CUDA Docs for Humans

modal.com/gpu-glossary

What is this?
Where did it come from?
What does it say?
Where is it going?

I started off at Cal, studying DNN optimization.

Finding Critical and Gradient-Flat Points of Deep Neural Network Loss Functions

by

Charles Gearhart Frye

A dissertation submitted in partial satisfaction of the

requirements for the degree of

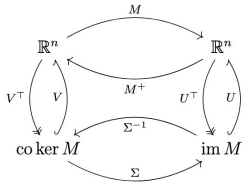
Doctor of Philosophy

Theorem 3.3: Kernel Equals Pseudo-Inverse Kernel for Symmetric M

Let $M \in \mathbb{R}^{n \times n}$ be a symmetric matrix. Then

$$\ker M = \ker M^{+} \tag{3.31}$$

Proof of Theorem 3.3:
We first repeat the commutative diagram relating the SVDs of a matrix and its pseudo-inverse, specialized to a square matrix.



https://charlesfrye.github.io/pdfs/thesis.pdf

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Empirical work done on CPUs with `autograd.numpy` 👴

At W&B, started helping people operationalize research.

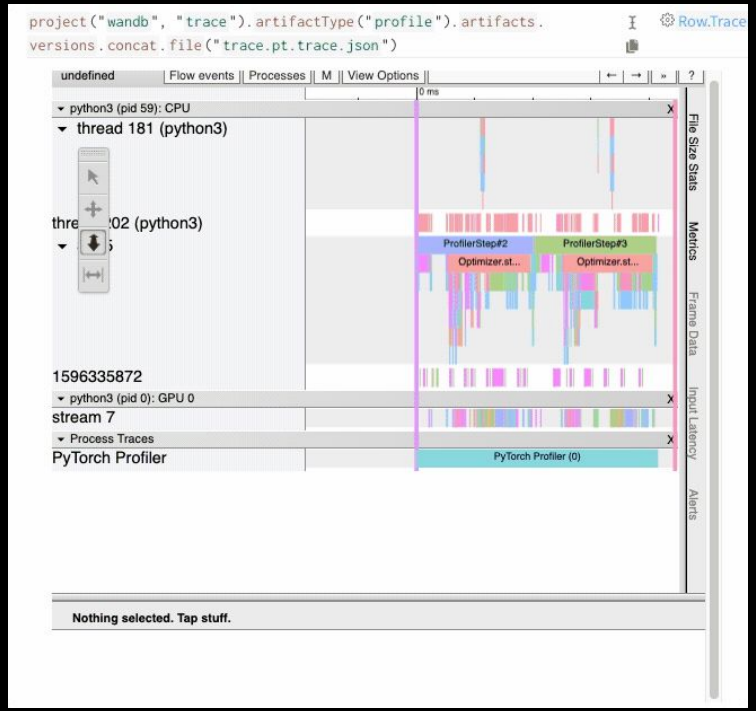
Public Dissection of a PyTorch Training Step

What really happens when you call .forward, .backward, and .step?

Charles Frye Share 9 comments 27 stars

Created on August 2 | Last edited on January 4

Rembrandt, 1632. *The Anatomy Lesson of Dr. Nicolaes Tulp.* wiki



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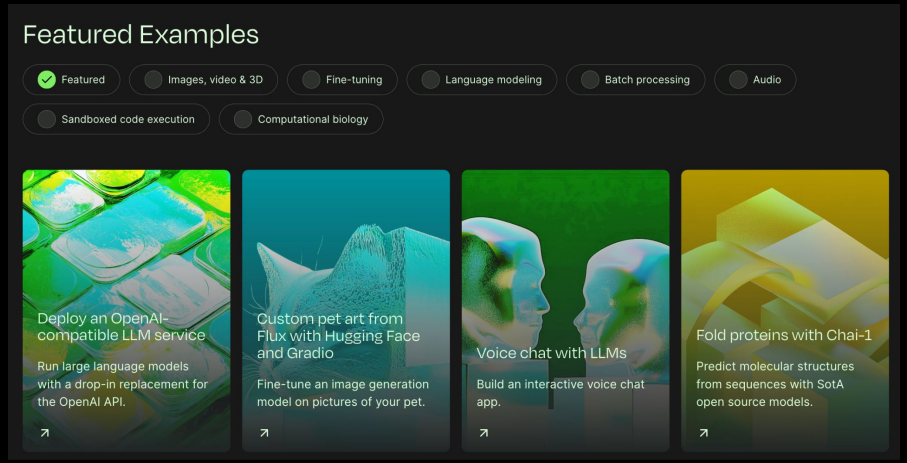
https://wandb.me/trace-report

Now, at Modal, I'm helping people with deployment!

Modal Blog

All Posts | Engineering | Customer Stories | Tutorials | News



https://modal.com/docs/examples

August 5, 2024

Beat GPT-4o at Python by searching with 100 dumb LLaMAs

Scale up smaller open models with search and evaluation to match frontier capabilities.

https://modal.com/blog/llama-human-eval

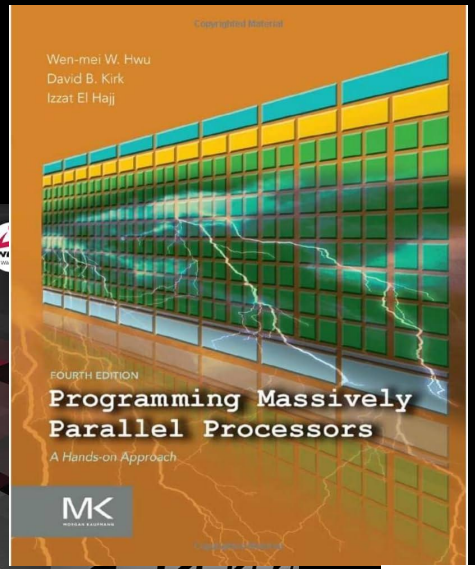
That involved a lot of environment debugging...

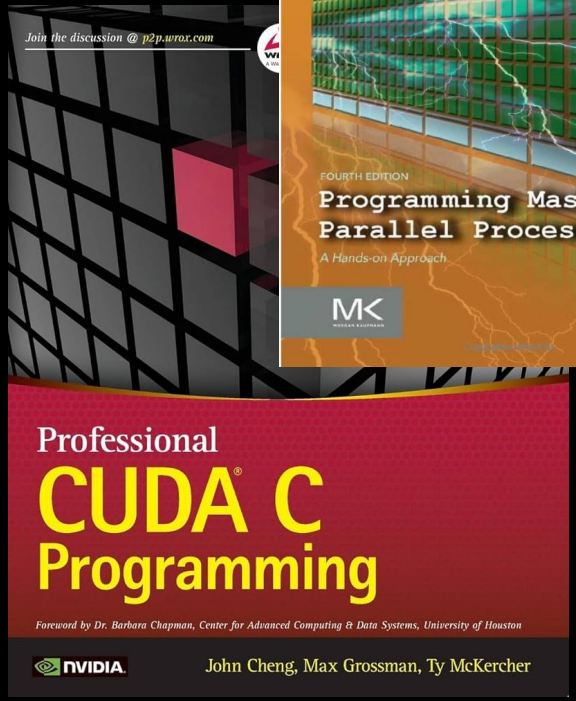
I Am Fucking Done Not Understanding The CUDA Stack

> "The CUDA development environment relies on **tight integration** with the host development environment, including the host compiler and C runtime libraries"
> — sauce, from the horse's mouth

It is unfortunately not possible to develop bleeding-edge applications of GPUs without understanding more about the underlying stack than most would like.

So let's dive in and understand what the layers of that stack are, step-by-step.





CUDA®

CUDA C++ Programming Guide

Release 12.6

NVIDIA Corporation

CUDA®

PTX ISA

Release 8.5

NVIDIA Corporation

CUDA®

NVIDIA CUDA Compiler Driver

Release 12.6

NVIDIA Corporation

RTFM.

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There is not one “CUDA”.

/device-hardware

Device Hardware

These terms and technologies are physical
NVIDIA's lingo.

→ CUDA (Device Architecture)

/host-software

Host Software

These terms and technologies are used on the CPU
running GPU programs.

→ CUDA (Software Platform)

→ CUDA C++ (programming language)

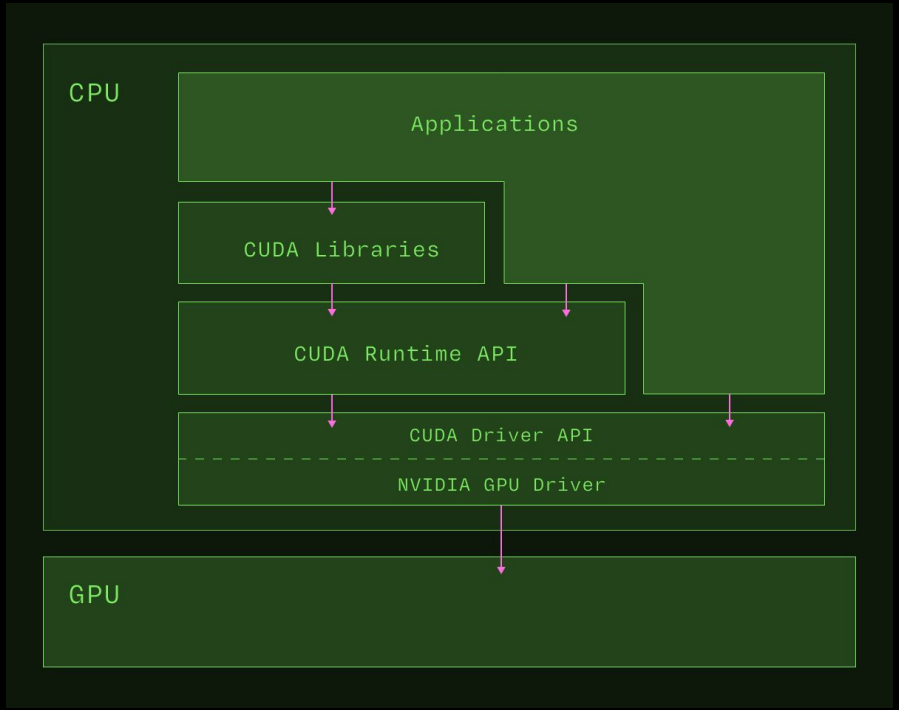
/device-software

Device Software

These terms and technologies are used
NVIDIA's lingo.

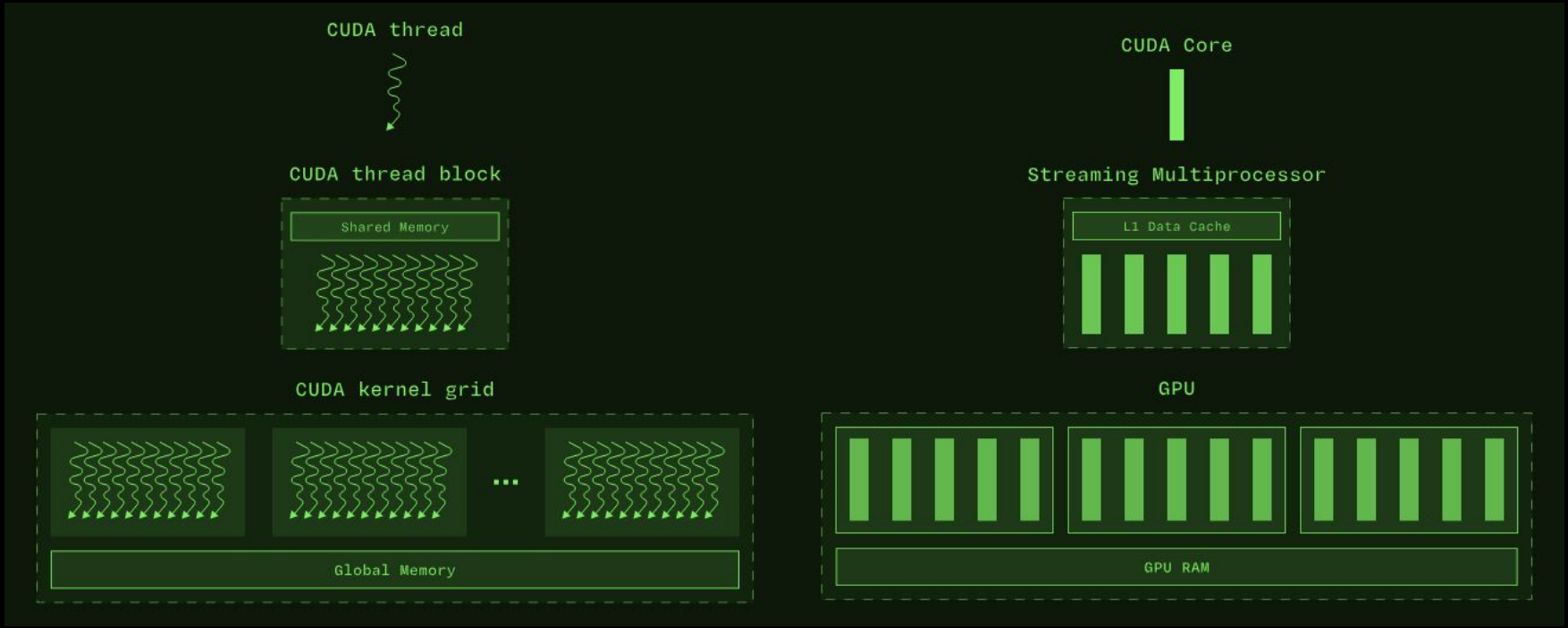
→ CUDA (Programming Model)

CUDA is a software platform.



https://modal.com/gpu-glossary/host-software/cuda-software-platform

CUDA is a programming model.



https://modal.com/gpu-glossary/device-software/cuda-programming-model

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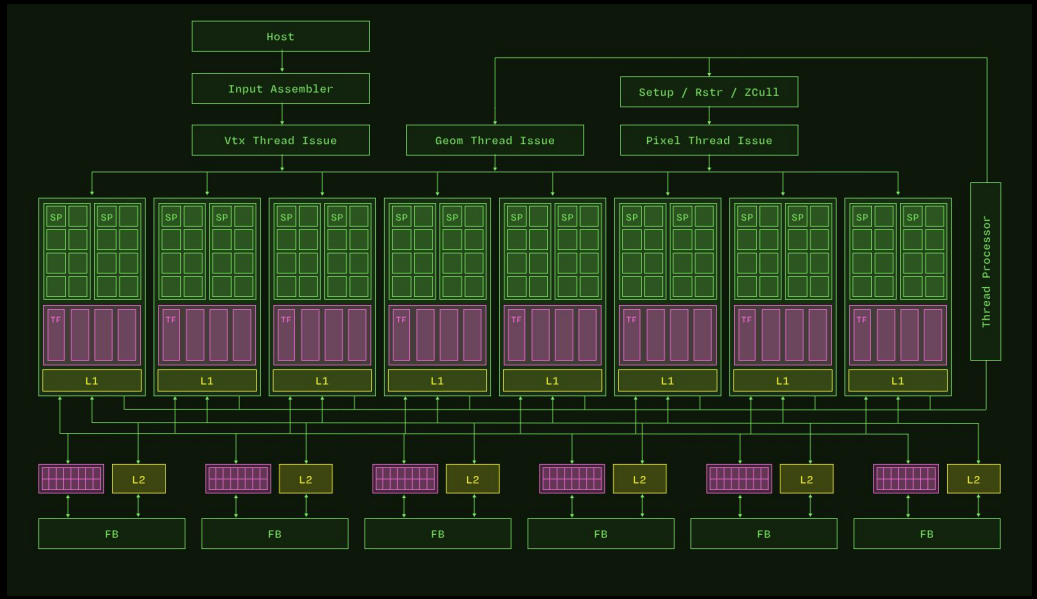
CUDA is a computer architecture principle.



https://modal.com/gpu-glossary/device-hardware/cuda-device-architecture

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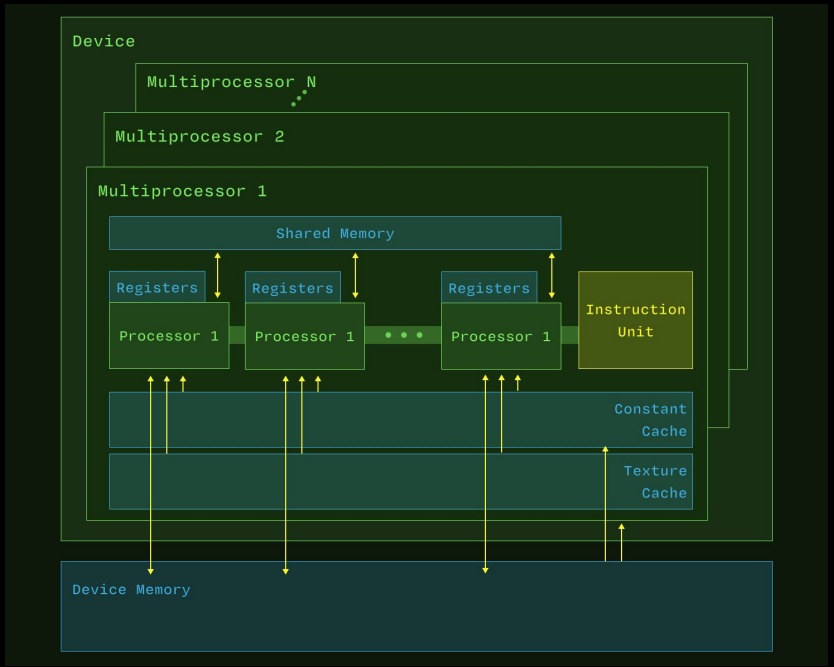
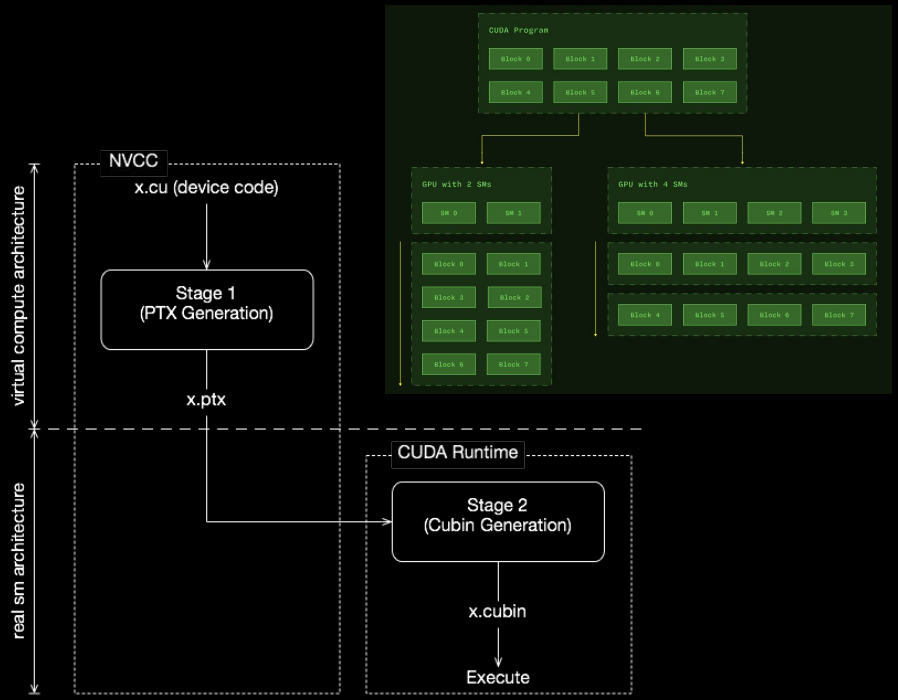
The most important part of the CUDA stack isn't called CUDA.





https://modal.com/gpu-glossary/device-software/parallel-thread-execution

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Short-term goals. Watch this space!

- ChatGPU
  - How do we make this as easy and extensible as possible? `llms.txt`?
- Interactive code snippets
  - Inspired by Rust By Example et al.
  - Will require a Modal acc't, but will fit in our free tier.
- Interactive diagrams
- Better content on synchronization
  - Atomics vs barriers
- Better content on warpgroups/thread block clusters

Mid-term goals. Looking for collaborators. We have the GPUs.

- Performance debugging
  - New terms: bank conflict, occupancy, coarsening
- GPU fleet mgmt
  - New terms: dcgm, thermal design power
- Multi-GPU hardware & programming
  - New terms: PCIe, SXM, NVLink, NCCL

Speculative goals. Can/should we do this?

- Multi-node hardware & programming
    - New terms: NVLink Switch, NIC, Ethernet, TCP, IP, Infiniband
- Triton?
    - We have even less experience here than in CUDA C++
- Open up the material on GitHub?
    - Open source succeeds when it deduplicates non-differentiating labor
- Online course? Partner with a university?

we're hiring btw :)

email charles@modal.com

if you want to go CUDA MODE