

# 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

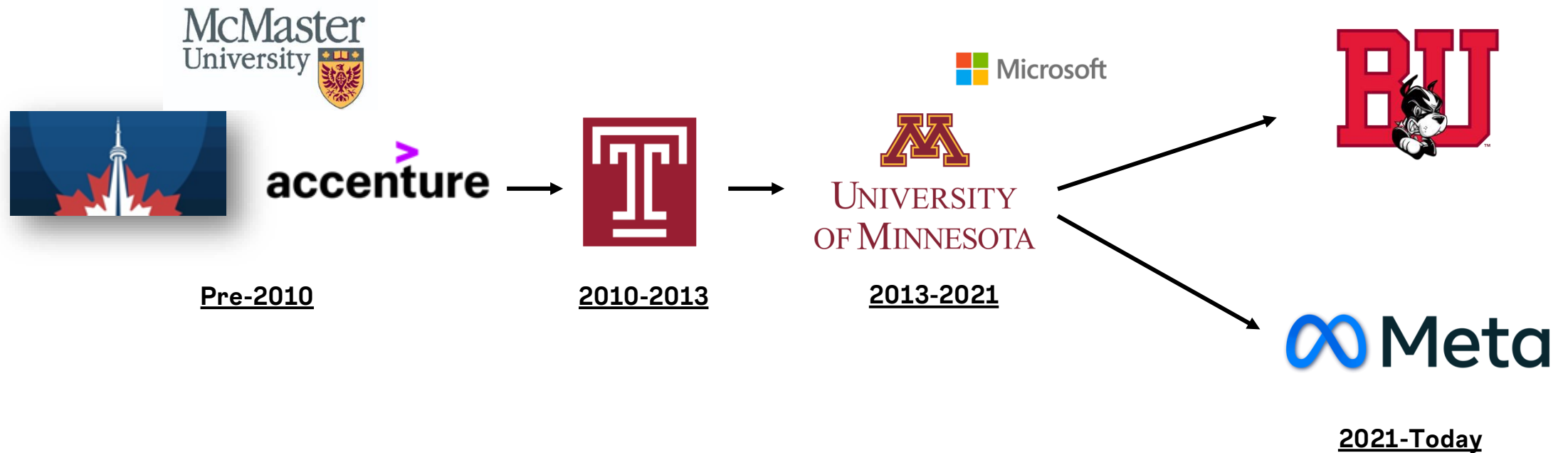
- Frivolous, academic, and practically useful.
- A recent failure, and societal concerns.

## 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\*

**Yuan Gao**  
Questrom School of Business  
Information Systems Department  
Boston University  
Boston, MA 02215  
yuangg@bu.edu

**Dokyun Lee**  
Questrom School of Business  
Information Systems Department and  
Computing & Data Sciences  
Boston University  
Boston, MA 02215  
dokyun@bu.edu

**Gordon Burtch**  
Questrom School of Business  
Information Systems Department  
Boston University  
Boston, MA 02215  
gburtch@bu.edu

**Sina Fazelpour**  
Department of Philosophy and  
Khouri College of Computer Sciences  
Northeastern University  
Boston, MA 02115  
s.fazel-pour@northeastern.edu

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

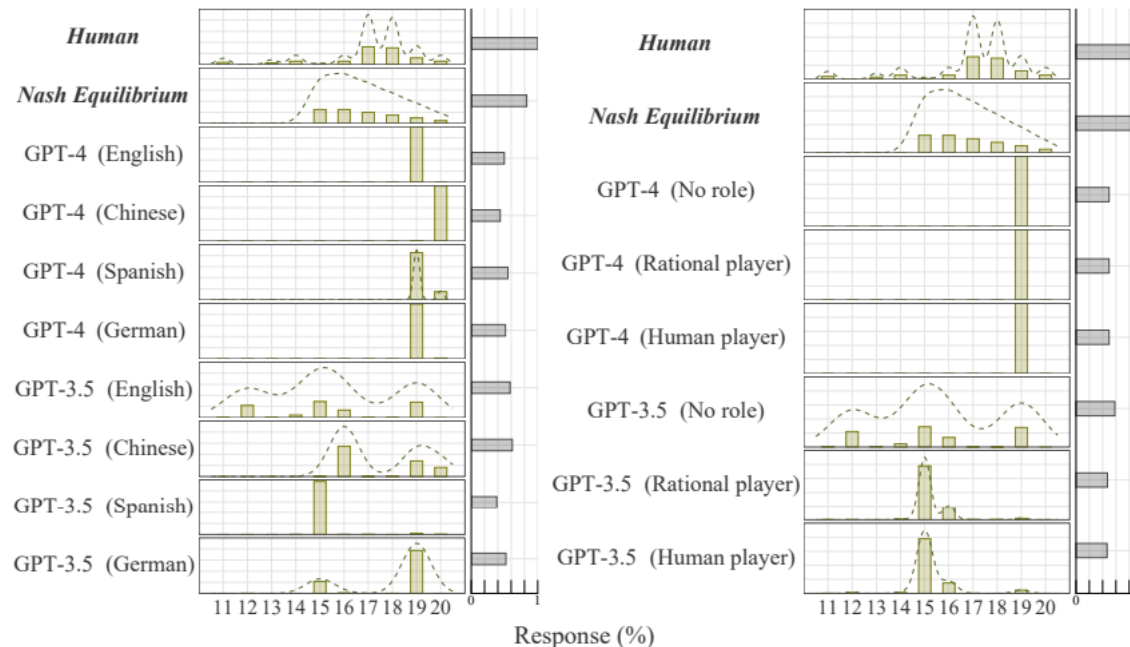
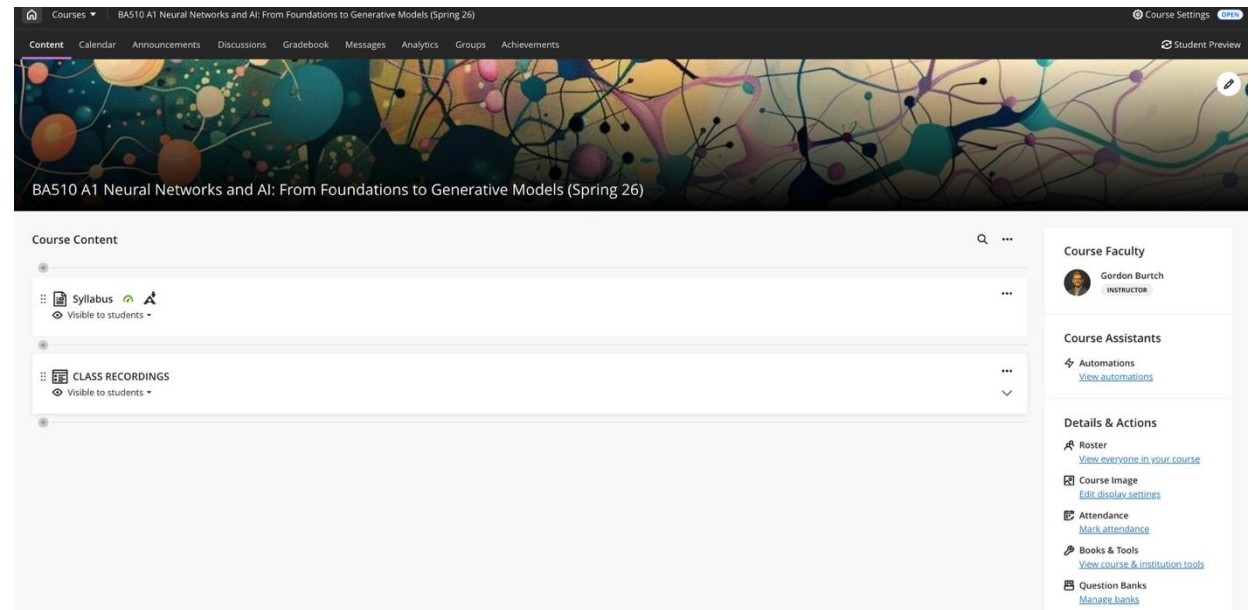


Figure 2: **Prompt Brittleness: Roles and Languages.** The bar chart on the right shows the similarity between the distribution of different subjects and human subjects, measured by Jensen-Shannon divergence scores. Density plots are omitted for subjects with over 98% of the data concentrated in a single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



## 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

## 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%

## 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.

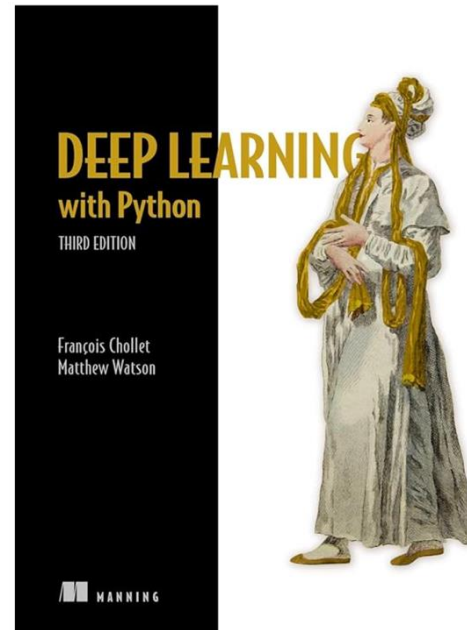
## QUIZZES

- 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.

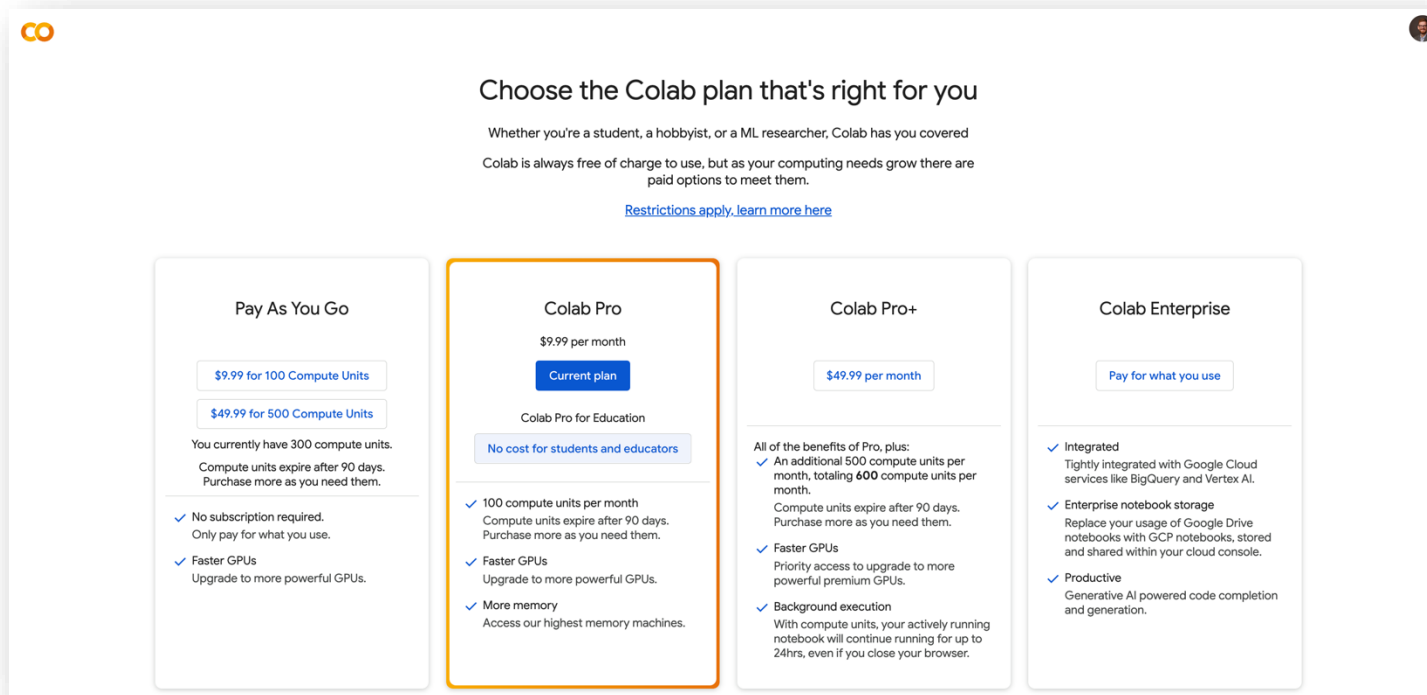
# Course Textbook



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!



Choose the Colab plan that's right for you

Whether you're a student, a hobbyist, or a ML researcher, Colab has you covered. Colab is always free of charge to use, but as your computing needs grow there are paid options to meet them.

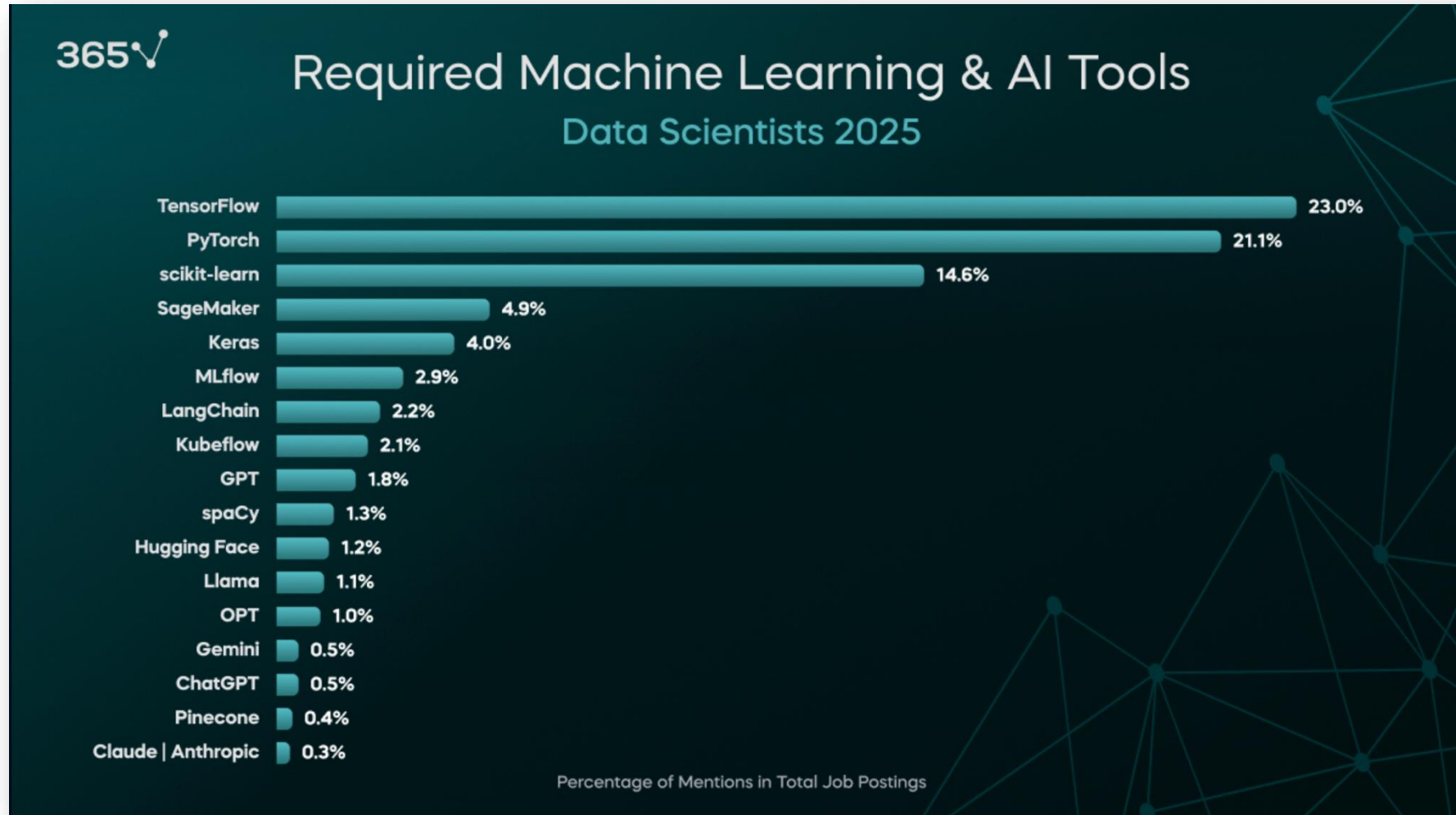
[Restrictions apply. learn more here](#)

Pay As You Go	Colab Pro	Colab Pro+	Colab Enterprise
<p>\$9.99 for 100 Compute Units</p> <p>\$49.99 for 500 Compute Units</p> <p>You currently have 300 compute units. Compute units expire after 90 days. Purchase more as you need them.</p> <ul style="list-style-type: none"><li>✓ No subscription required. Only pay for what you use.</li><li>✓ Faster GPUs. Upgrade to more powerful GPUs.</li></ul>	<p>\$9.99 per month</p> <p><b>Current plan</b></p> <p>Colab Pro for Education</p> <p><a href="#">No cost for students and educators</a></p> <ul style="list-style-type: none"><li>✓ 100 compute units per month. Compute units expire after 90 days. Purchase more as you need them.</li><li>✓ Faster GPUs. Upgrade to more powerful GPUs.</li><li>✓ More memory. Access our highest memory machines.</li></ul>	<p>\$49.99 per month</p> <p>All of the benefits of Pro, plus:</p> <ul style="list-style-type: none"><li>✓ An additional 500 compute units per month, totaling 600 compute units per month. Compute units expire after 90 days. Purchase more as you need them.</li><li>✓ Faster GPUs. Priority access to upgrade to more powerful premium GPUs.</li><li>✓ Background execution. With compute units, your actively running notebook will continue running for up to 24hrs, even if you close your browser.</li></ul>	<p>Pay for what you use</p> <ul style="list-style-type: none"><li>✓ Integrated. Tightly integrated with Google Cloud services like BigQuery and Vertex AI.</li><li>✓ Enterprise notebook storage. Replace your usage of Google Drive notebooks with GCP notebooks, stored and shared within your cloud console.</li><li>✓ Productive. Generative AI powered code completion and generation.</li></ul>






# Why Keras?



# Google Colab




 Making the Most of your Colab Subscription

File Edit View Insert Runtime Tools Help

Q Commands + Code + Text ▶ Run all Copy to Drive

Share

Connect

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

# 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.

(Subject to Revision Depending on Progress)

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

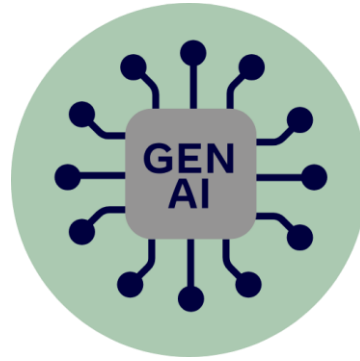


## LECTURES

- 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

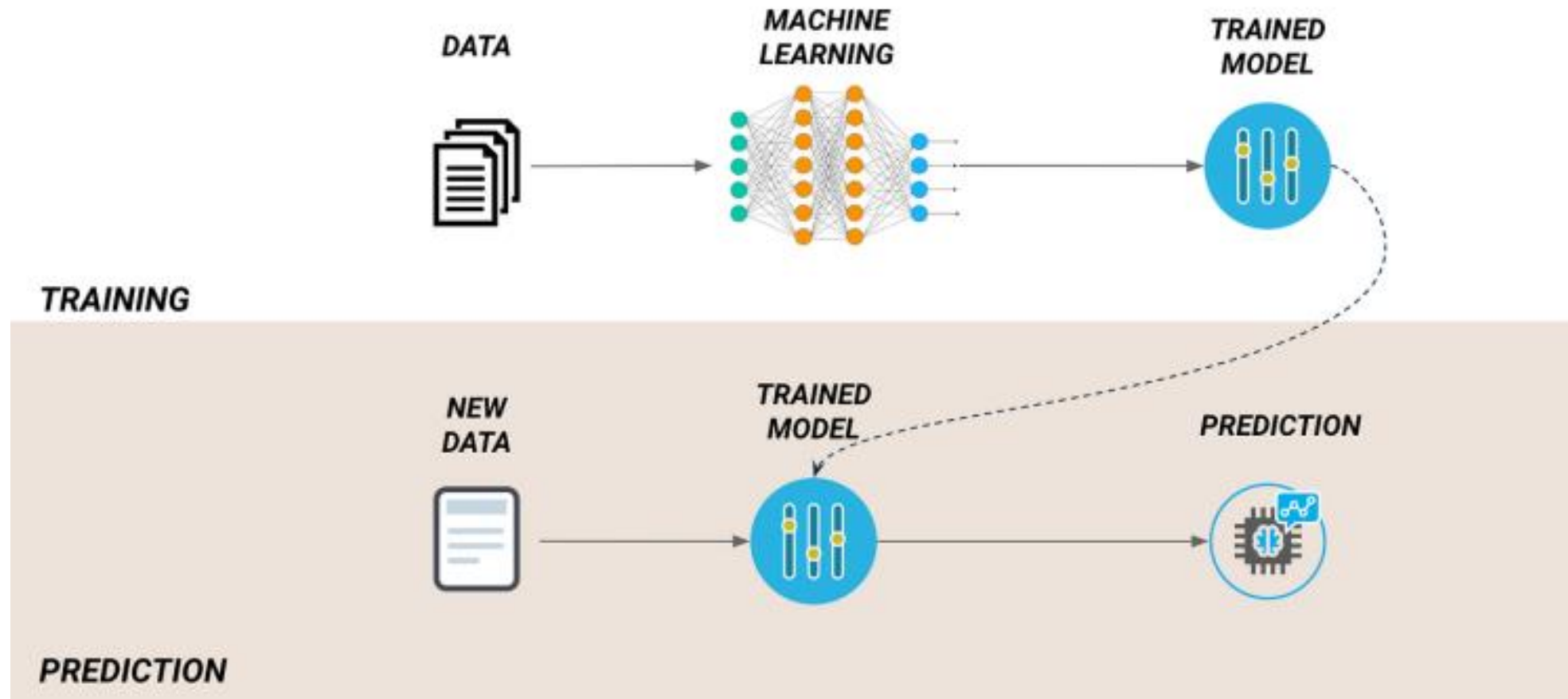
I expect you to use these tools, but the way you use them matters. Some valid use cases include i) implementing data munging tasks that you already understand based on past coursework, e.g., pre-processing text, or ii) automatic generation of code comments or documentation.

## 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.

# Questions?

# Supervised Learning

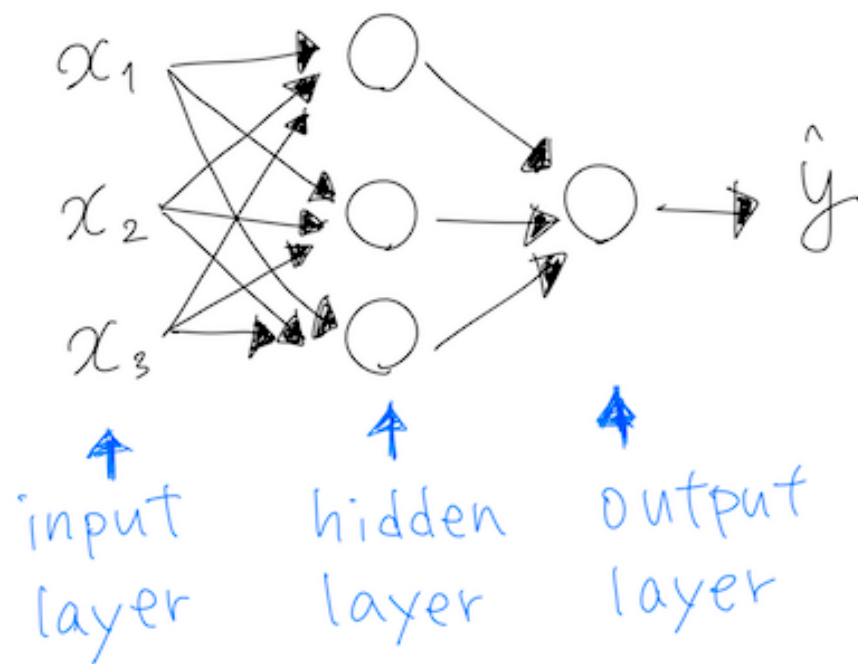


# So, What is 'Deep' (vs. Shallow) Learning?

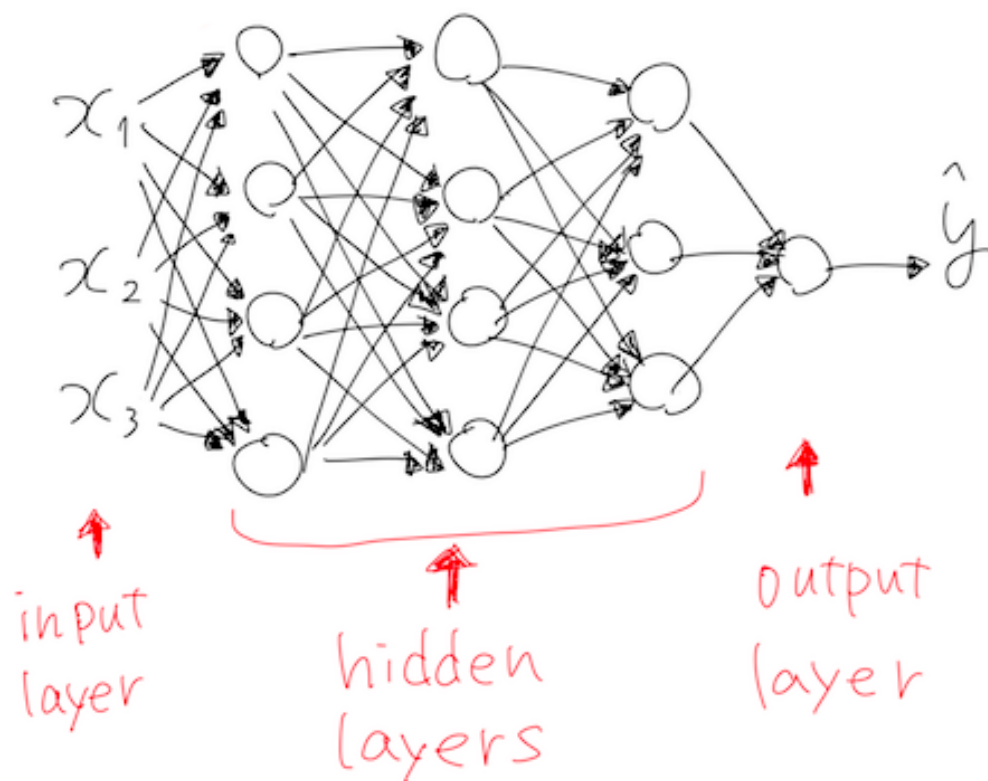
<https://chat.openai.com/chat>



## 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.

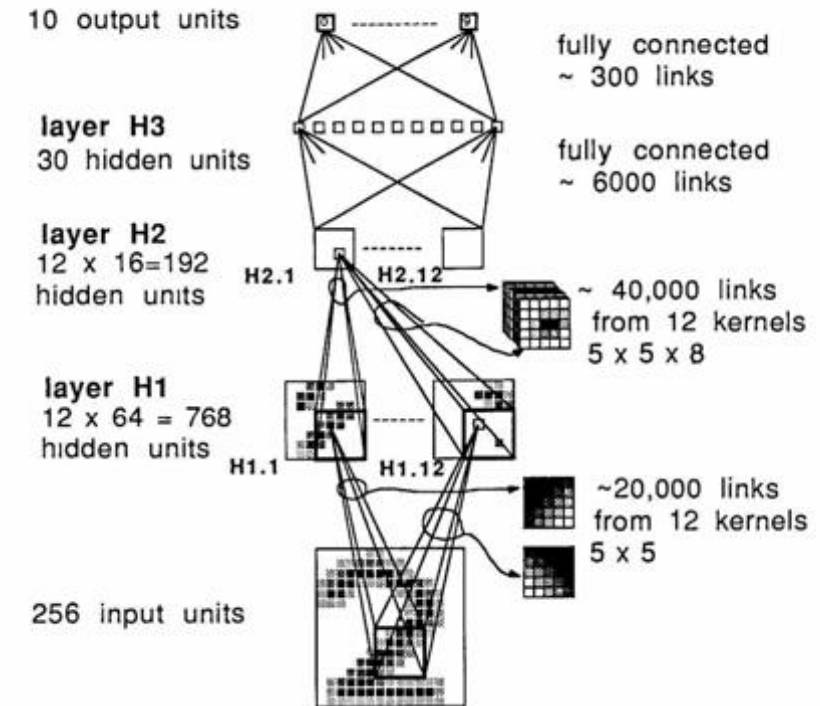
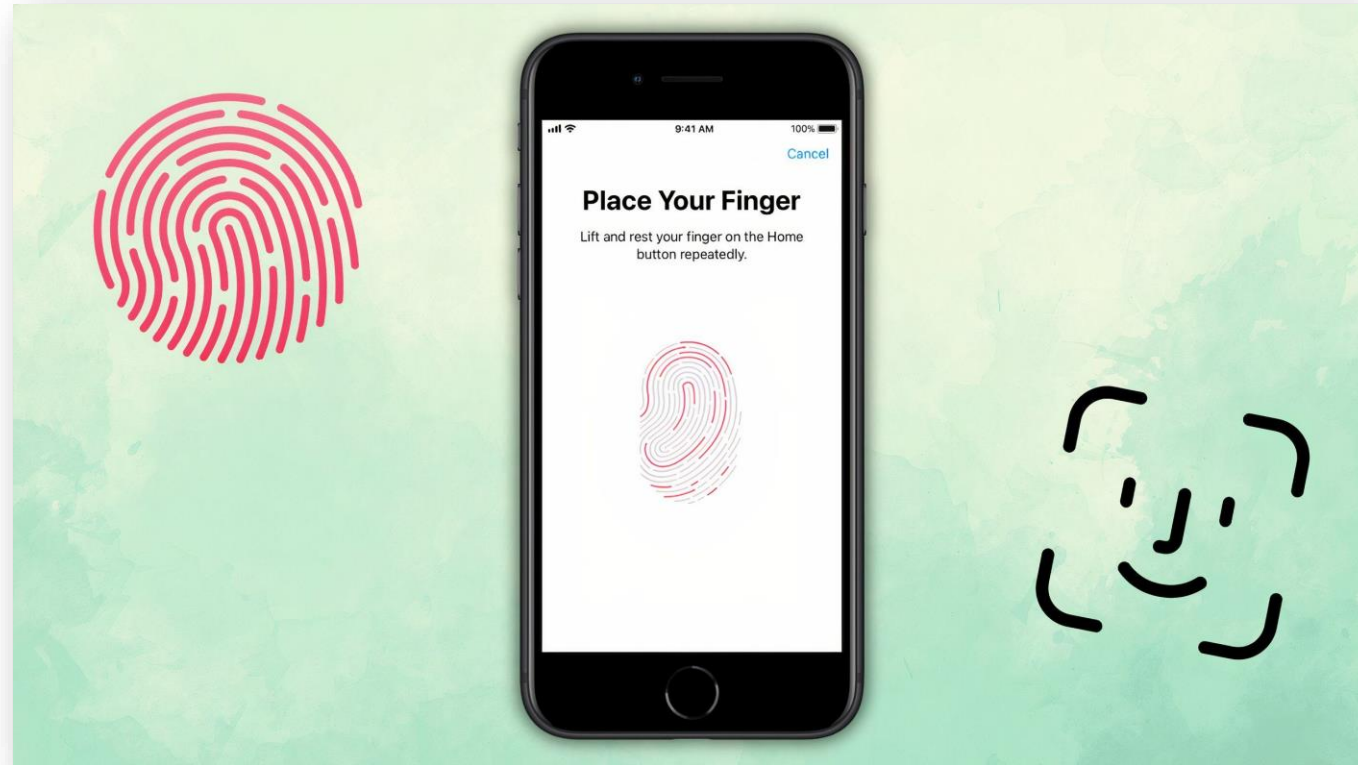


Figure 3 Log mean squared error (MSE) (top) and raw error rate (bottom) versus number of training passes

# 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.

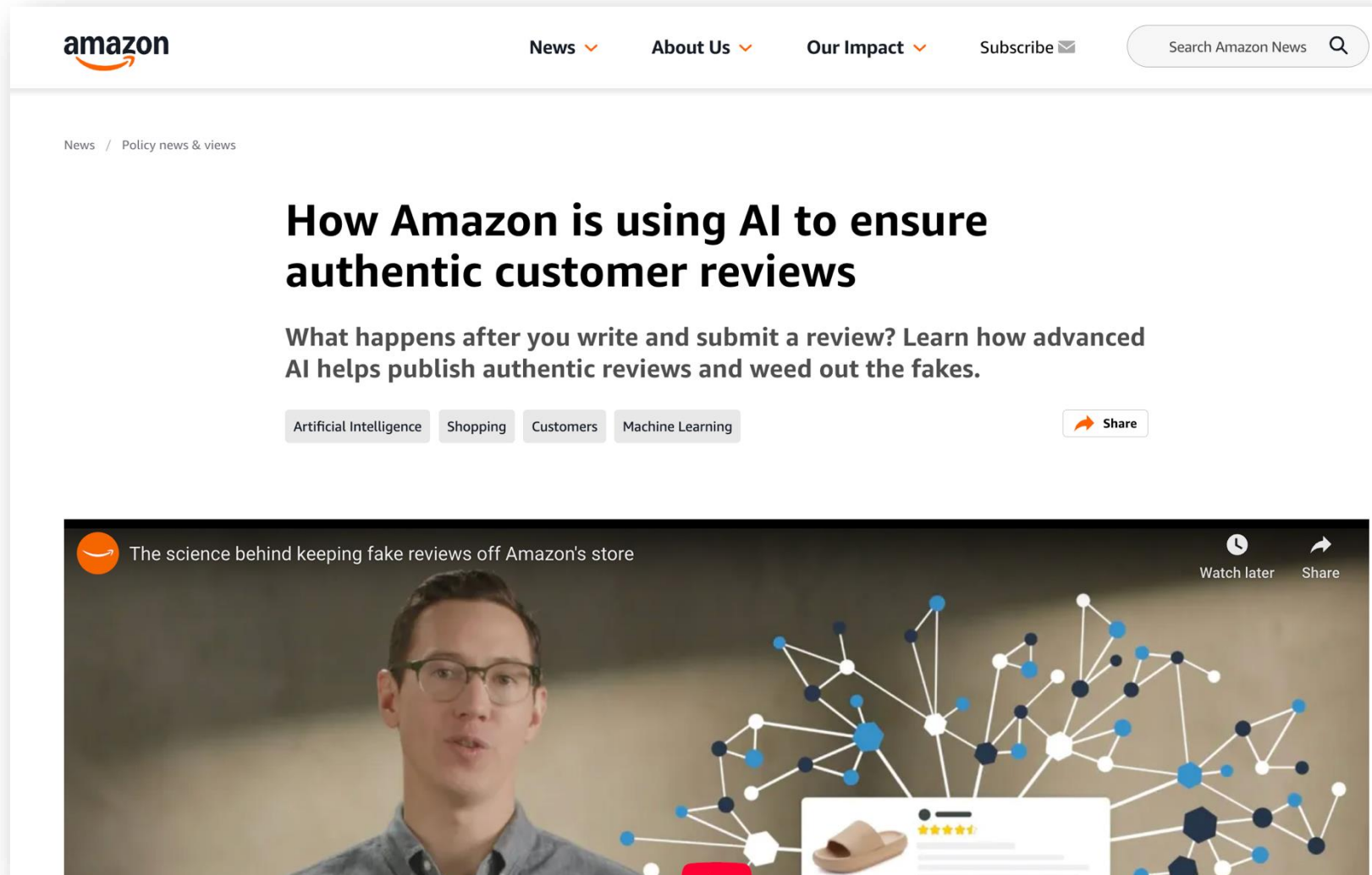
EXPLORE HOW IT WORKS →

TALK WITH AN EXPERT

 **neuroID**  
A part of  experian.



# Modern Examples: Fake Review Detection



# Modern Examples: Gunfire Detection





# Modern Examples: Part Failure Prediction



Industries ▾

Products ▾

Resources ▾

Events ▾

Careers

Contact Us

COMPANIES









## Azima DLI

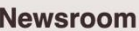
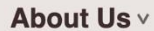


Maximize uptime and demonstrate the ROI of your reliability program with vibration monitoring, advanced AI analysis, and enterprise reporting.

Contact Us



# Modern Examples: Audio Transcription






## 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



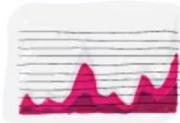
#### Note Summarization

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



# Modern Examples: AI Text Detector

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.

[Try it for free](#) [Get in touch](#)

Check for AI by simply clicking a button!

 Reviewed as the proven, **most reliable** and **most accurate** AI detection tool by third parties including University of Maryland

[Screenshot](#)

### Enter text below to check for AI

Try an example text.

[Random review](#) [Random blog post](#) [Random essay](#)

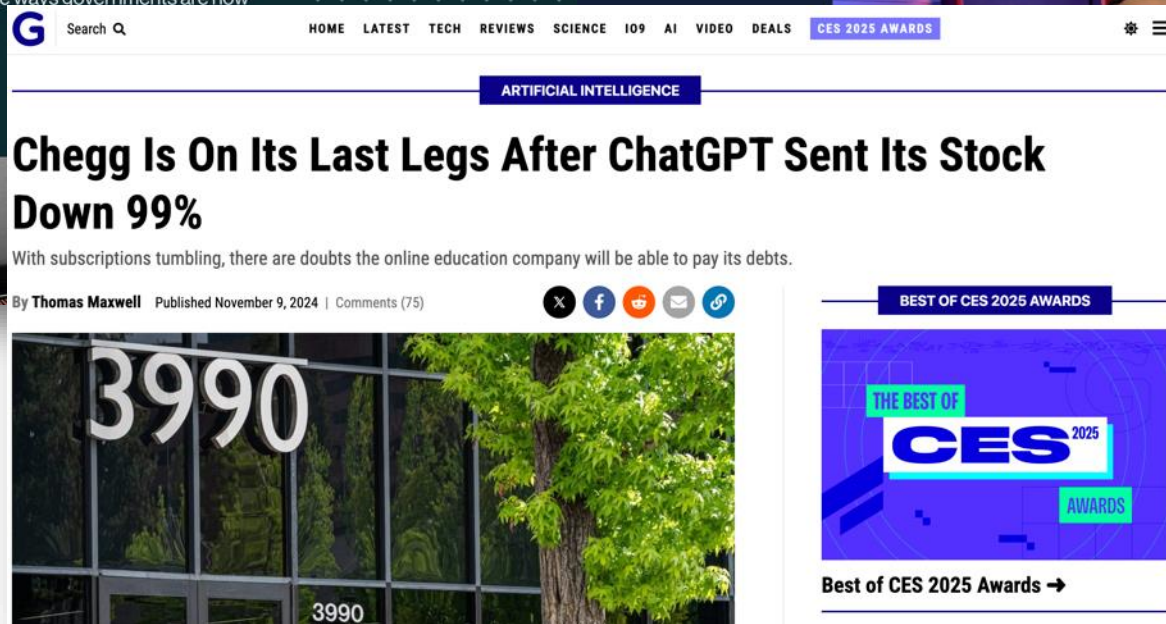
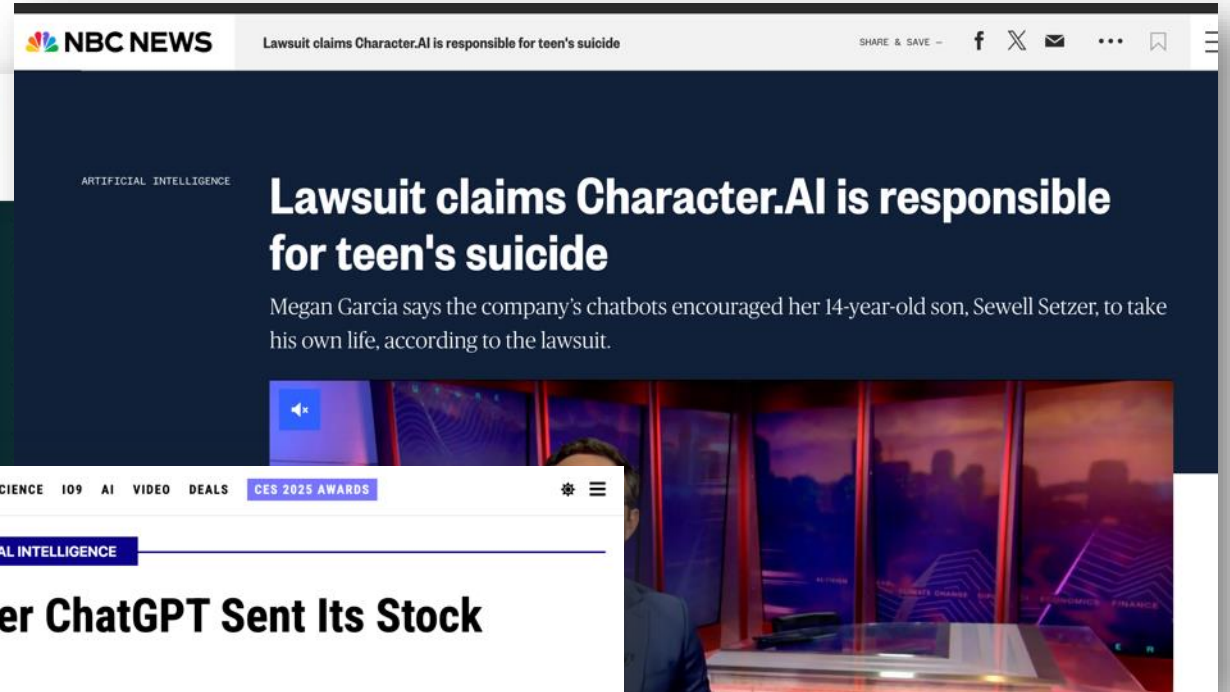
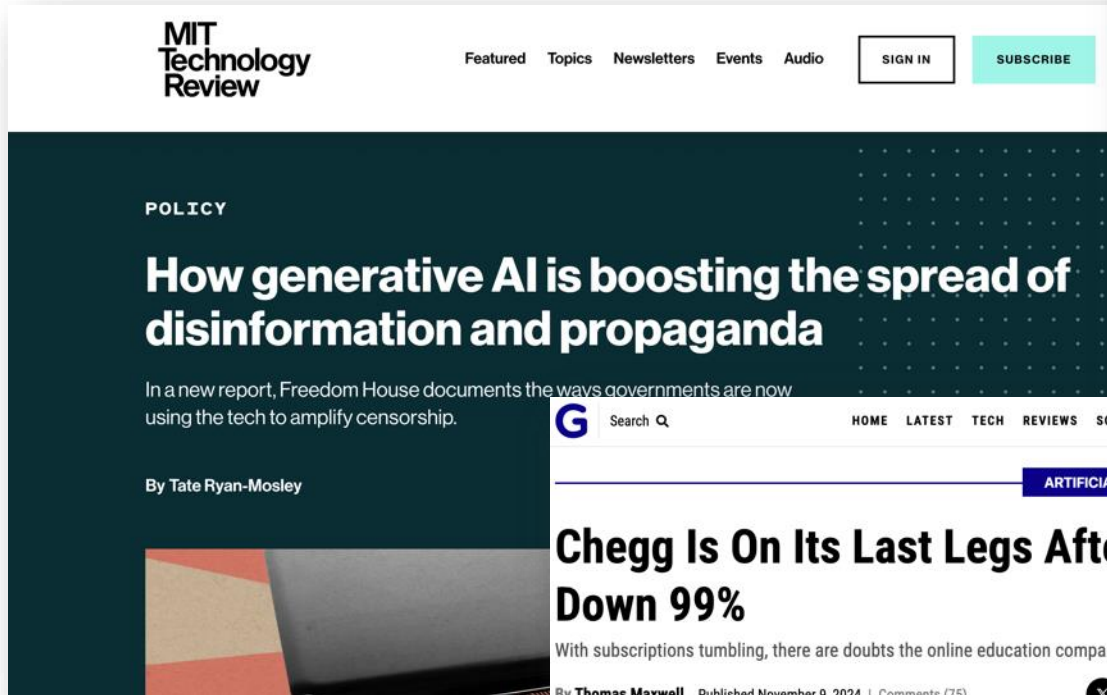
[Random ChatGPT review](#) [Random ChatGPT blog post](#)

[Random ChatGPT essay](#)

Enter some text to check for AI.

[Upload](#) [Scan for AI](#)

# These Technologies Bring New Problems





# 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

**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

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](#)

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

**ZEGNA**

**ZEGNA**

// 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

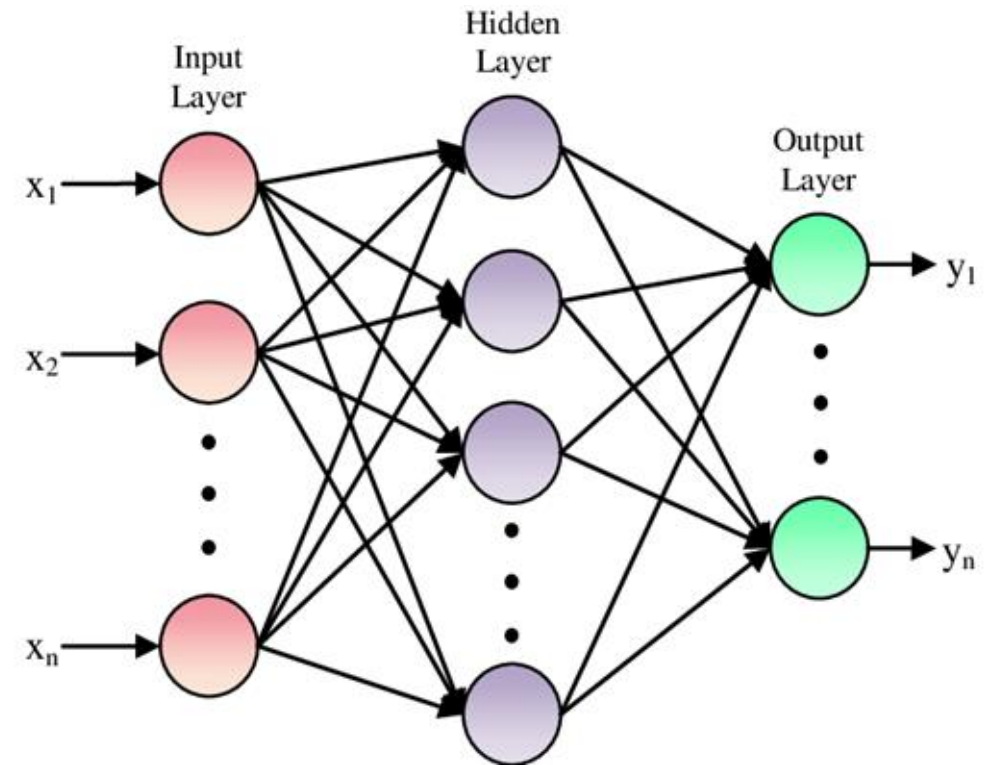
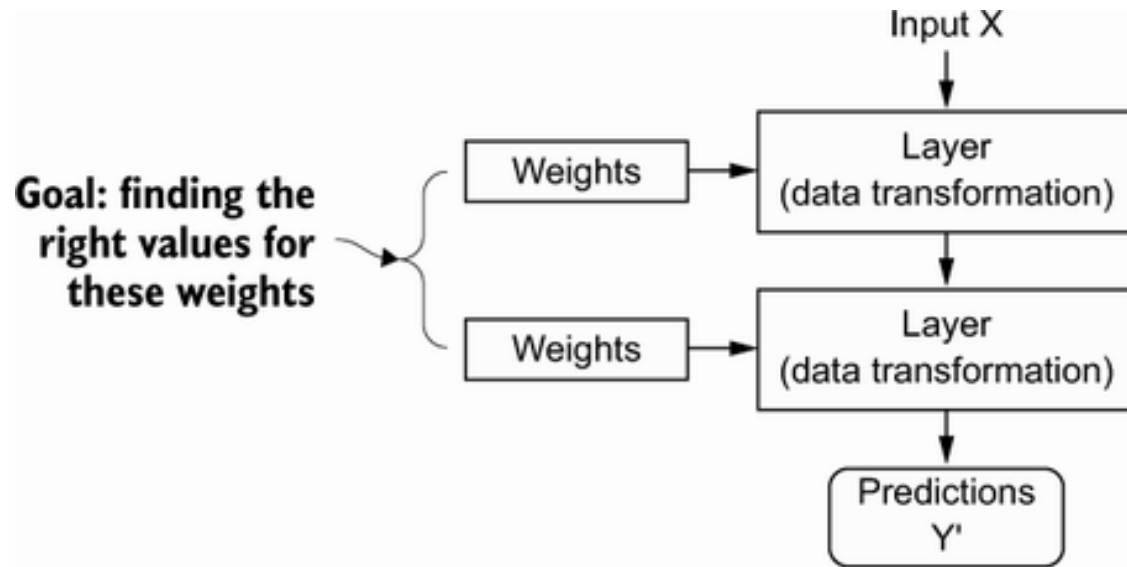
10 minutes  
11 comments

By Dylan Patel and Afzal Ahmad

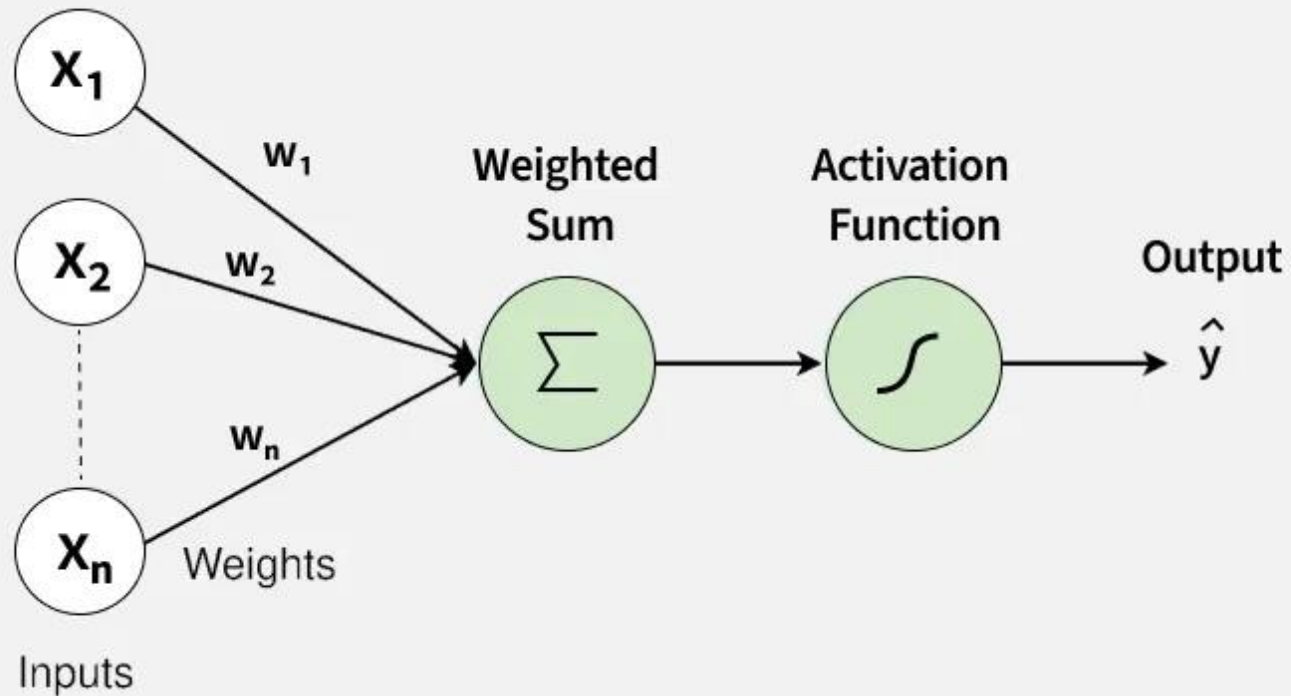
[↻](#) [in](#) [X](#) [f](#)

# How It Works, Conceptually

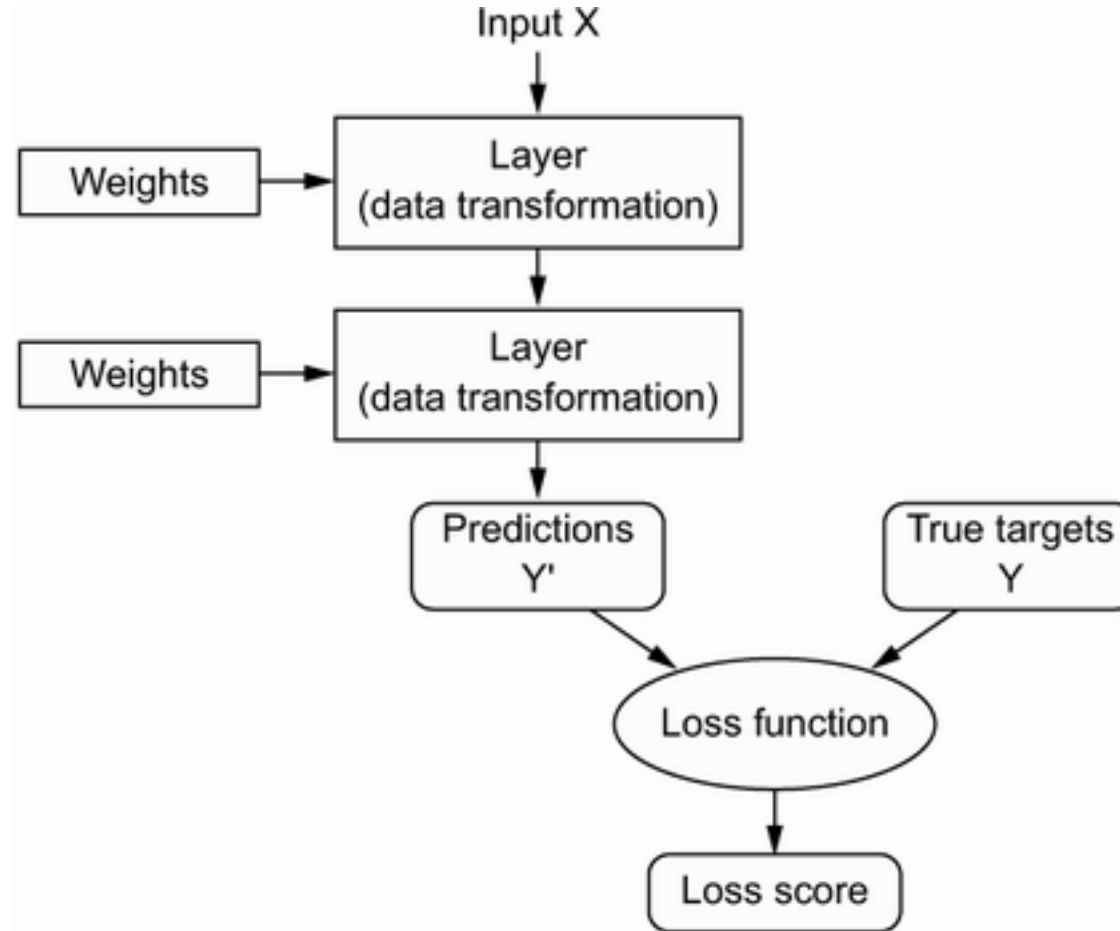
# Model Parameters



# Model Parameters

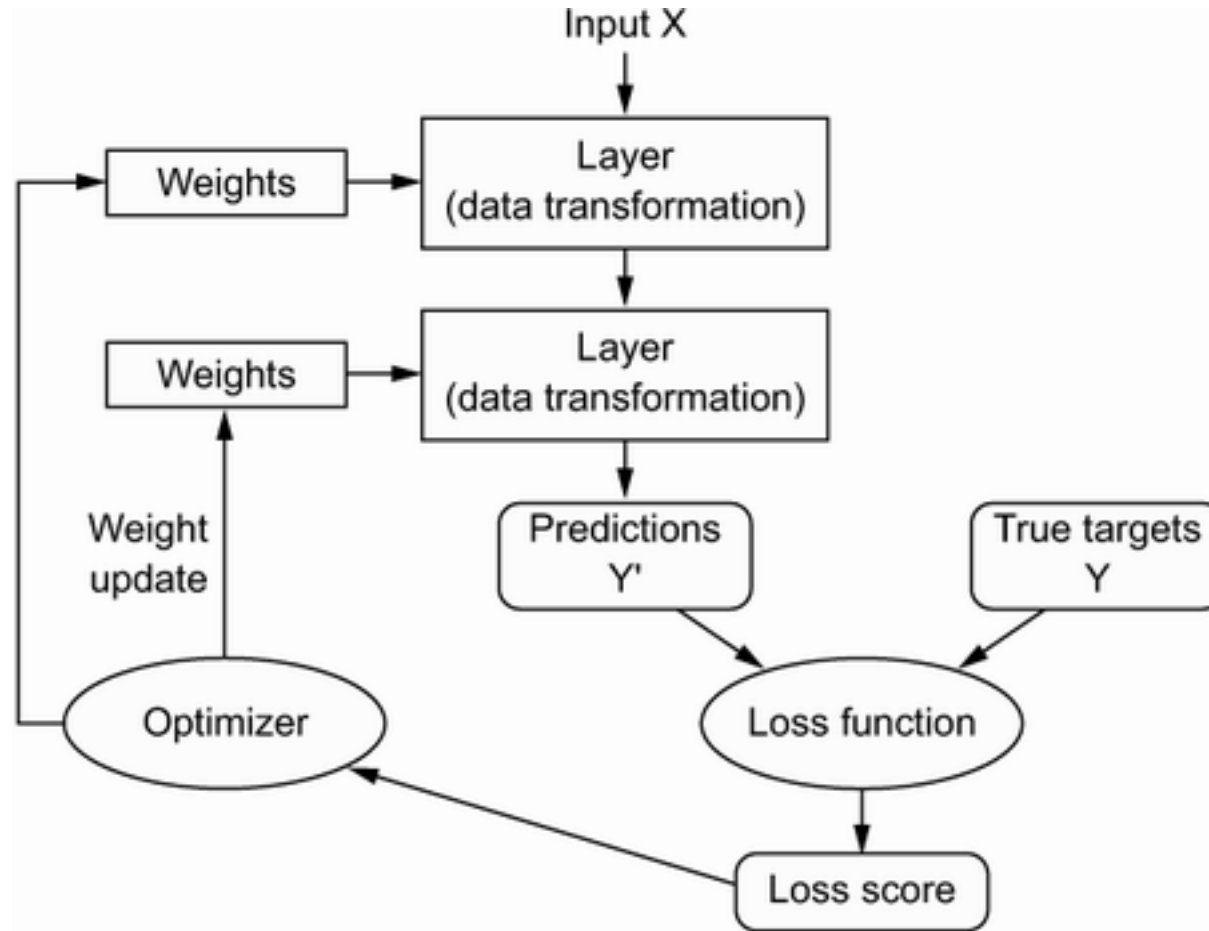


# Loss Function (Error)





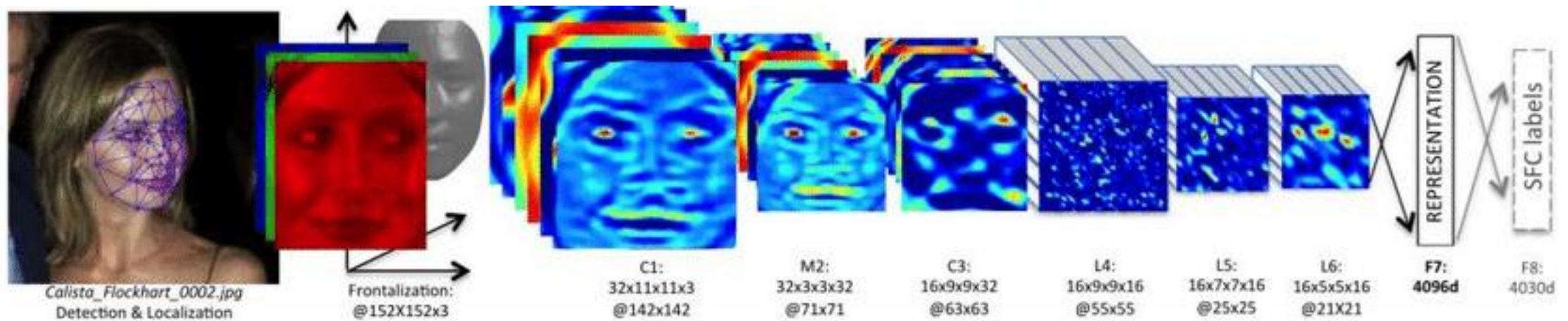
# Optimization



# When to Learn Deeply (vs. Not)

## COMPLEX RELATIONSHIPS

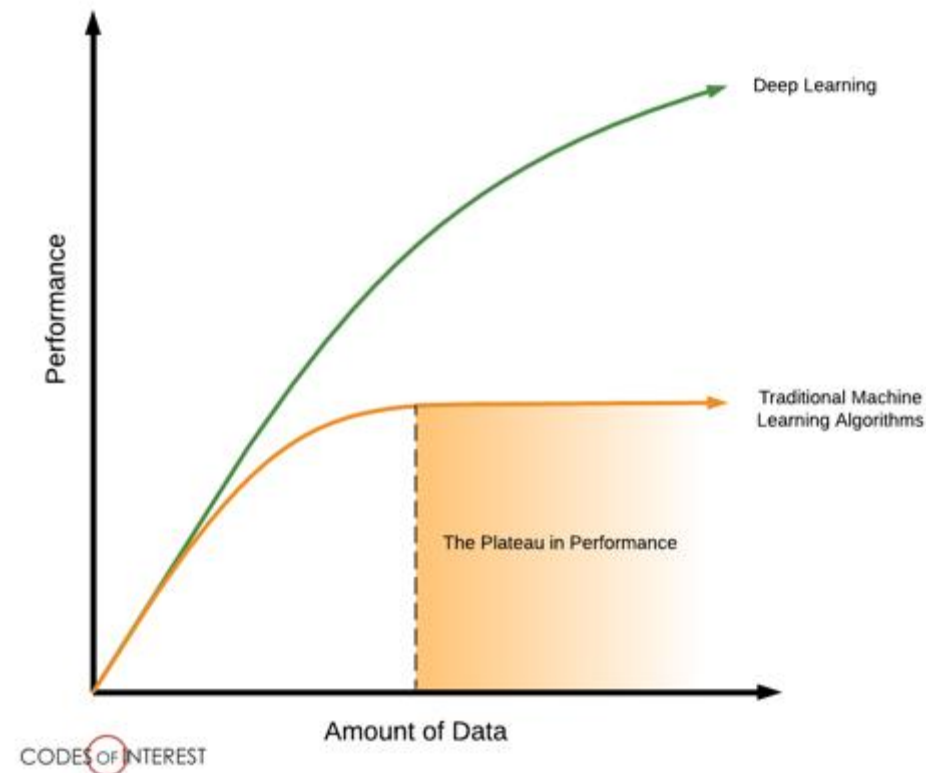
- Complex, non-linear, interactive relationships and mappings; common use cases involve unstructured (high dimensional) data. Deep learning techniques remove the need for feature engineering, a daunting task.



# When to Learn Deeply (vs. Not)

## LOTS OF DATA ON HAND

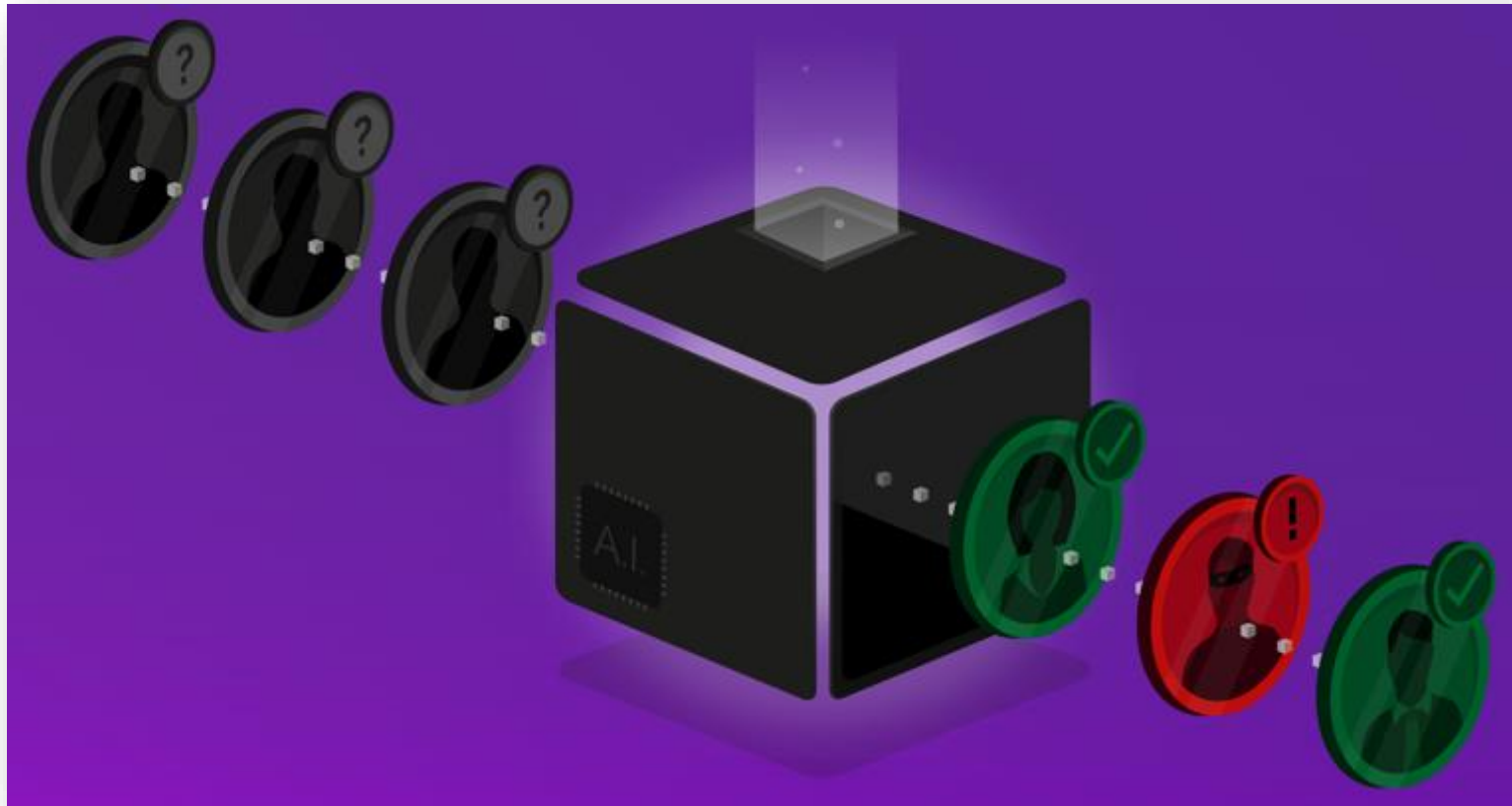
- To be able to learn those complex mappings, typically requires many, many, many training examples.



# 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.



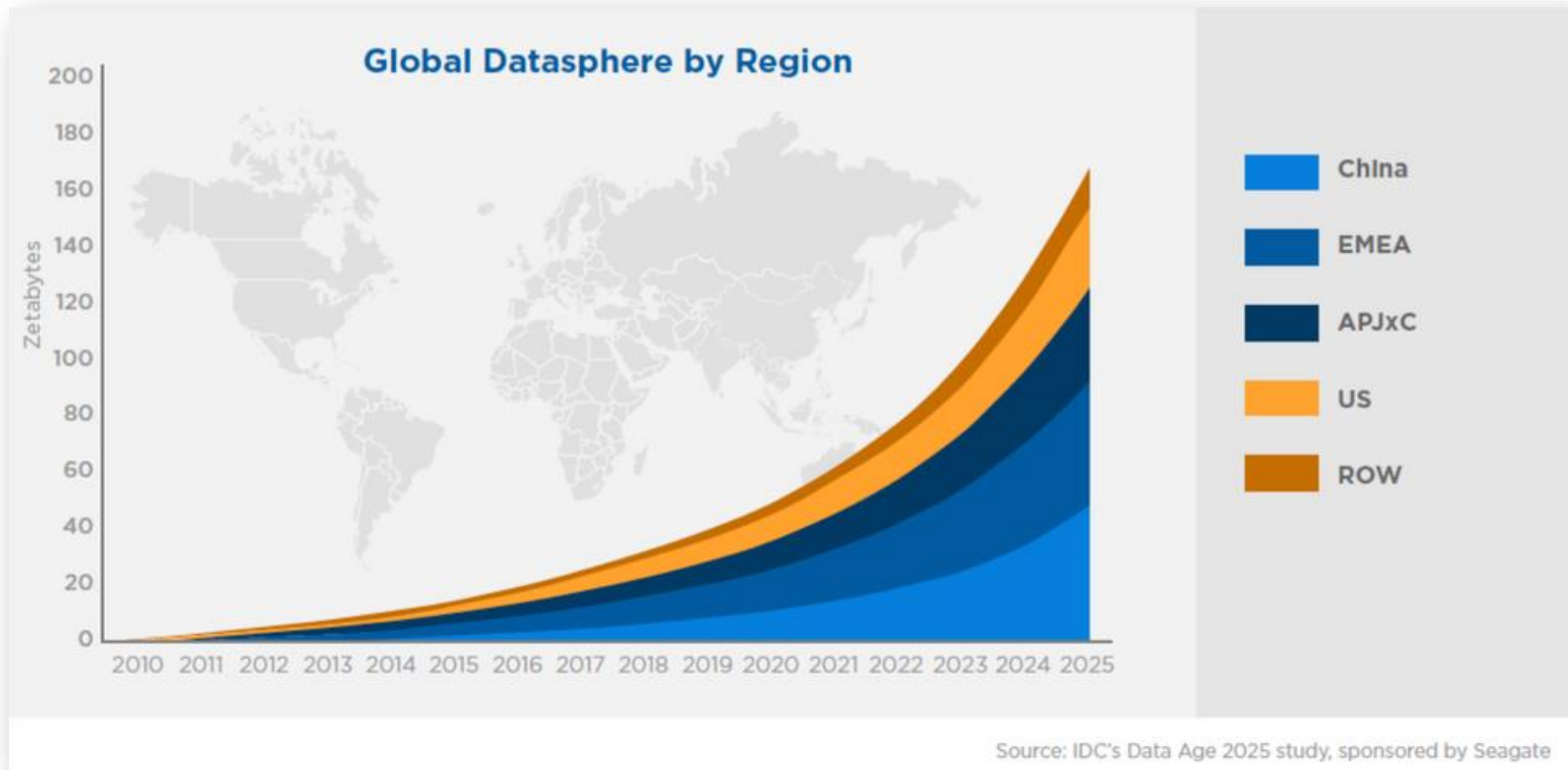
# Why Did Deep Learning Take Off?



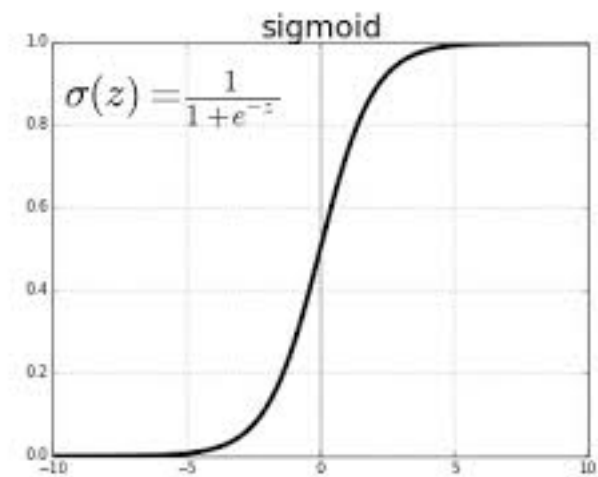
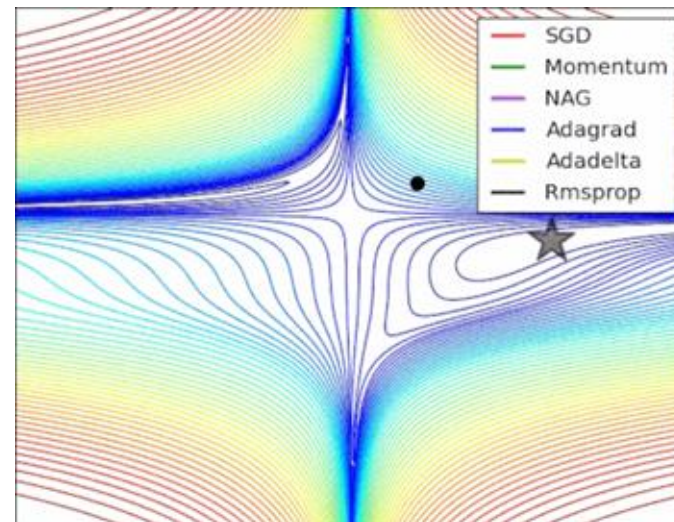
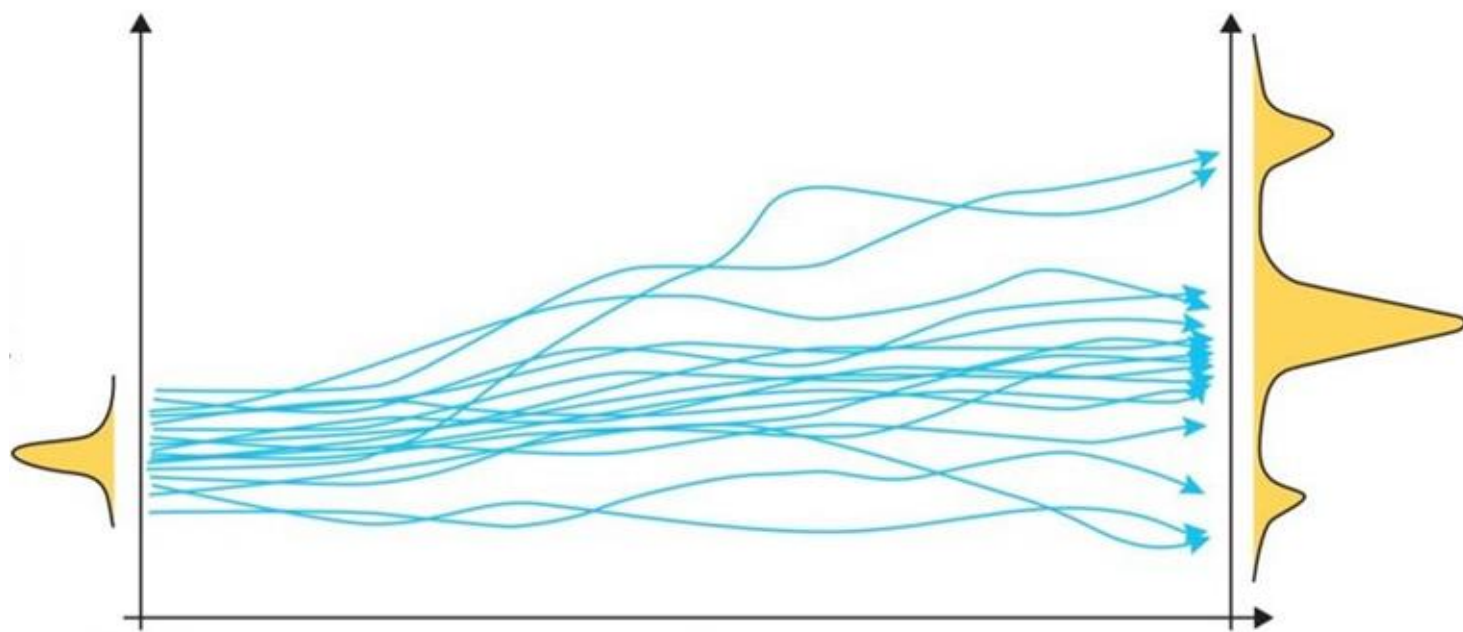
# Video Games



# Data



# Algorithmic Improvements





# Questions?