

# 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

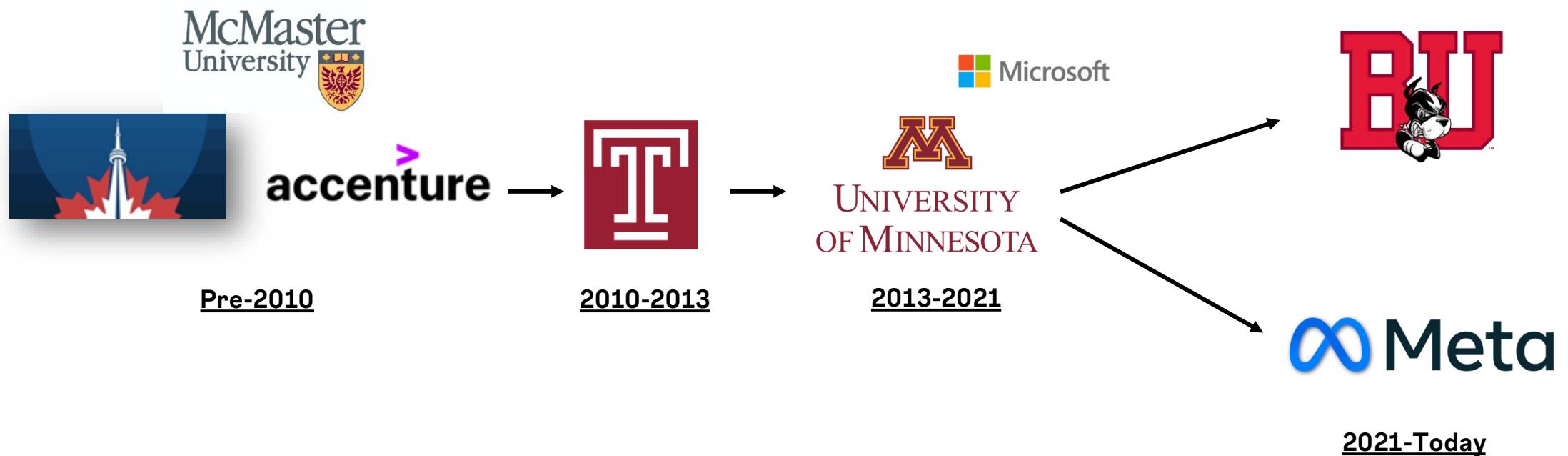
- Frivolous, academic, and practically useful.
- A recent failure, and societal concerns.

## 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<sup>†</sup>

### 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)

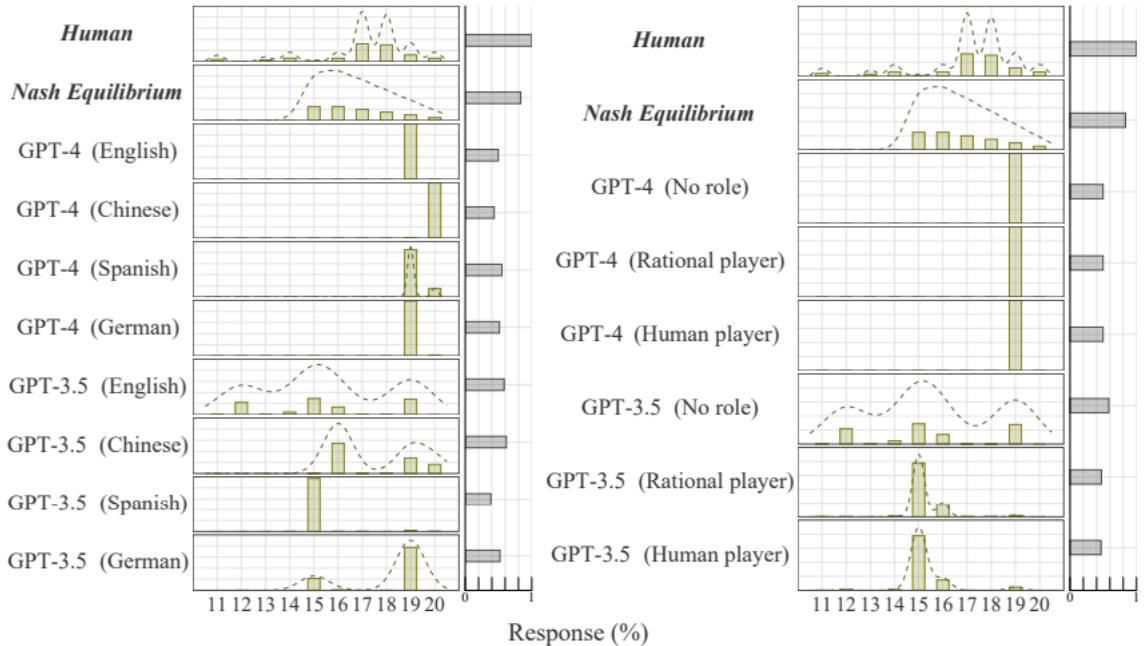
### Introduction

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

<sup>†</sup>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.

A screenshot of a Blackboard course website. The top navigation bar includes 'Courses' (with a dropdown arrow), 'BA510 A1 Neural Networks and AI: From Foundations to Generative Models (Spring 26)', 'Course Settings' (with an 'OPEN' button), and 'Student Preview'. Below the navigation is a decorative banner with a colorful, abstract neural network or molecular structure. The main content area is titled 'Course Content' and lists two items: 'Syllabus' (marked as 'Visible to students') and 'CLASS RECORDINGS' (also marked as 'Visible to students'). To the right of the content area is a sidebar titled 'Course Faculty' featuring a profile for 'Gordon Burch INSTRUCTOR'. Other sections in the sidebar include 'Course Assistants', 'Automations', 'Details &amp; Actions' (with links for 'Roster', 'Course Image', 'Attendance', 'Books &amp; Tools', and 'Question Banks'), and 'Institution tools'. A search bar and a three-dot menu are also visible.



## 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.

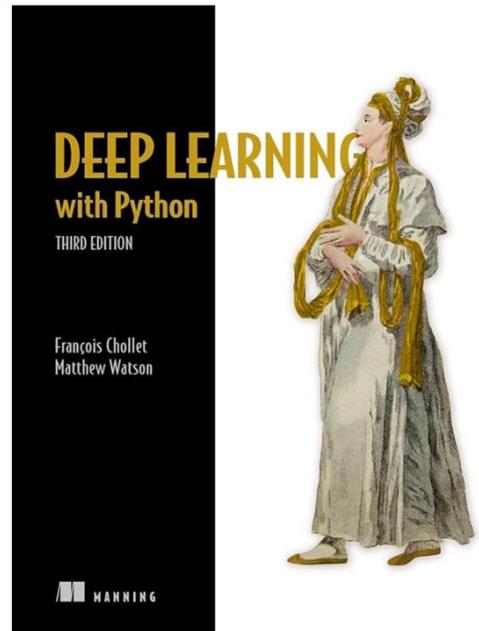
## FINAL PROJECT

- 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%
<b>TOTAL:</b>	<b>100%</b>

# Course Textbook



Chollet, François. (2025). *Deep Learning with Python (3<sup>rd</sup> 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!

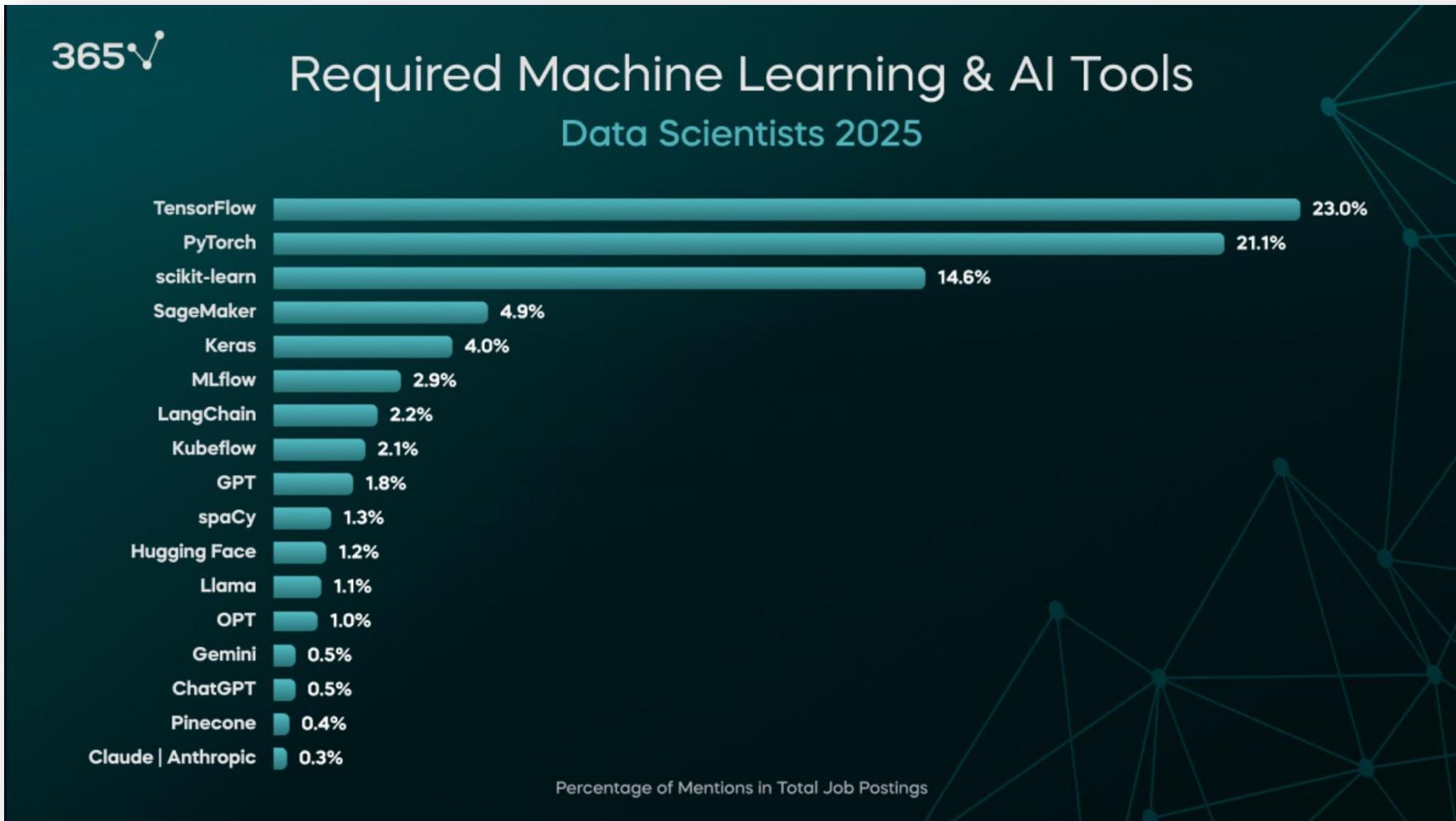
The screenshot shows the Google Colab pricing page. At the top, it says "Choose the Colab plan that's right for you". It explains that Colab is free but offers paid options for more computing power. Below this, there are four plans:

- 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', a 'PRO' badge, and standard menu options: File, Edit, View, Insert, Runtime, Tools, Help. To the right are 'Share', 'Connect', and a user profile icon. Below the bar is a toolbar with 'Commands', 'Code', 'Text', 'Run all', 'Copy to Drive', and a search bar. The main content area displays a notebook cell with the title 'Making the Most of your Colab Subscription'. Below it, another cell contains the text 'Google Colab is available in VS Code!' followed by three icons: CO logo, a red heart, and a blue VS Code logo. A note encourages users to try the new Google Colab extension for VS Code, providing instructions on how to install it. The interface includes a sidebar with various icons and a footer with a copyright notice.

Making the Most of your Colab Subscription

PRO File Edit View Insert Runtime Tools Help

Commands + Code + Text Run all Copy to Drive Share Connect

Making the Most of your Colab Subscription

Google Colab is available in VS Code!

Try the new [Google Colab extension](#) for Visual Studio Code. You can get up and running in just a few clicks:

- In VS Code, open the **Extensions** view and search for 'Google Colab' to install.
- Open the kernel selector by creating or opening any `.ipynb` notebook file in your local workspace and either running a cell or clicking the **Select Kernel** button in the top right.
- Click **Colab** and then select your desired runtime, sign in with your Google account, and you're all set!

See more details in our [announcement blog here](#).

Access Popular LLMs via Google-Colab-AI Without an API Key

Users with Colab's paid plans have free access to most popular LLMs via `google-colab-ai` Python library. For more details, refer to the [getting started with google colab ai](#).

```
[ ] from google.colab import ai
response = ai.generate_text("What is the capital of France?")
print(response)
```

Faster GPUs

(Subject to Revision Depending on Progress)

# 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)
<b>SPRING RECESS</b>				
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

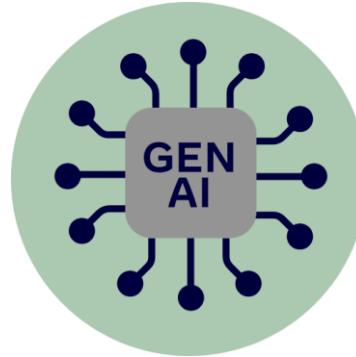


## LECTURES

- 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

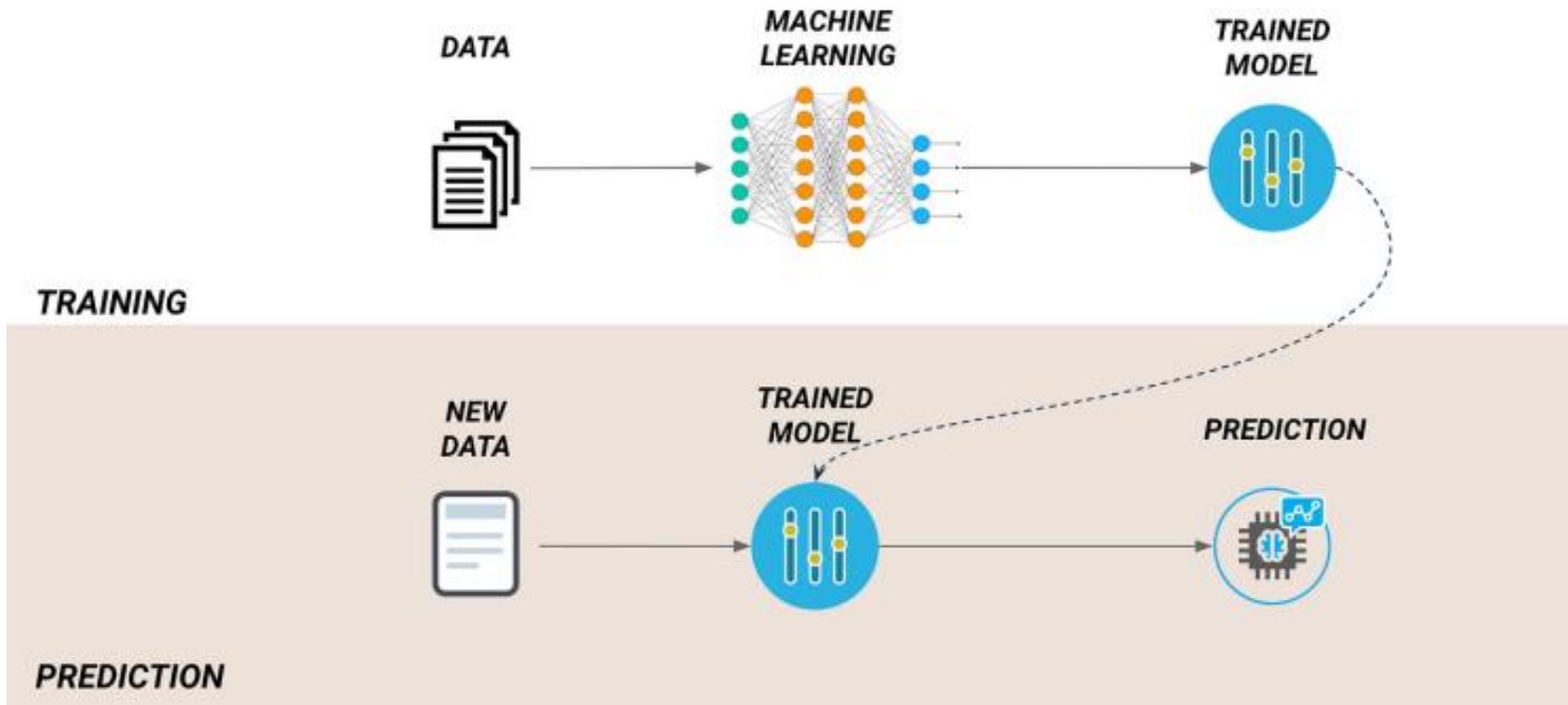
I expect you to use these tools, but the way you use them matters. Some valid use cases include i) implementing data munging tasks that you already understand based on past coursework, e.g., pre-processing text, or ii) automatic generation of code comments or documentation.

## 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.

# Questions?

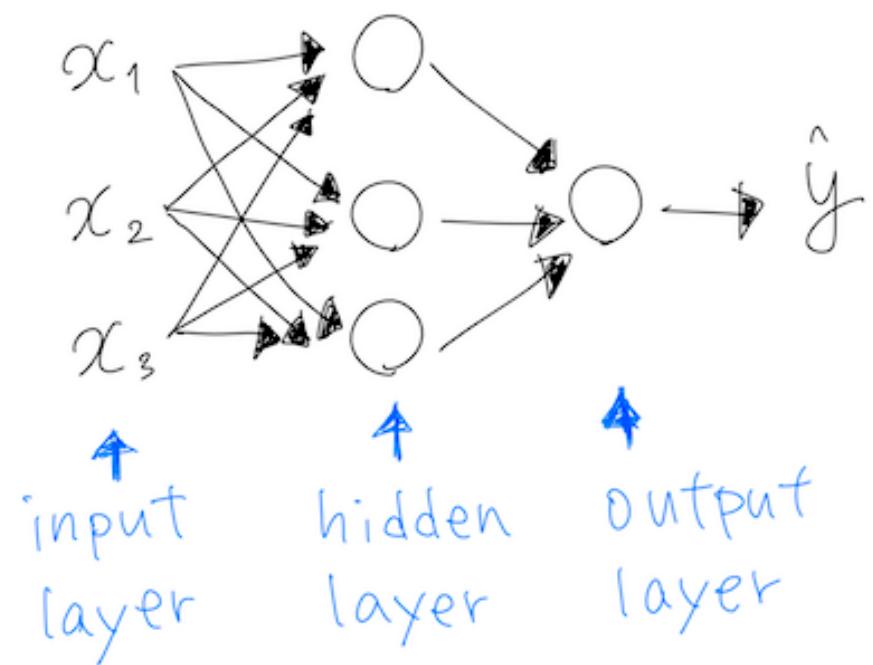
# Supervised Learning



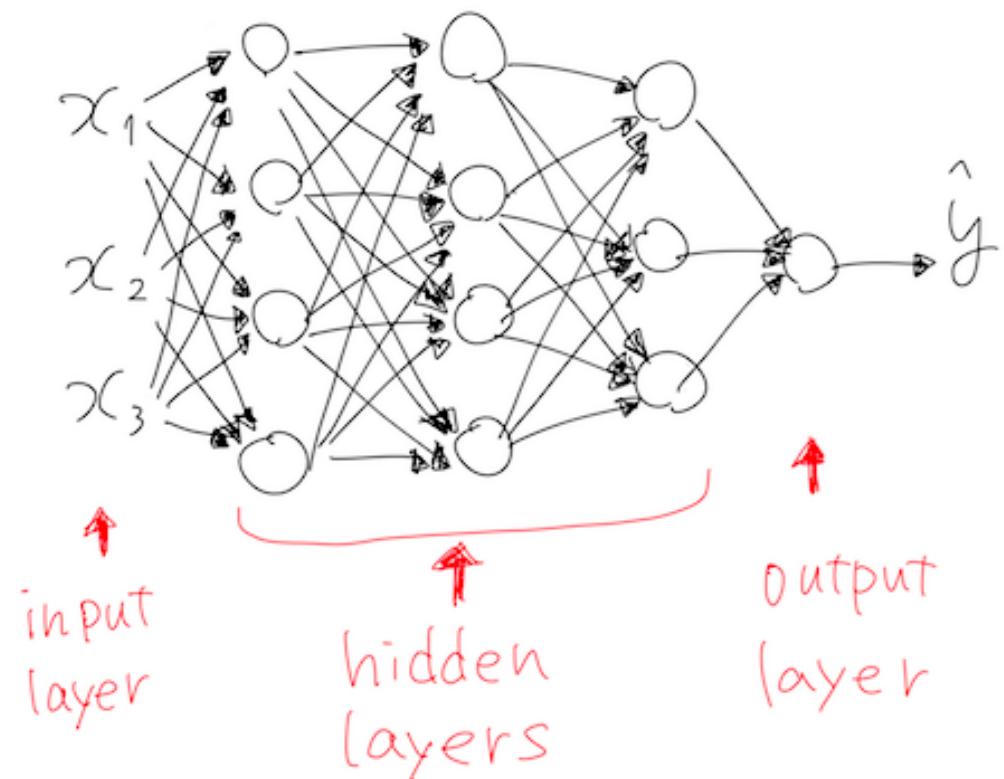
# So, What is ‘Deep’ (vs. Shallow) Learning?

<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.

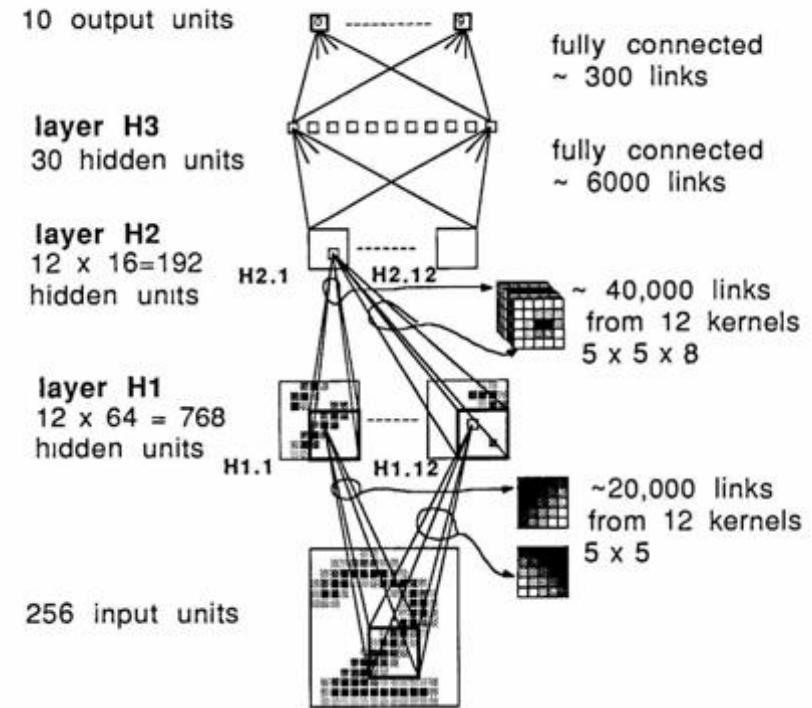
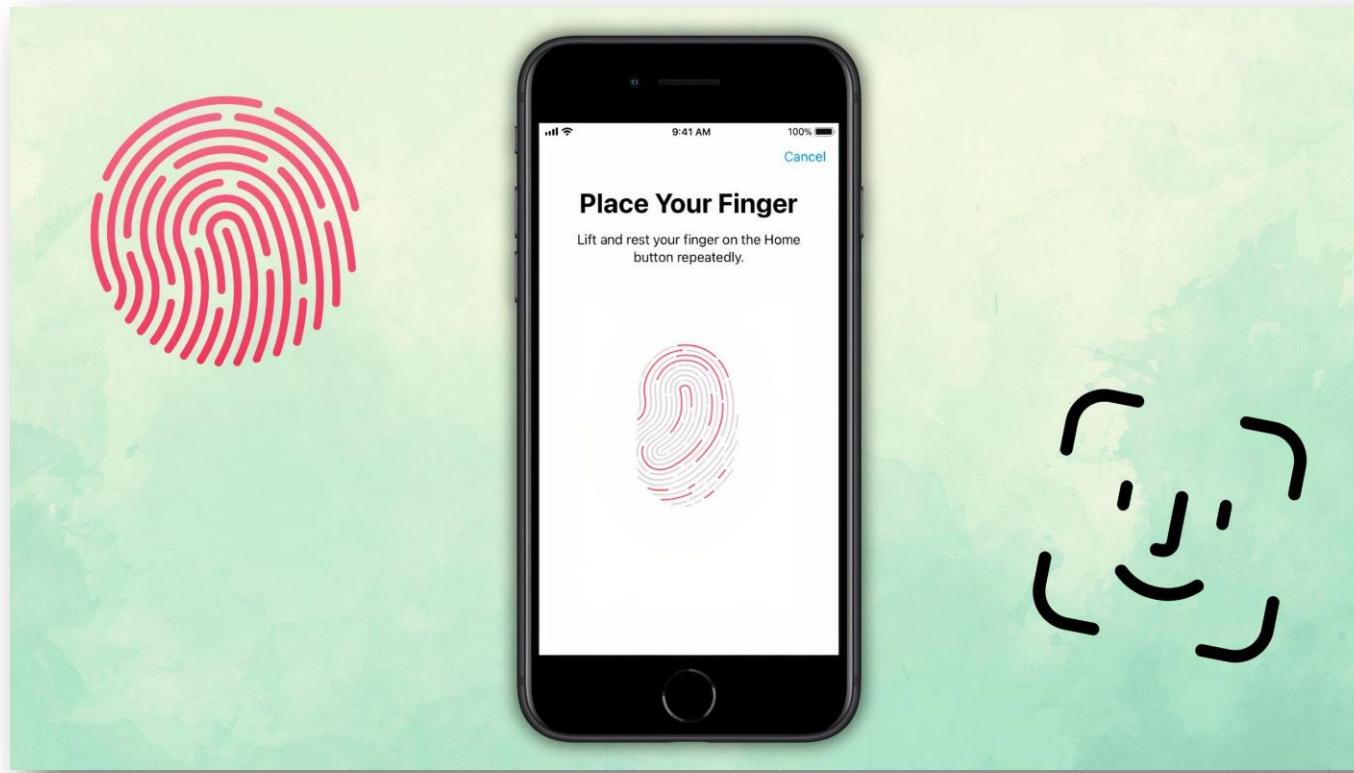


Figure 3 Log mean squared error (MSE) (top) and raw error rate (bottom) versus number of training passes

# 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 protection. Five dashed green lines extend from the shield to five circular icons arranged in a circle around it, representing various stages of a user journey: 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 work), and a person with a smartphone (representing mobile devices). This visualizes how the fraud detection system monitors activity across multiple touchpoints in a user's digital life.

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<sup>TM</sup>



# 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 complex interface with data tables, graphs, 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 with a red header bar containing links for Epic, EpicShare, Epic Research, Cosmos, MyChart, OPEN, UserWeb, and SHOWROOM. Below the header is a navigation bar with links for Epic, Software (highlighted in red), About Us, and Newsroom. The main content area has a red gradient background and features a section titled "AI for Clinicians" with the sub-section "Before the Visit – Catching Up on Patients". This section includes three cards: "Note Summarization" (monitor icon), "Inpatient Summarization" (stethoscope and clipboard icon), and "End of Shift Notes" (waveform icon). Each card contains a brief description of how AI helps clinicians.

## AI for Clinicians

Learn how clinicians in the Epic community use AI to more quickly learn about their patients, complete documentation, and wrap up visits.

### Before the Visit – Catching Up on Patients

**Note Summarization**



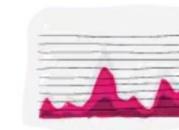
To help clinicians efficiently prep for outpatient visits, AI reviews recent notes and external data, and provides concise summaries of relevant details with references to the notes where specific details were discussed.

**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 man's face. On the right side, there is a large image of a man in a suit and tie.

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 reads "AI Detection that actually works." Below the headline, a paragraph states: "Pangram's AI detector tool beats all other detectors in the market." followed by a bulleted list of features: "▶ Detect AI writing from ChatGPT, Claude, Gemini, Perplexity and more.", "▶ Clear and trusted results with a near-zero false positive rate.", and "▶ Developed by experienced AI researchers with backgrounds from Stanford, Tesla and Google.". Two calls-to-action buttons are visible: "Try it for free" and "Get in touch". A circular arrow icon points from the "Try it for free" button to the "Get in touch" button. A note below says "Check for AI by simply clicking a button!". On the right side, there is a large input field labeled "Enter text below to check for AI" with 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 this is another input field labeled "Enter some text to check for AI." At the bottom, there are "Upload" and "Scan for AI" buttons. The background features a colorful illustration of a person riding a bicycle. The University of Maryland logo is at the bottom left, and a footer note at the bottom center states: "Reviewed as the proven, most reliable and most accurate AI detection tool by third parties including University of [redacted] Screenshot".

# 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.

**POLICY**

## 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

**G** Search HOME LATEST TECH REVIEWS SCIENCE I/O AI VIDEO DEALS CES 2025 AWARDS ARTIFICIAL INTELLIGENCE

## 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 →

# 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

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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

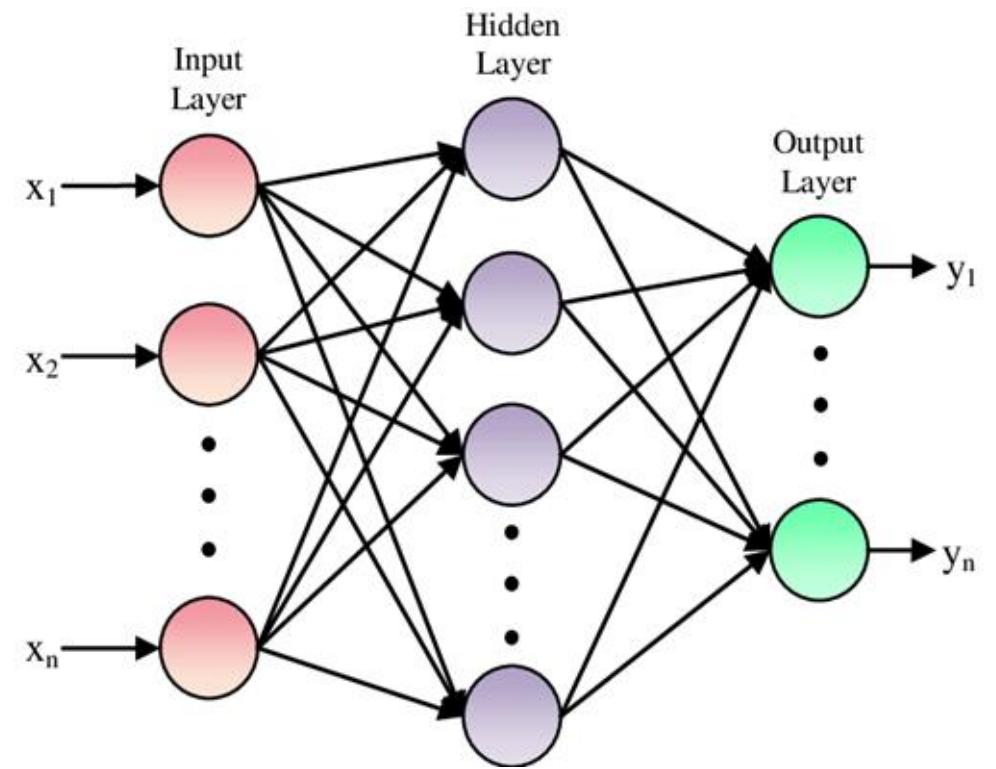
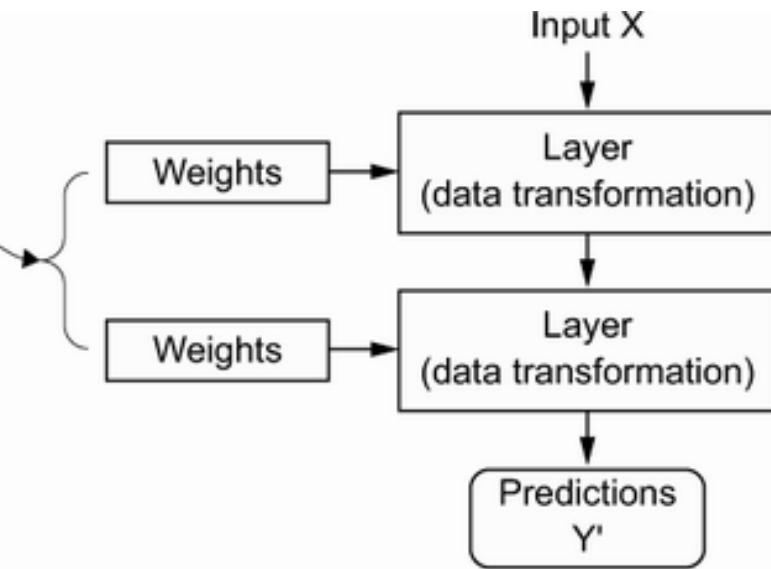
By Dylan Patel and Afzal Ahmad



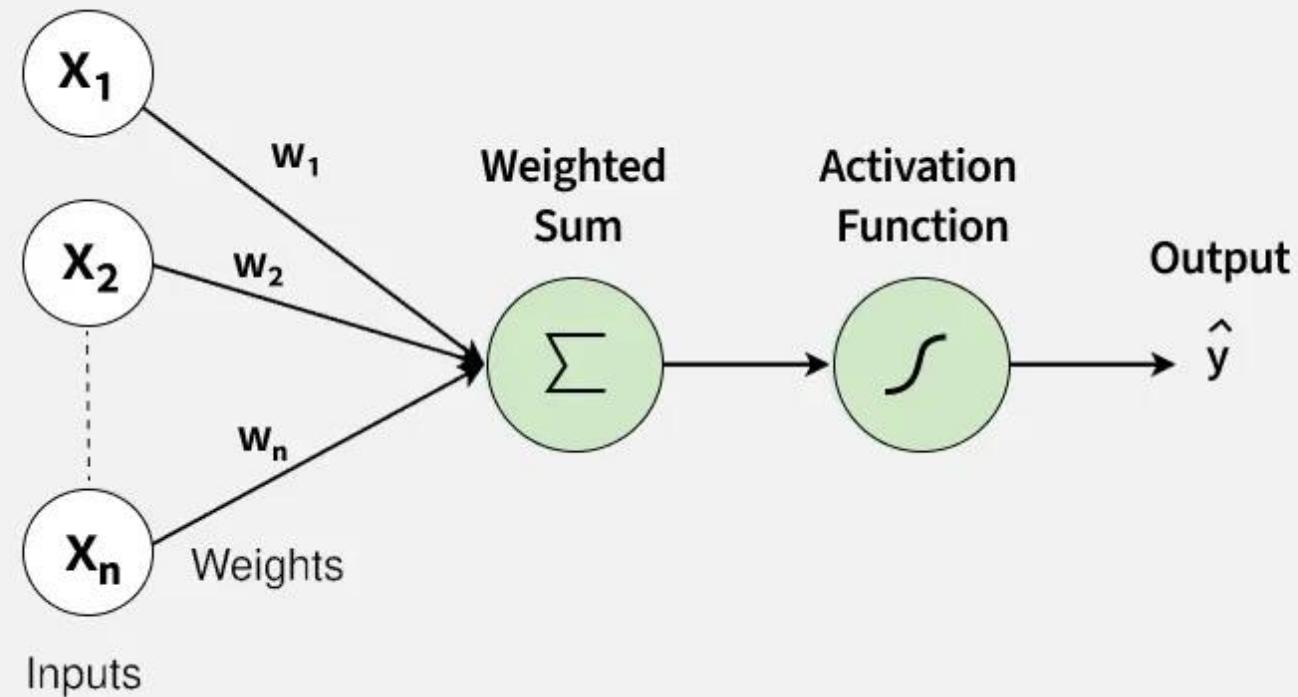
# How It Works, Conceptually

# Model Parameters

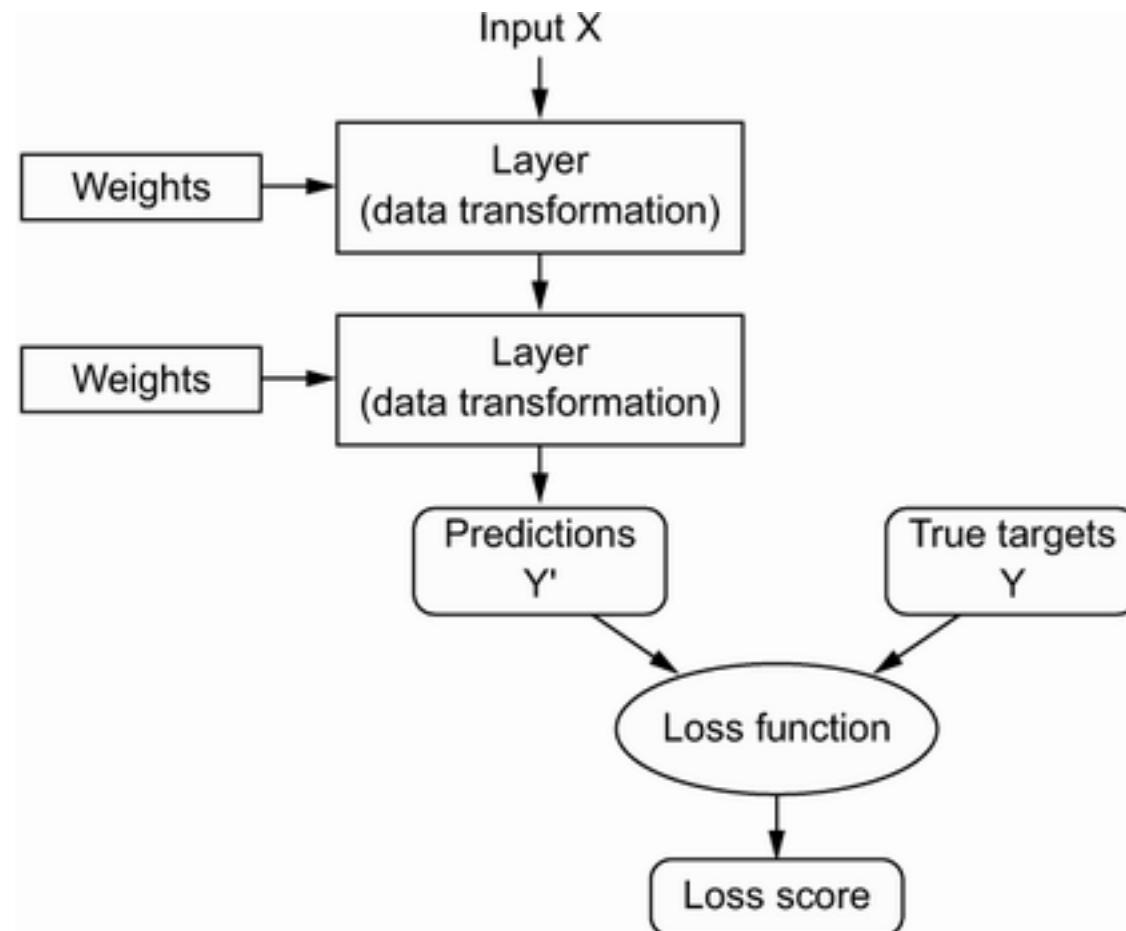
**Goal: finding the right values for these weights**



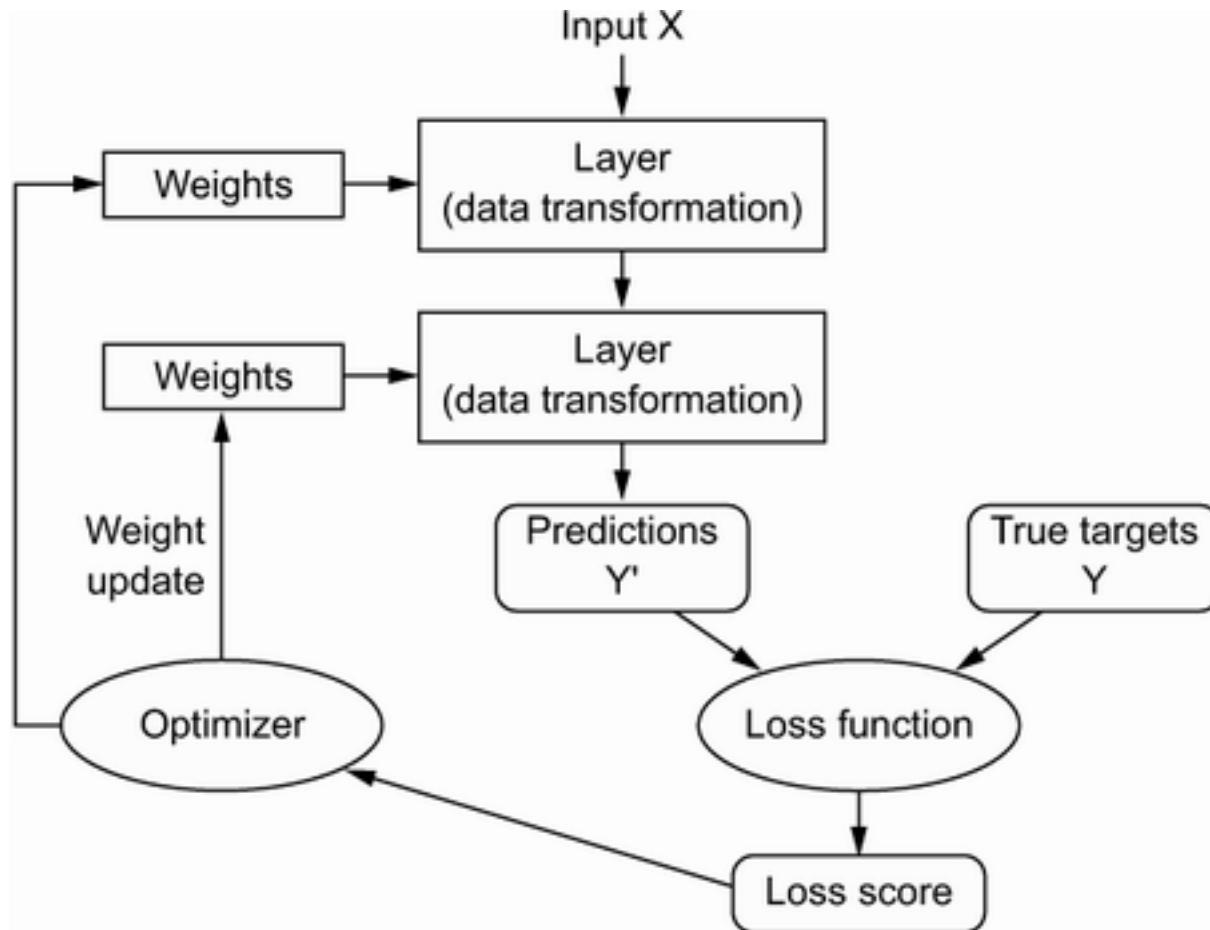
# Model Parameters



# Loss Function (Error)



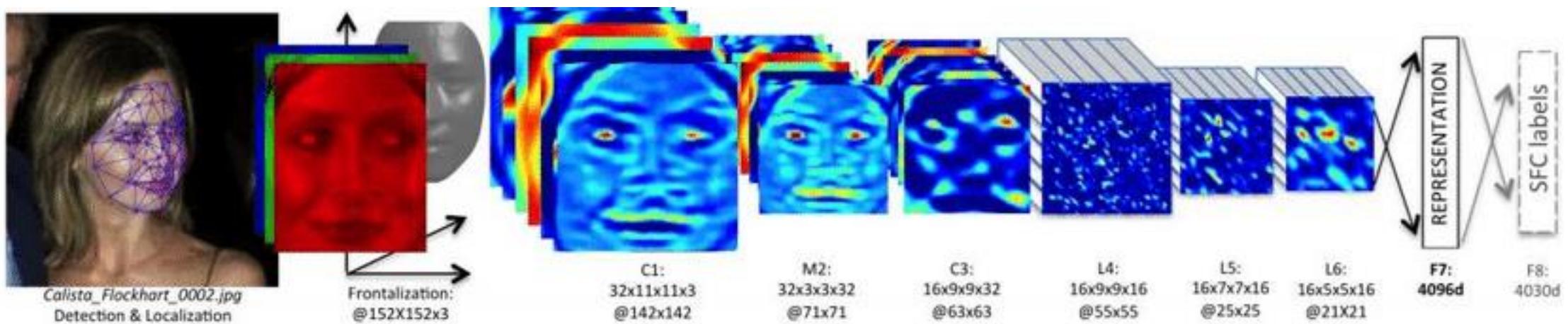
# Optimization



# When to Learn Deeply (vs. Not)

## COMPLEX RELATIONSHIPS

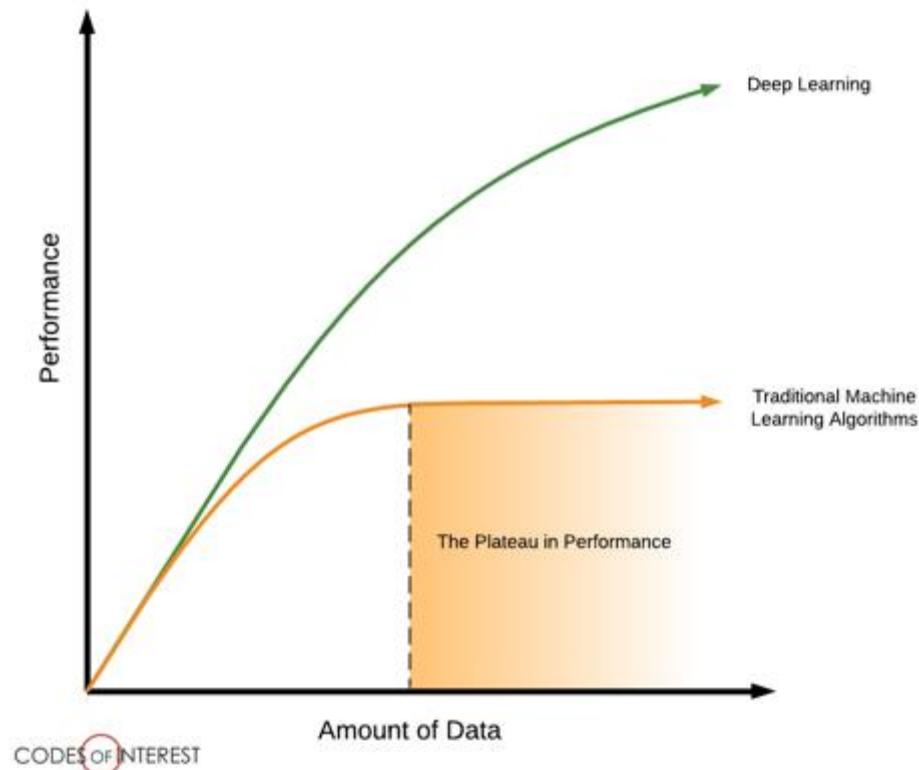
- Complex, non-linear, interactive relationships and mappings; common use cases involve unstructured (high dimensional) data. Deep learning techniques remove the need for feature engineering, a daunting task.



# When to Learn Deeply (vs. Not)

## LOTS OF DATA ON HAND

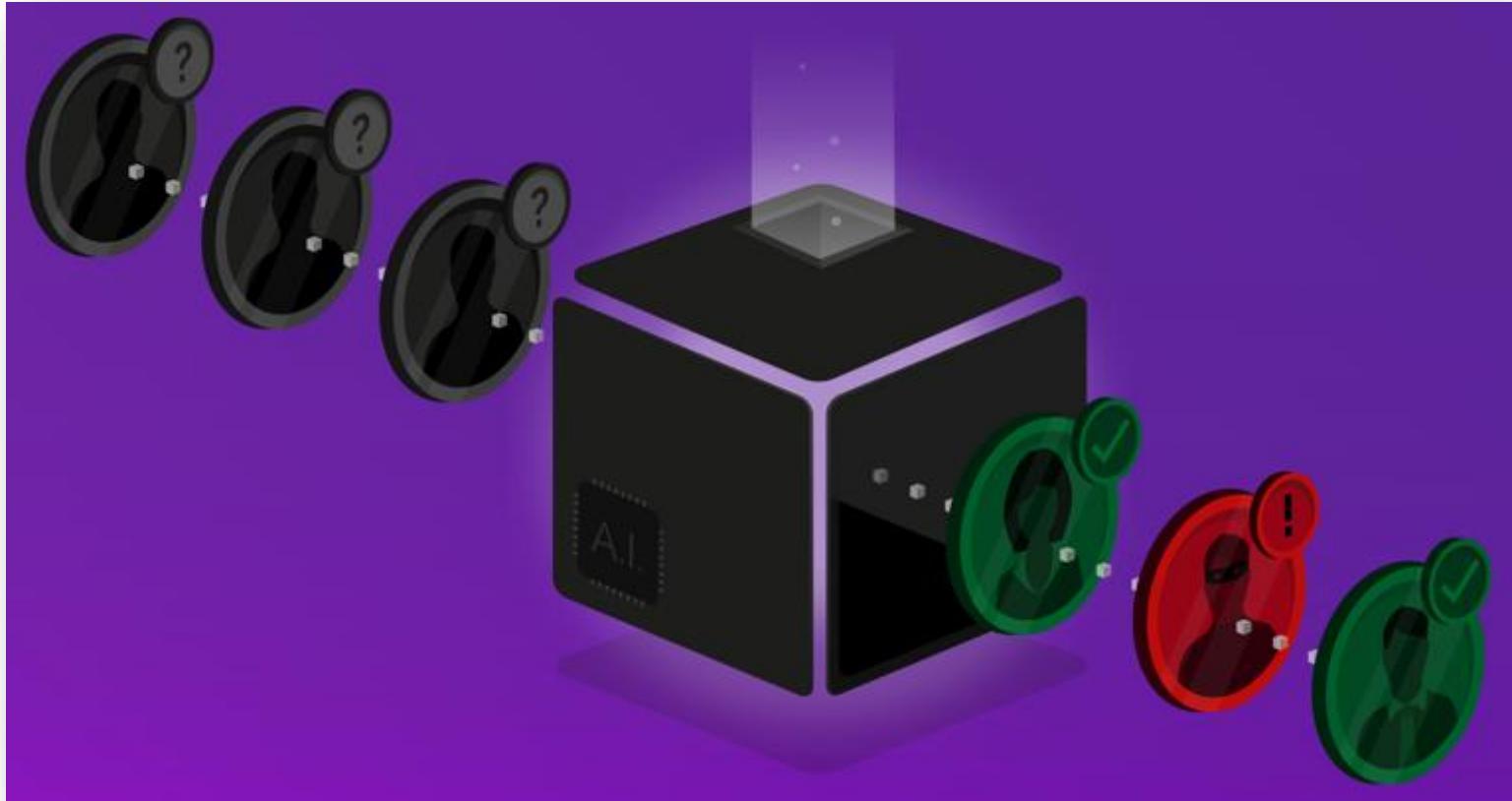
- To be able to learn those complex mappings, typically requires many, many, many training examples.



# 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.

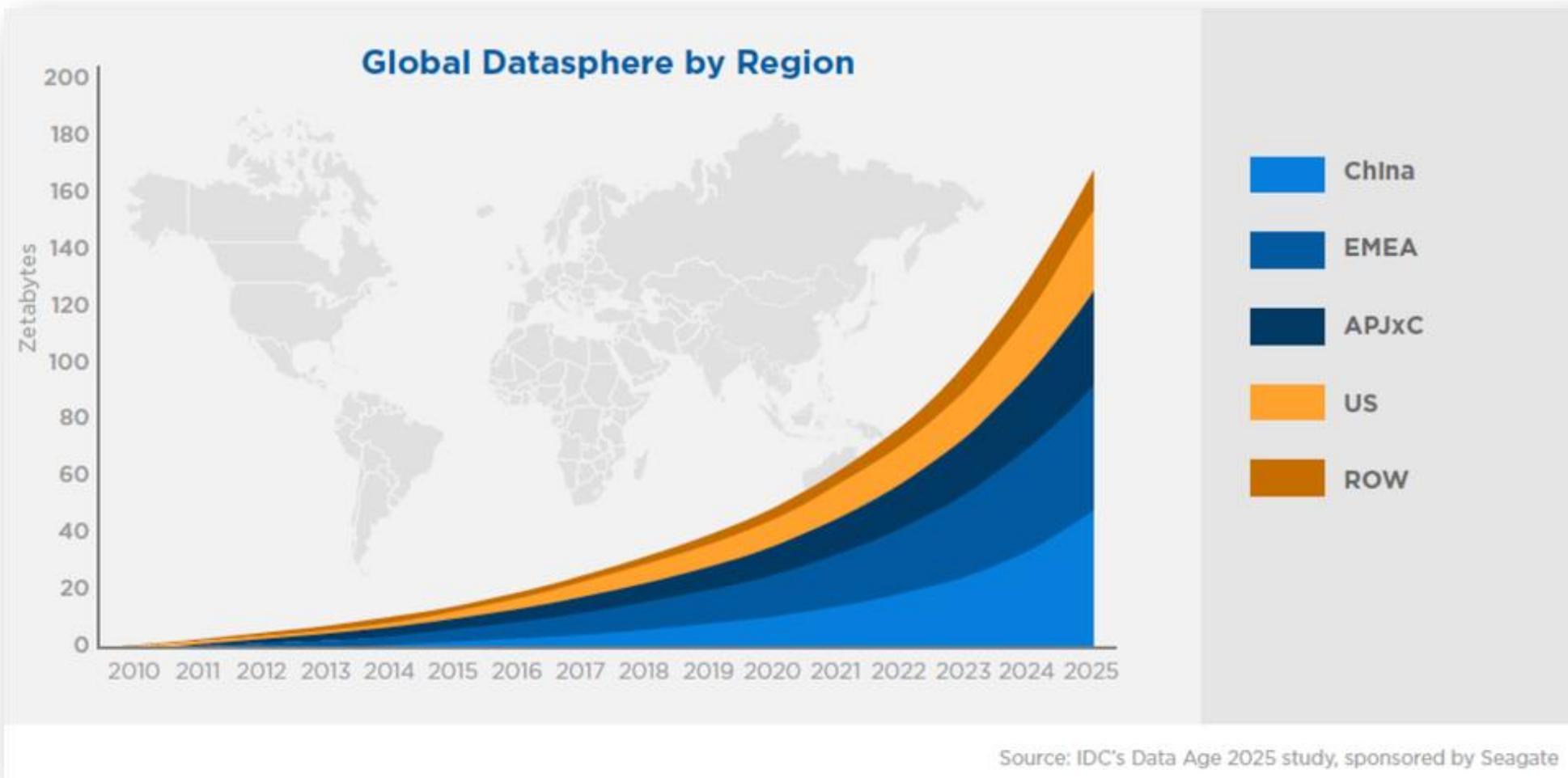


# Why Did Deep Learning Take Off?

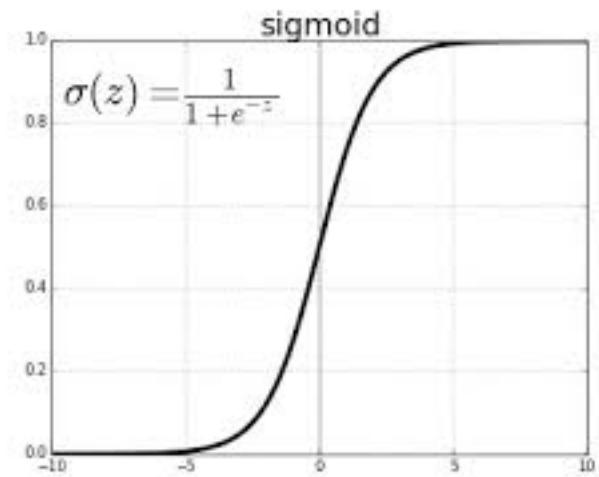
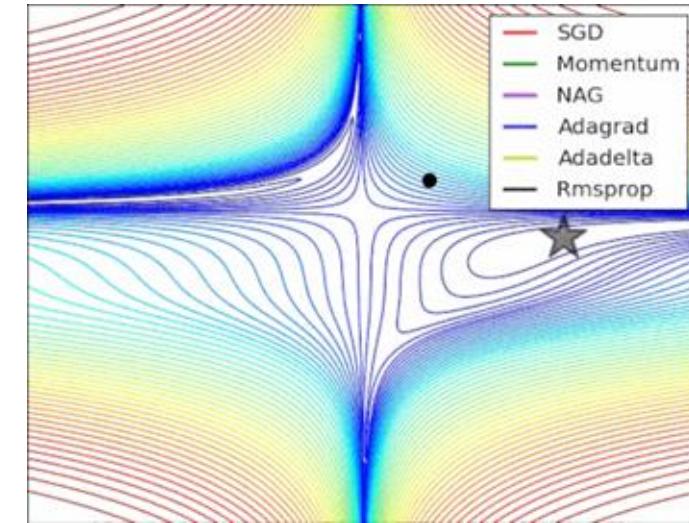
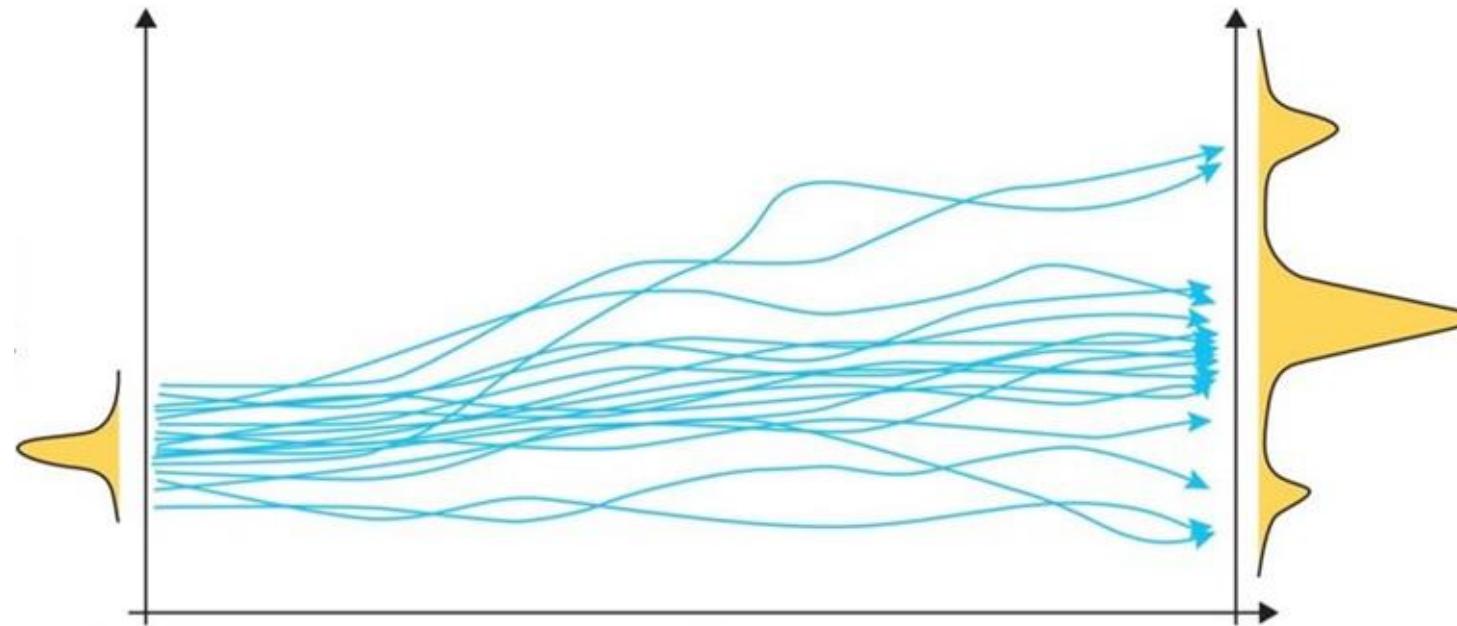


# Video Games

# Data



# Algorithmic Improvements



# Questions?