Computational Economics and the AI Revolution

John Stachurski

2025

Topics

1. Introduction
2. ANNs and deep learning
3. ML and deep learning frameworks (programming)
4. Stochastic approximation
5. Dynamic programming
6. Reinforcement learning
7. Economic applications

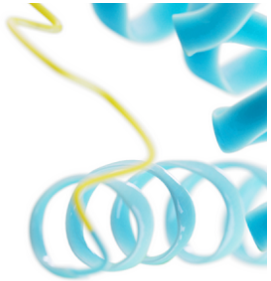
The AI revolution

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

AlphaFold

Accelerating breakthroughs in biology with AI

Explore the AlphaFold Database ›



AlphaFold

- 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

LLMs

J 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
```

J 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.

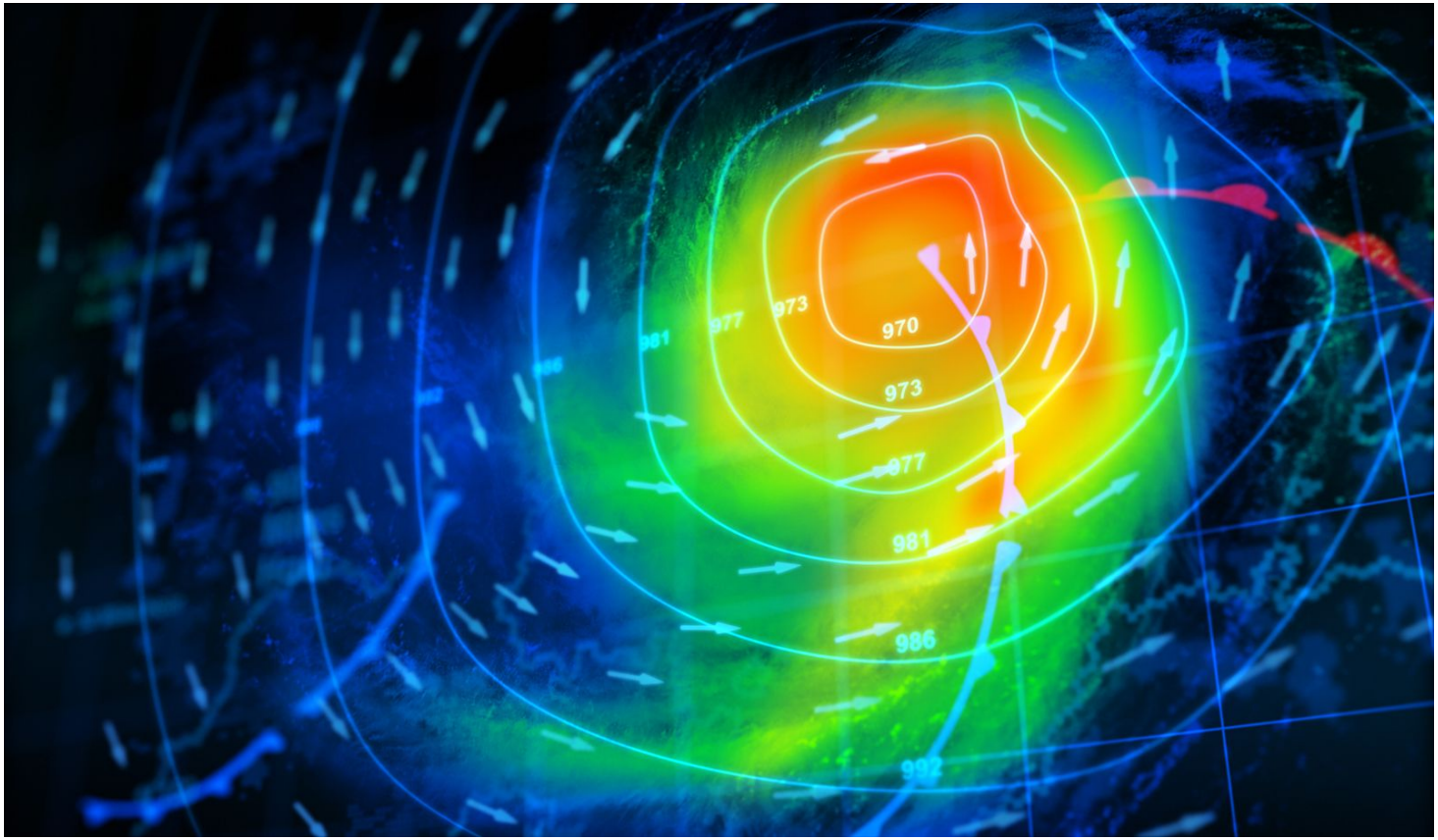
Would you like me to search for more recent information about John Stachurski's work and contributions?

Retry

Claude can make mistakes. Please double-check responses.

Image Generators

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

Translation Engines

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?

Statistical learning (induction)

We observe input-output pairs (x, y), where

- $x \in \mathbb{R}^k$
- $y \in \mathbb{R}$ (for example)

Examples.

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

Problem:

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

Deep Learning (DL)

Training:

1. Choose function class $\{f_\theta\}_{\theta \in \Theta}$
2. Minimize loss

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

In the case of DL, elements of $\{f_\theta\}_{\theta \in \Theta}$ have a particular structure

- each f_θ is a neural net — we discuss more soon
- typically, $\theta \mapsto f_\theta(x)$ is smooth for all x
- MSE is a popular loss function but others are also used

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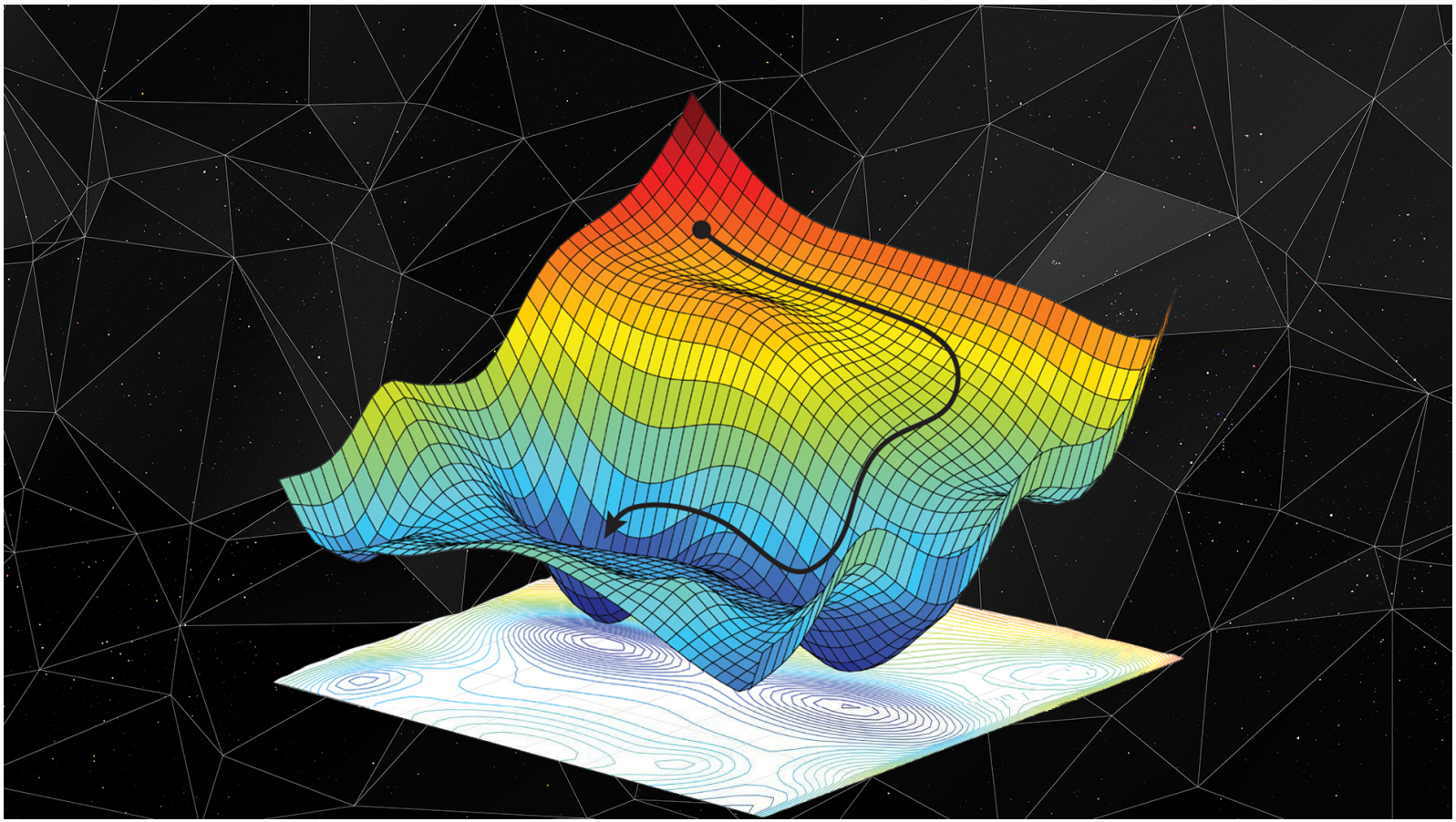
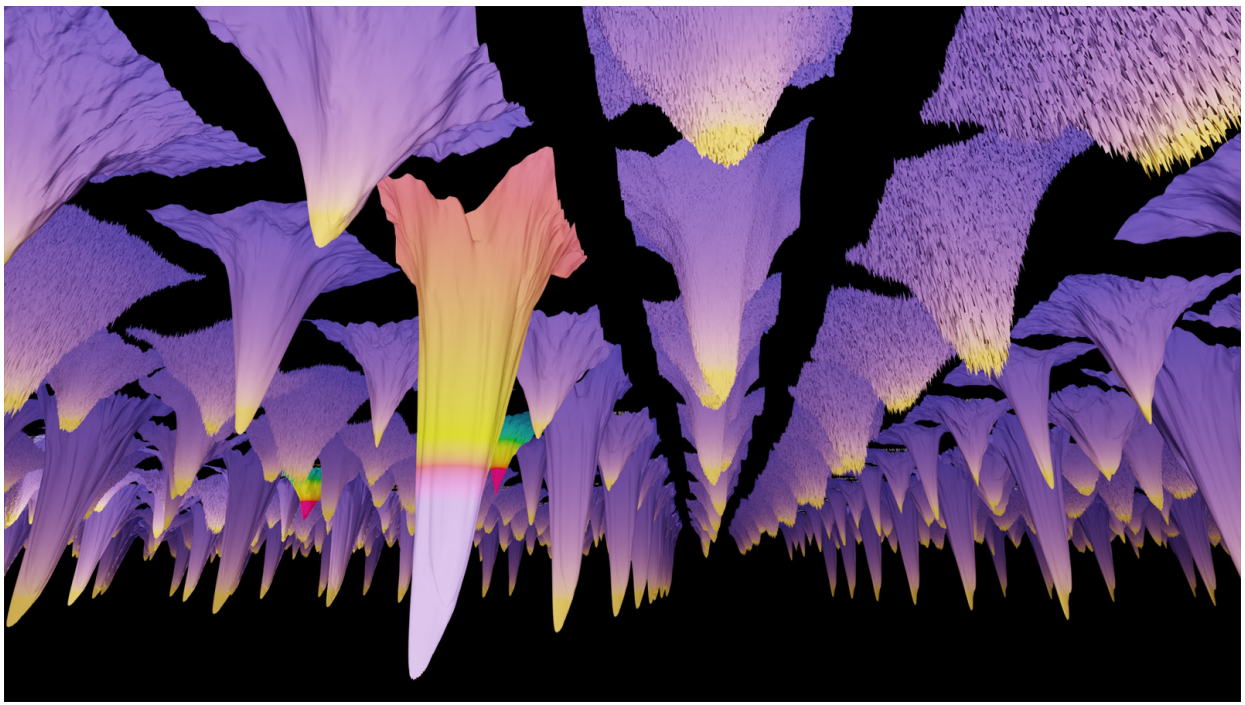
Minimizing a smooth loss functions – what algorithm?



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 parallized machine code

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Parallelization

Multithreading and multiprocessing

- Multithreading over 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(data_sets)
```

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

Automatic differentiation

"Exact numerical" differentiation

```
from jax import grad

def f(θ, x):
    # add details here

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

loss_gradient = grad(loss)
d = loss_gradient(θ, x_data, y_data)
θ = θ - λ * d
```

Just-in-time compilers

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

Advantages over AOT compilers:

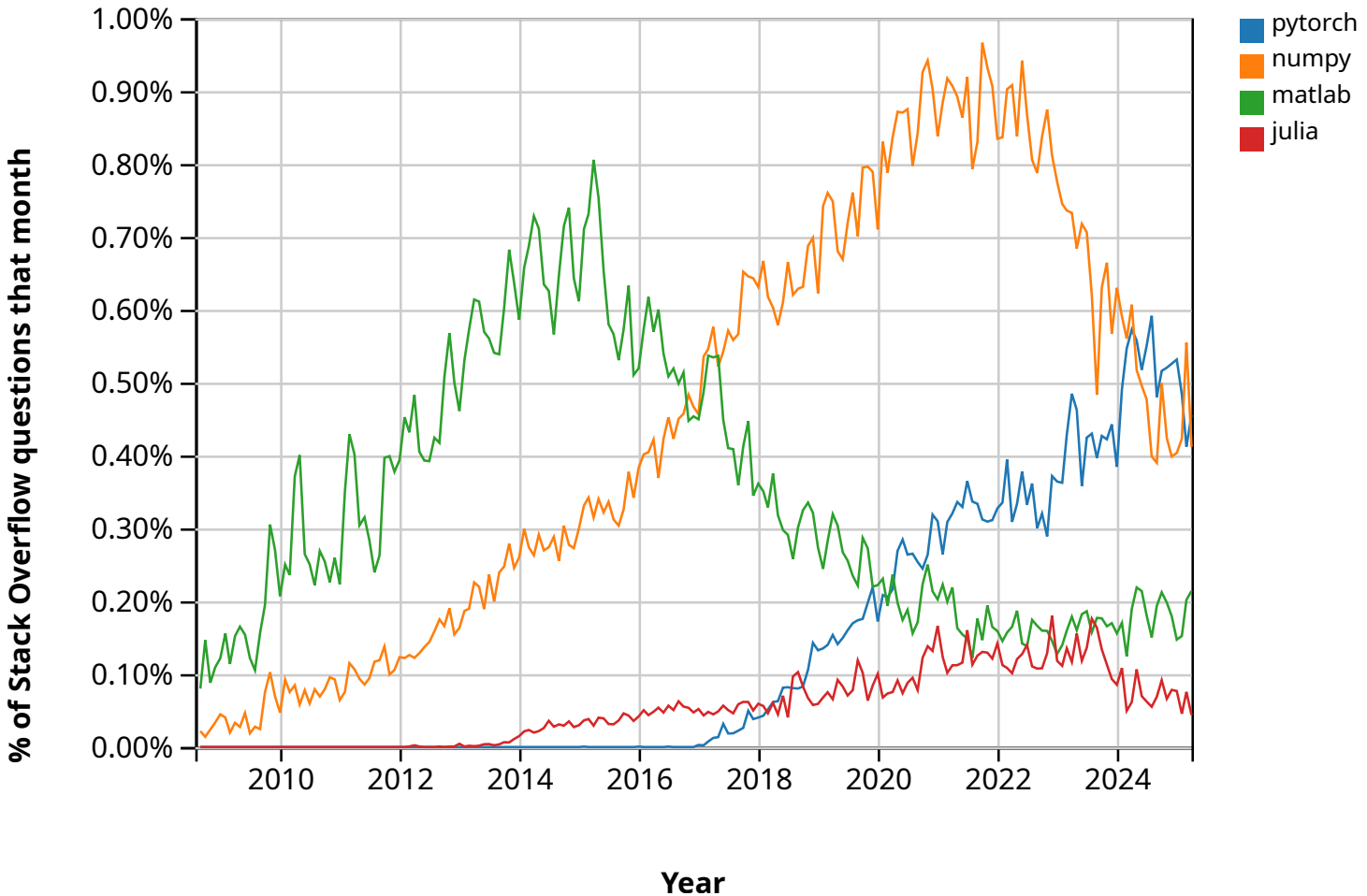
- cleaner code
- more portable
- lower compile times
- automatic parallelization (same code for CPUs / GPUs)

Platforms

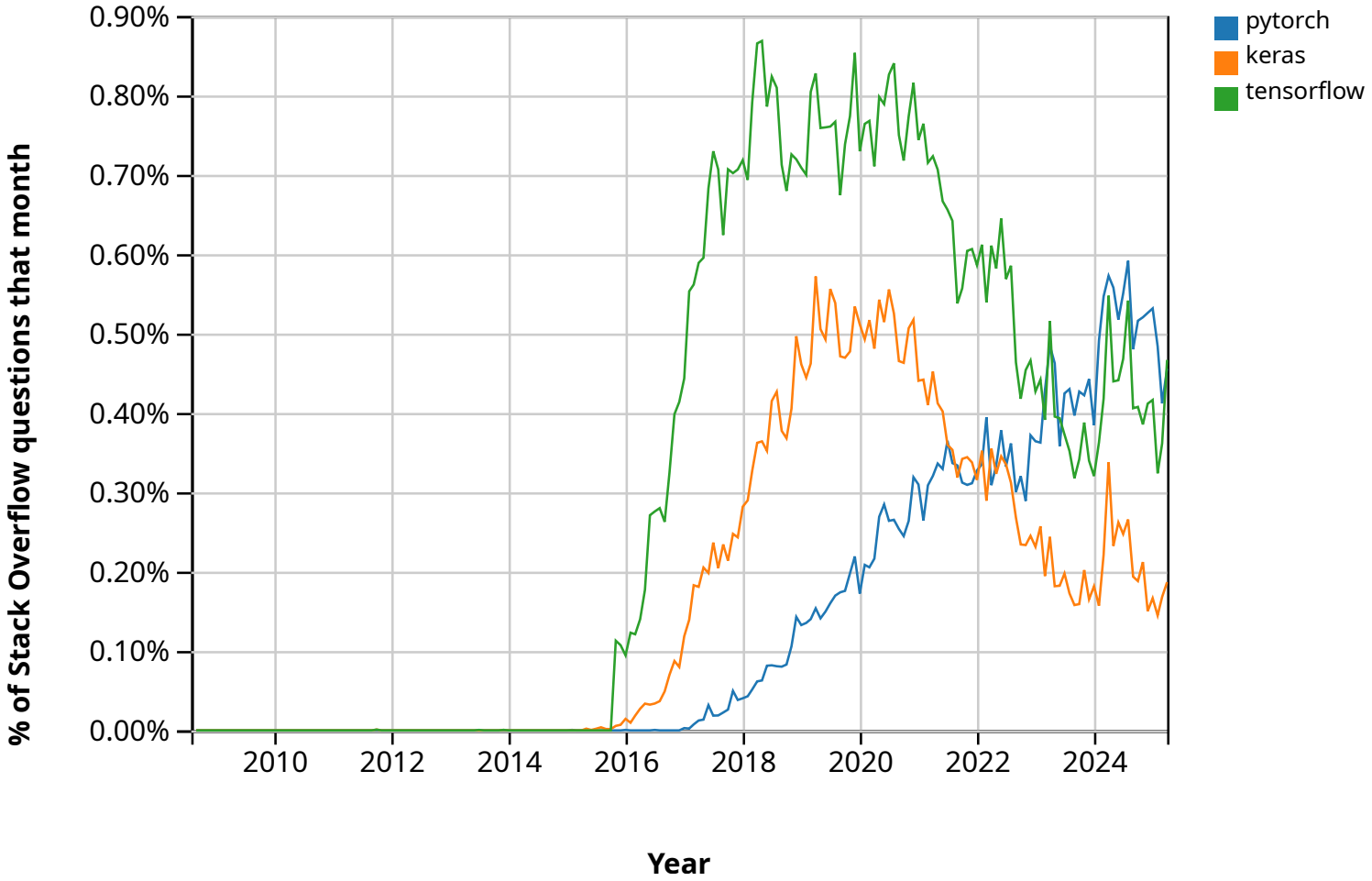
Platforms that support AI / deep learning:

- 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

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

Here's a gradient descent function in 6 lines:

python

```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

Let's say that you want to do computational economics without deep learning

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 $\rightarrow$ 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

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