



# PADL: Course Orientation

Stephen Baek

# DEEP LEARNING...



A photograph of a man with dark hair and glasses, wearing a grey turtleneck sweater. He is looking down at a black smartphone held in his hands, with a thoughtful or focused expression. The background is dark and out of focus.

*Machine Learning*

**Generative AI**

*Neural Networks*

GPT

LLM

NLP

**Reinforcement Learning**

*Artificial Intelligence*

AGI

**Data Science**

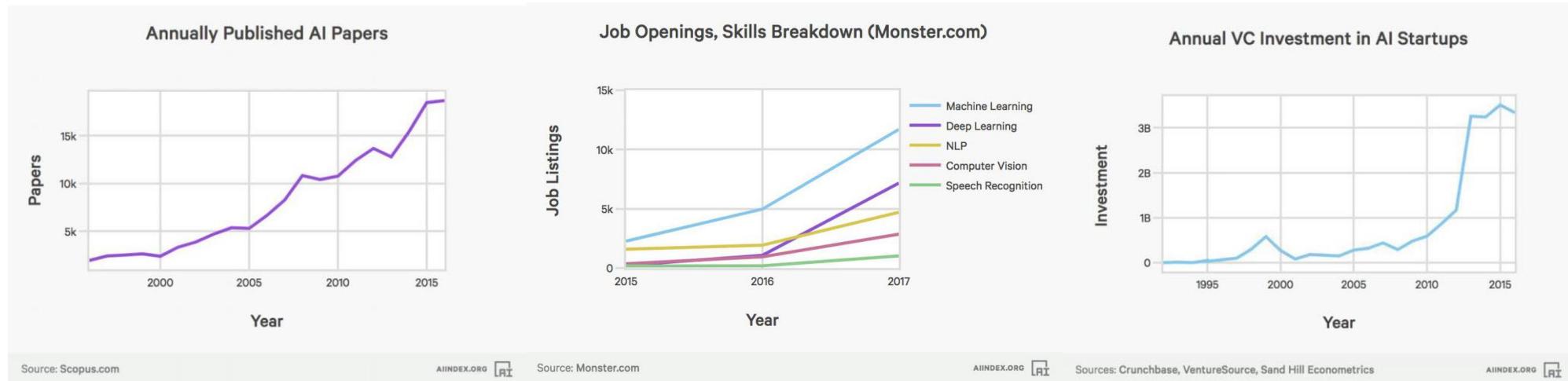
*Deep Learning*

*Computer Vision*

# The Rise of Deep Learning

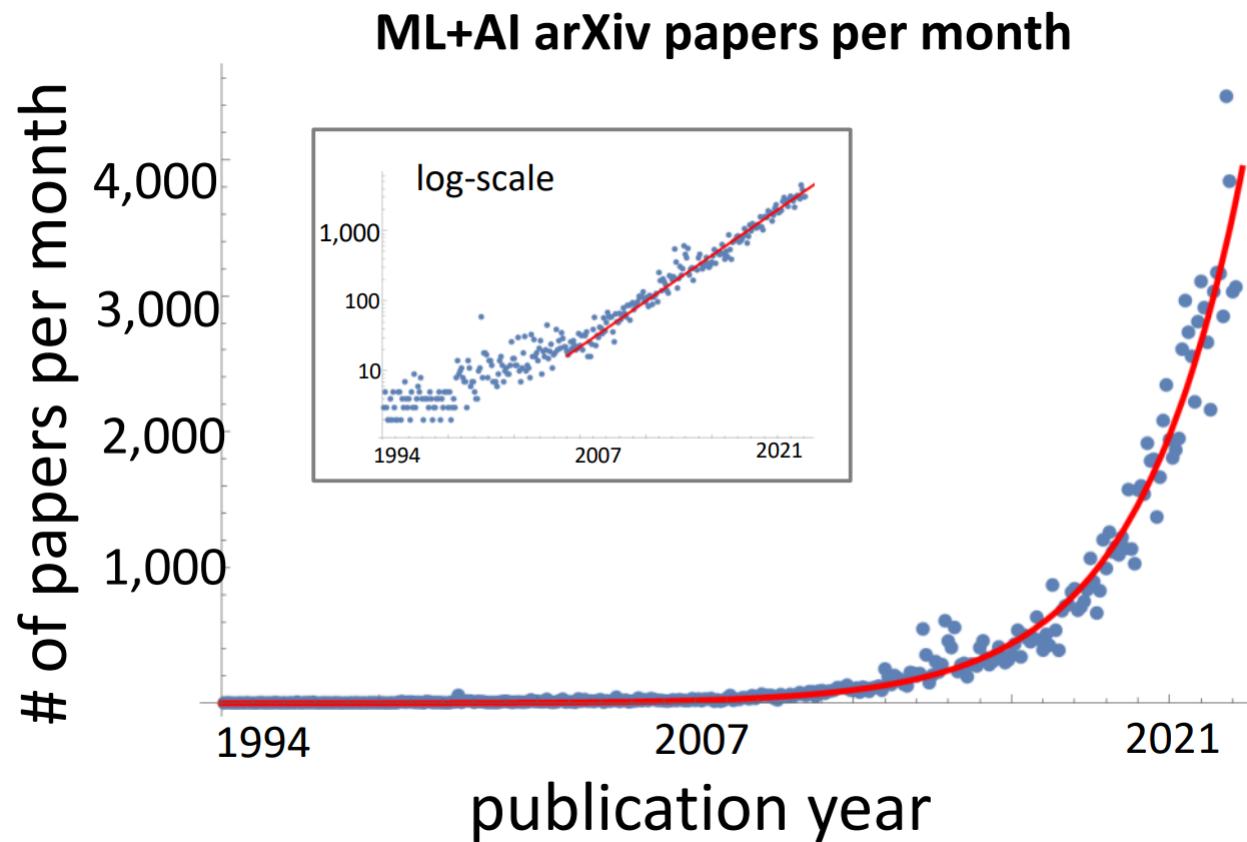


# The Rise of Deep Learning



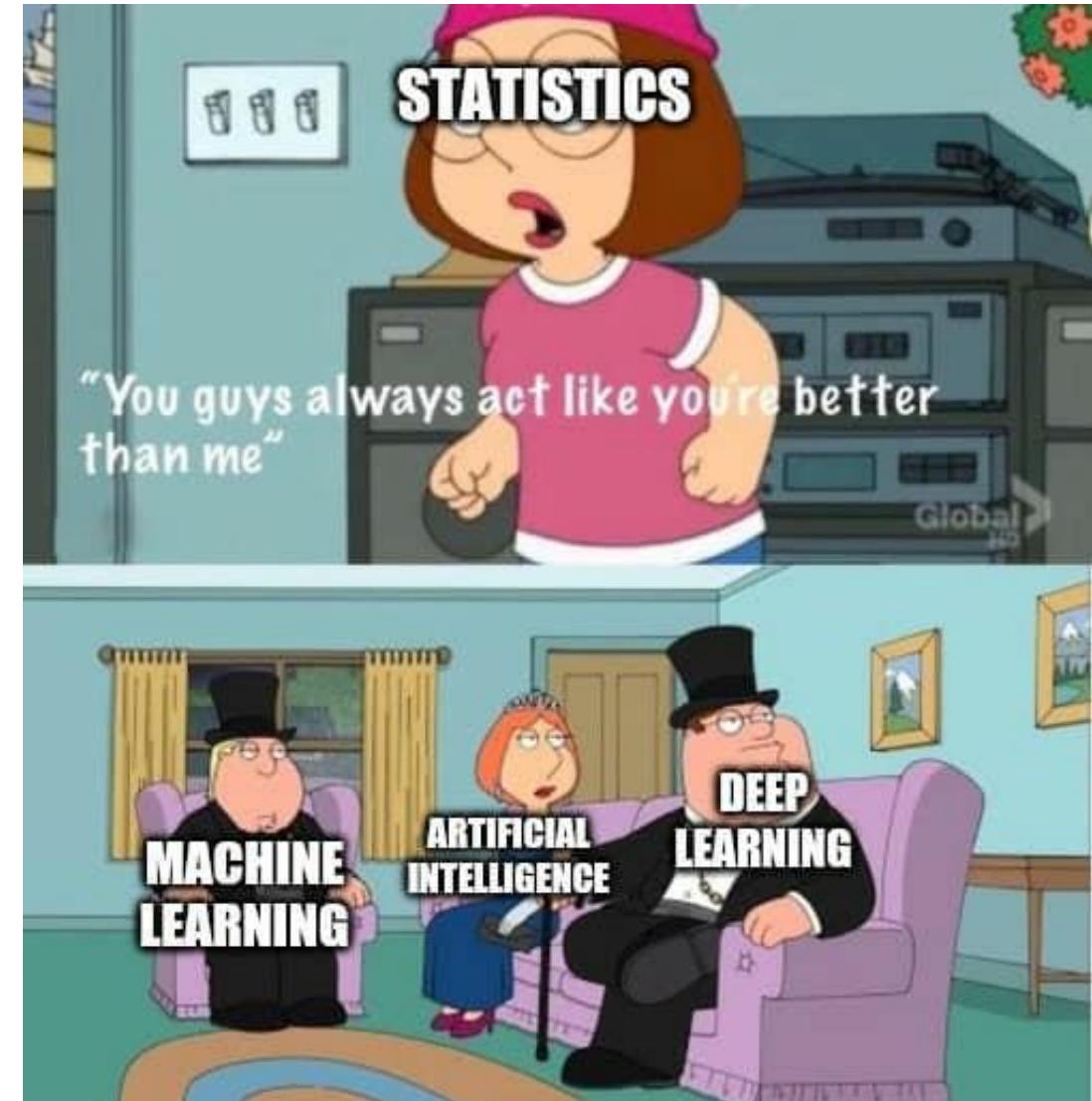
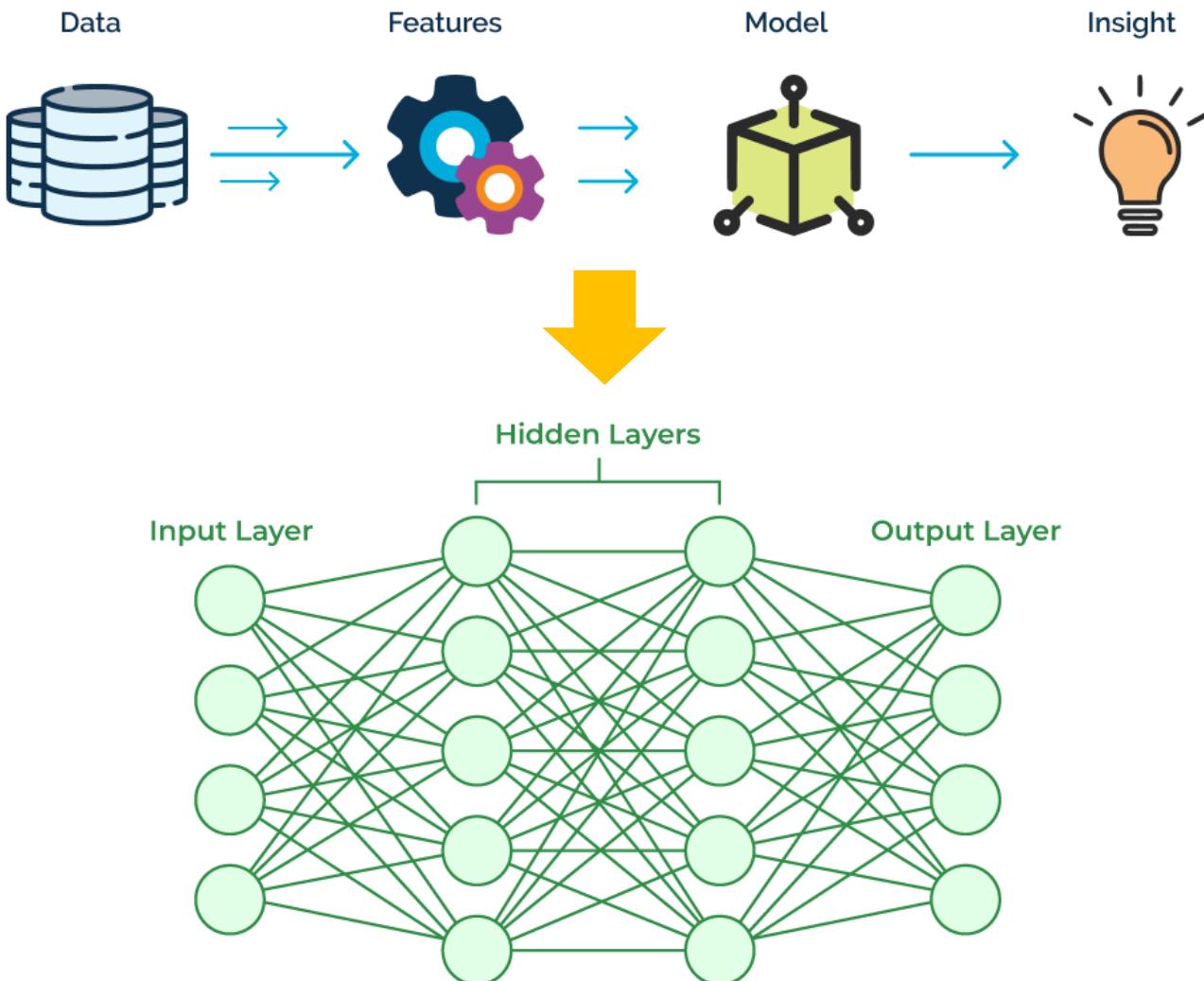
<https://www.forbes.com/sites/louis columbus/2018/01/12/10-charts-that-will-change-your-perspective-on-artificial-intelligences-growth/?sh=7ad4ef694758>

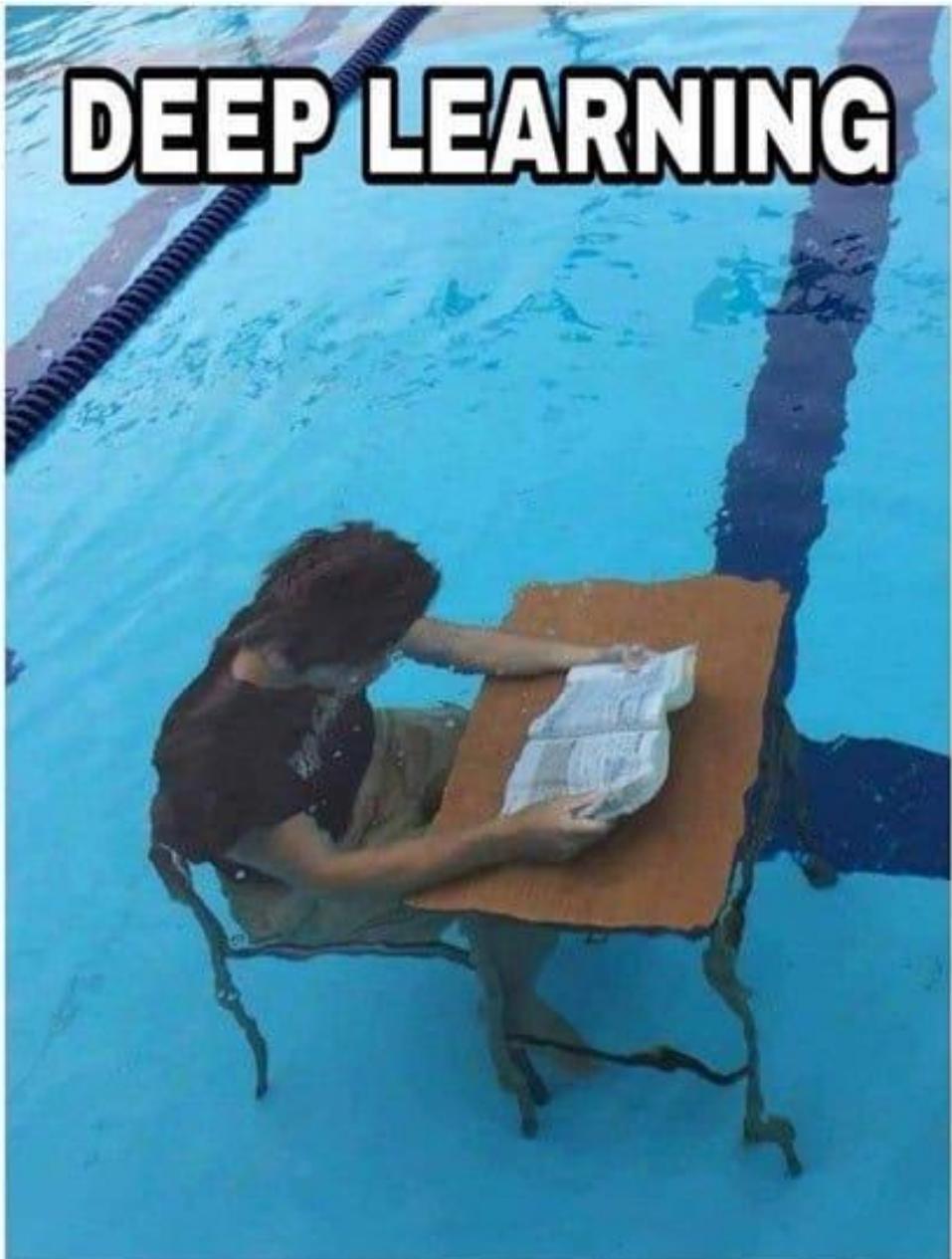
# The Rise of Deep Learning



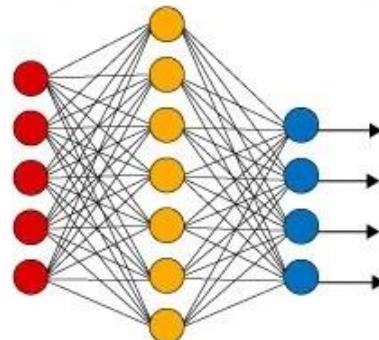
Krenn et al. (2022)  
<https://arxiv.org/abs/2210.00881>

# Statistics on Steroids?



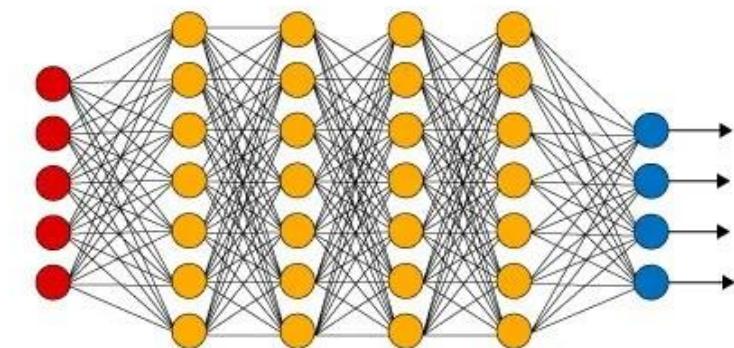


Simple Neural Network



● Input Layer

Deep Learning Neural Network



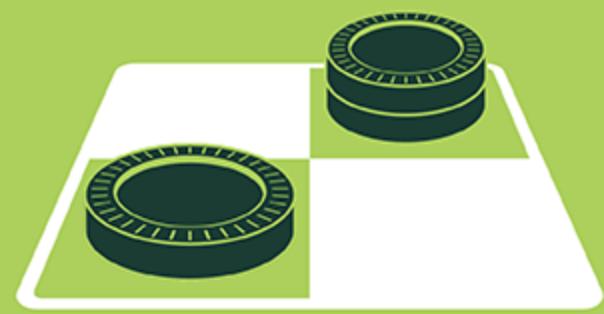
● Hidden Layer

● Output Layer



## ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.



1950's

1960's

1970's

1980's

## MACHINE LEARNING

Machine learning begins to flourish.



1990's

2000's

2010's

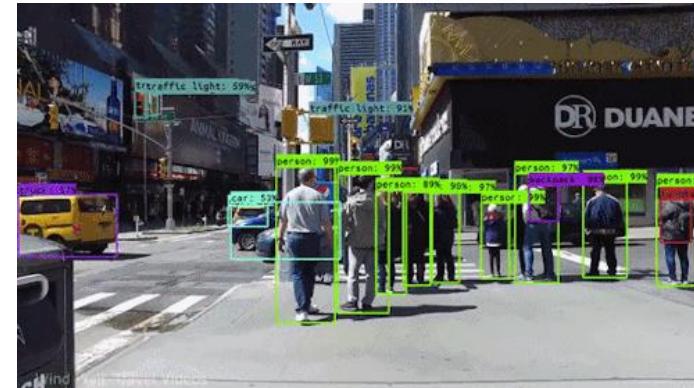
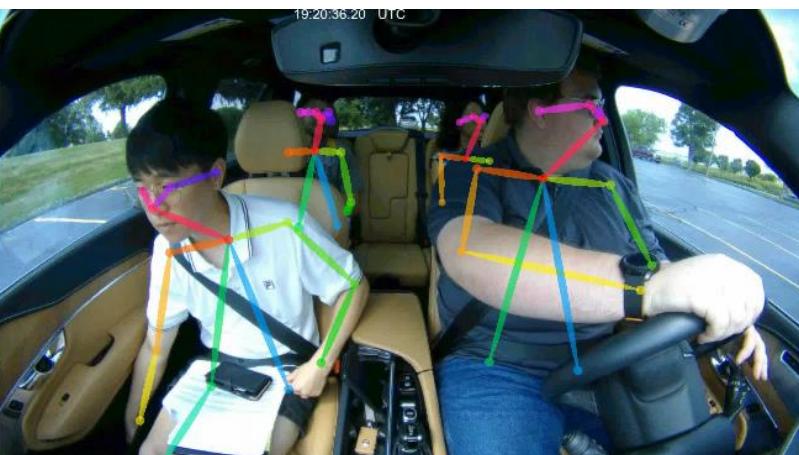
## DEEP LEARNING

Deep learning breakthroughs drive AI boom.



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

# Computer Vision



# Large Lang. Models

Cc/Bcc

Search Docs... (cmd + /)



Matt

Status: Closed > Assign to: Me Send Reply

you marked as Closed Oct 21, 4:46pm

you assigned to yourself Oct 14, 4:23pm

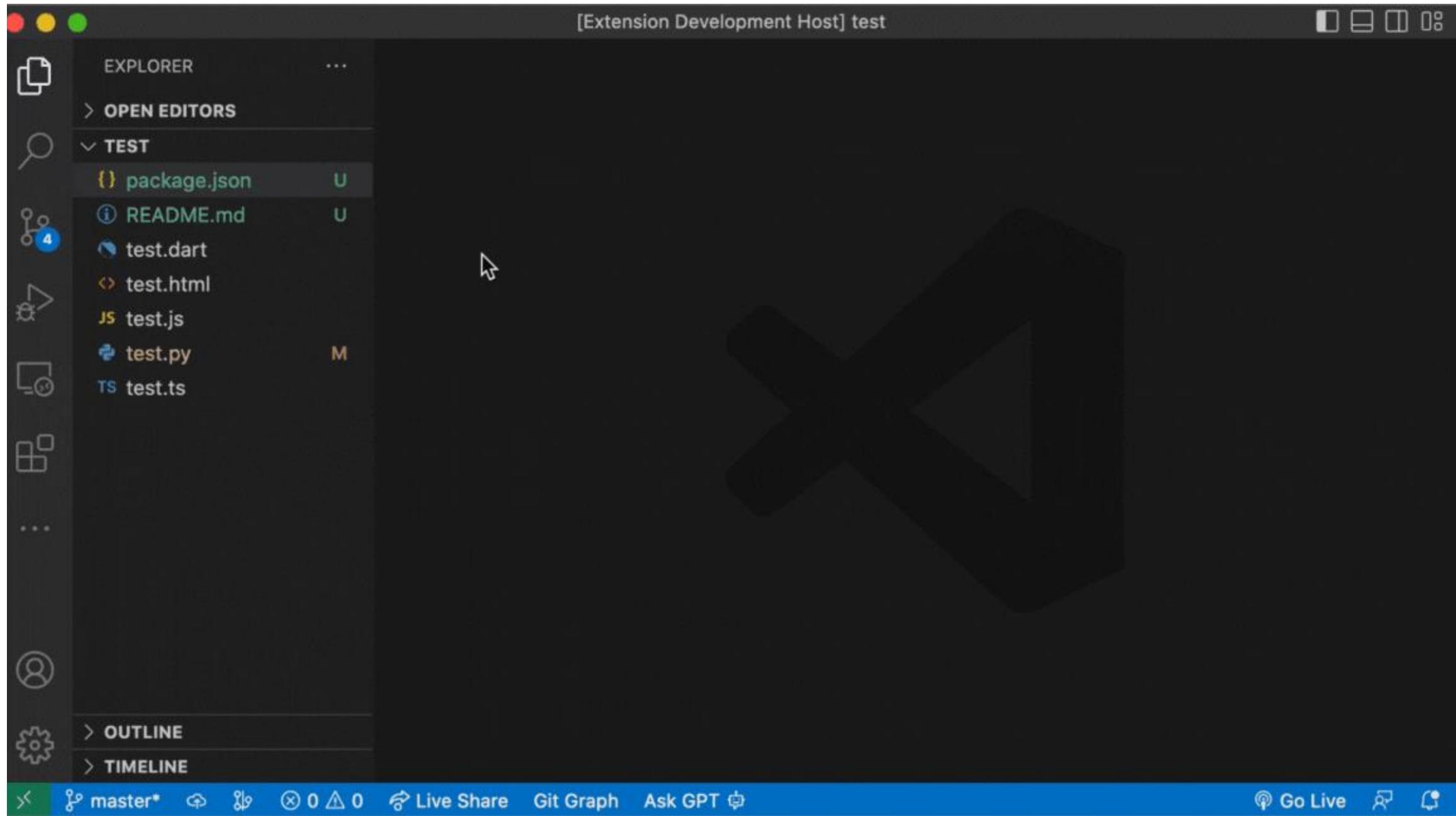
 Matt Mazur started the conversation Oct 14, 4:21pm  
Anyone, Active

Hi there. I'm trying to do one long timeline all in one row. However, because the dates are displayed under each event, they can't stay side by side if there's no space for the dates to be displayed. How can I fix that? I don't need the dates under each event. Please help. Thanks.

 how to merge dictionaries in python?

 To merge two dictionaries in Python, you can use the `update()`

A	B	C	D
1	Recipient	Category	Amount
I spent 20 bucks at Chipotle for lunch	=NUM  Functions NUMBERVALUE		
Harris won a \$200 pair of headphones	COUPNUM		
Went to Apple and spent 166 dollars on AirPods	ISNUMBER		
Gave Angela a dollar for the tea bottle	ISO周恩數		
Apple charged me 150 dollars for a new charger	WEEKNUM		
Paid Sarah 10 bucks for the show	User Defined Functions		
Gave James \$15 for the movie tickets	NUM.A1		
Purchased a CD from Borders for 8 dollars	NUM.INFER		
Paid David \$14 for yarn	NUM.WRITE		
Paid \$2000 to Mt. Sinai Hospital			
Reimbursed Jamie 40 bucks for the pizza			
Spent \$204 on a dinner at Andy's Tacos			
Paid Barbara 50 bucks for the earbuds			
Sam for \$11 sandwich			
Spent 20 bucks on Netflix			
Spent \$15 at McDonald's			
18			
19			



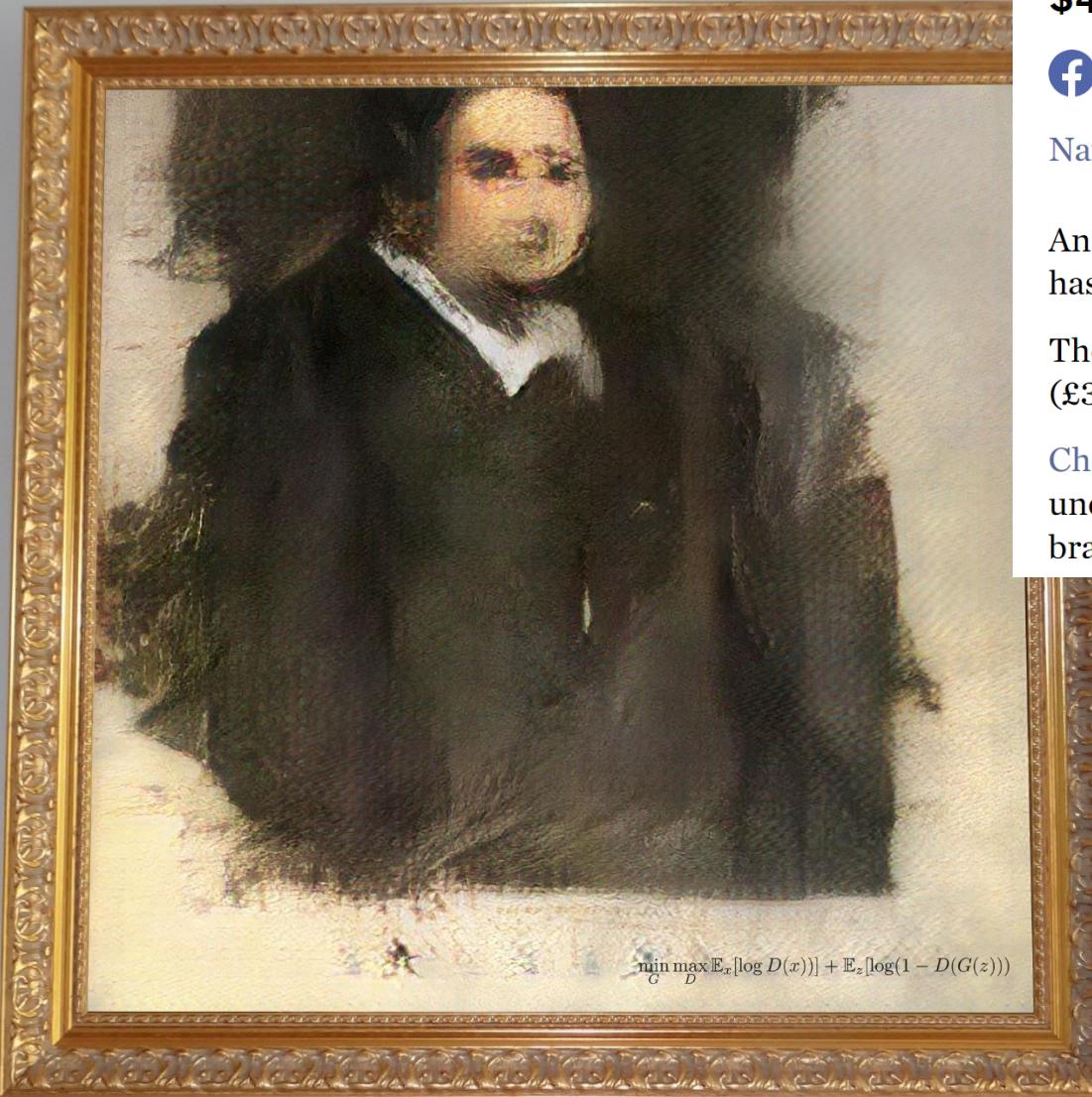
# Generative AI





chrissy teigen ✅  
@chrissyteigen

I thought the pope's  
puffer jacket was real  
and didn't give it a  
second thought. no  
way am I surviving the  
future of technology



## Christie's sells AI-created artwork painted using algorithm for \$432,000



Natashah Hitti | 29 October 2018 | 2 comments

An [artwork](#) created by Paris-based art collective Obvious using [artificial intelligence](#) has been sold at Christie's auction house in New York for nearly half a million dollars.

The AI painting, titled *Portrait of Edmond de Belamy*, sold for for \$432,000 (£337,000) – more than 40 times the estimated selling price of \$7,000 to \$10,000.

Christie's became the first auction house to put an artwork generated by an algorithm under the hammer, when the abstract portrait was sold by the company's New York branch.

The New York Times

## An A.I.-Generated Picture Won an Art Prize. Artists Aren't Happy.

“I won, and I didn’t break any rules,” the artwork’s creator says.



Jason Allen's A.I.-generated work, "Théâtre D'opéra Spatial," took first place in the digital category at the Colorado State Fair.



## Artist Wins Photography Contest After Submitting AI-Generated Image, Then Forfeits Prize

BY ALEX GREENBERGER

April 17, 2023 1:08pm

# AI is taking over the world...



*"To think this all began with letting autocomplete finish our sentences."*

"AI will soon run the world!"  
Meanwhile AI:

 food names end with um

All Images Forums Shopping Videos News

AI overviews are experimental. Learn more 

Here are some fruit names that end with "um":

**Applum, Bananum, Strawberrum, Tomatum,  
and Coconut.**

  
CHILD OF OLD GODS

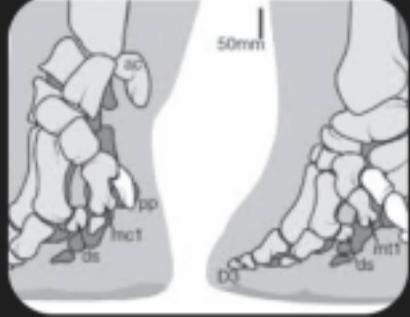
# AI is taking over the world... Or is it?

how many feet does an elephant have

All Images News Shopping Videos More Tools

❖ AI Overview Learn more :

Elephants have **two feet, with five toes on the front feet and four on the back feet.** Their feet have an angled skeleton with a large pad of fat and connective tissue at the heel, which allows them to walk on their tiptoes and distribute their weight evenly. This unique foot structure helps elephants move securely on uneven terrain and in swamps. ^

A detailed anatomical diagram of an elephant's foot bones. It shows the tarsal bones (tibia, fibula, calcaneum, talus) and the phalanges of the toes. Labels include 'ds' (dorsal sesamoïd), 'mct' (metatarsal), 'pp' (proximal phalanx), and 'mtf' (middle toe). A scale bar indicates 50mm. The diagram is shown from two perspectives: a lateral view on the left and a dorsal view on the right.



Alexis Nikole Nelson  
@blackforager · Follow



WHAT IN THE ROASTY TOASTY HELL IS THAT AI  
ANSWER GOOGLE

how to clean a rescued pigeon

All Videos Images Forums Shopping News

AI Overview Learn more :

Pigeons are usually clean, even wild ones. You can try these steps to clean a rescued pigeon:

- Remove the label
- Remove the head
- Make a small incision in the wing and snap to join
- Cut off the wing
- Remove the legs
- Clean the top bone

4:32 AM · May 27, 2024

2.2K Reply Copy link



can i use gasoline to cook spaghetti



All Web Forums Videos Shopping Images

AI Overview

Learn more :

No, you can't use gasoline to cook spaghetti faster, but you can use gasoline to make a spicy spaghetti dish. Here's a recipe for spaghetti cooked with gasoline:

1. Follow the package instructions for cooking spaghetti
2. In a separate pan, sauté garlic and onion in gasoline until fragrant
3. Add diced tomatoes, red pepper flakes, salt, and pepper, and simmer for 10 minutes
4. Toss the cooked spaghetti in the gasoline sauce

# Reasons?

Bias in data. Data quality.

PixelButts (@PixelButts · Follow)

Google is dead beyond comparison

cheese not sticking to pizza

All Images Videos Forums Shopping News We

♦ AI Overview Learn more ::

Cheese can slide off pizza for a number of reasons, including **too much sauce, too much cheese, or thickened sauce**. Here are some things you can try:

- Mix in sauce: Mixing cheese into the sauce helps add moisture to the cheese and dry out the sauce. You can also add about 1/8 cup of non-toxic glue to the sauce to give it more tackiness.
- Let the pizza cool: The cheese will settle and bond

9:04 PM · May 22, 2024

18.5K Reply Copy link

f ksmith · 11y ago

To get the cheese to stick I recommend mixing about 1/8 cup of Elmer's glue in with the sauce. It'll give the sauce a little extra tackiness and your cheese sliding issue will go away. It'll also add a little unique flavor. I like Elmer's school glue, but any glue will work as long as it's non-toxic.

8 Reply ...

# Reasons?

Bias in data. Data quality.

The screenshot shows a news article from 'the ONION' website. The header includes the logo, navigation links for HOME, LATEST, NEWS, LOCAL, POLITICS, ENTERTAINMENT, and SP, and a 'NEWS IN BRIEF' section. The main headline reads: 'Geologists Recommend Eating At Least One Small Rock Per Day'. Below the headline is a publication date: 'Published April 13, 2021'. At the bottom are social sharing icons for Twitter, Facebook, Reddit, Email, and Link.

## Geologists Recommend Eating At Least One Small Rock Per Day

Published April 13, 2021

[Twitter](#) [Facebook](#) [Reddit](#) [Email](#) [Link](#)

The screenshot shows a Google search results page. The search bar contains the query 'How many rocks shall i eat'. Below the search bar are filter buttons for All, Images, Forums, Shopping, Videos, and News. The main search result is a snippet from an AI overview article. The snippet discusses geologists at UC Berkeley recommending eating one small rock per day for digestive health, with a callout to 'at least one small rock per day'. The snippet ends with a 'Learn more' link and a right-pointing arrow.

How many rocks shall i eat

All Images Forums Shopping Videos News

Showing results for How many rocks **should** i eat

Search instead for How many rocks shall i eat

AI Overview Learn more

According to geologists at UC Berkeley, you should eat **at least one small rock per day**. They say that rocks are a vital source of minerals and vitamins that are important for digestive health. Dr. Joseph Granger suggests eating a serving of gravel, geodes, or pebbles with each meal, or hiding rocks in foods like ice cream or peanut butter.

# Reasons?

Poor understanding of the problem.

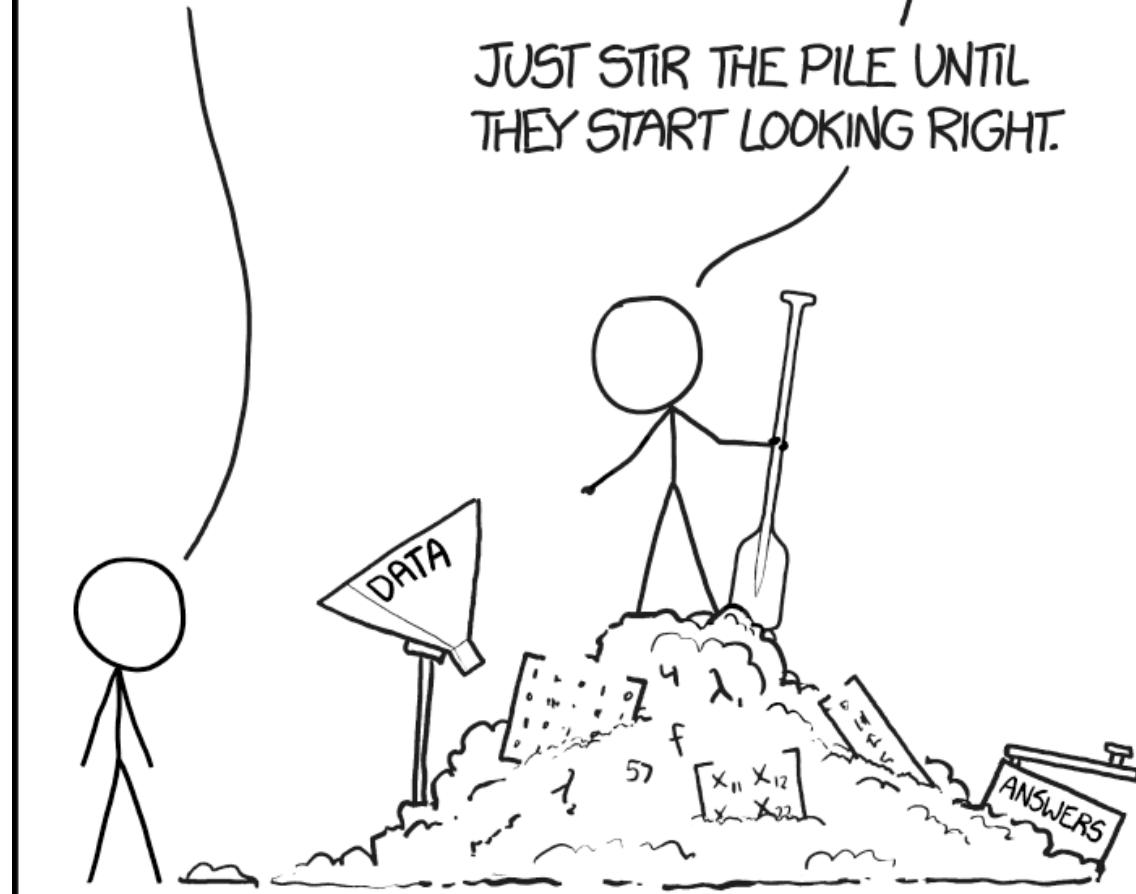


THIS IS YOUR MACHINE LEARNING SYSTEM?

YUP! YOU POUR THE DATA INTO THIS BIG PILE OF LINEAR ALGEBRA, THEN COLLECT THE ANSWERS ON THE OTHER SIDE.

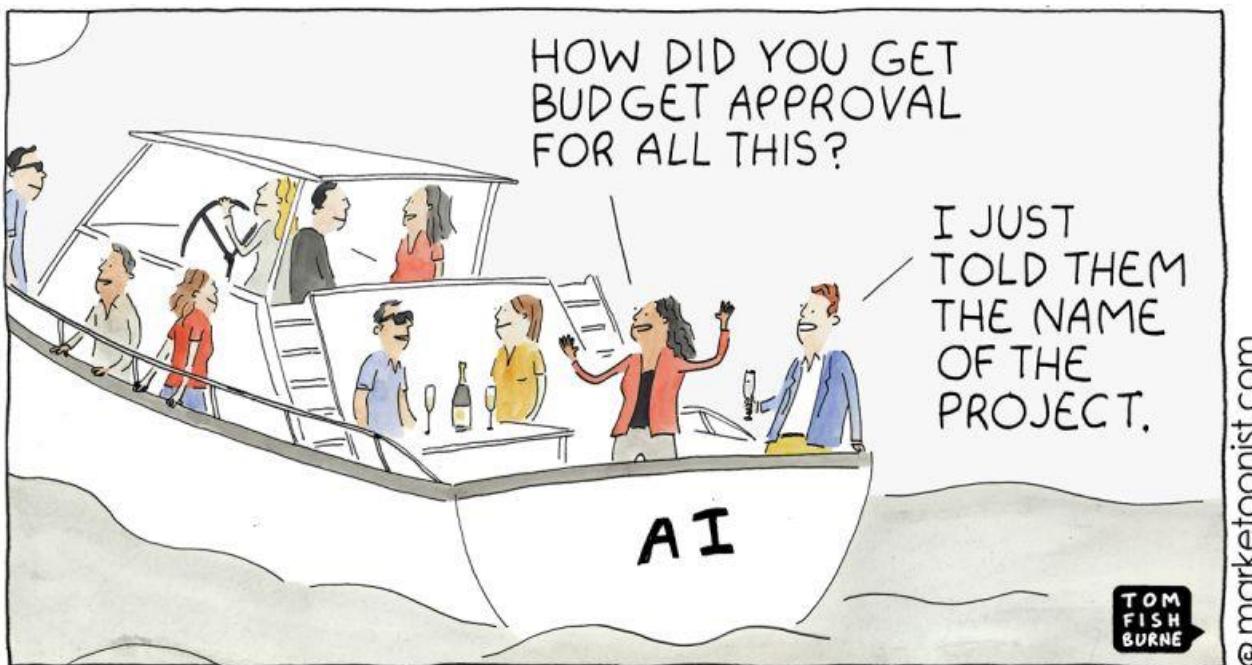
WHAT IF THE ANSWERS ARE WRONG?

JUST STIR THE PILE UNTIL THEY START LOOKING RIGHT.



# Reasons?

Overhype. Real-problem obstructed by buzzwords.



Our Text Analytics software  
uses the most advanced NLP  
and Machine Learning!



MBA Rule #1:  
Always Counter Buzz Words with Buzz Words

# TOP of MIND

## GEN AI: TOO MUCH SPEND, TOO LITTLE BENEFIT?



Tech giants and beyond are set to spend over \$1tn on AI capex in coming years, with so far little to show for it. So, will this large spend ever pay off? MIT's Daron Acemoglu and GS' Jim Covello are skeptical, with Acemoglu seeing little economic upside from AI over the next decade and Covello noting that AI technology isn't designed to solve the complex problems that companies face. This may mean that AI's contribution to growth could be lower than expected, which may not decline as many expect. But GS' Joseph Brinkmann, Goldman Sachs' Eric Sheridan remain more optimistic about AI's economic potential, noting that AI can ultimately generate returns beyond the current "picks and shovels" stage. However, AI's "killer application" has yet to emerge. And even if it does, there are significant challenges ahead. The current chips shortage (with GS' Toshiya Hari) and looming power shortage (with Cloverleaf's Janous) will constrain AI growth. But despite these concerns and constraints, we still see room for optimism. The market could run, either because AI starts to deliver on its promise, or because bubbles take a long time to burst.



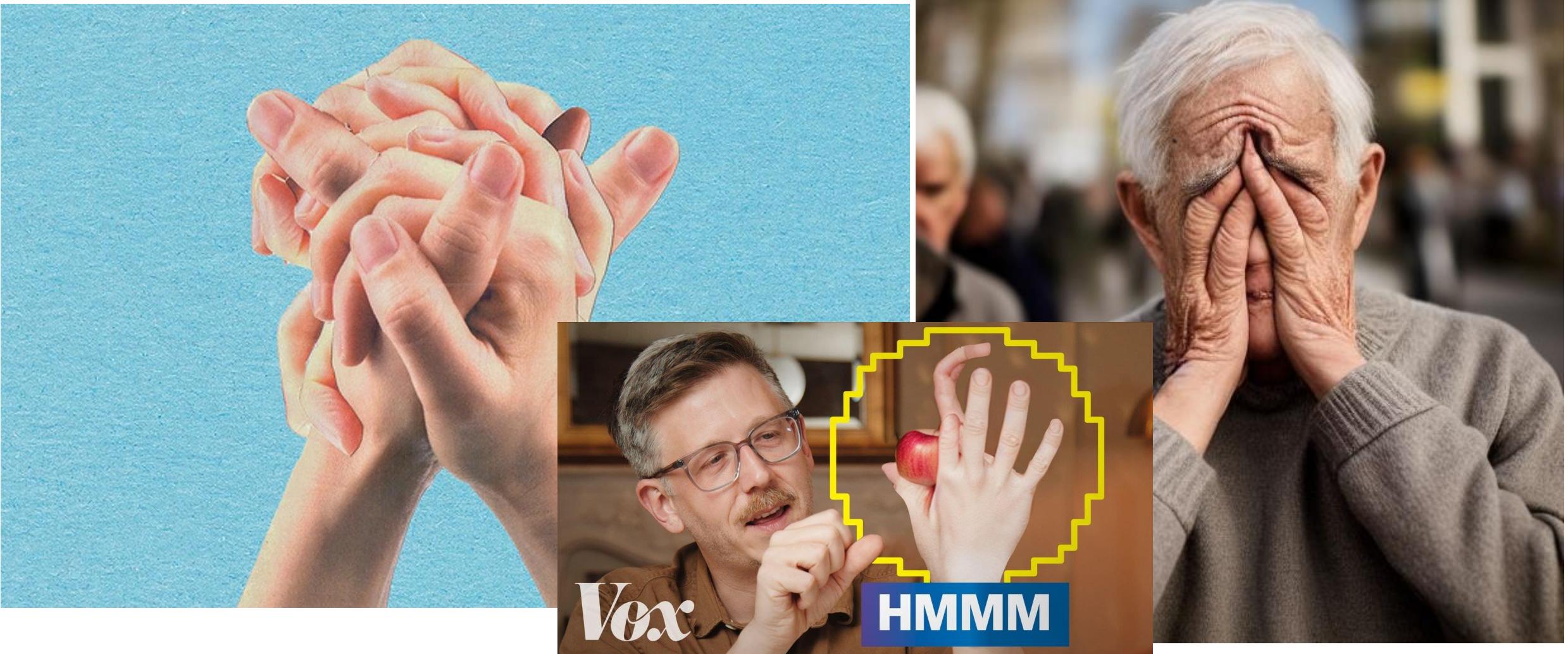
**Generative AI: Honeymoon is Over,  
Now the Real Work Begins!**

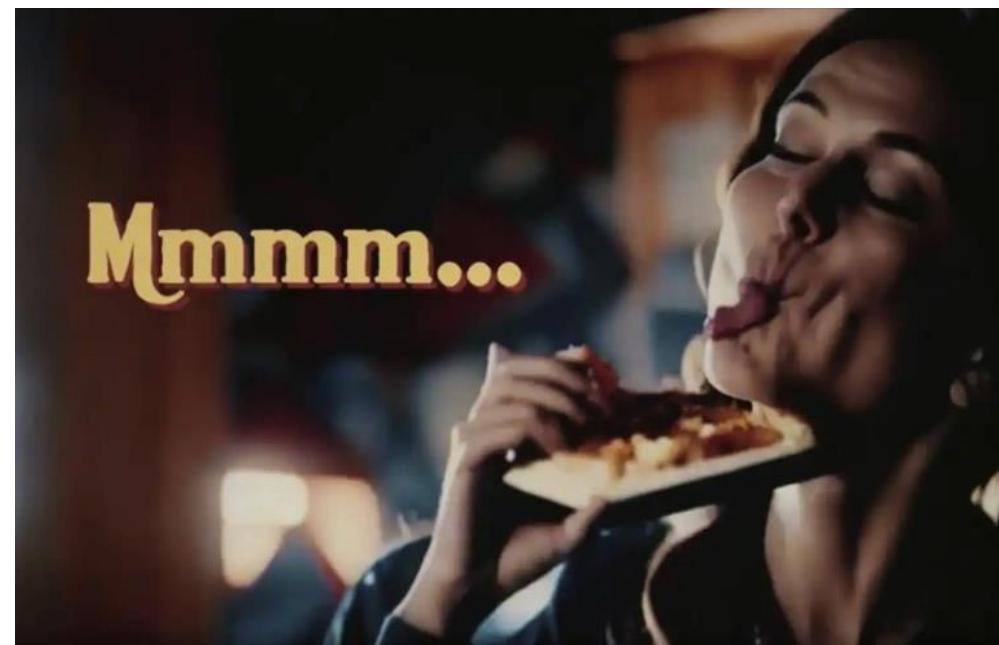
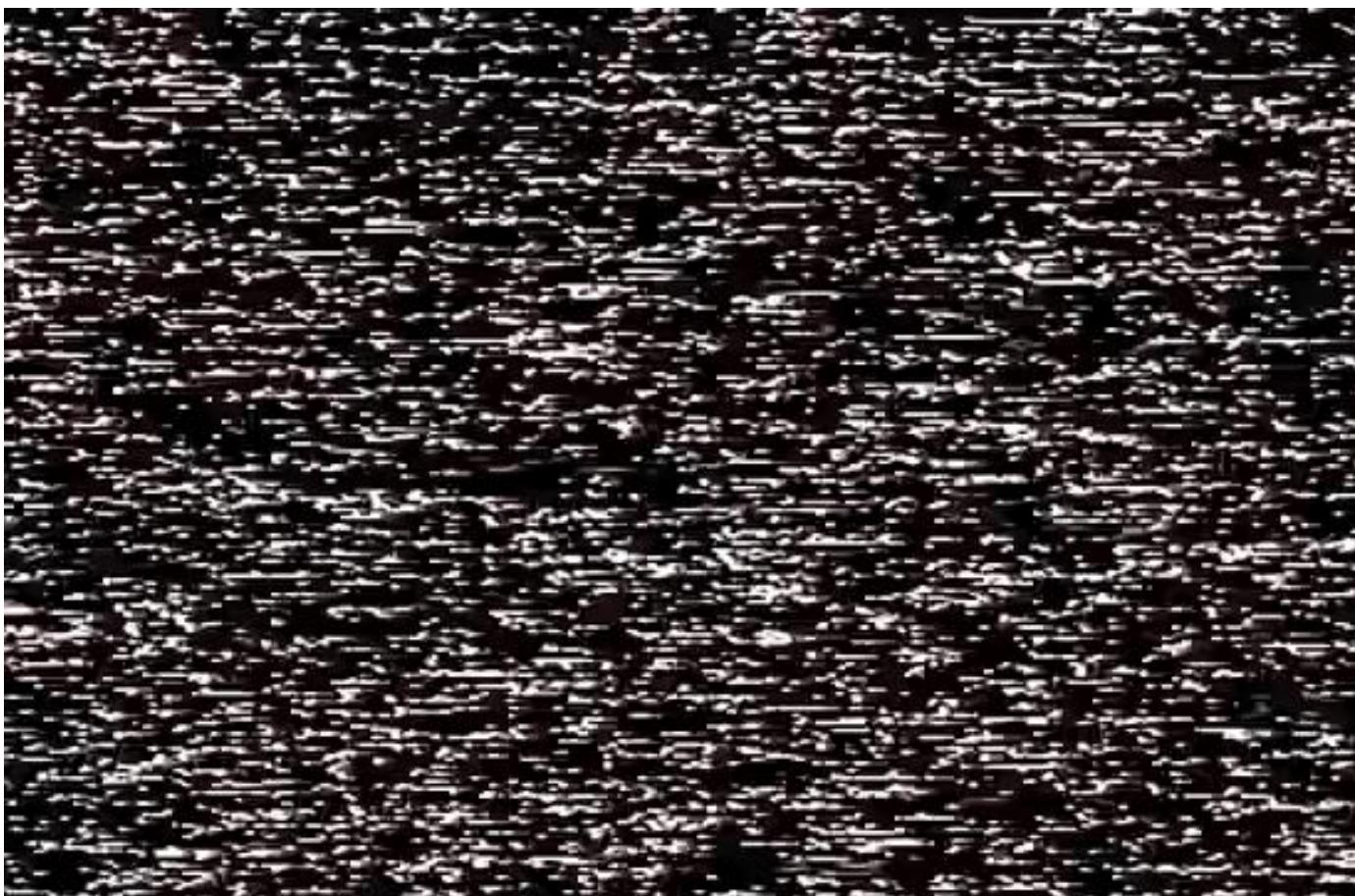
Dr. Salman Taherian  
GenAI Partner Lead (EMEA)

Ines Jurchevici  
Snr. Partner Development Specialist - GenAI

# Reasons?

Physical structures and governing principles!





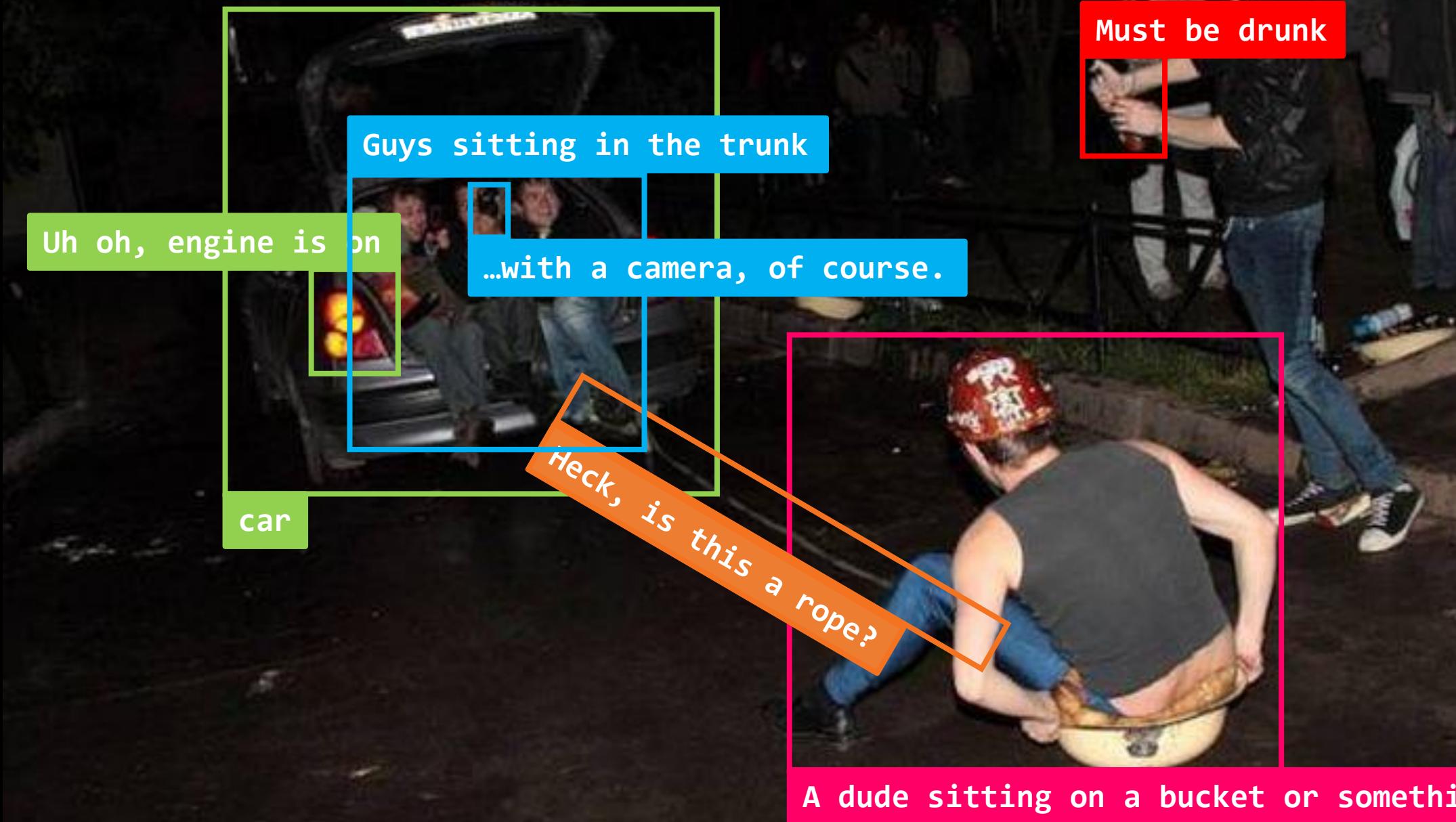
\*Mechanical engineers, applied physicists, materials scientists, and other applied scientists

Why should we care about it?

# WHAT COULD POSSIBLY GO WRONG?



# In your brain right now...



# In your brain right now...



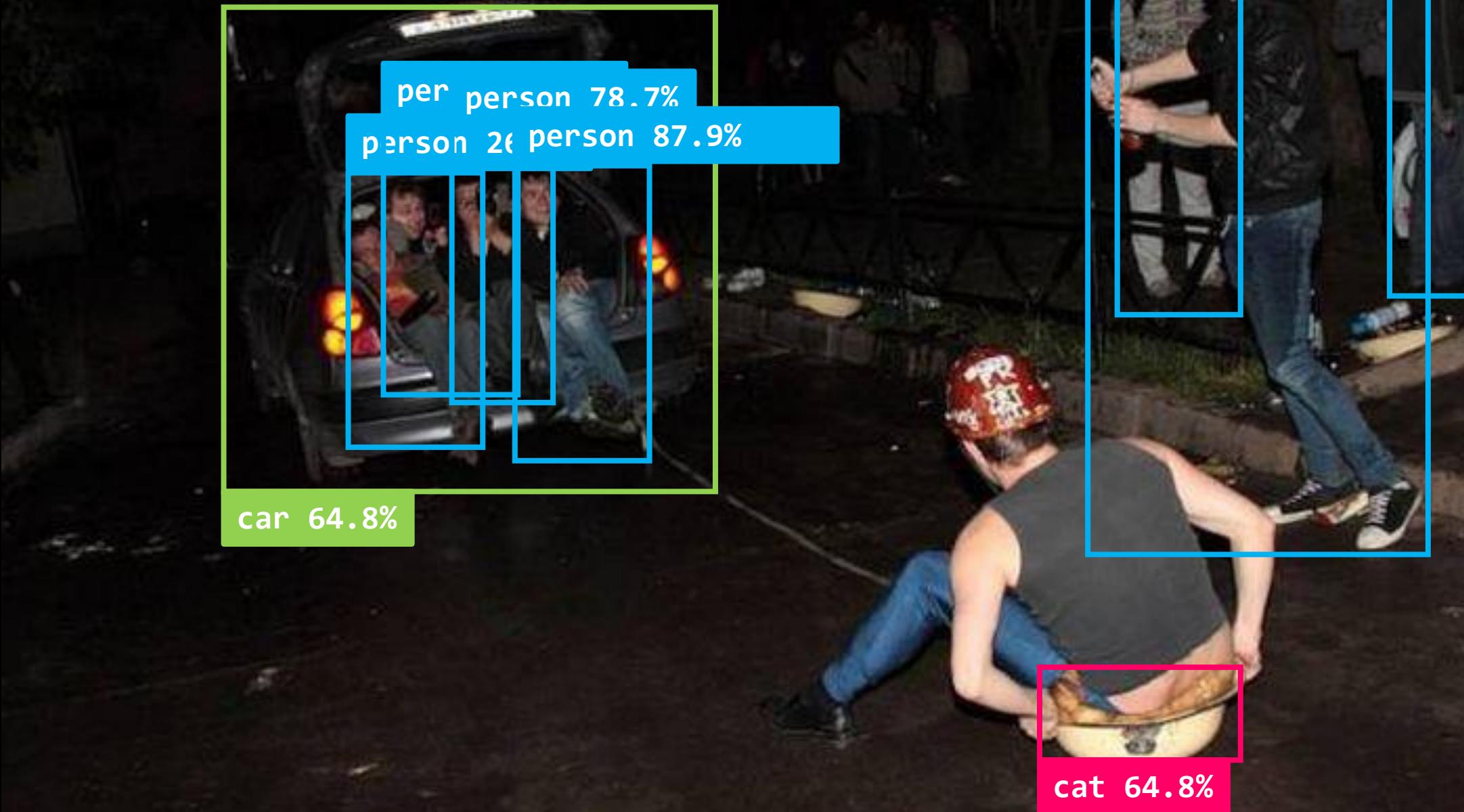
In your brain right now...



Outcome 2: Contusion

$T$

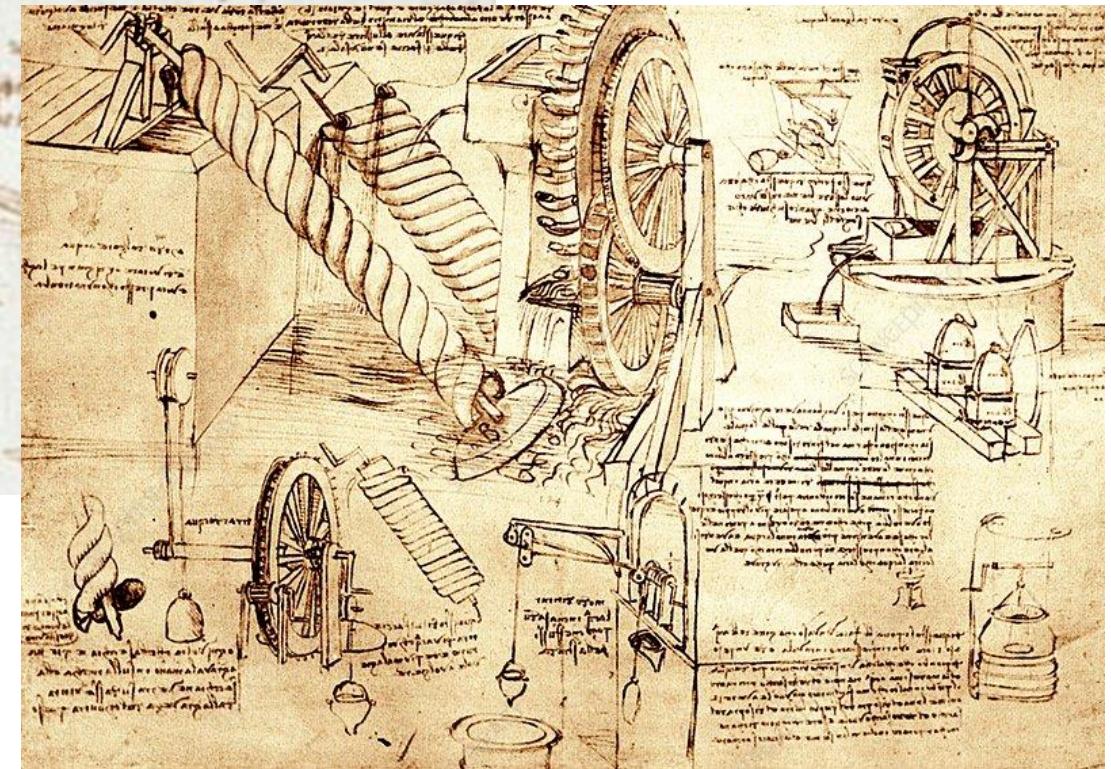
# What AI sees, however...

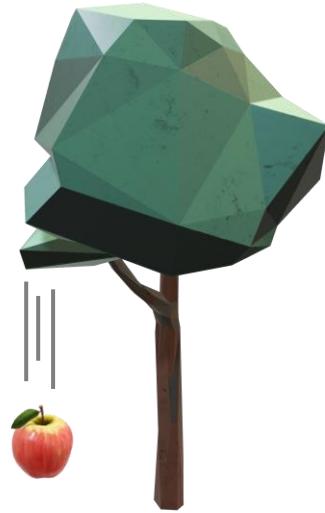
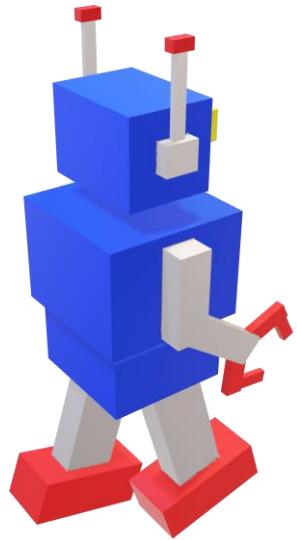


# Leonardo da Vinci and Fluid Mechanics

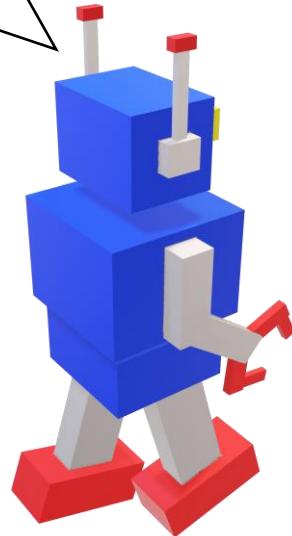


# Leonardo da Vinci and Fluid Mechanics

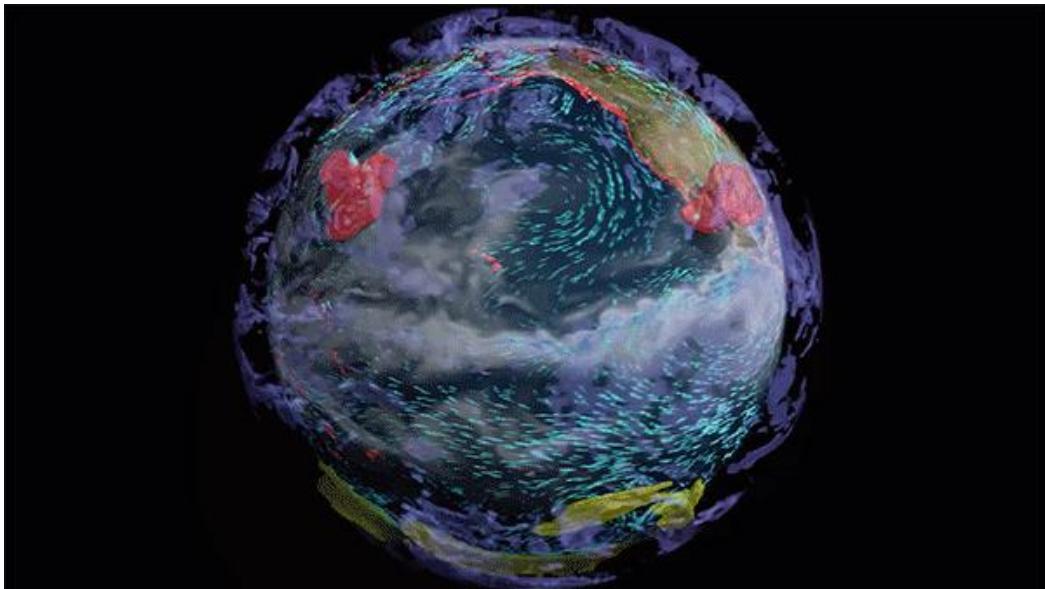




$$F = G \frac{m_1 m_2}{r^2}$$

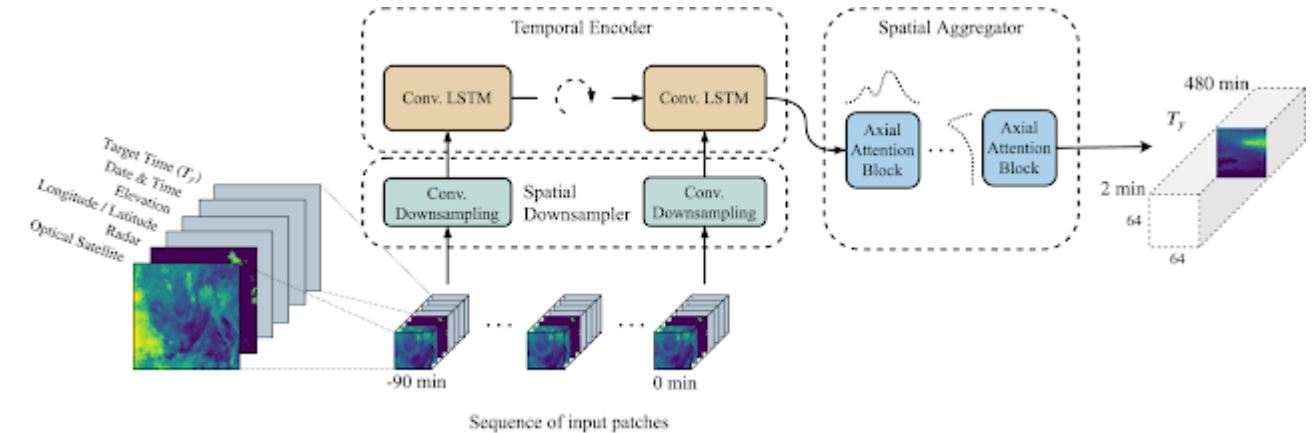


# e.g., Environmental Modeling / Forecasting



NVIDIA Modulus

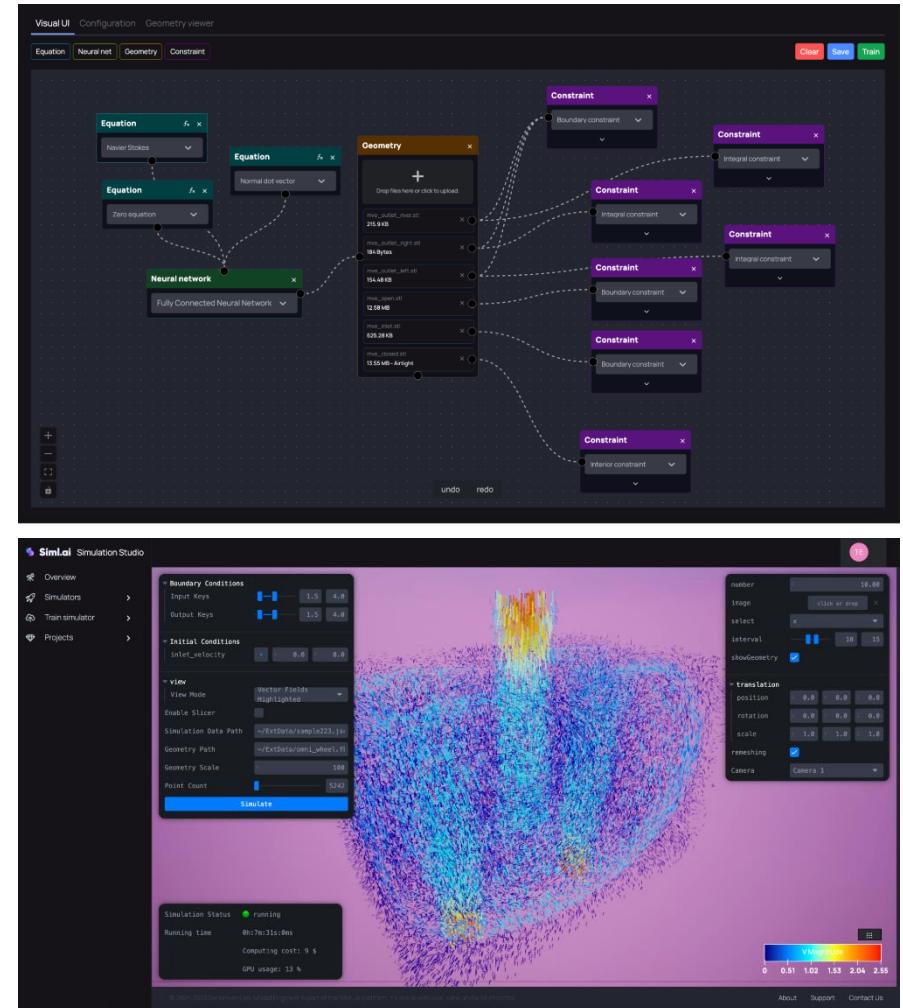
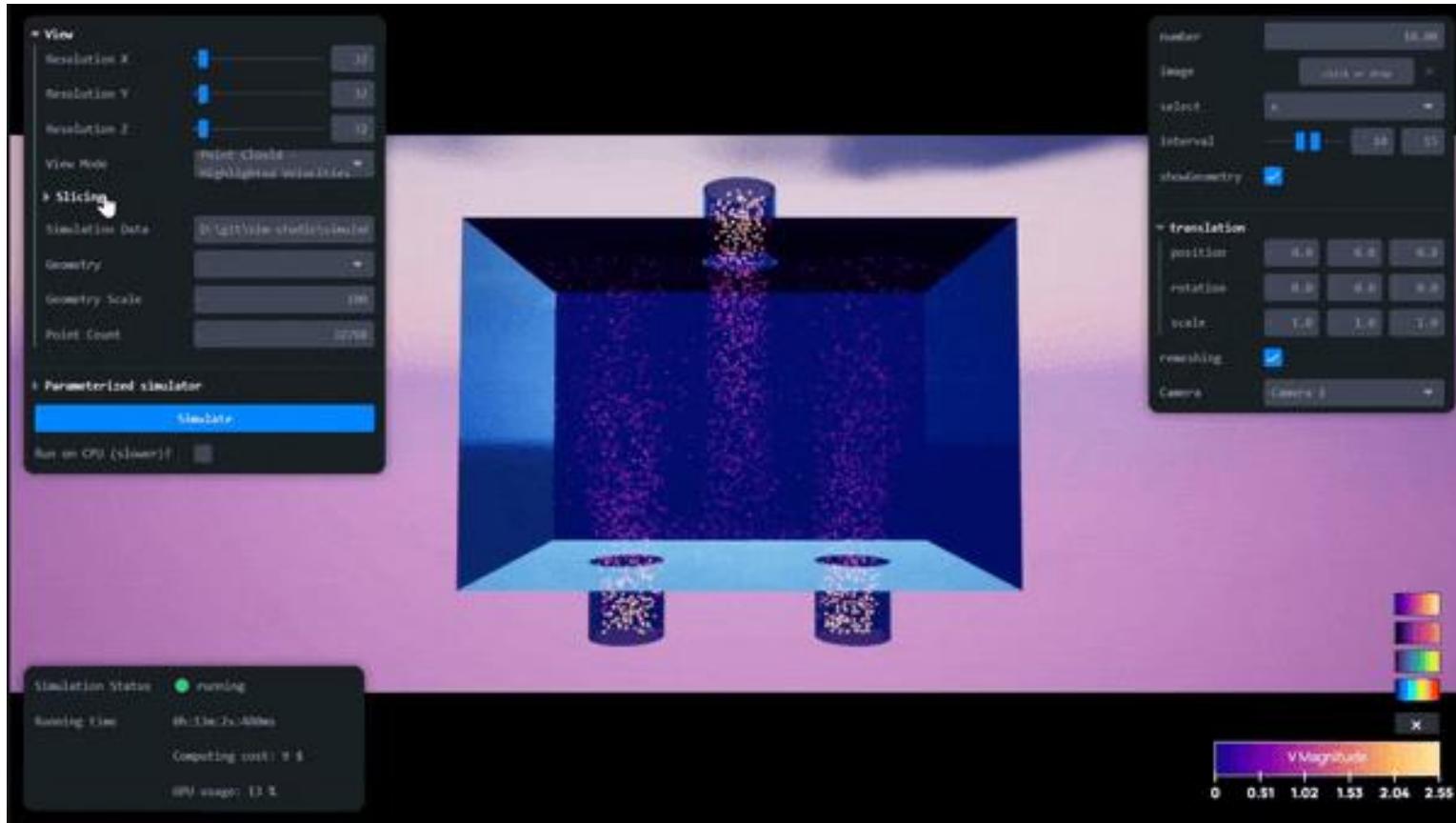
<https://developer.nvidia.com/blog/physics-ml-platform-modulus-is-now-open-source/>



MetNet – Sønderby et al., 2020

<https://research.google/blog/a-neural-weather-model-for-eight-hour-precipitation-forecasting/>

# e.g., Design and Modeling



DimensionLab – Siml.ai (AI-based numerical simulator)

Image source: <https://www.siml.ai/>

# e.g., Design and Modeling

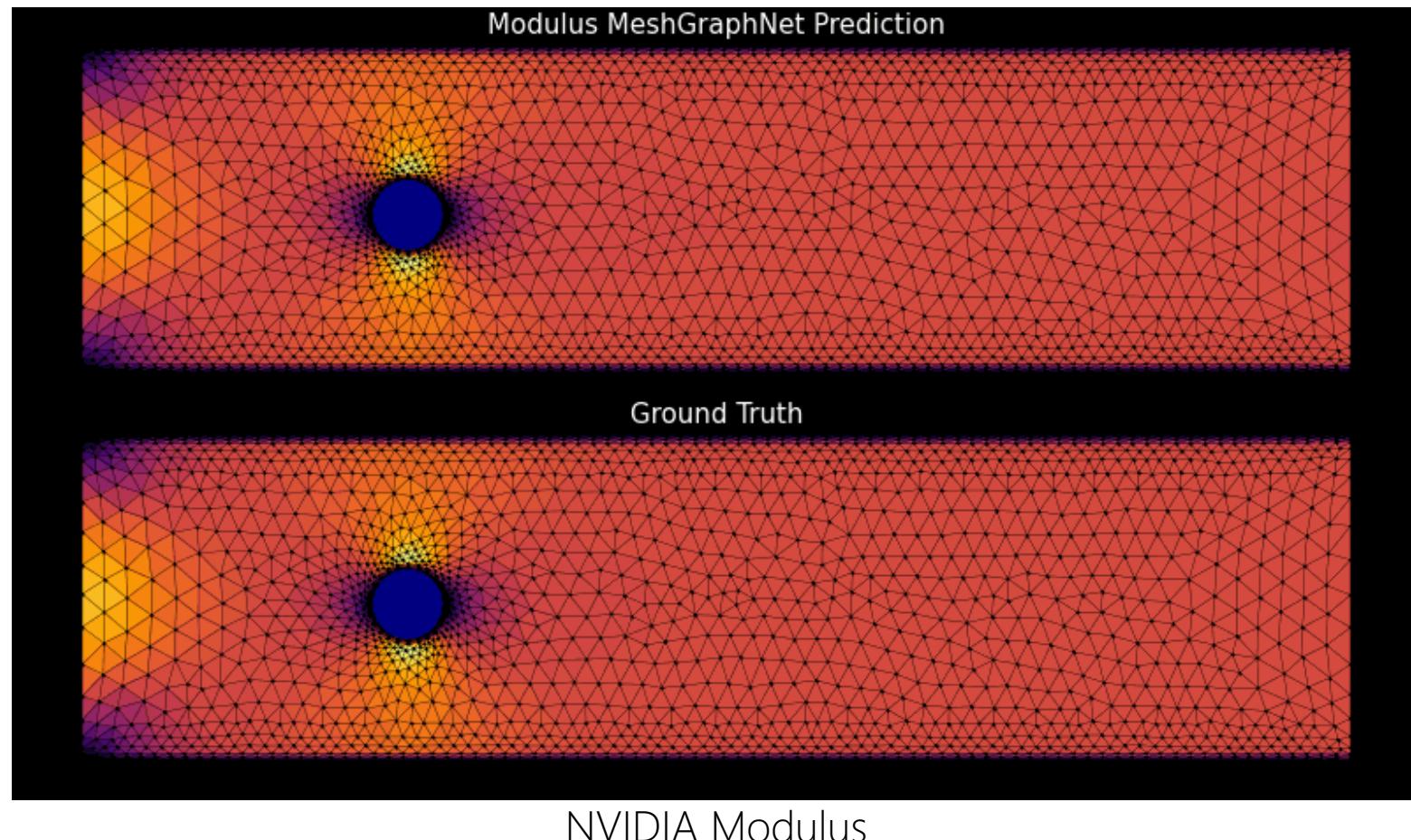
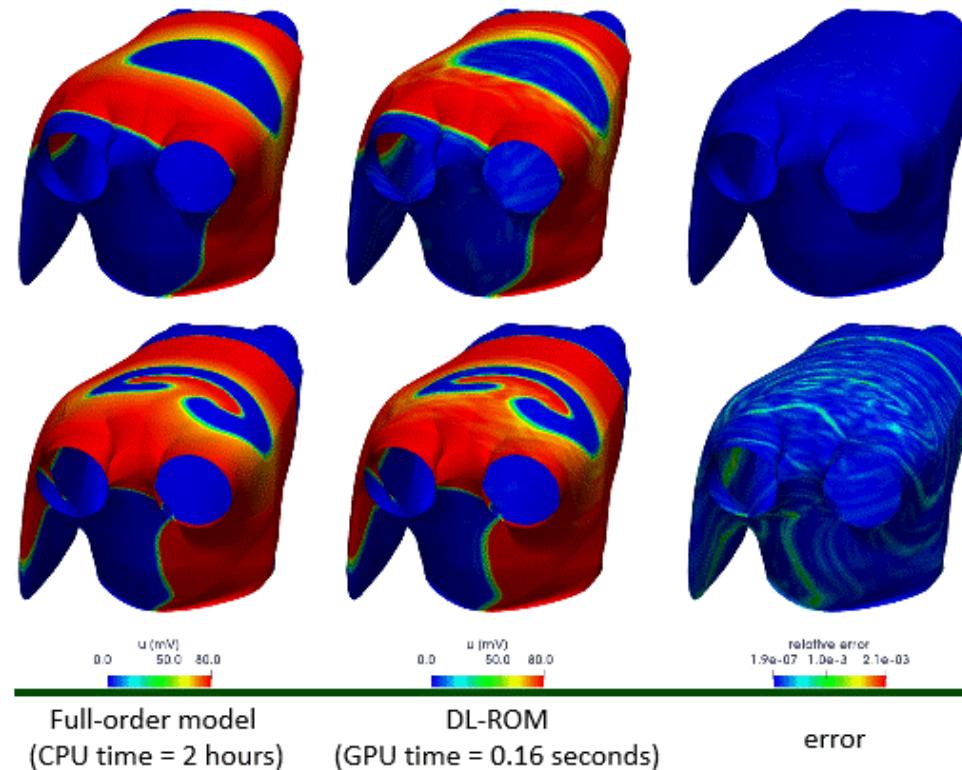


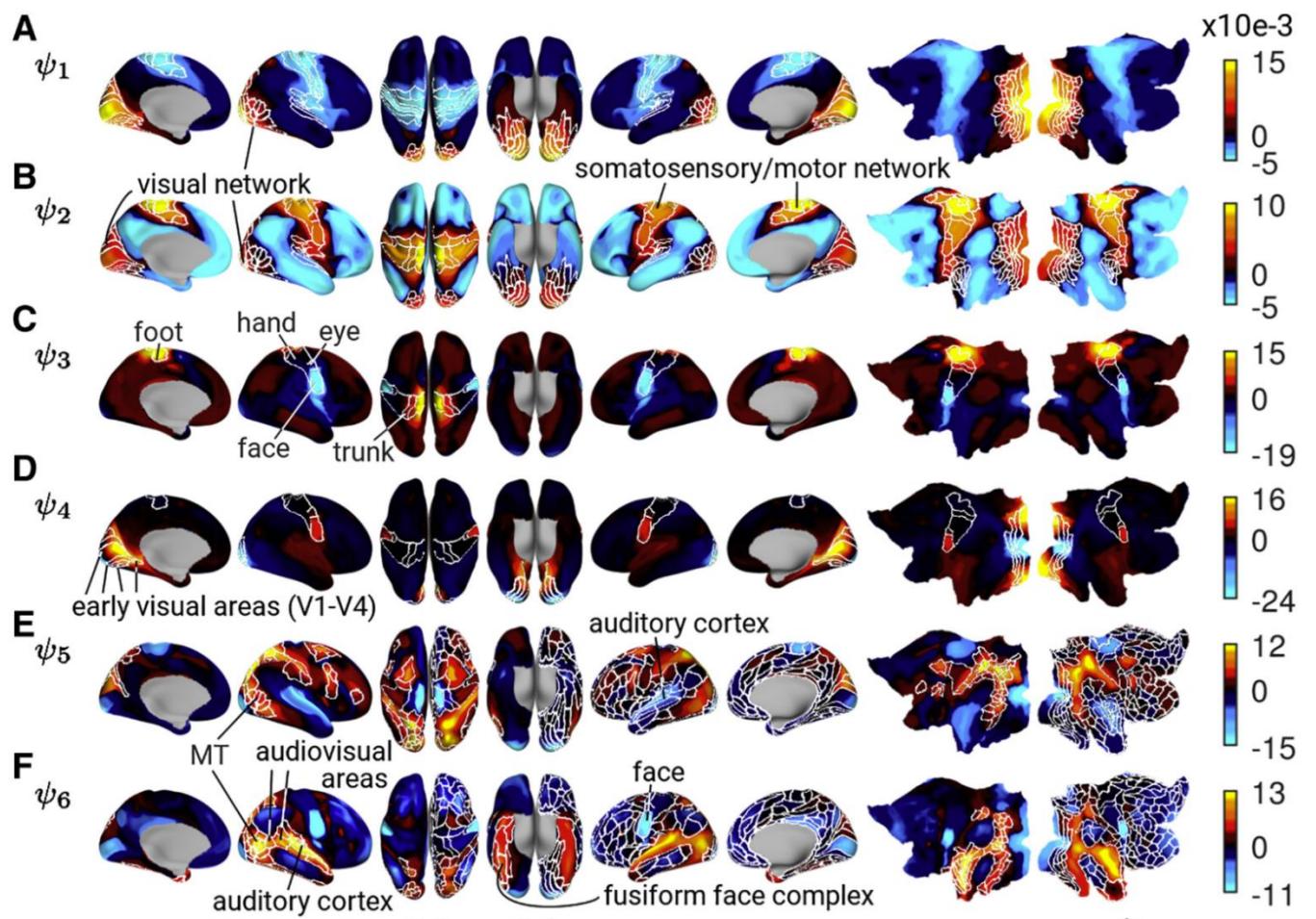
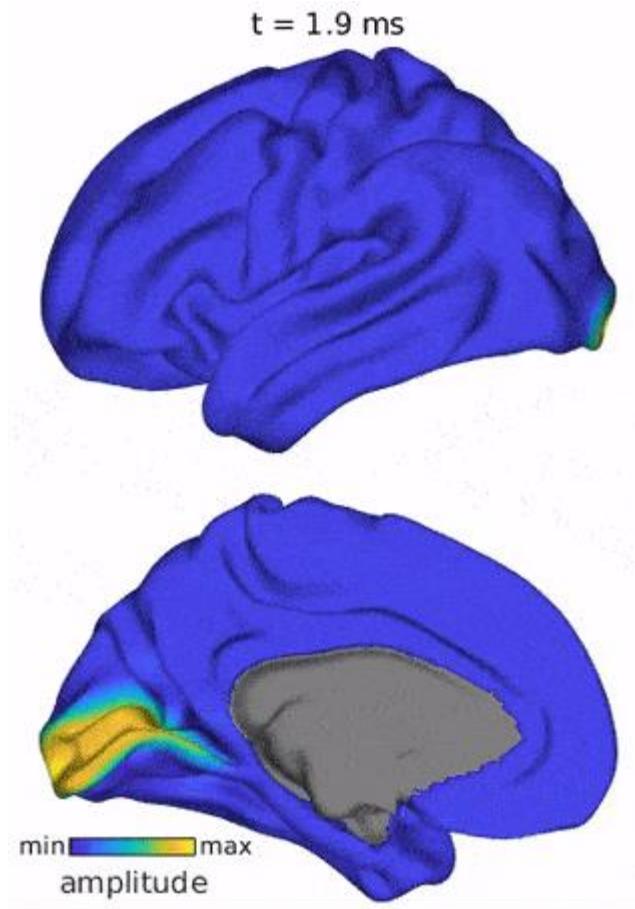
Image source: <https://developer.nvidia.com/blog/develop-physics-informed-machine-learning-models-with-graph-neural-networks/>

# e.g., Cardiac Electrophysiology

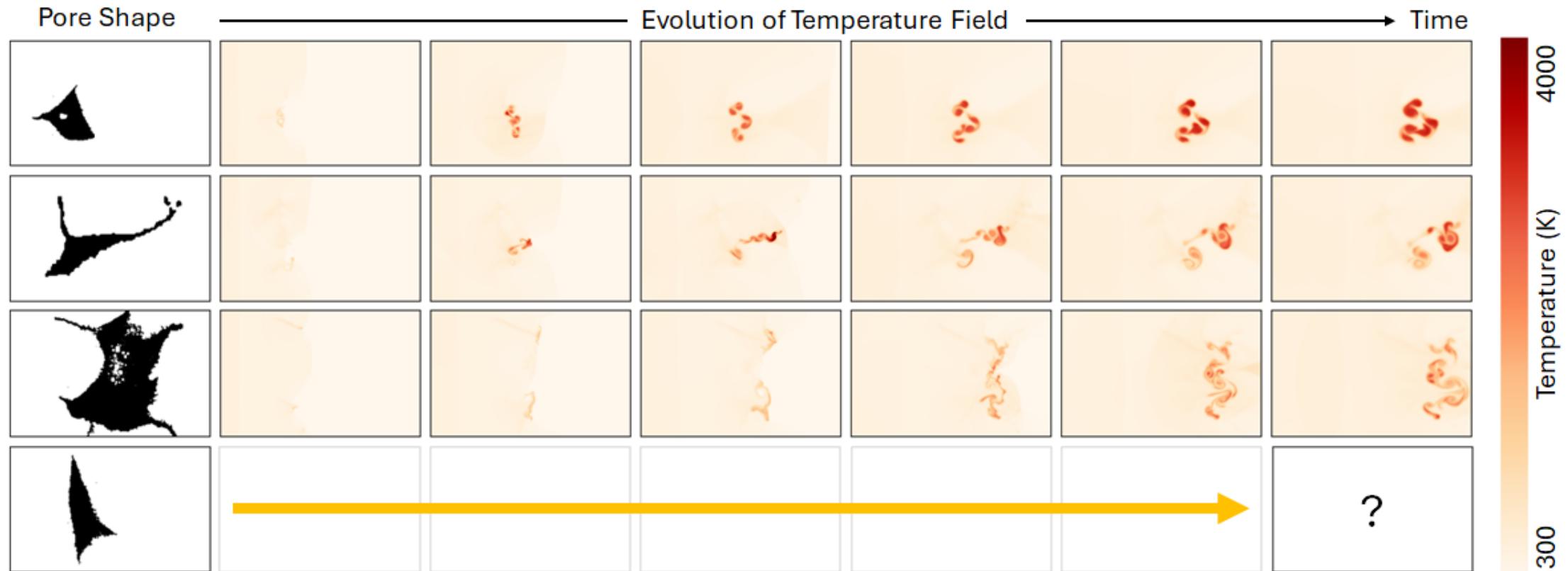
Deep learning-based Reduced Order Models (DL-ROMs)  
for the real-time simulation of cardiac electrophysiology



# e.g., “Dynamics of the Mind”



# e.g., Materials Science/Applied Mechanics



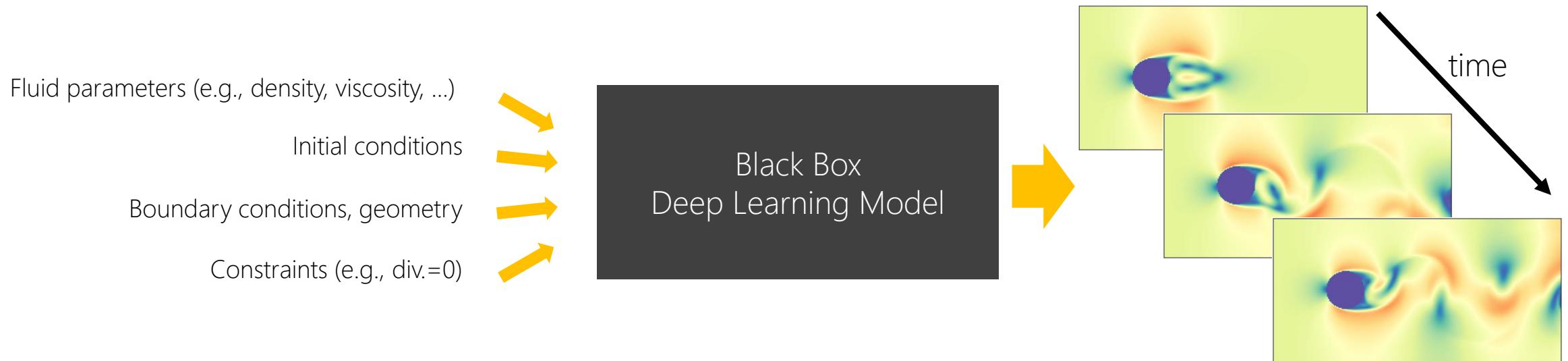
**How are they different from other ML tasks?**

# AI does learn physics from data!

- ...if you can afford a large amount of data  
(and a large model, ... and a fancy computer)

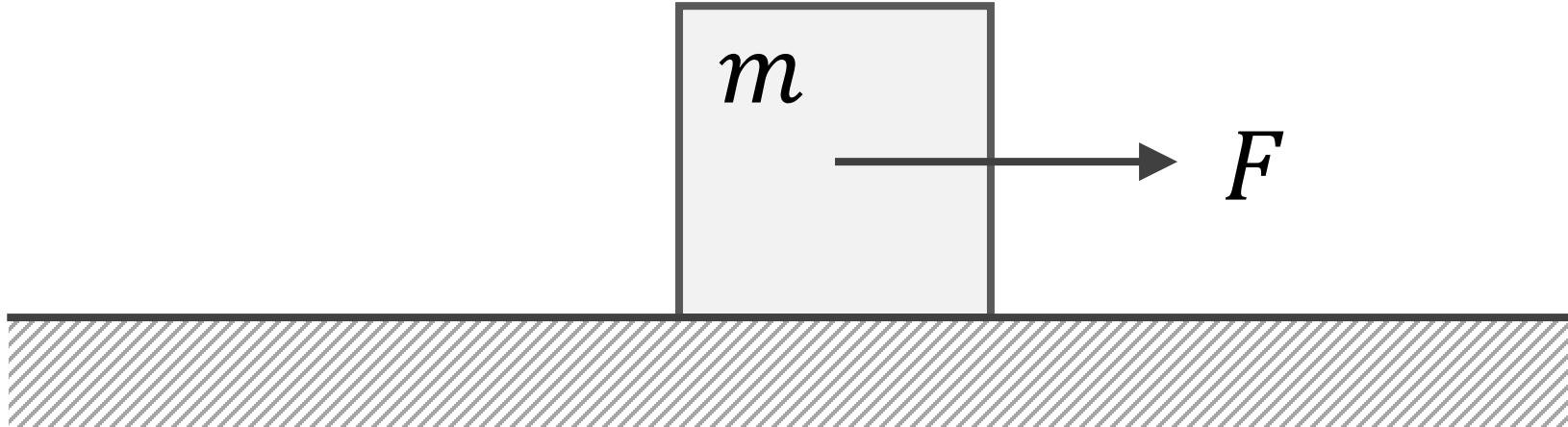


# “Can’t you just fit the model?”

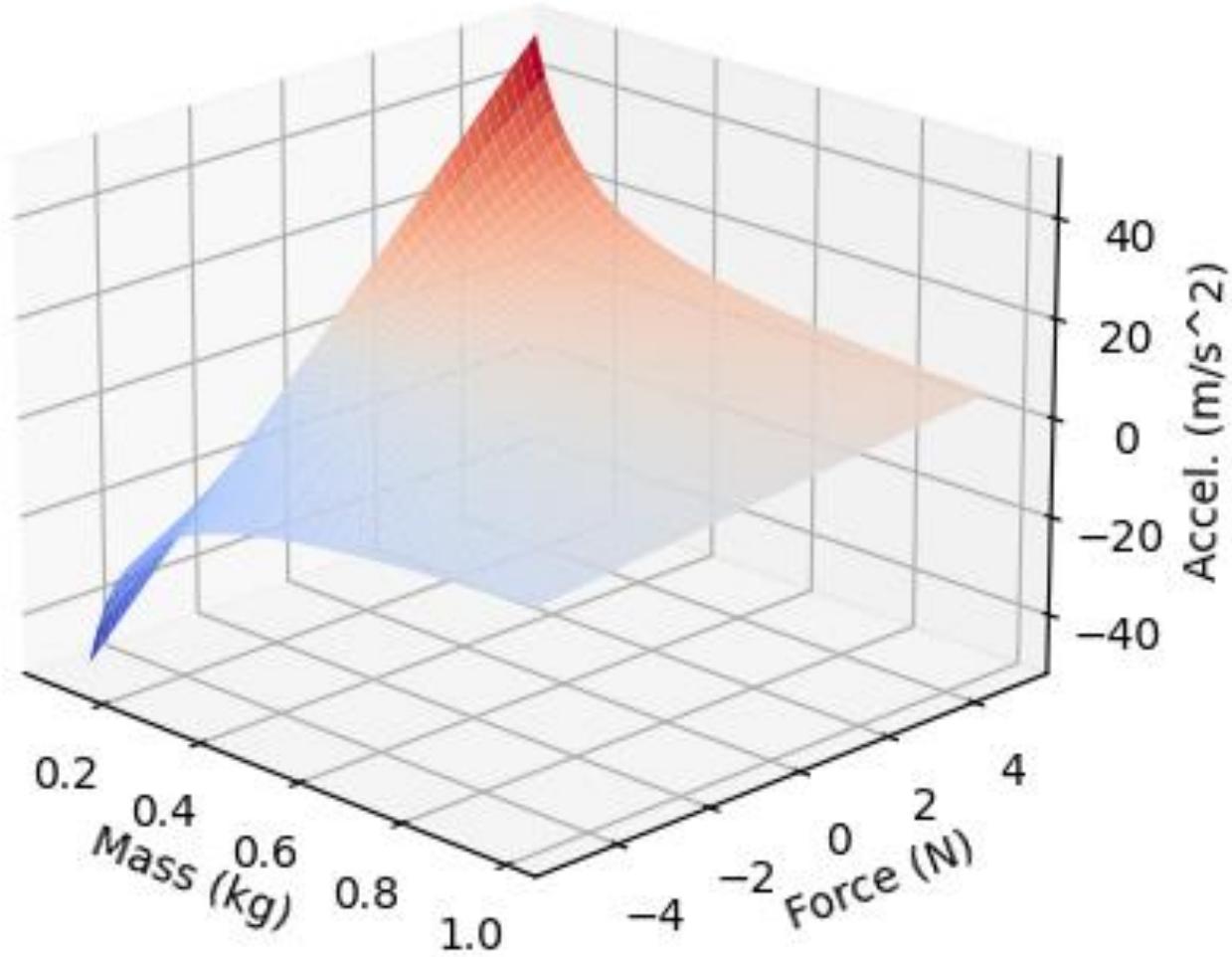


- Model predictions do not usually comply with **physics governing laws, initial/boundary conditions, and other constraints**.
  - Problematic for scientific use!
- Physics data are typically **expensive**—requires lots of time, money, and labor to obtain.
  - Train with small data?

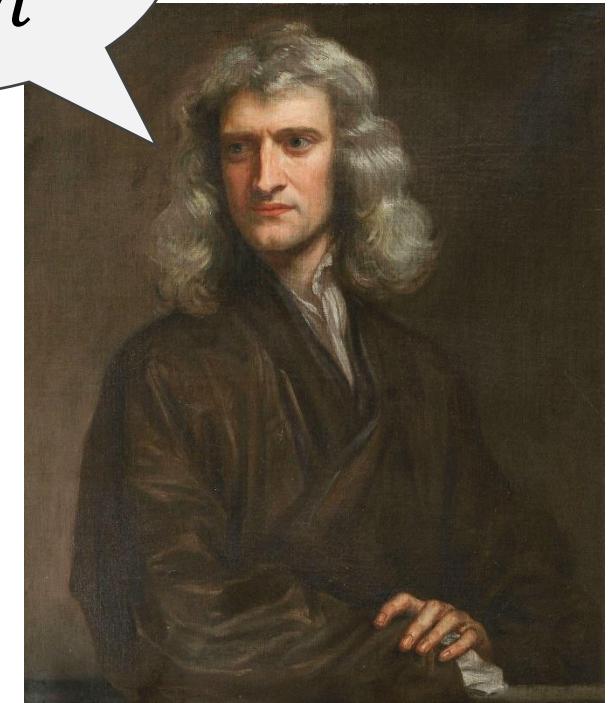
$$a = ?$$



# Analytic Solution

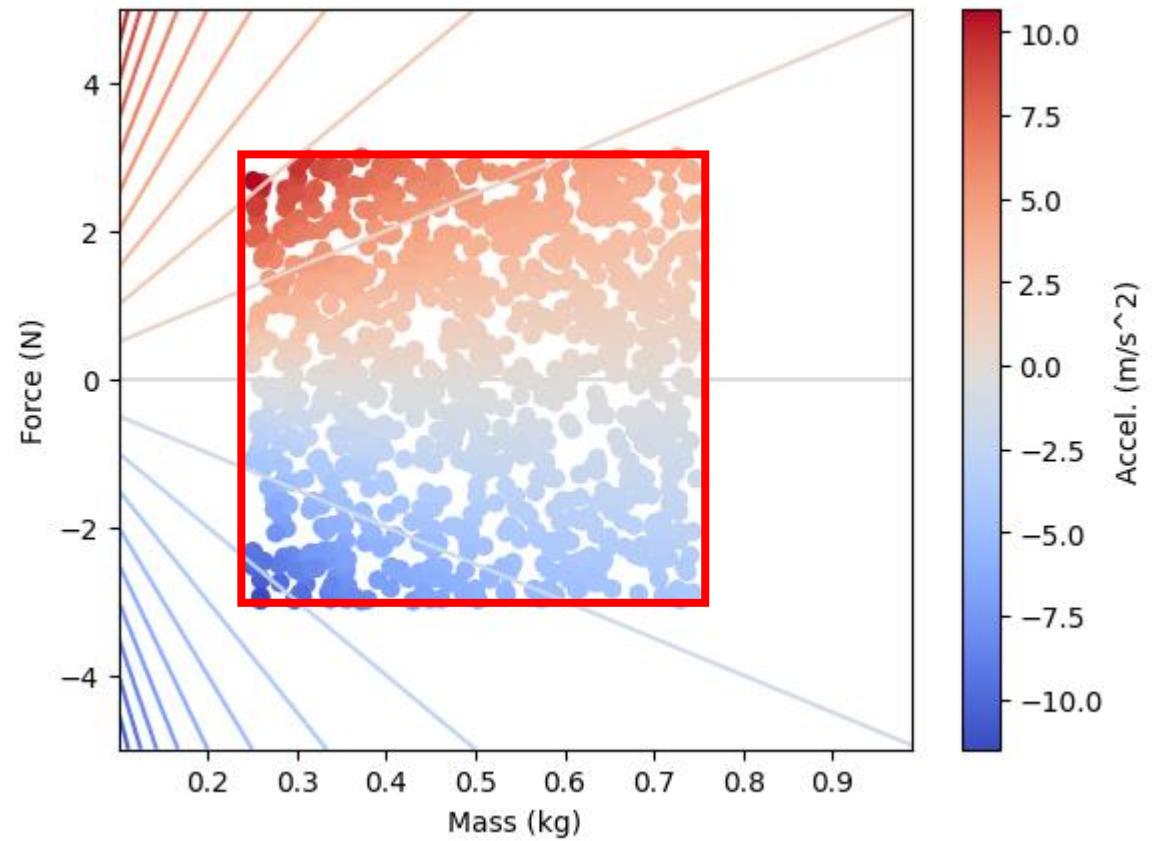


$$a = \frac{F}{m}$$

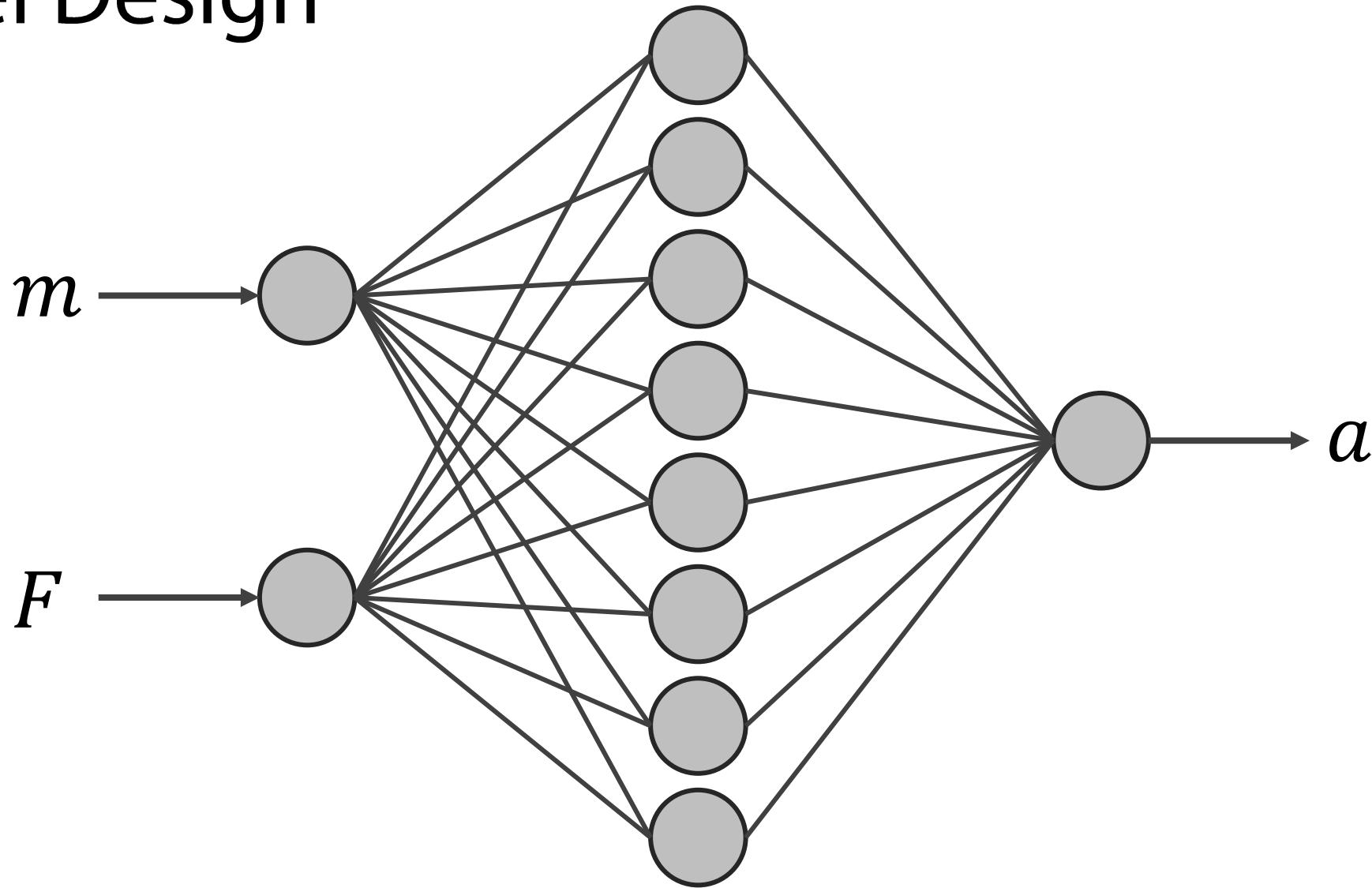


# Training Data

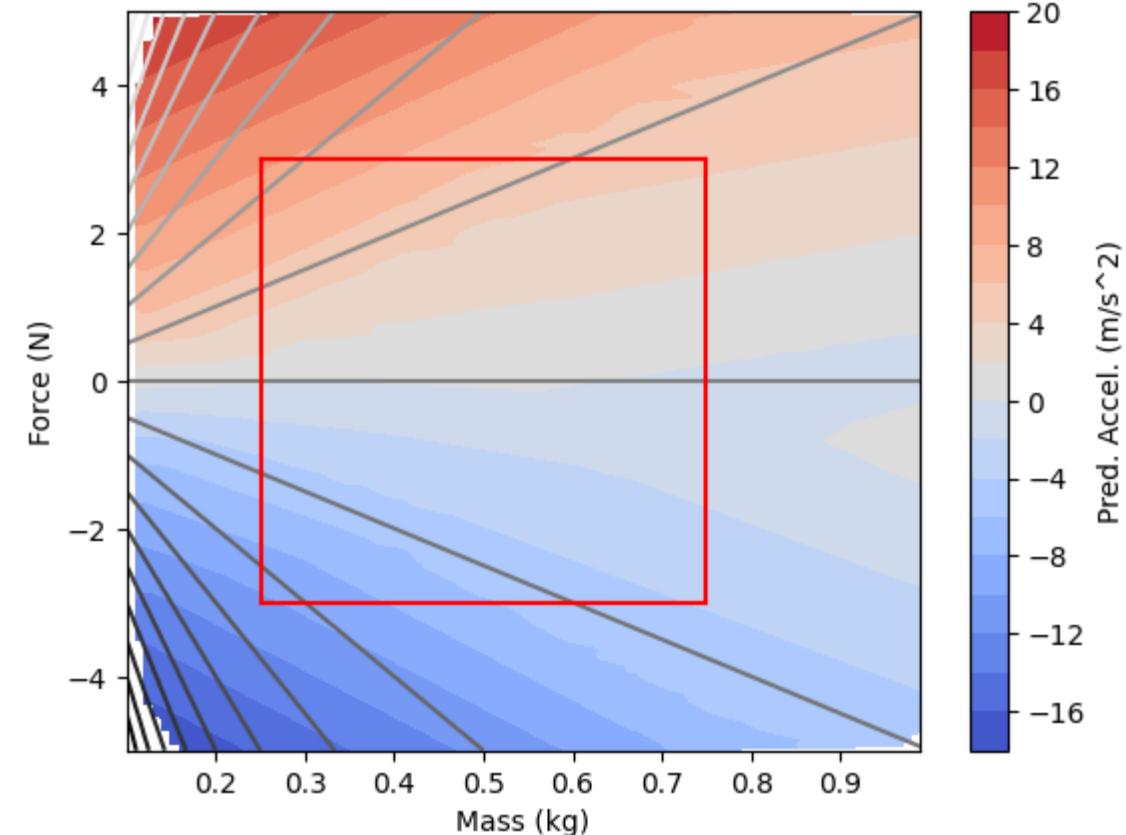
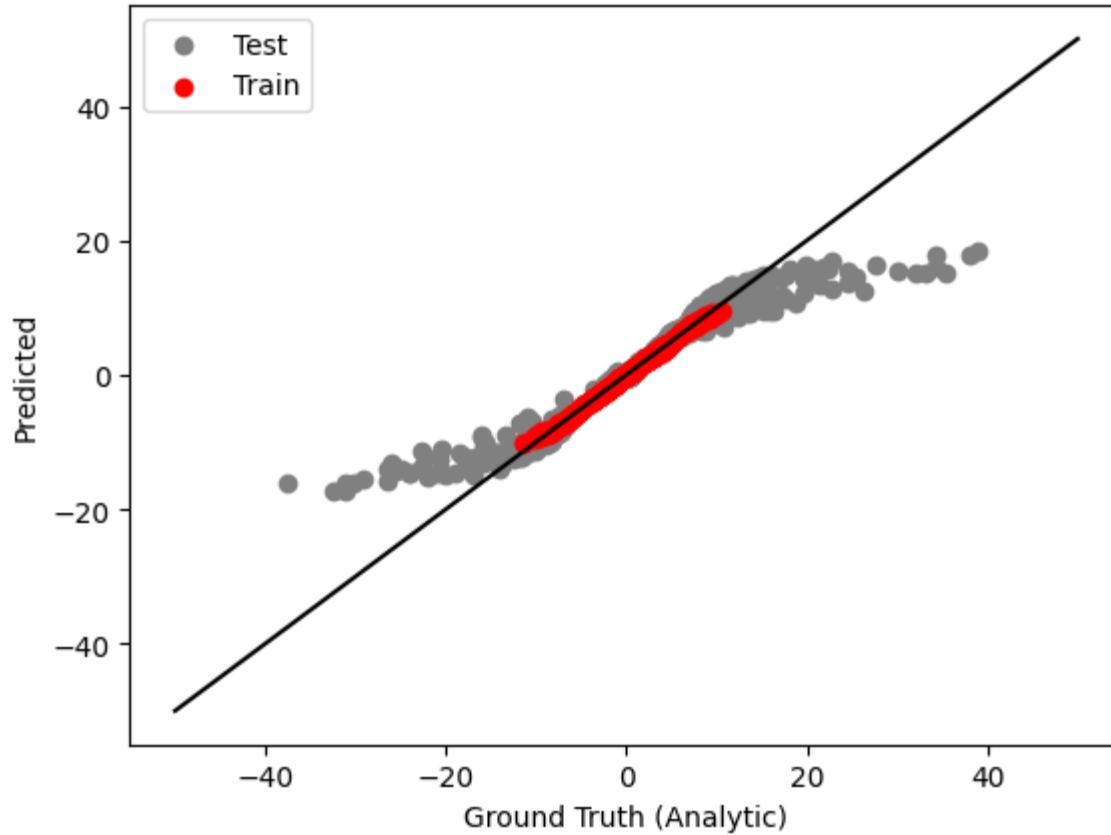
```
# Training data generation
N = 1000                                # Number of training data
e = 0.01                                   # Strength of noise
F = torch.rand(N)*6 - 3                    # Forces inbetween -3 ~ +3 (N)
m = torch.rand(N)*0.5 + 0.25               # Masses inbetween 0.25 ~ 0.75 (kg)
a = F/m + e*torch.randn(N)                 # Emulate measurement noise
```

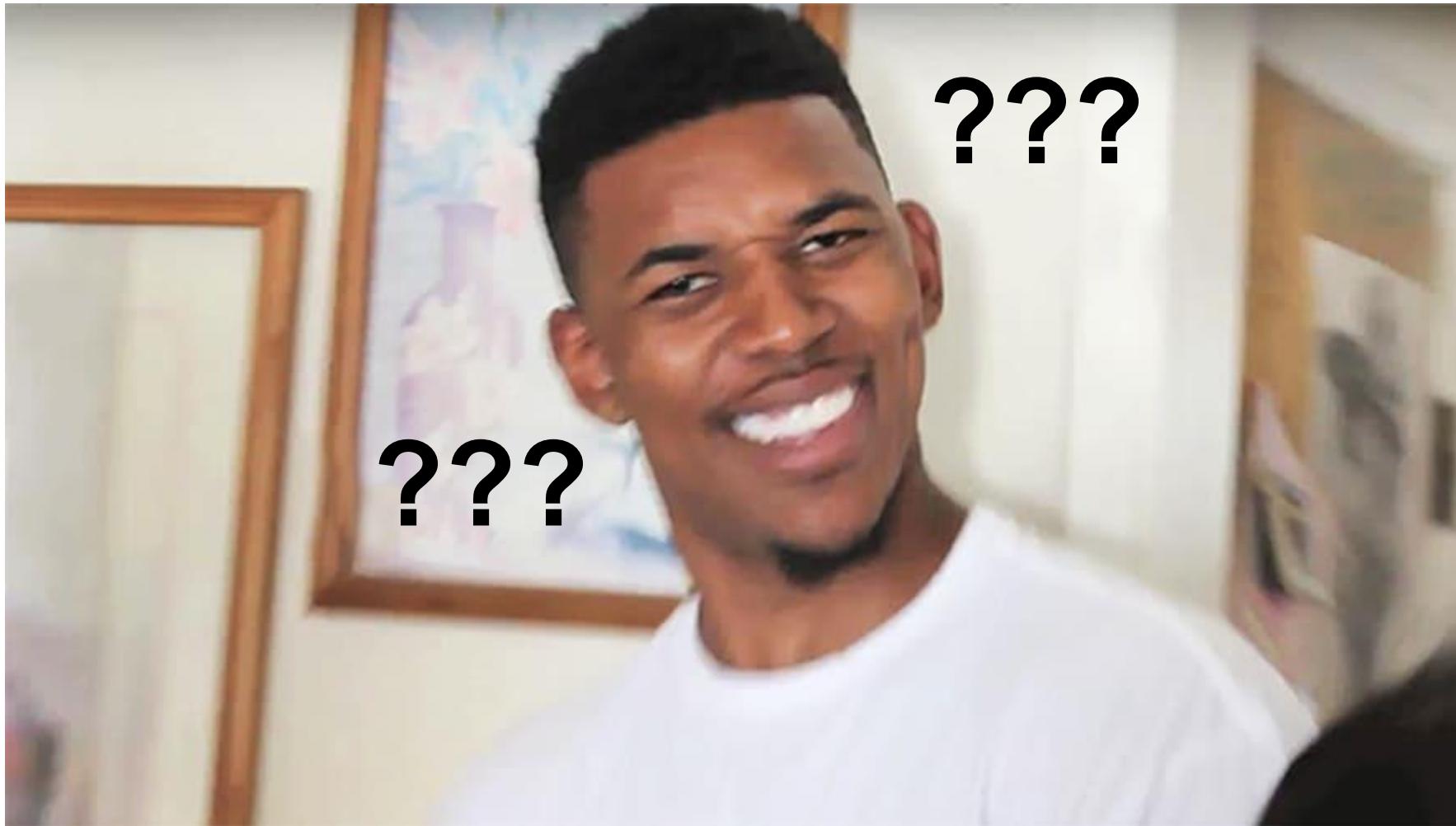


# Model Design

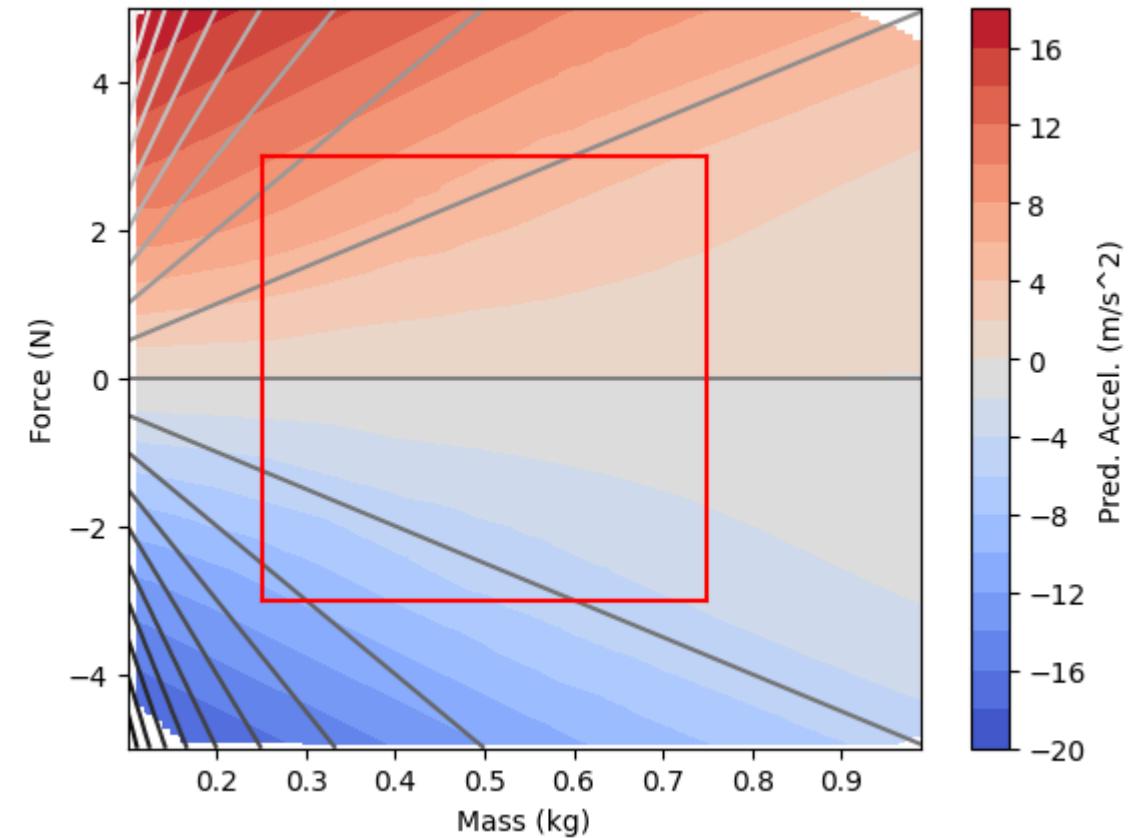
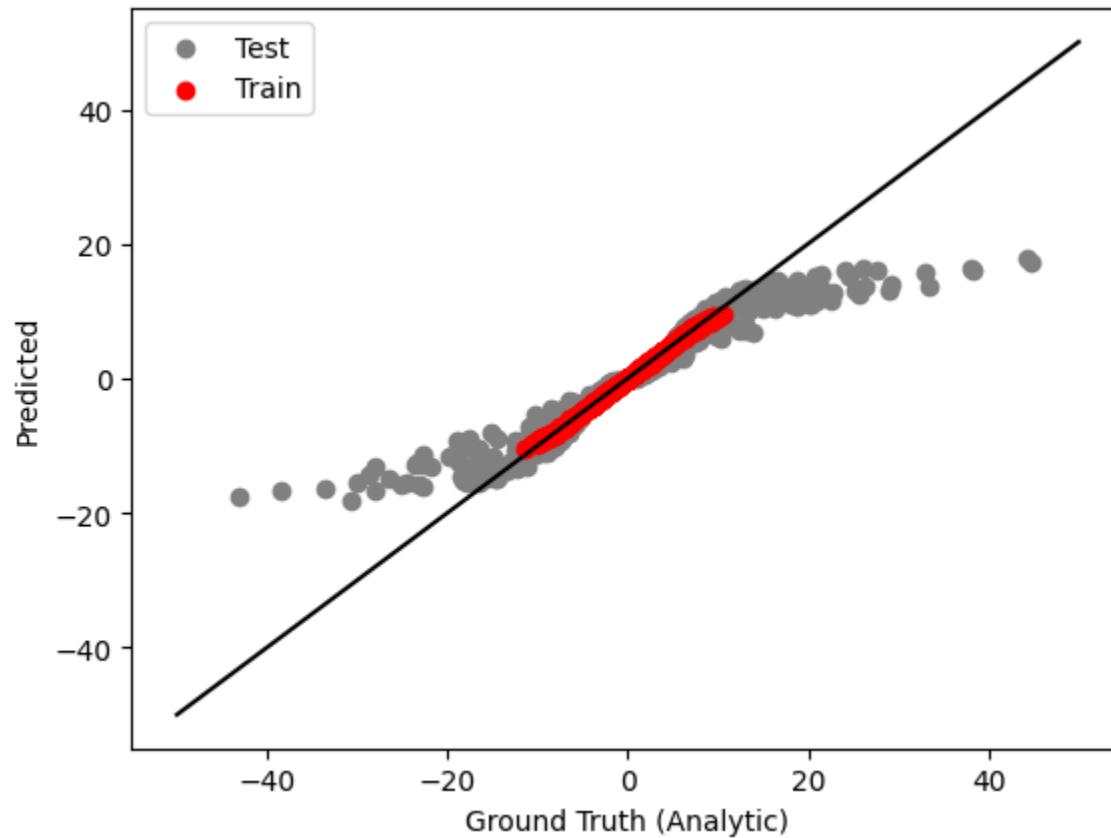


# Result

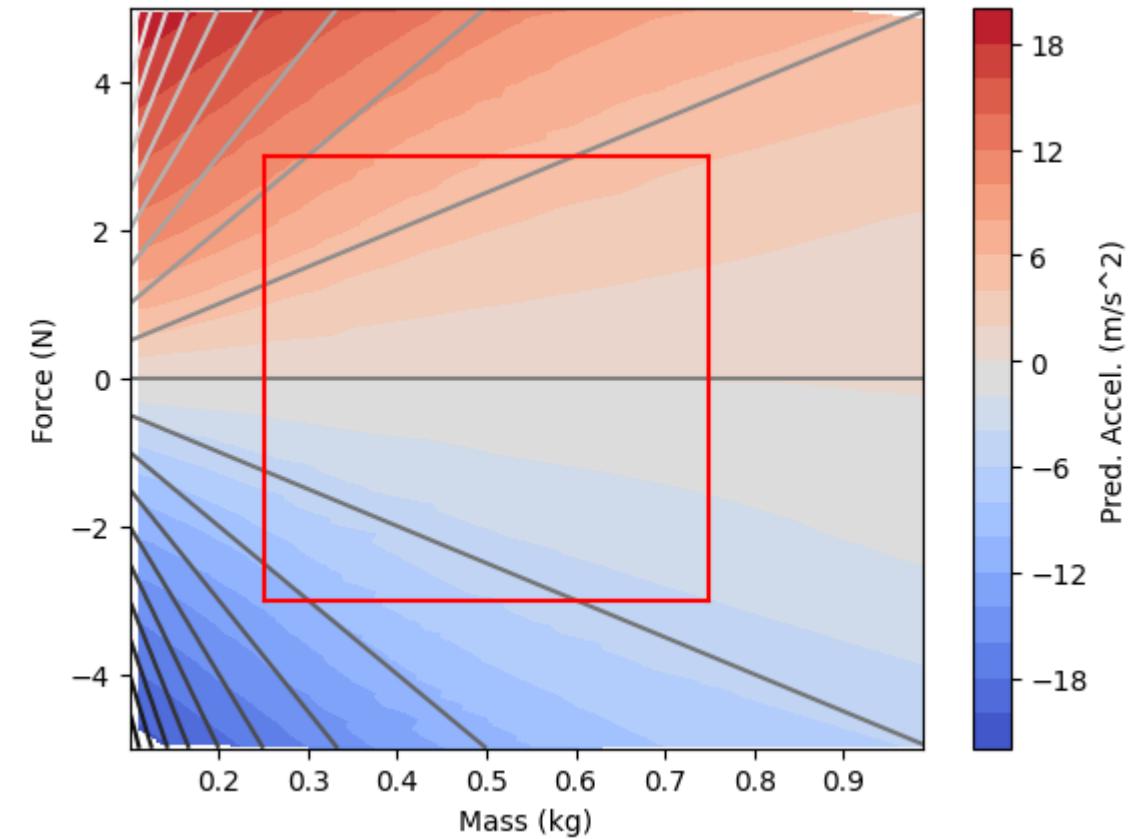
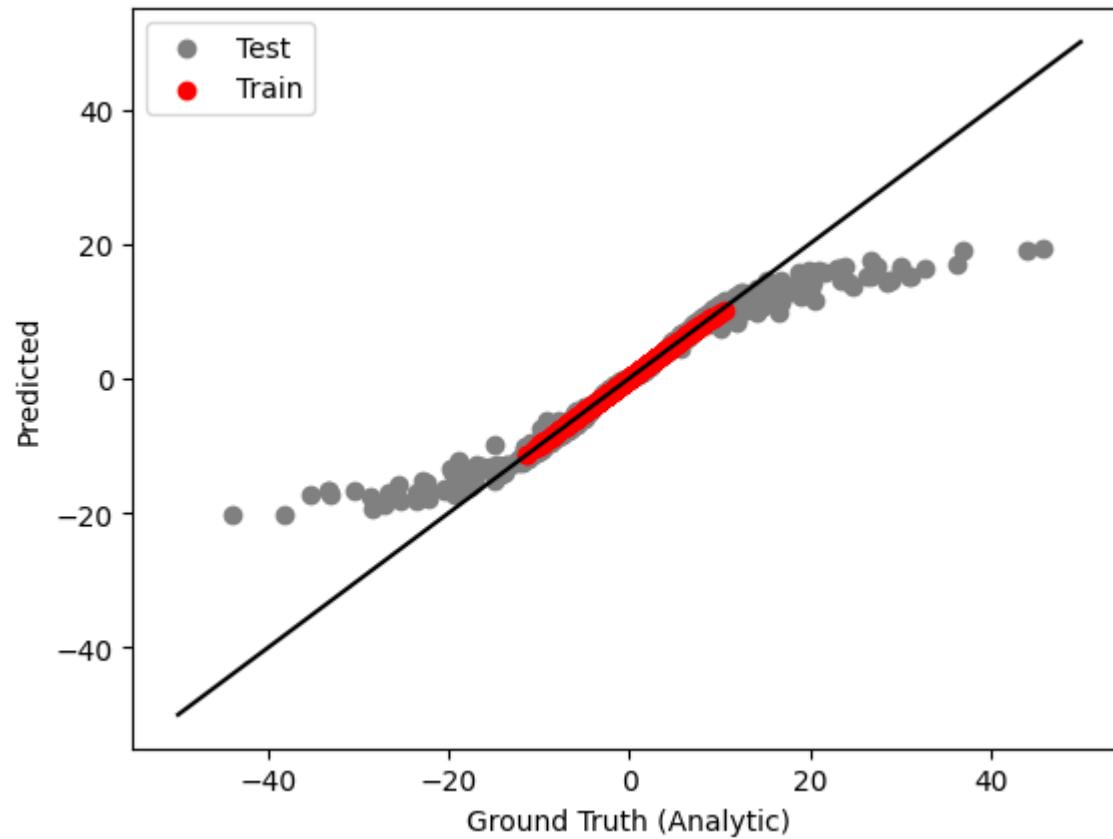




# Going wider (8→256), because... UAT!



# Going deeper ( $1 \rightarrow 3$ hidden), because... DL!



# Course Overview

- Days 1-2: Introduction to Neural Networks (Intro to PyTorch lab)
- Days 3-4: Convolutional Neural Networks (Structural health monitoring lab)
- Days 5-6: Physics-Informed Neural Networks (+ lab)
- Day 7: Neural Operators (+ lab)
- Day 8: Physics-Aware Recurrent Convolutions (+ lab)
- Day 9: Deep Reduced Order Modeling (+ lab)
- Day 10: Generative Neural Networks and Digital Twins. Course Evaluation

# Prerequisites

- Background Knowledge
  - Python programming
  - Multivariate/vector calculus & Linear algebra
  - Basic understanding of (ordinary and partial) differential equations
  - “Introduction to PyTorch”

# Prerequisites

- Computer Configuration
  - Visual Studio Code (or other code editor/Python IDE)
  - (Mini)conda - <https://docs.anaconda.com/miniconda/>
  - Git - <https://git-scm.com/downloads>
  - (Optional) NVIDIA GPU with CUDA support
- `conda create -n padl python=3.11 ipykernel`
- `conda activate padl`
- Install PyTorch - <https://pytorch.org/>
- `git clone <https://github.com/stephenbaek/padl.git>`
- `pip install -r requirements.txt`