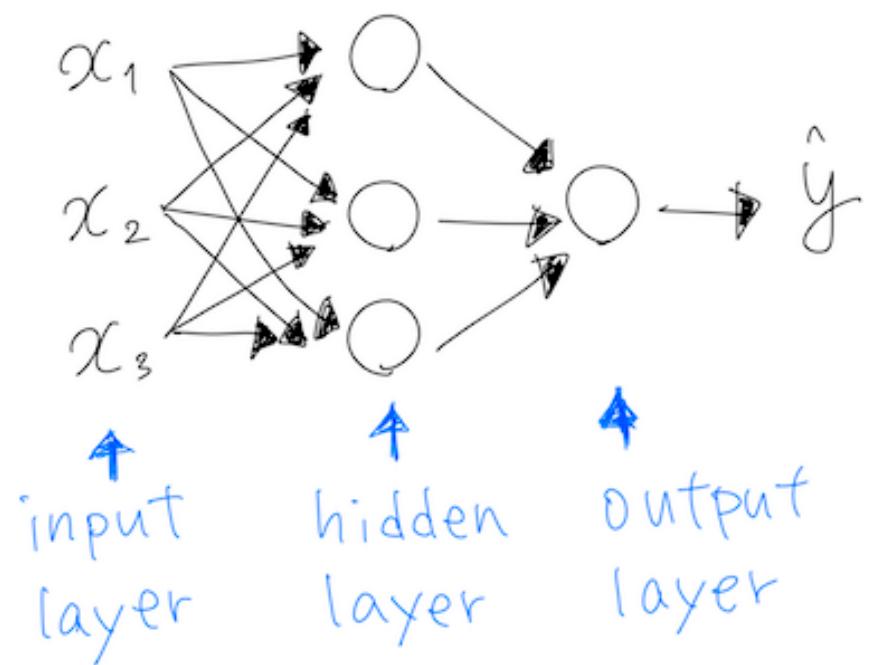
Supervised Learning



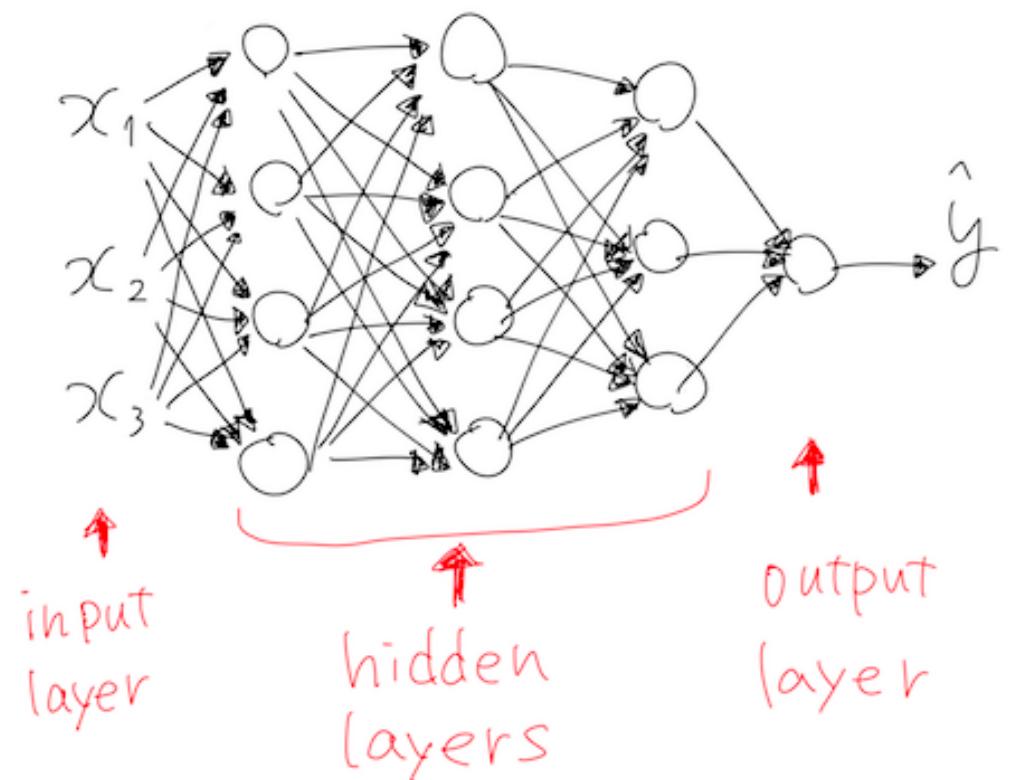
So, What is ‘Deep’ (vs. Shallow) Learning?

<https://chat.openai.com/chat>

Shallow Neural Network



Deep Neural Network



Where Deep Learning Started

Communicated by Dana Ballard

Backpropagation Applied to Handwritten Zip Code Recognition

Y. LeCun
B. Boser
J. S. Denker
D. Henderson
R. E. Howard
W. Hubbard
L. D. Jackel

AT&T Bell Laboratories Holmdel, NJ 07733 USA

The ability of learning networks to generalize can be greatly enhanced by providing constraints from the task domain. This paper demonstrates how such constraints can be integrated into a backpropagation network through the architecture of the network. This approach has been successfully applied to the recognition of handwritten zip code digits provided by the U.S. Postal Service. A single network learns the entire recognition operation, going from the normalized image of the character to the final classification.

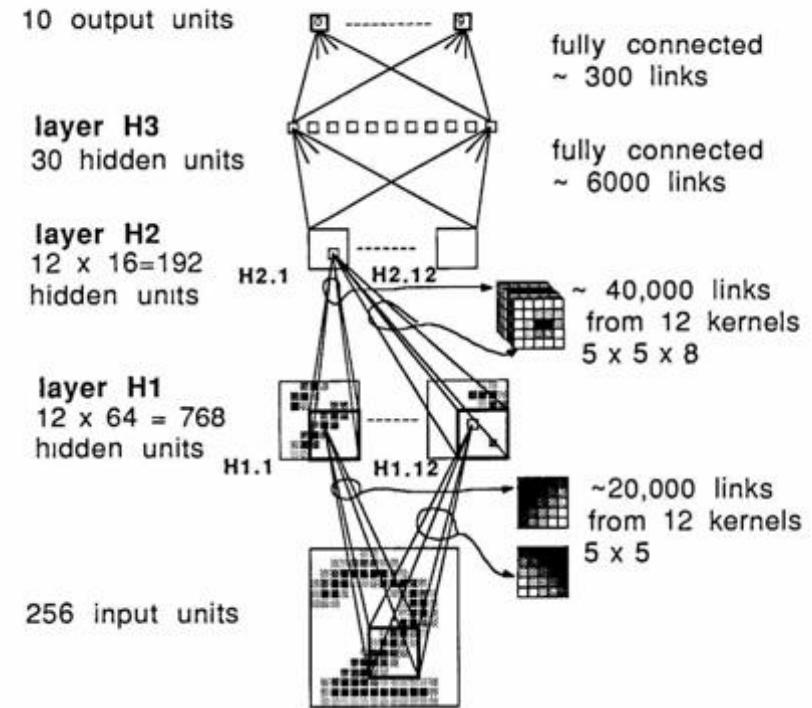
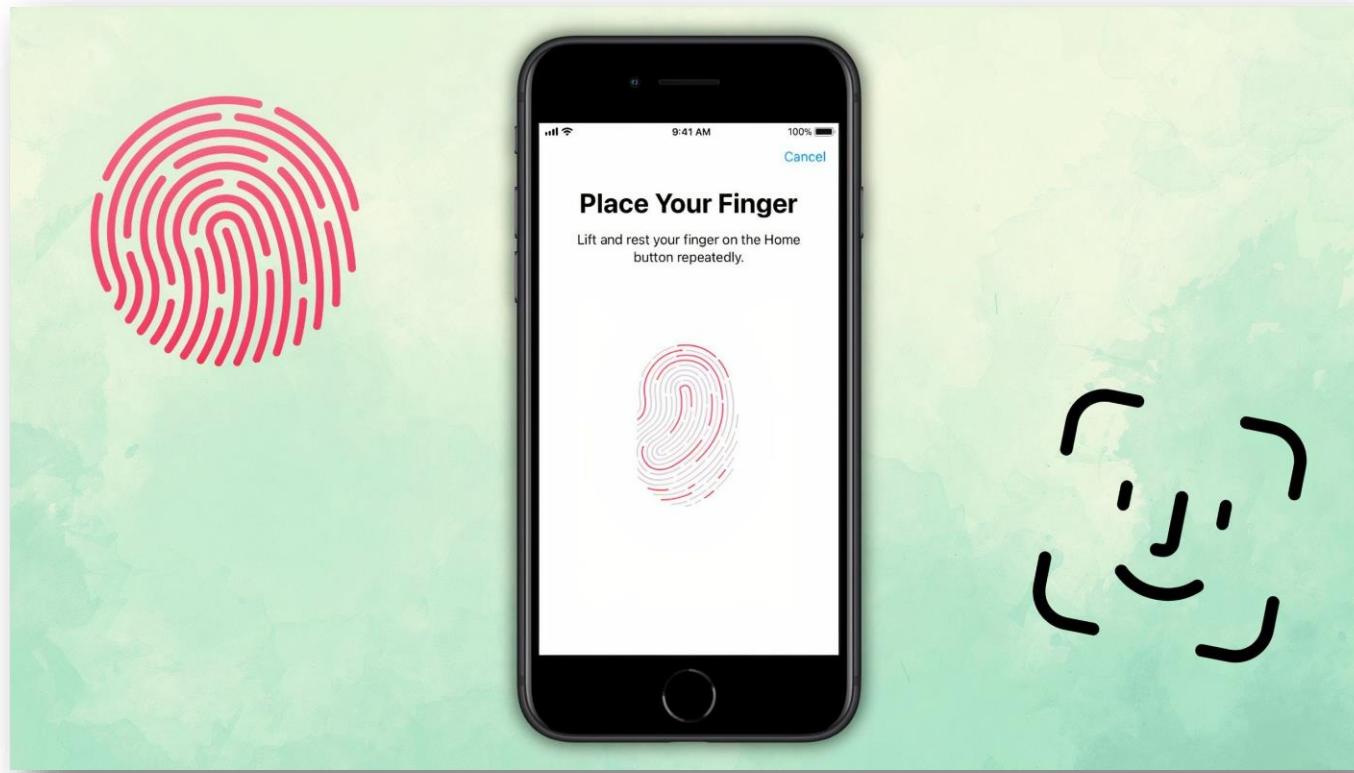


Figure 3 Log mean squared error (MSE) (top) and raw error rate (bottom) versus number of training passes

Modern Examples: Identity Verification



Modern Examples: Fraud Detection

NEXT-GEN FRAUD PROTECTION

Upgrade to Frictionless, End-to-End Fraud Protection

Detect fraud rings, malicious bots, and other bad actors, anywhere across your user journey, starting on day 1.

[EXPLORE HOW IT WORKS →](#) [TALK WITH AN EXPERT](#)

The diagram illustrates the 'Frictionless, End-to-End Fraud Protection' mentioned in the text. It features a central green shield with a white 'N' logo, symbolizing the core protection system. Five dashed green lines extend from the shield to five circular icons arranged in a circle around it, representing various points in a user journey where fraud detection is applied. These icons include a dollar sign (representing financial transactions), a person with a checkmark (representing account verification), a shopping cart (representing e-commerce purchases), a person with a laptop (representing digital communication or logins), and a person with a smartphone (representing mobile devices). This visualizes how the protection system monitors multiple touchpoints simultaneously.

The logo for neuroID, a part of Experian. It features a stylized 'N' icon composed of three dots and a line, followed by the word 'neuroID' in lowercase. Below it, it says 'A part of experian.' with the Experian logo.

Modern Examples: Fake Review Detection

amazon

News About Us Our Impact Subscribe Search Amazon News

News / Policy news & views

How Amazon is using AI to ensure authentic customer reviews

What happens after you write and submit a review? Learn how advanced AI helps publish authentic reviews and weed out the fakes.

Artificial Intelligence Shopping Customers Machine Learning Share

The science behind keeping fake reviews off Amazon's store

Watch later Share

Modern Examples: Gunfire Detection

SOUNDTHINKING™



Modern Examples: Part Failure Prediction

FLUKE®
Reliability

Industries ▾ Products ▾ Resources ▾ Events ▾ Careers

Contact Us

C O M P A N I E S

Azima DLI

Maximize uptime and demonstrate the ROI of your reliability program with vibration monitoring, advanced AI analysis, and enterprise reporting.

Contact Us



The illustration depicts a modern industrial setting where various pieces of machinery, including a conveyor belt system, a factory building, and a large pipe, are interconnected via a network of lines. A central monitor displays a detailed dashboard with graphs, data tables, and status indicators. This visualizes how different parts of a manufacturing or processing plant are monitored and managed through a centralized digital platform.

Modern Examples: Audio Transcription

The screenshot shows the Epic Software website's homepage. At the top, there is a navigation bar with links to various Epic products: Epic, EpicShare, Epic Research, Cosmos, MyChart, OPEN, UserWeb, SHOWROOM, Epic, Software, About Us, and Newsroom. The main title "AI for Clinicians" is displayed prominently in red. Below it, a sub-headline reads: "Learn how clinicians in the Epic community use AI to more quickly learn about their patients, complete documentation, and wrap up visits." The page is divided into three sections, each featuring an icon and a brief description of an AI feature:

- Before the Visit – Catching Up on Patients**
 - Note Summarization**
To help clinicians efficiently prep for outpatient visits, AI reviews recent notes and external data, and provides concise summaries of relevant details with references to the notes where specific details were discussed.
 - Inpatient Summarization**
To help clinicians prepare for their patients, AI sifts through recent patient data and highlights important updates, providing concise summaries of each patient's status.
 - End of Shift Notes**
Nurses can get a head start on documentation by having AI draft end-of-shift notes using shift data already available in the patient's chart—including progress on patient goals. Concise, detailed summaries help the next shift get up to speed.

Audio Translation

The image is a screenshot of the Spotify 'For the Record' website. At the top left is the Spotify logo and the text 'For the Record'. To the right are navigation links for 'News' and 'Company', and a search bar with a magnifying glass icon. The main content area features a purple banner with a yellow soundwave graphic. The text on the banner reads 'Introducing Voice Translation for podcasters'. Below the banner is another purple section with a yellow soundwave graphic. On the left side of the page, there are two smaller images: one showing two people in a podcast studio and another showing a portrait of a man.

For the Record

News Company

Search...

Introducing
Voice Translation
for podcasters

Spotify

Modern Examples: AI Text Detector

The screenshot shows the Pangram website homepage. At the top, a yellow banner displays the text "Pangram detects GPT-5 with 99.8%+ accuracy! [Learn more](#)". Below the banner is a navigation bar with links for "Products", "Use Cases", "Company", "Resources", "Blog", "Pricing", "Login", and a prominent orange "Try it for free" button. The main headline on the left side reads "AI Detection that actually works." A subtext below it states, "Pangram's AI detector tool beats all other detectors in the market." To the right of the text area is a large, colorful illustration of a person riding a bicycle. On the right side of the page is a large white input field labeled "Enter text below to check for AI". Inside this field, there is a placeholder text "Try an example text." and several "Random" buttons: "Random review", "Random blog post", "Random essay", "Random ChatGPT review", "Random ChatGPT blog post", and "Random ChatGPT essay". Below the input field is another smaller input field with the placeholder text "Enter some text to check for AI.". At the bottom of the page, there are two calls-to-action: "Upload" with an upward arrow icon and "Scan for AI" with a camera icon. The footer contains the University of Maryland logo, a link to a "Screenshot" page, and a copyright notice: "Reviewed as the proven, most reliable and most accurate AI detection tool by third parties including University of Maryland".

Pangram detects GPT-5 with 99.8%+ accuracy! [Learn more](#)

Pangram. Products ▾ Use Cases ▾ Company ▾ Resources ▾ Blog Pricing Login Try it for free

AI Detection that actually works.

Pangram's AI detector tool beats all other detectors in the market.

- ▶ Detect AI writing from ChatGPT, Claude, Gemini, Perplexity and more.
- ▶ Clear and trusted results with a near-zero false positive rate.
- ▶ Developed by experienced AI researchers with backgrounds from Stanford, Tesla and Google.

Check for AI by simply clicking a button!

Try it for free Get in touch

Reviewed as the proven, **most reliable** and **most accurate** AI detection tool by third parties including University of Maryland [Screenshot](#)

Upload Scan for AI

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These Technologies Bring New Problems

NBC NEWS Lawsuit claims Character.AI is responsible for teen's suicide

ARTIFICIAL INTELLIGENCE

Lawsuit claims Character.AI is responsible for teen's suicide

Megan Garcia says the company's chatbots encouraged her 14-year-old son, Sewell Setzer, to take his own life, according to the lawsuit.

ARTIFICIAL INTELLIGENCE

How generative AI is boosting the spread of disinformation and propaganda

In a new report, Freedom House documents the ways governments are now using the tech to amplify censorship.

By Tate Ryan-Mosley

CHEGG IS ON ITS LAST LEGS AFTER CHATGPT SENT ITS STOCK DOWN 99%

With subscriptions tumbling, there are doubts the online education company will be able to pay its debts.

By Thomas Maxwell Published November 9, 2024 | Comments (75)

BEST OF CES 2025 AWARDS

THE BEST OF CES 2025 AWARDS

Best of CES 2025 Awards →

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Business Process / Model Still Matters

Bloomberg Opinion

Money Stuff

Sorry, Zillow's Computer Can't Buy Your House Right Now

Also CEO pay, the Boredom Markets Hypothesis and Big Short guys being big short.

By Matt Levine [+Sign Up](#)
October 18, 2021, 1:18 PM EDT

Matt Levine is a Bloomberg Opinion columnist covering finance. He was an editor of Dealbreaker, an investment banker at Goldman Sachs, a mergers and acquisitions lawyer at Wachtell, Lipton, Rosen & Katz, and a clerk for the U.S. Court of Appeals for the 3rd Circuit.

[Read more opinion](#)

Zillow

Deciding how much you should pay for a share of large-cap publicly traded stock is not an *entirely* solved problem, but it's pretty close. If someone comes to you and says "hey I have 100 shares of Microsoft Corp. stock for sale, how much will you pay me for it," a pretty decent answer would be to look at the last price at which Microsoft traded – like a millisecond ago – and subtract, you know, one cent from that price. That will get you a price that is likely to be competitive (the seller might actually sell to you), likely to be profitable (you might be able to sell it for more than you paid), and

LIVE ON BLOOMBERG
Watch Live TV >
Listen to Live Radio >



// Menu > Institutional > Tools About Archive Events

May 4, 2023

Google “We Have No Moat, And Neither Does OpenAI” // Leaked Internal Google Document Claims Open Source AI Will Outcompete Google and OpenAI

10 minutes
11 comments

By Dylan Patel and Afzal Ahmad



AI In the News



World ▾ Business ▾ Markets ▾ Sustainability ▾ Legal ▾ Commentary ▾ Technology ▾ Investigations More ▾

Apple, Google strike Gemini deal for revamped Siri in major win for Alphabet

By Zaheer Kachwala and Aditya Soni

January 13, 2026 4:30 AM EST · Updated January 13, 2026



AI In the News

The screenshot shows a news article from The Register. The header features the site's logo and a search bar. Below the header, the main content is titled "eBay updates legalese to ban AI-powered shop-bots". A sidebar on the left lists "AI + ML". The article includes a comment count of "15", a timestamp of "Thu 22 Jan 2026 // 03:37 UTC", and author information for "Simon Sharwood". Social sharing icons for Twitter, Facebook, LinkedIn, and others are present. The text of the article discusses eBay's decision to ban agentic shopping bots from its platform.

SIGN IN / UP

The Register | HPE

AI + ML

eBay updates legalese to ban AI-powered shop-bots

15

This establishment does not serve agents, says digital tat bazaar

Simon Sharwood Thu 22 Jan 2026 // 03:37 UTC

eBay has decided to ban agentic shopping bots from its digital tat bazaar.

The company's decision emerged in an update to its [user agreement](#) posted on January 20th, which insists users must not use "buy-for-me agents, LLM-driven bots, or any end-to-end flow that attempts to place orders without human review" on the site, unless eBay grants approval.

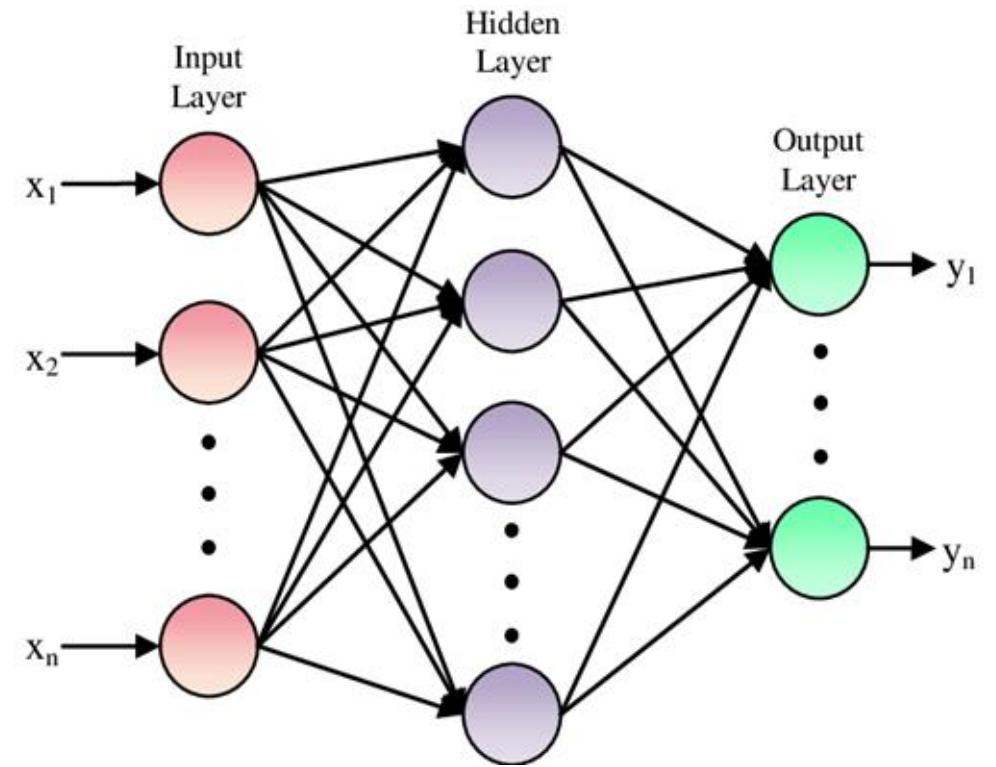
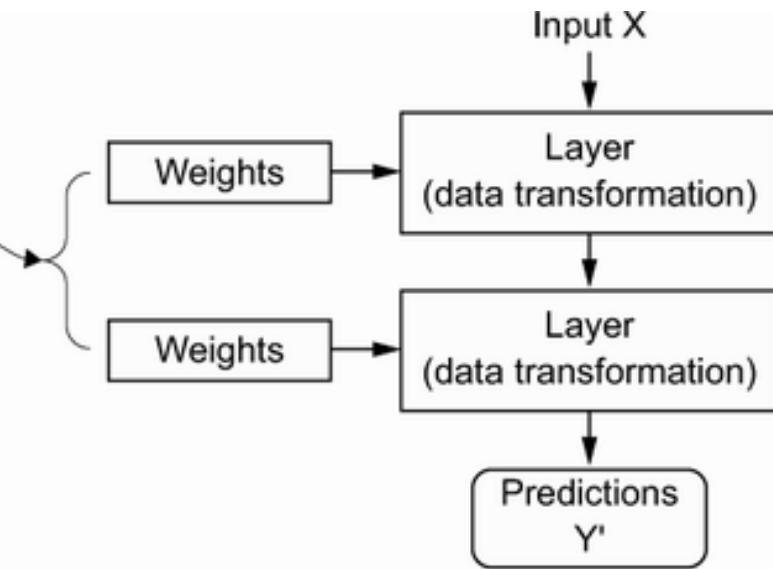
The revised agreement, and eBay's previous legalese, prohibit use of "any robot, spider, scraper, data mining tools, data gathering and extraction tools, or other automated means to access our Services for any purpose."

Advocates for agentic commerce imagine a world in which shoppers can tell an autonomous agent what they want to buy and authorize the software to purchase it on their behalf.

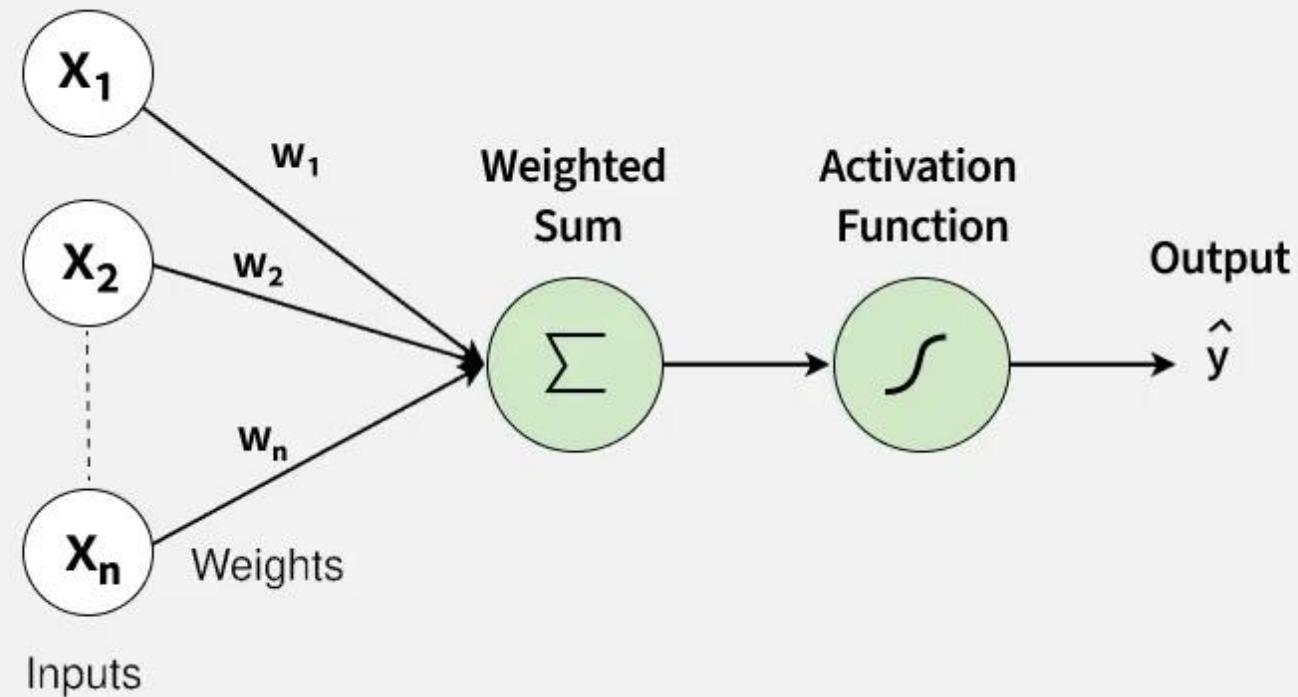
How It Works, Conceptually

Model Parameters

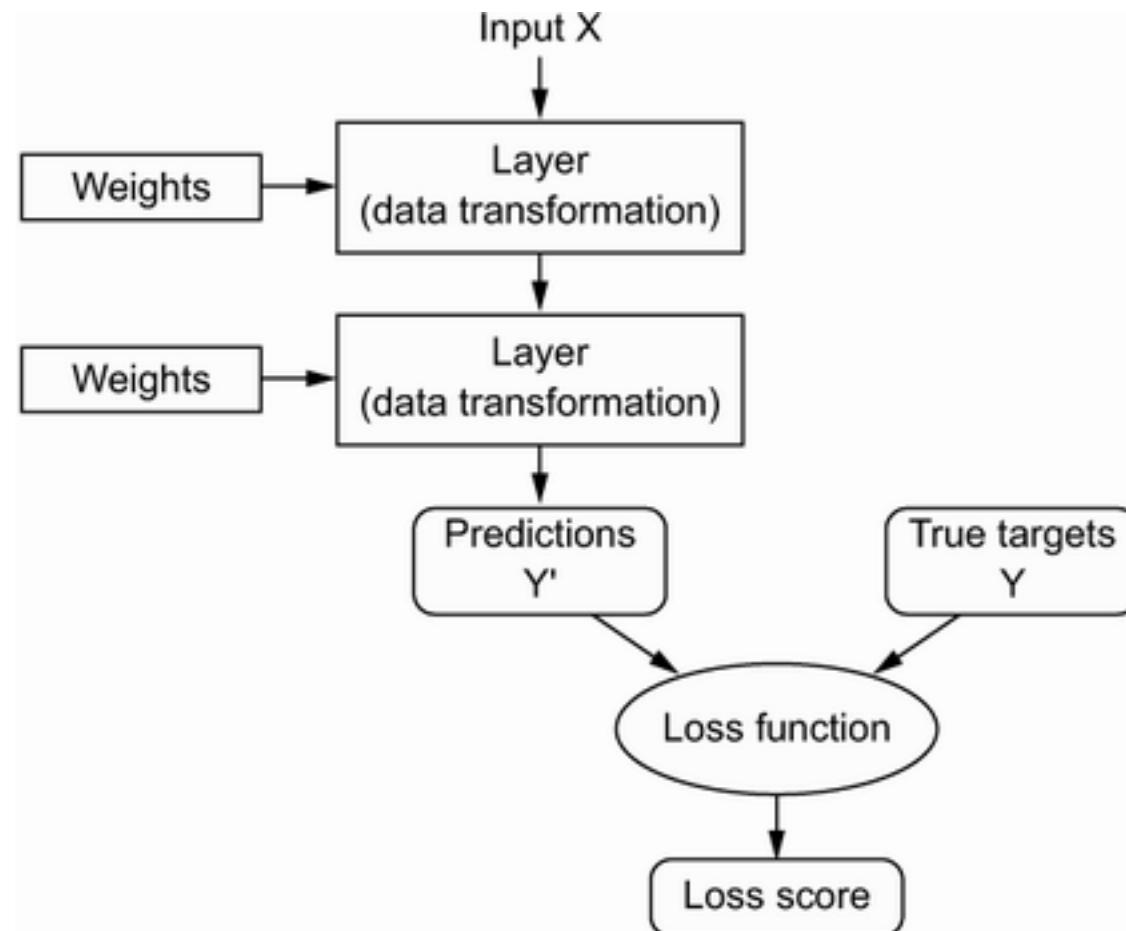
Goal: finding the right values for these weights



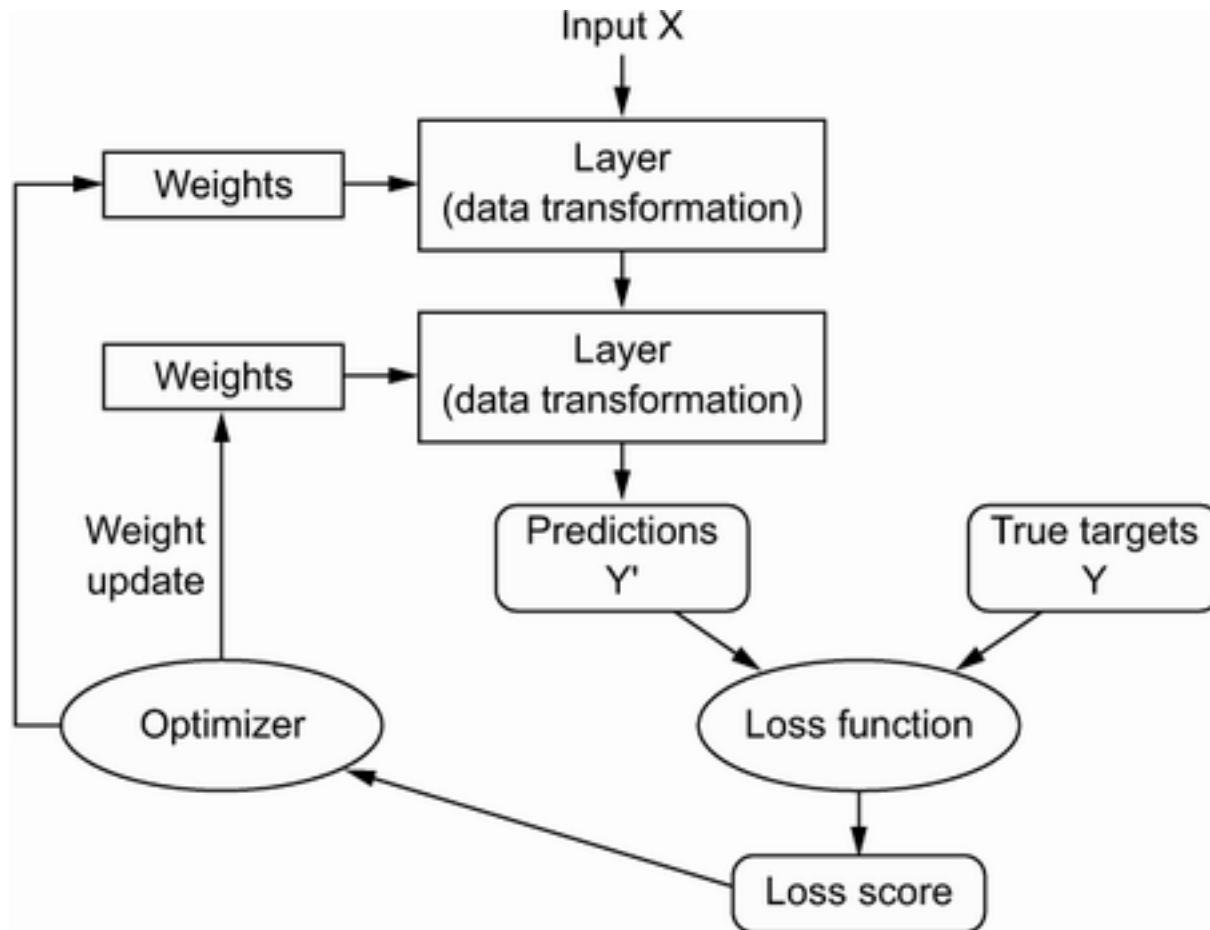
Model Parameters



Loss Function (Error)



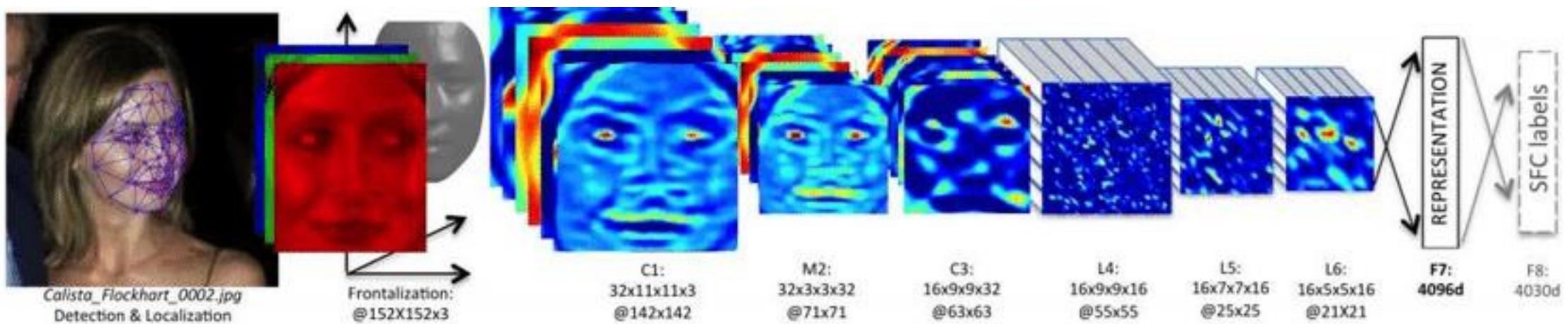
Optimization



When to Learn Deeply (vs. Not)

COMPLEX RELATIONSHIPS

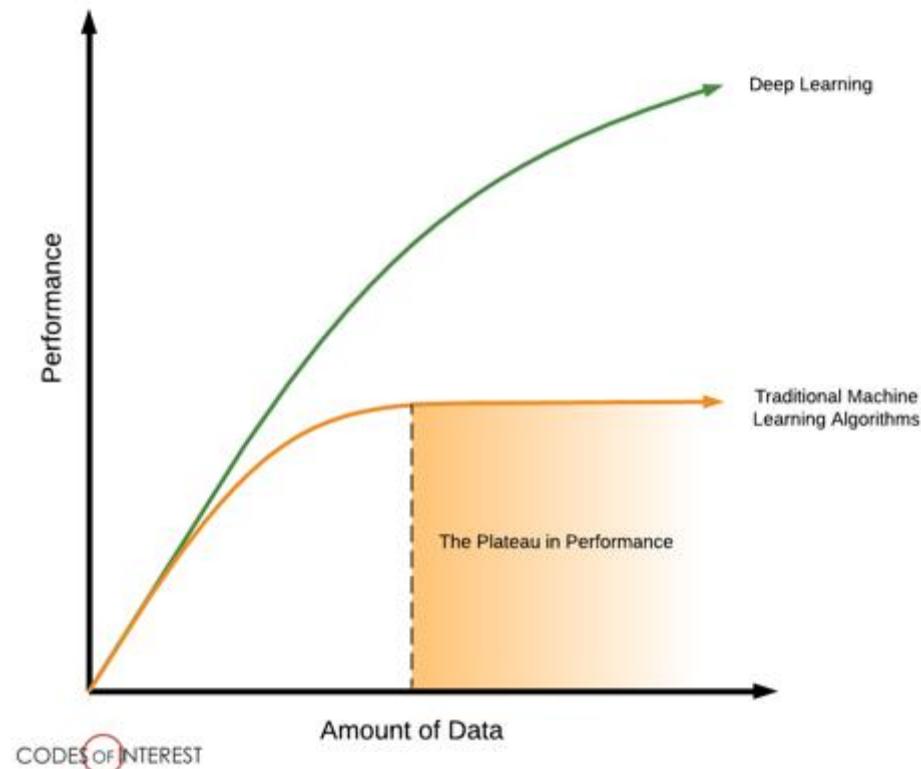
- Complex, non-linear, interactive relationships and mappings; common use cases involve unstructured (high dimensional) data. Deep learning techniques remove the need for feature engineering, a daunting task.



When to Learn Deeply (vs. Not)

LOTS OF DATA ON HAND

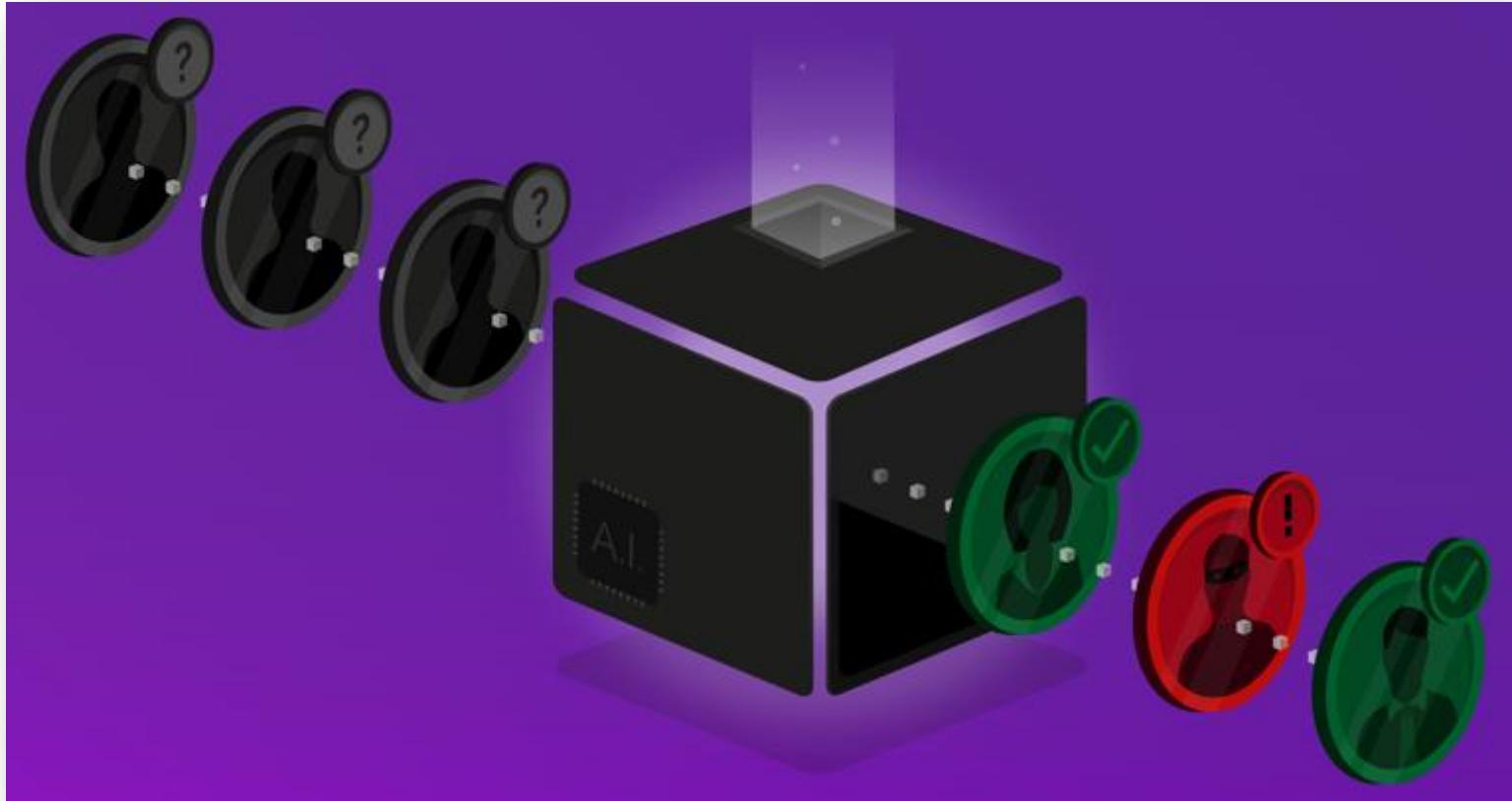
- To be able to learn those complex mappings, typically requires many, many, many training examples.



When to Learn Deeply (vs. Not)

LITTLE NEED FOR UNDERSTANDING

- Although there have been advancements in explainable and interpretable AI, deep nets are notoriously “black box” algorithms.

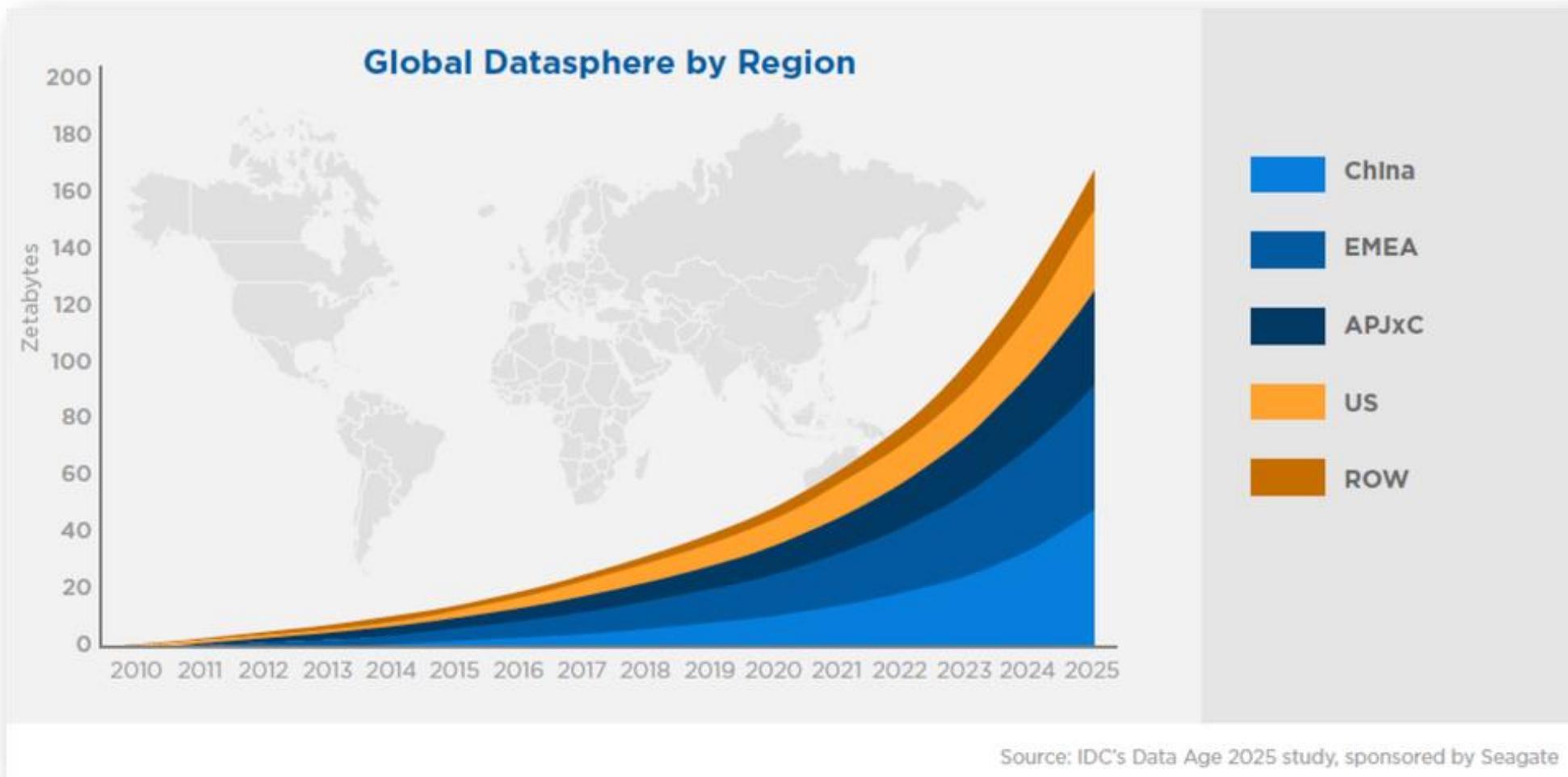


Why Did Deep Learning Take Off?

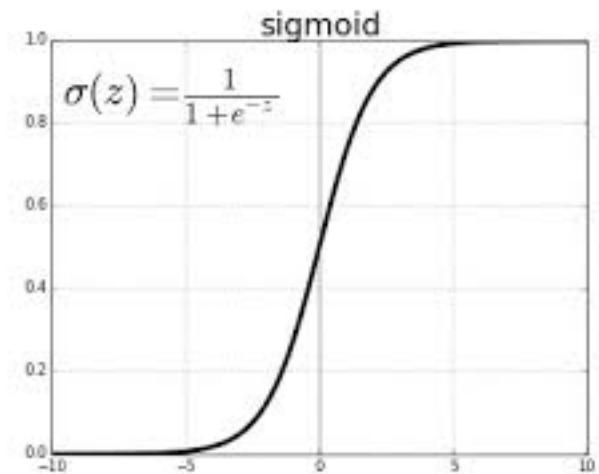
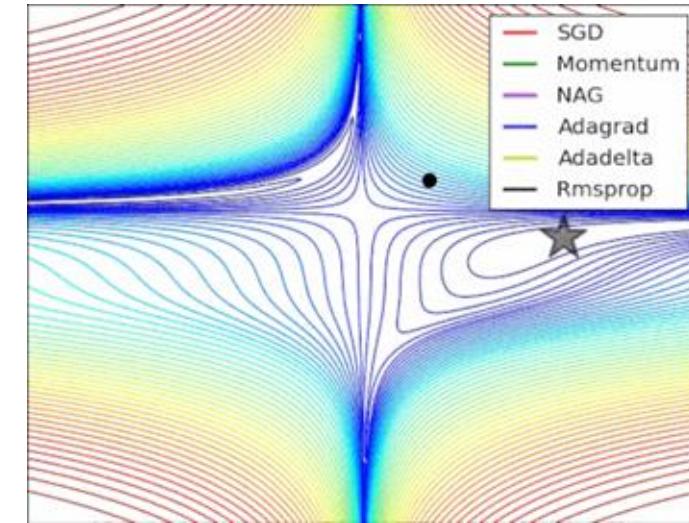
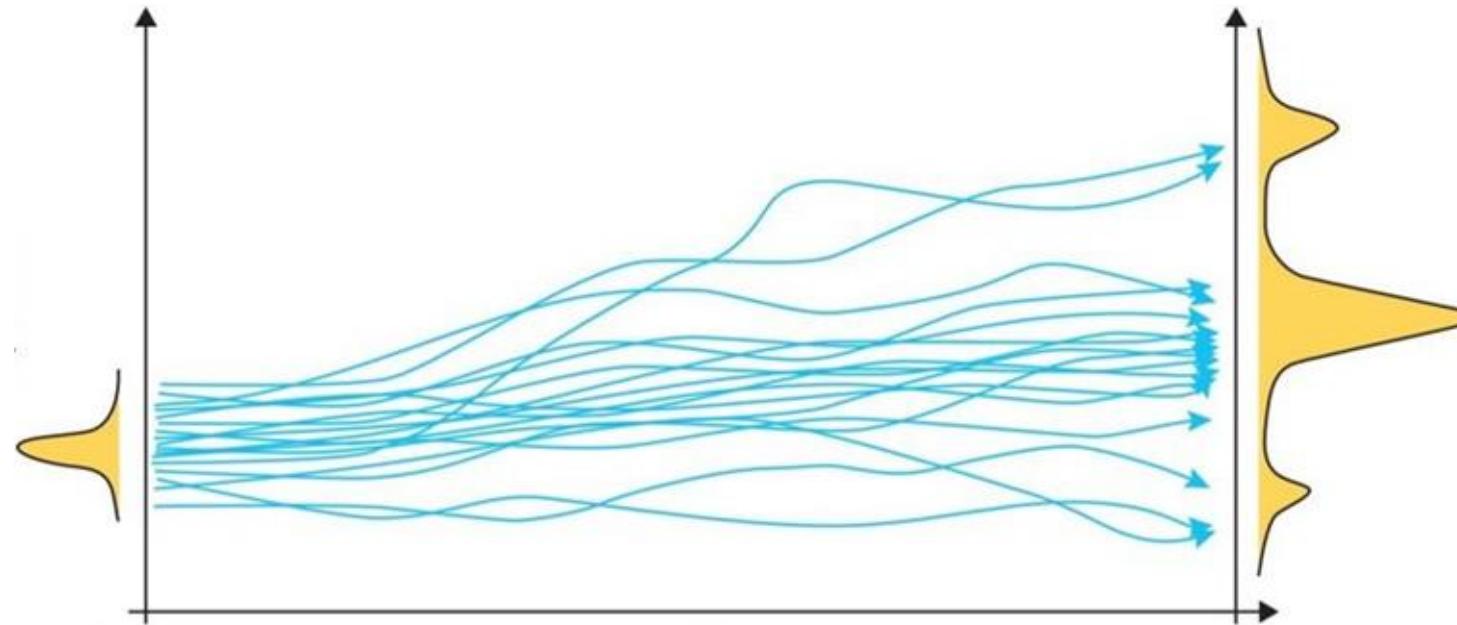


Video Games

Data



Algorithmic Improvements



Questions?