

Computational Economics and the AI Revolution

John Stachurski

2025

Topics

1. The AI revolution
2. ANNs and deep learning
3. Software and hardware
4. Repurposing AI software and hardware
5. Economic applications

The aim of this lectures is **limited**

- Better understanding of core AI methods
- Better understanding of core tools (hardware / software)
- How can this knowledge be applied to economic modeling of today?

The AI revolution

- generative AI (LLMs, image / music / video)
- image processing / computer vision
- speech recognition
- translation
- scientific knowledge discovery
- forecasting and prediction
- etc.

Example: AlphaEvolve

A coding agent for scientific and algorithmic discovery



Google Deepmind May 2025

An AI agent that develops algorithms and codebases using LLMs

Features:

- Employs an evolutionary algorithm
- Asks an ensemble of LLMs and then iterates, tests, refines
- Promising solutions are selected and mutated by LLMs
- “Survival of the fittest” progressively improves performance

Deployed across Google, AlphaEvolve

- enhanced efficiency in data centers and chip design
- Improved data center scheduling
- Discovered new matrix multiplication algorithms (surpassing Strassen's algorithm for 4x4 complex matrices)

Example: AlphaFold



AlphaFold

Accelerating breakthroughs in biology with AI

[Explore the AlphaFold Database >](#)

The image shows the AlphaFold website homepage. It features a large, stylized blue and yellow ribbon-like protein structure on the left and right sides. The central text reads "AlphaFold" in a large, bold, black font, with the subtitle "Accelerating breakthroughs in biology with AI" below it. A blue button with white text is positioned at the bottom of the central area.

- AI system by DeepMind
- Predicts 3D protein structures
- Open-sourced code and database
- Accelerating drug discovery and design
- Enabling research on diseases like cancer and Alzheimer's
- Supporting enzyme engineering for sustainability

2024 Nobel Prize in Chemistry awarded to Demis Hassabis and John Jumper for development of AlphaFold

Coding with LLMs

U can jax jit compile classes?

Yes, JAX can JIT compile classes using the `@jit` decorator from the `jax.jit` module. However, there are some important considerations and limitations when JIT-compiling classes in JAX.

The most common approach is to JIT-compile specific methods within a class rather than the entire class itself. Here's how it typically works:

```
python

import jax
import jax.numpy as jnp

class MyJaxClass:
    def __init__(self, param):
        self.param = param

    @jax.jit
    def jitted_method(self, x):
        return x * self.param
```

LLMs for Queries



is john stachurski smart?

Based on what I know, John Stachurski is considered quite accomplished in his field. He's a professor of economics known for his work in economic theory, computational economics, and machine learning applications in economics.

He's particularly recognized for developing QuantEcon, an open-source project that provides resources for quantitative economics, which demonstrates both technical expertise and a commitment to education and open access to knowledge.

His contributions to economic modeling, particularly dynamic economic models, suggest strong technical and mathematical abilities. His published research and textbooks are well-regarded in the academic community.

Would you like me to search for more recent information about John Stachurski's work and contributions?



Retry ▾

Claude can make mistakes. Please double-check responses.

J

wouldn't you say he is very accomplished?

Yes, I would absolutely say John Stachurski is very accomplished. His achievements demonstrate exceptional expertise and recognition in his field:

- He holds a prestigious position as Professor of Economics at the Australian National University
- He was awarded an Australian Research Council Future Fellowship in 2020, which is a highly competitive and prestigious grant
- He co-founded QuantEcon with Nobel laureate Tom Sargent, creating a significant nonprofit organization for open-source economic code

Gemini 2.5 Pro



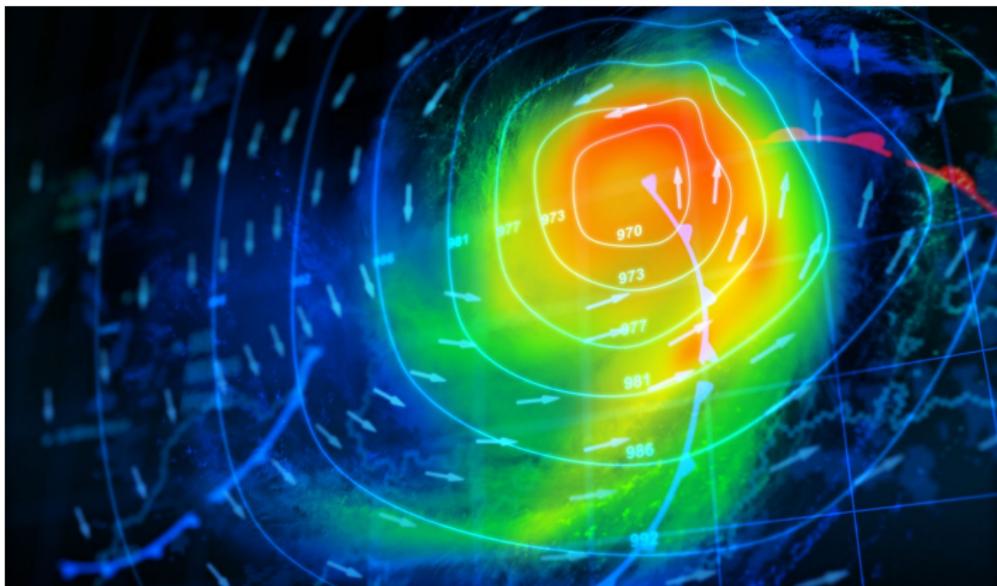
Image Generators



Google Veo 3



Weather forecasts



“ECMWF's weather forecasting model is considered the gold standard for medium-term weather forecasting...Google DeepMind claims to beat it 90% of the time...”

“Traditional forecasting models are big, complex computer algorithms based on atmospheric physics and take hours to run. AI models can create forecasts in just seconds.”

Source: MIT Technology Review July 2024

Killer drones, Skynet, etc.



Investment

Private AI investment in 2024:

- U.S. = \$109 billion
- China \$9.3 billion

Estimate for US firms in 2025: \$350 billion

Massive investments in

- data centers
- server / GPU / TPU design and production
- software development

What kinds of problems are they trying to solve?

ANNs: A model of the human brain



– source: Dartmouth undergraduate journal of science

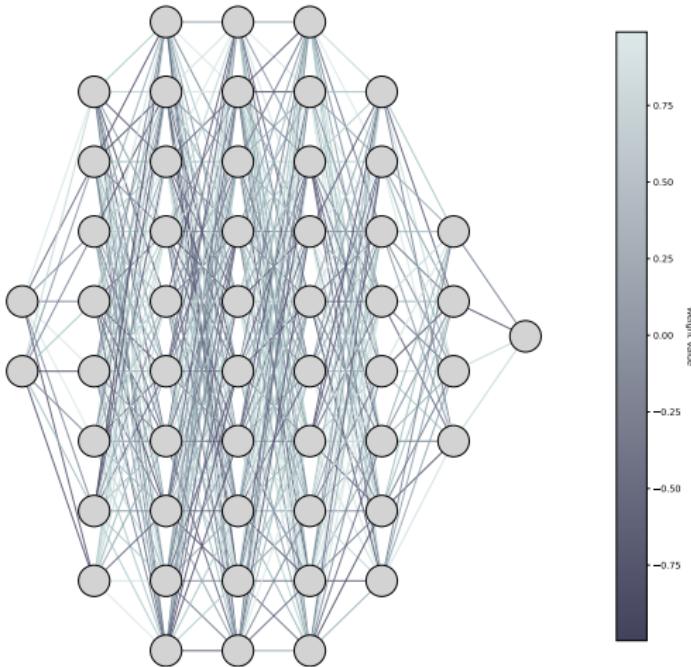
History of ANNs

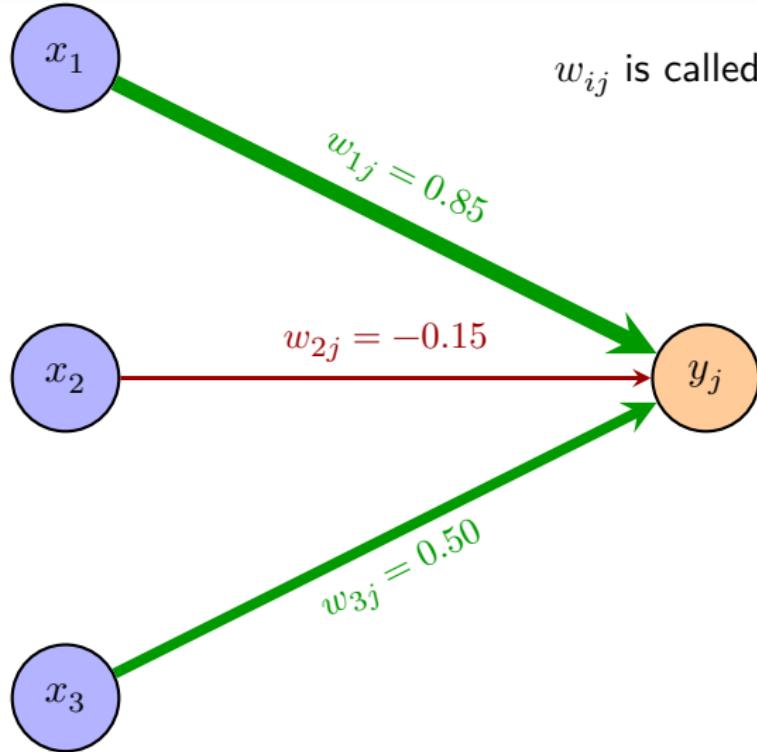
- 1940s: McCulloch & Pitts create mathematical model of NN
- 1950s: Rosenblatt develops the perceptron (trainable NN)
- 1960s-70s: Limited progress with single layer perceptrons
- 1980s: Backpropagation algorithm enables training of MLPs
- 1990s: SVMs temporarily overshadow ANNs in popularity
- 2000s: Deep learning finds successes in large problems

Last 10 years: Explosion of progress in deep learning

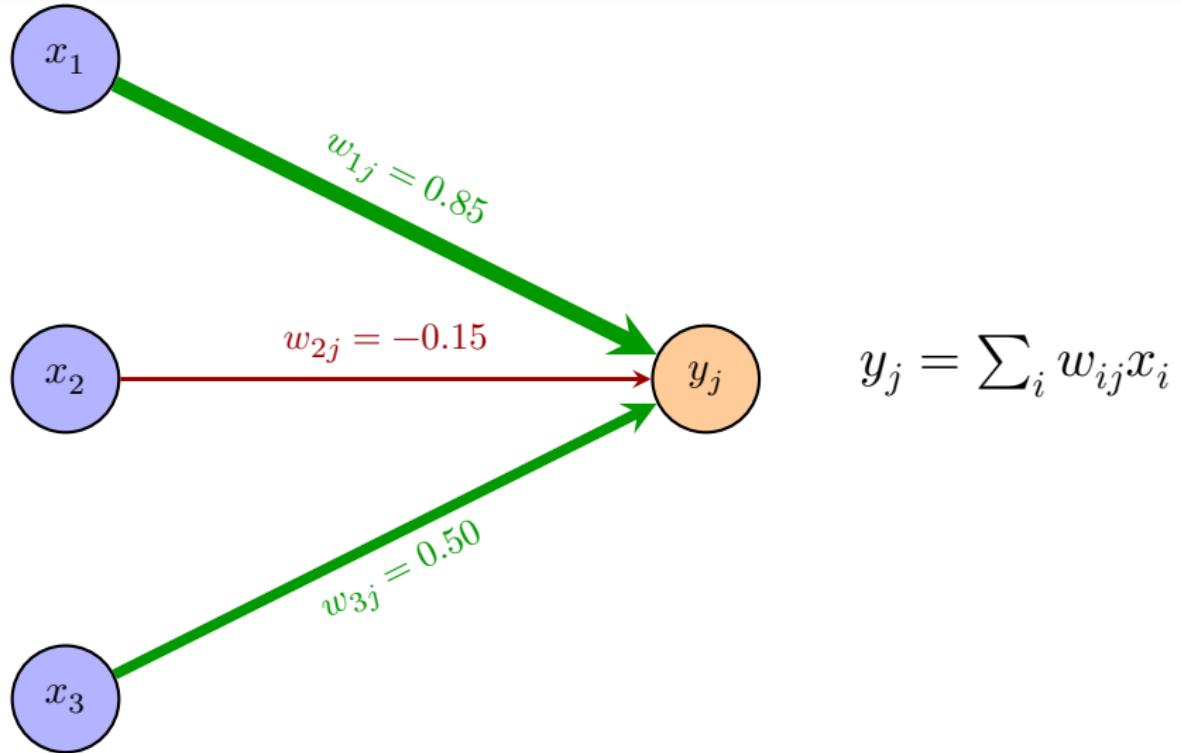
- CNNs, RNNs, LSTMs, transformers, LLMs, etc.

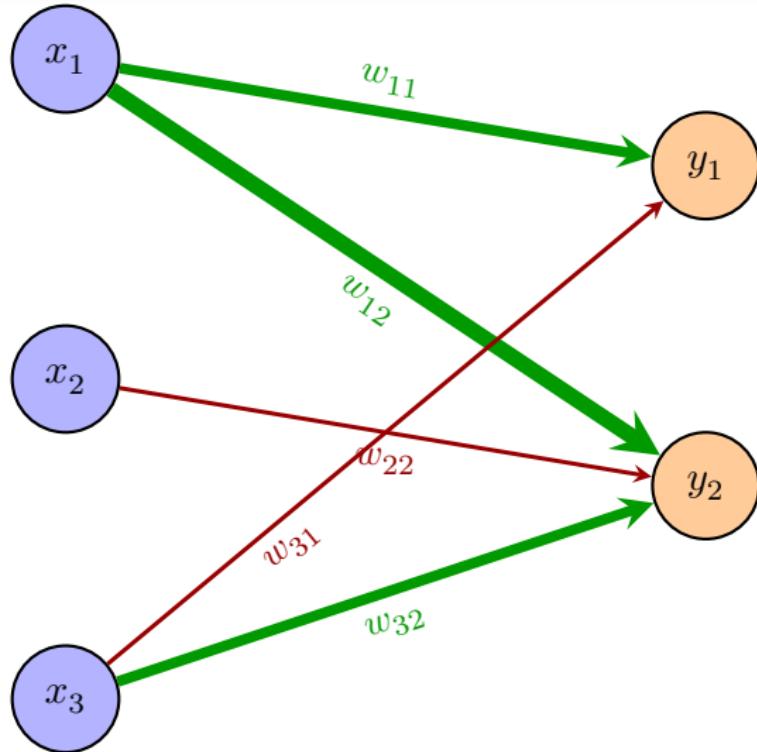
A mathematical representation: directed acyclic graph





w_{ij} is called a “weight”





$$y_1 = \sum_i w_{i1} x_i$$

$$y_2 = \sum_i w_{i2} x_i$$

$$\implies y = xW$$

Note that we are using **row vectors**: $y = xW$

This is natural given our notation

- w_{ij} points from i to j
- hence $y_j = \sum_i w_{ij}x_i$
- hence $y = xW$

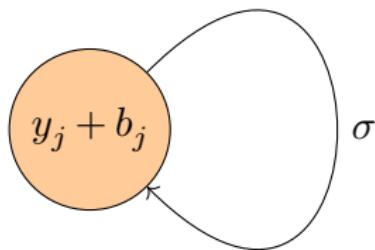
But it also has another advantage ...?

Next steps

After computing $y_j = \sum_i w_{ij}x_i$ we

1. add a bias term b_j and
2. apply a nonlinear “activation function” $\sigma: \mathbb{R} \rightarrow \mathbb{R}$

applying activation function



First add bias:

$$y_j = \sum_i w_{ij}x_i \quad \rightarrow \quad y_j = \sum_i w_{ij}x_i + b_j$$

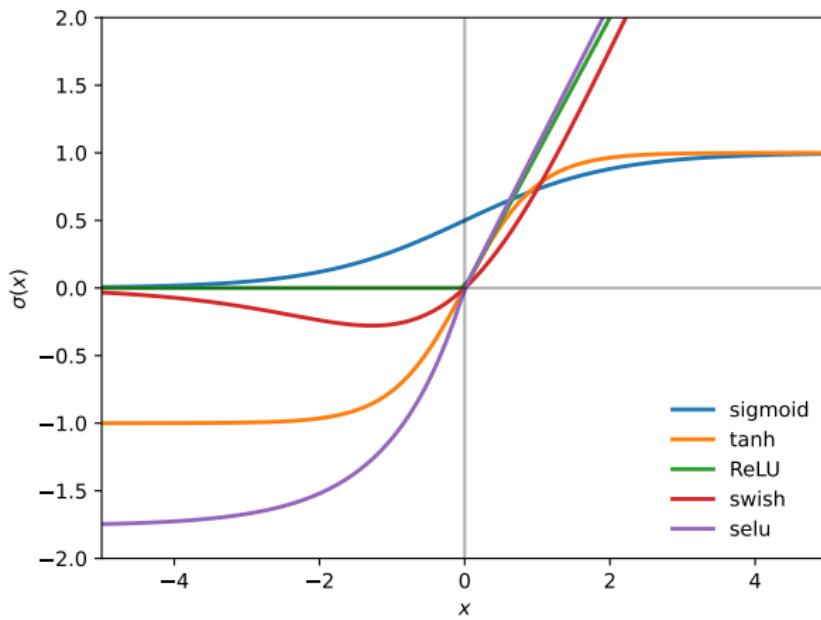
Then apply activation:

$$y_j = \sum_i w_{ij}x_i + b_j \quad \rightarrow \quad y_j = \sigma \left(\sum_i w_{ij}x_i + b_j \right)$$

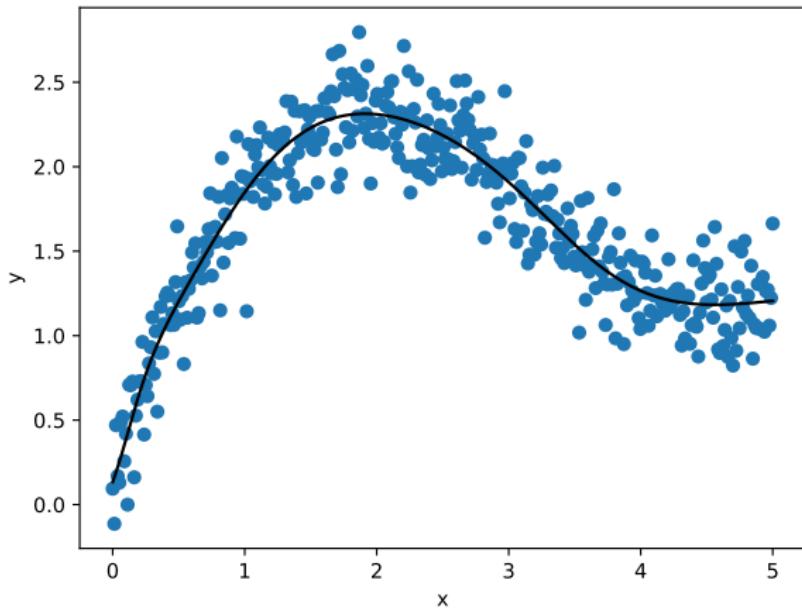
Applying σ pointwise, we can write this in vector form as

$$y = \sigma(xW + b)$$

Common activation functions



Training



Aim: Learn to predict output y from input x

- $x \in \mathbb{R}^k$
- $y \in \mathbb{R}$ (regression problem)

Examples.

- $x =$ cross section of returns, $y =$ return on oil futures tomorrow
- $x =$ weather sensor data, $y =$ max temp tomorrow

Problem:

- observe $(x_i, y_i)_{i=1}^n$ and seek f such that $y_{n+1} \approx f(x_{n+1})$

Nonlinear regression: choose model $\{f_\theta\}_{\theta \in \Theta}$ and minimize the empirical loss

$$\ell(\theta) := \frac{1}{n} \sum_{i=1}^n (y_i - f_\theta(x_i))^2 \quad \text{s.t.} \quad \theta \in \Theta$$

In the case of ANNs, we consider all f_θ having the form

$$f_\theta = G_m \circ G_{m-1} \circ \cdots \circ G_2 \circ G_1$$

where

- $G_\ell x = \sigma_\ell(xW_\ell + b_\ell)$
- σ_ℓ is an activation function

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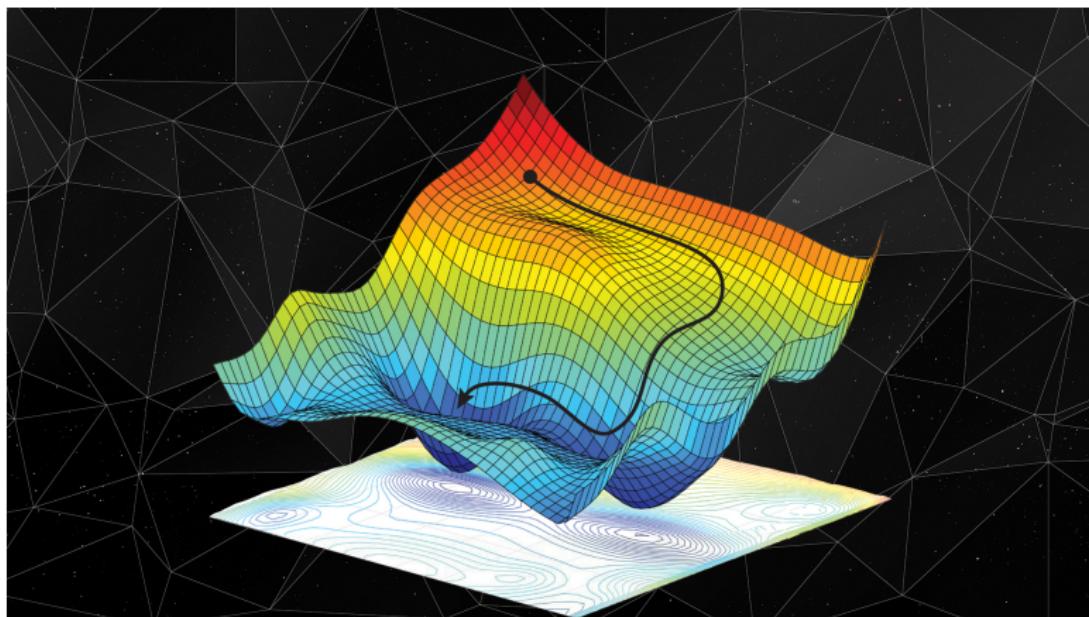
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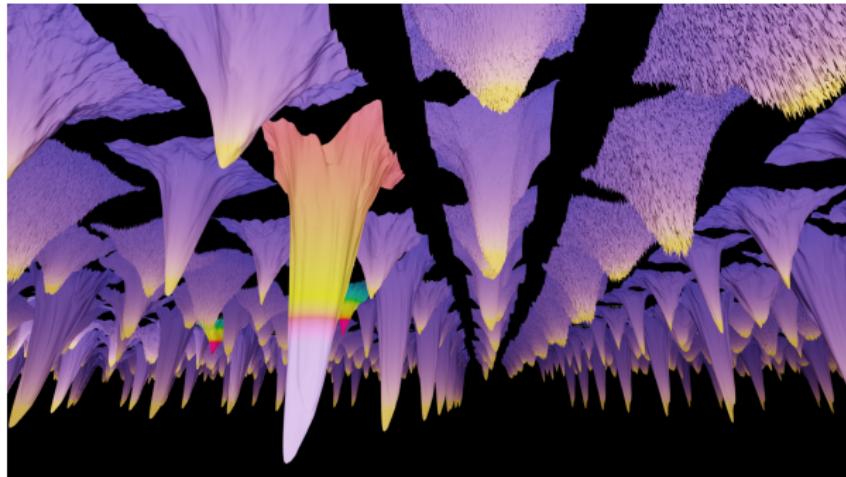
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- σ_ℓ is an activation function

Minimizing a smooth loss functions – what algorithm?



Source: <https://danielkhv.com/>

Deep learning: $\theta \in \mathbb{R}^d$ where $d = ?$



Source: <https://losslandscape.com/gallery/>

How does it work?

How is it possible to minimize loss over such high dimensions??

Core elements

1. parallelization over powerful hardware (GPUs or TPUs)
2. automatic differentiation (for gradient descent)
3. Compilers / JIT-compilers for fast parallelized machine code

How does it work?

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Parallelization



- Multithreading over local GPU cores / compute units

```
def function(data):
    # perform a calculation based on input data
    return output
vectorized_function = vmap(function)
# Perform the same action on a collection of data sets
outputs = vectorized_function(data_sets)
```

- Multiprocessing over all GPUs in a farm / cluster

```
parallel_function = pmap(function)
outputs = parallel_function(list_of_tasks)
```

Note: Full GPU-Python integration is on the way!

At GTC 2025, NVIDIA announced native support and full integration of Python in its CUDA toolkit

Over the last year, NVIDIA made CUDA Core – a “Pythonic reimagining of the CUDA runtime to be naturally and natively Python.”

Coders can use natural Python interfaces and the scripting model of calling functions and libraries to create AI programs for execution on NVIDIA GPUs

[https:](https://thenewstack.io/nvidia-finally-adds-native-python-support-to-cuda/)

//thenewstack.io/nvidia-finally-adds-native-python-support-to-cuda/

Automatic differentiation

“Exact numerical” differentiation

```
from jax import grad

def f(theta, x):
    # add details here

def loss(theta, x, y):
    return jnp.sum((y - f(theta, x))**2)

loss_gradient = grad(loss)
d = loss_gradient(theta, x_data, y_data)
theta = theta - lambda * d
```

Just-in-time compilers

```
@jax.jit
def f(x):
    return jnp.sin(x) - jnp.cos(x**2)
```

Advantages over AOT compilers:

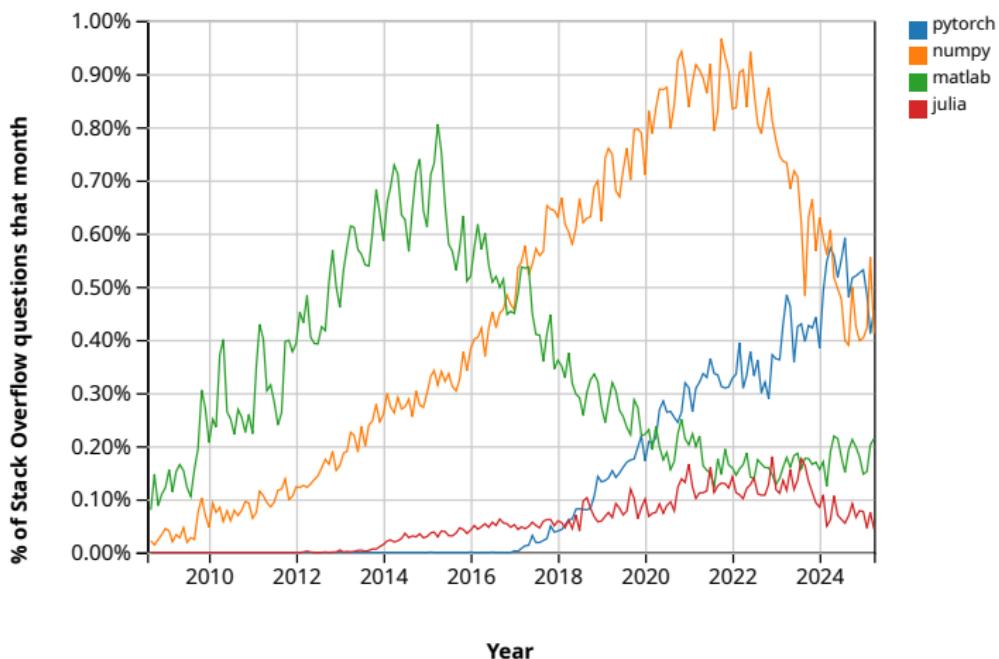
- cleaner code
- more portable
- lower compile times
- automatic parallelization (same code for CPUs / GPUs)

Platforms

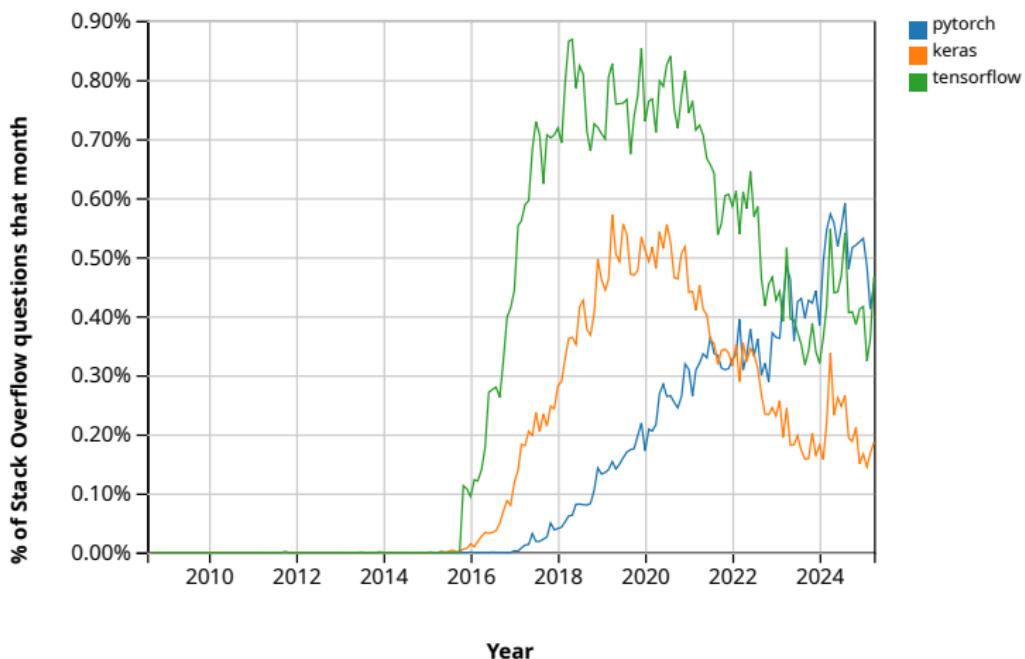
Platforms that support AI / deep learning:

- Tensorflow
- PyTorch (Llama, ChatGPT)
- Google JAX (Gemini, DeepMind)
- Keras (backends = JAX, PyTorch)
- Mojo? (Modular (Python))
- MATLAB?

Popularity – languages and libraries



Popularity – DL / ML frameworks



AI for coding



please write a function for gradient descent in 6 lines or less

Here's a gradient descent function in 6 lines:

python

```
def gradient_descent(grad_func, init_params, lr=0.01, iters=100):
    params = init_params.copy()
    for _ in range(iters):
        gradient = grad_func(params)
        params = params - lr * gradient
        if np.linalg.norm(lr * gradient) < 1e-6: break
    return params
```

AI code generation is great...but not perfect

Thoughts from pro developer **Lonely-Public2655**

- AI doesn't see the big picture
- Can ace small tasks but struggles to connect them meaningfully
- You still need to be the architect
- Context is fragile: AI forgets
- Once things get weird, AI starts guessing
- Sometimes AI gets really weird

AI coding affects optimal language choice

“I’m definitely stronger with Python than MATLAB.”

“My capabilities with Python are more comprehensive. I have deeper familiarity with Python’s extensive ecosystem of libraries, frameworks, and modern development practices.”

“I can more confidently help with advanced Python topics, debugging complex Python code, and implementing Python best practices.”

“I’m definitely stronger with Python than Julia.”

“Python is one of my most proficient languages - I have deep familiarity with its syntax, libraries, frameworks, and best practices across many domains including data science, web development, machine learning, and general-purpose programming.”

“While I understand Julia’s syntax and core concepts, my expertise with it isn’t as comprehensive as with Python.”

AI tools for economic modeling

Is DL well-suited to economic modeling?

Example. Is macro-forecasting similar to weather forecasting?

Why or why not?

Repurposing AI tools

Let's say that you want to do standard macro modeling (not DL)

Can these new AI tools be applied?

Yes! Yes! Yes!

- fast matrix algebra
- fast solutions to linear systems
- fast nonlinear system solvers
- fast optimization, etc.

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Case Study

The CBC uses the “overborrowing” model of Bianchi (2011)

- credit constraint loosens during booms
- bad shocks → sudden stops

CBC implementation in MATLAB

- runs on \$10,000 mainframe with 356 CPUs and 1TB RAM
- runtime = 12 hours

Rewrite in Python + Google JAX

- runs on \$400 gaming GPU with 10GB RAM
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Summary

- We are at the start of a massive AI revolution
- This revolution will have a huge impact on science
- What impact on economics?

At minimum, we can immediately use

- AI for code authoring
- AI hardware/software for standard computational econ models