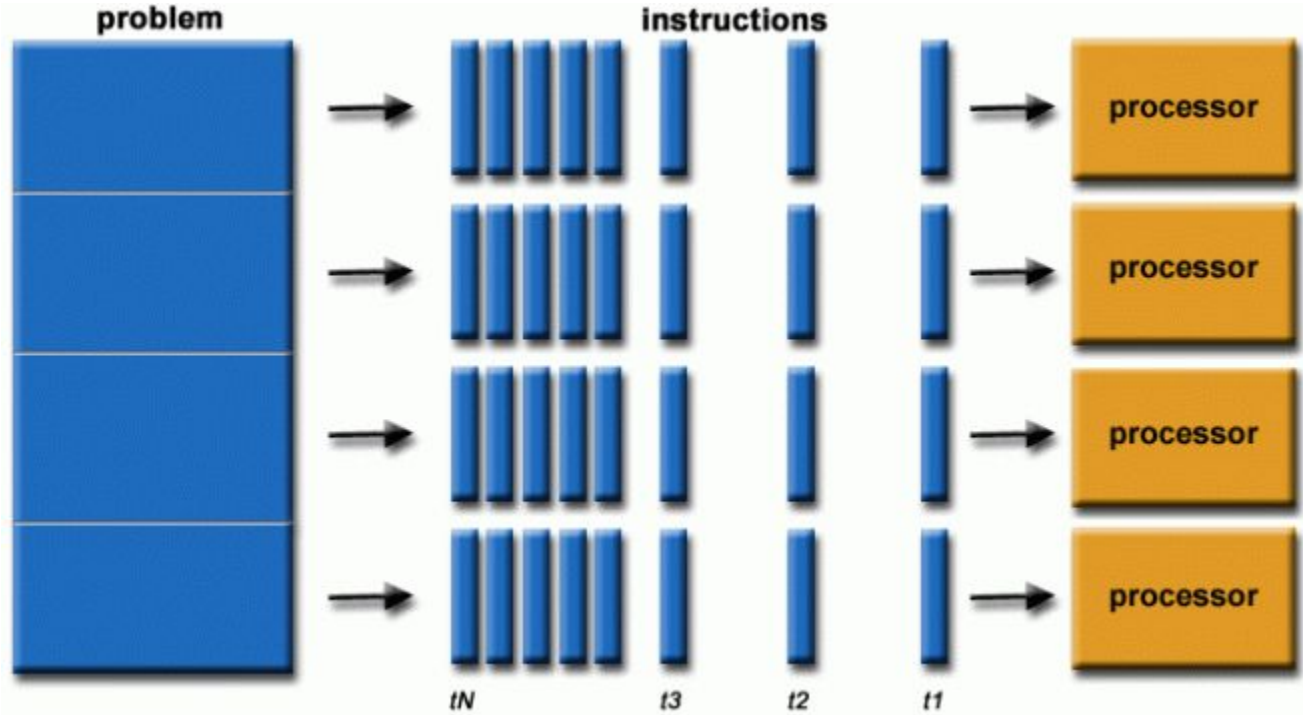


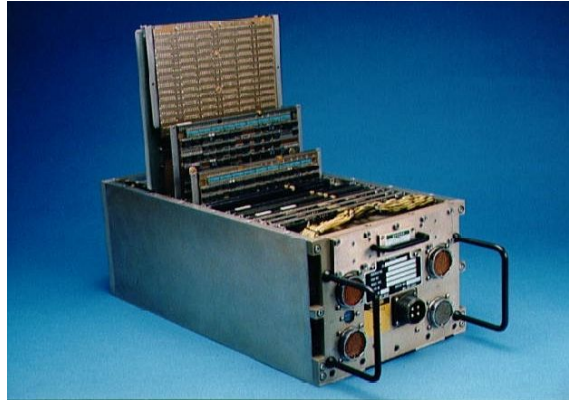
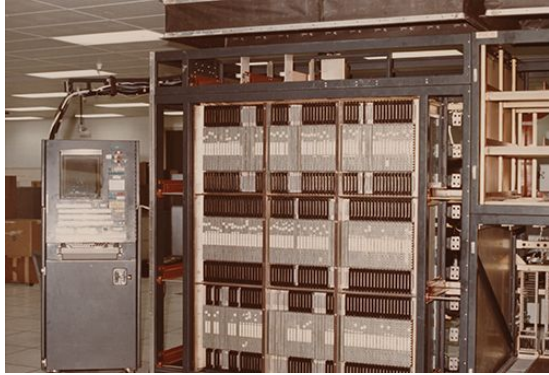
PARALLEL COMPUTATIONS

Vasiliy Gorelov
Danil Yusupov

WHAT IS PARALLEL COMPUTATION?



HISTORY OF PARALLEL COMPUTATION



BASIC METHODS AND PRINCIPLES OF PARALLEL COMPUTING

Task Decomposition

Synchronization

Data Parallelism

Control Structure

Task Parallelism

Distributed
Computing

Execution Model

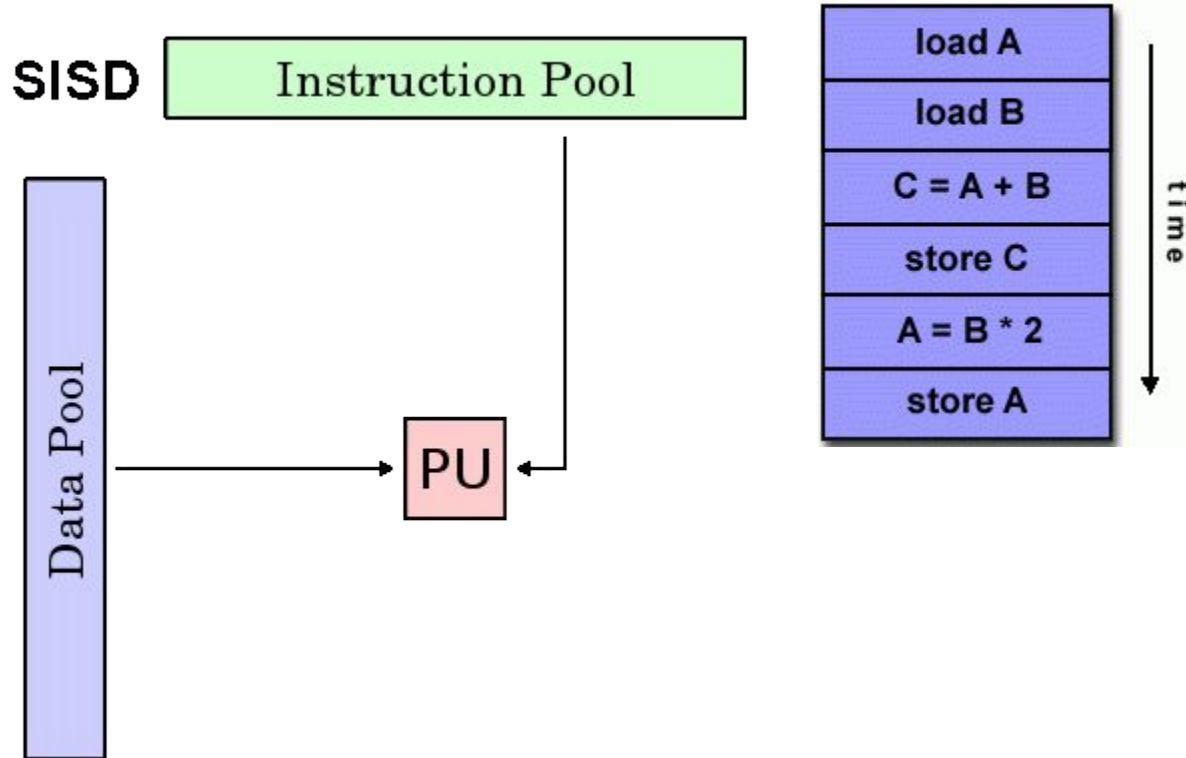
Parallel Algorithms



FLYNN'S TAXONOMY

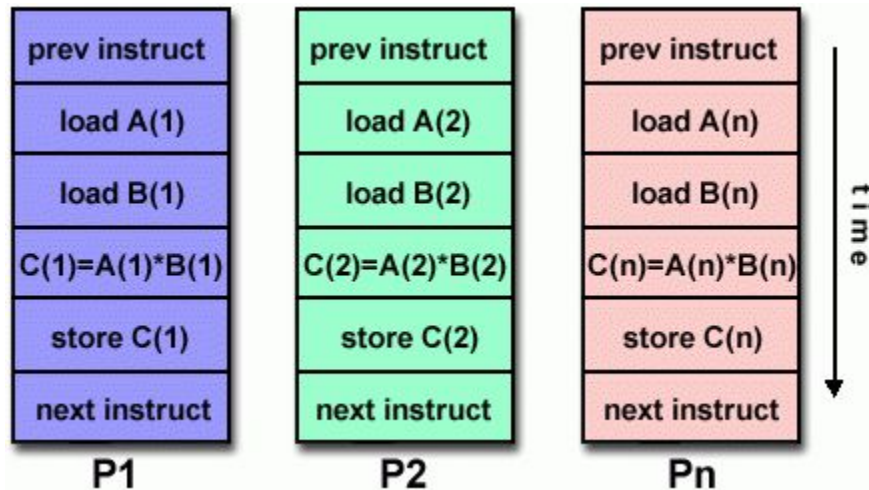
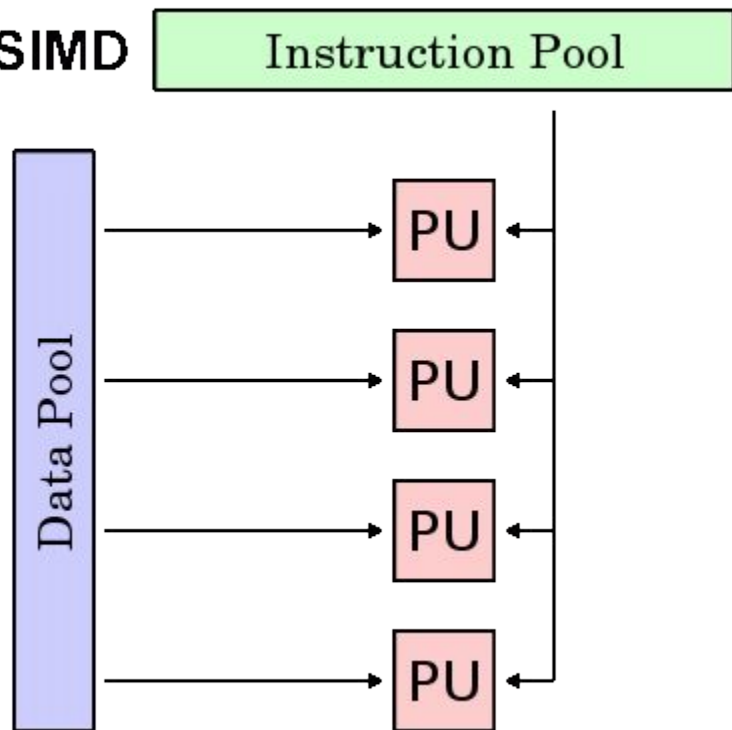
S I S D Single Instruction stream Single Data stream	S I M D Single Instruction stream Multiple Data stream
M I S D Multiple Instruction stream Single Data stream	M I M D Multiple Instruction stream Multiple Data stream

FLYNN'S TAXONOMY (SISD)

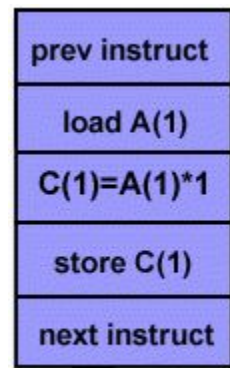
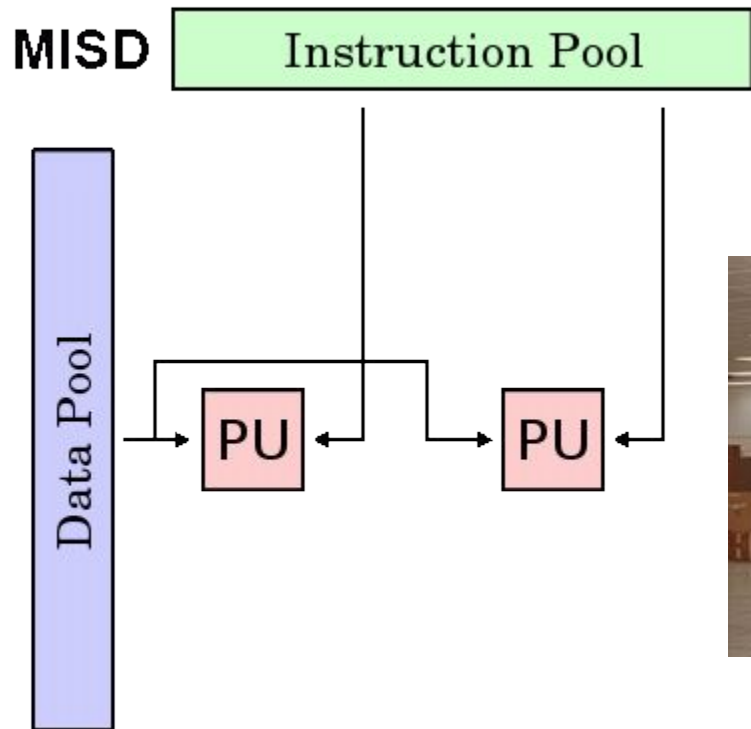


FLYNN'S TAXONOMY (SIMD)

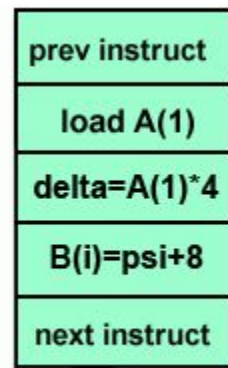
SIMD



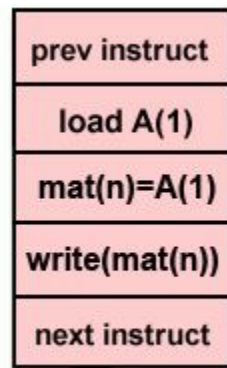
FLYNN'S TAXONOMY (MISD)



P1



P2



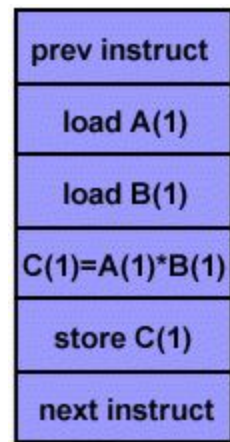
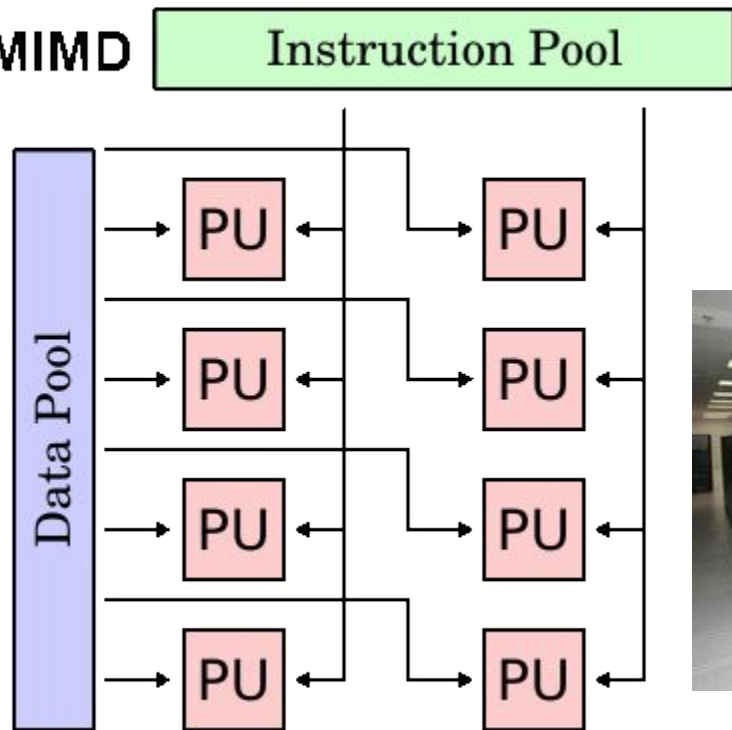
Pn

time ↓

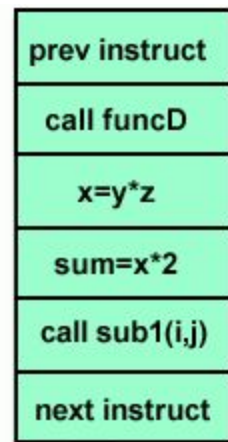


FLYNN'S TAXONOMY (MIMD)

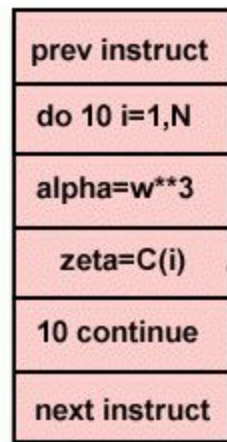
MIMD



P1



P2

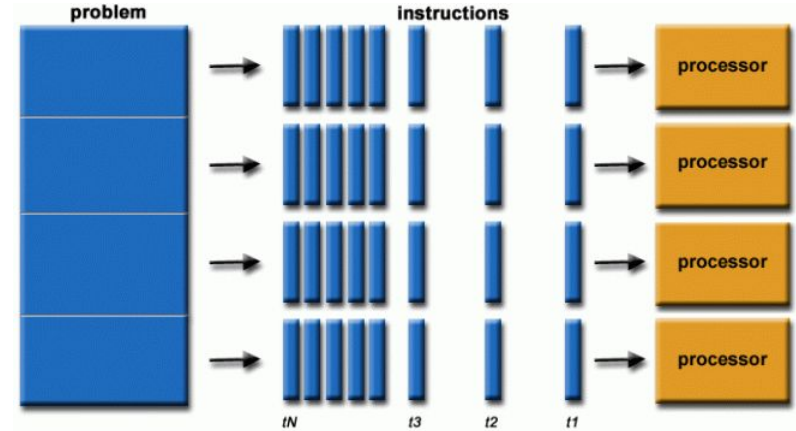
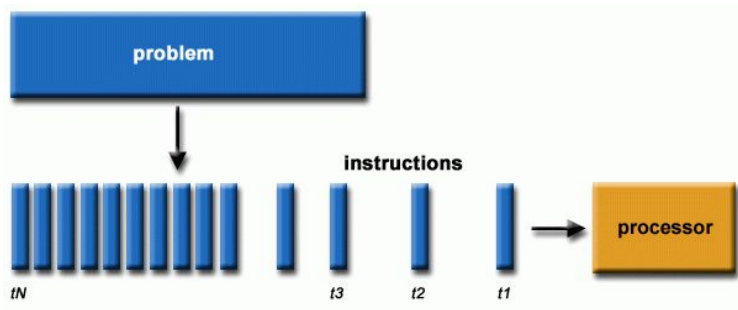


Pn

time ↓



DIFFERENCE BETWEEN SERIAL AND PARALLEL COMPUTING



ADVANTAGES & DISADVANTAGES OF PARALLEL COMPUTING



Повышенная
производительность

Масштабируемость

Обработка в
реальном времени

Использование
ресурсов

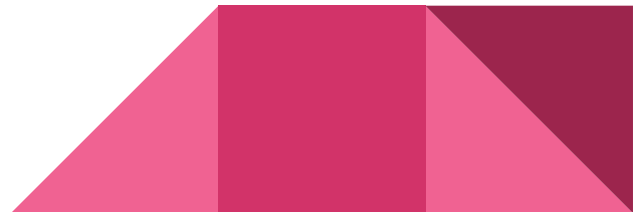


Сложность

Накладная
синхронизация

Закон Амдала

Стоимость и
инфраструктура



CAN THE ALGORITHM BE PARALLELIZED?

Зависимости данных

Разделяй и властвуй

Циклы и итерации

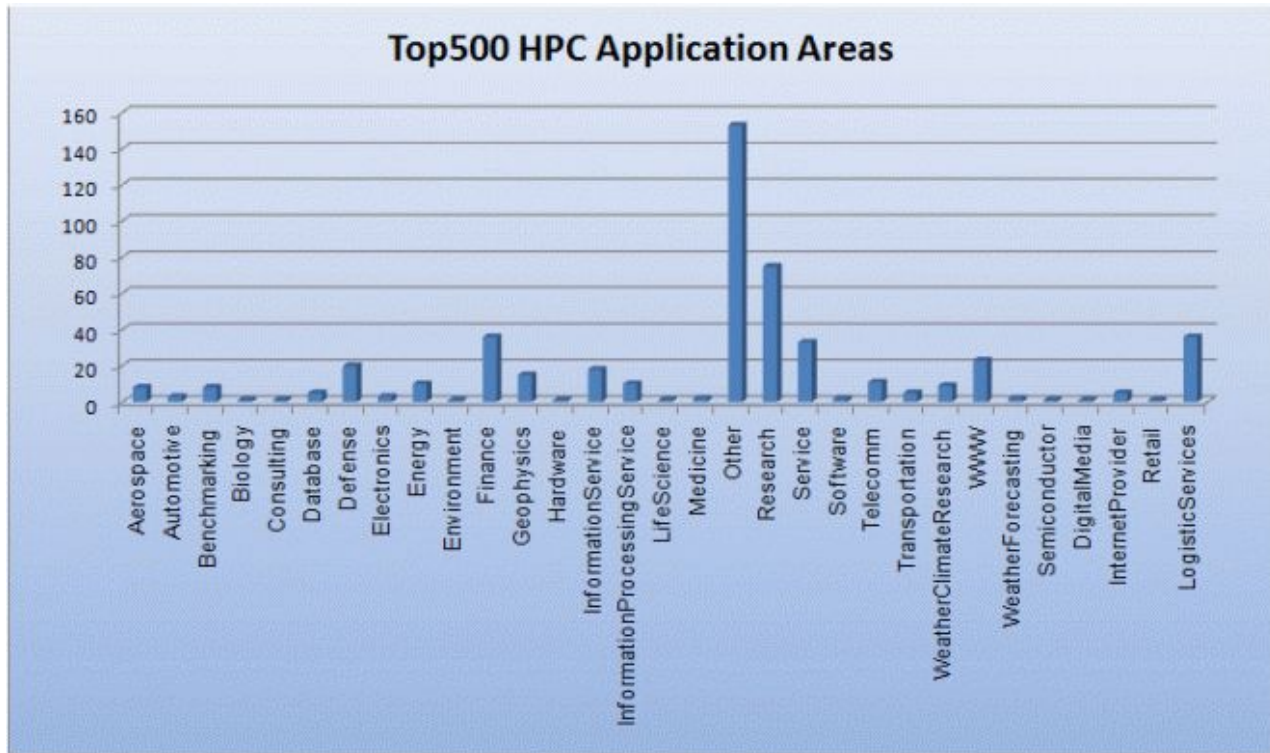
Наличие
независимых задач

Анализ зависимостей
данных

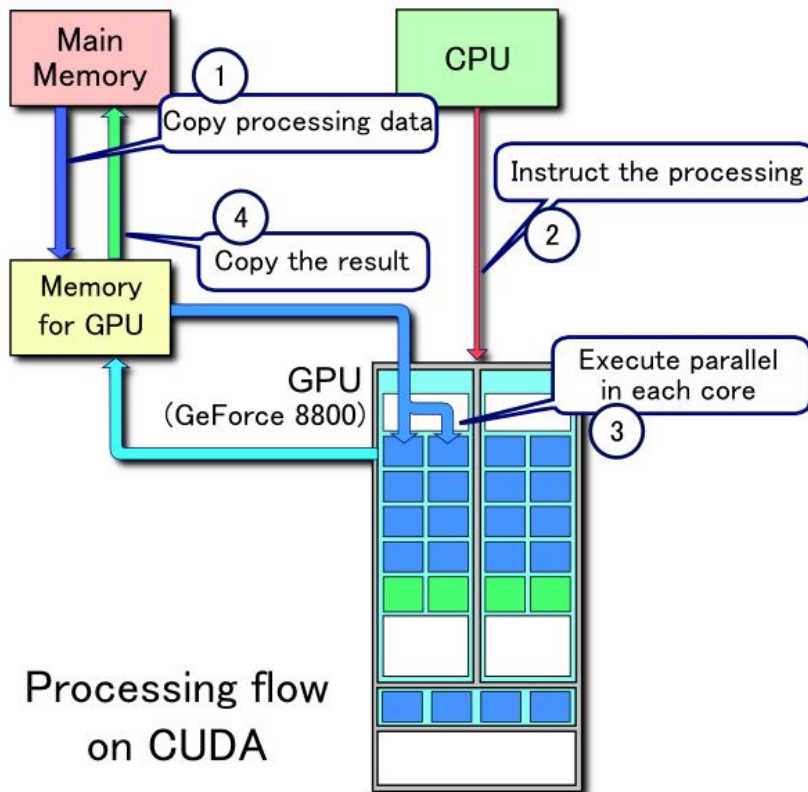
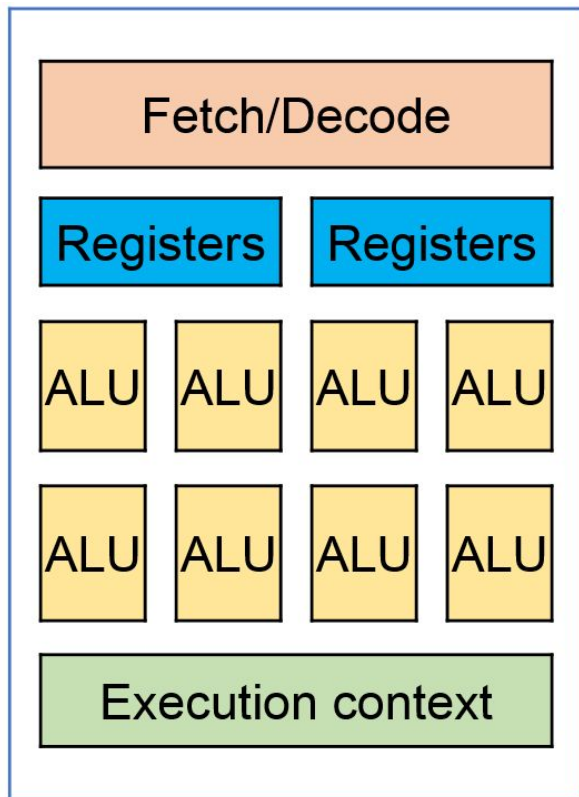
Анализ времени
выполнения



PARALLEL COMPUTATIONS IN OUR DAYS

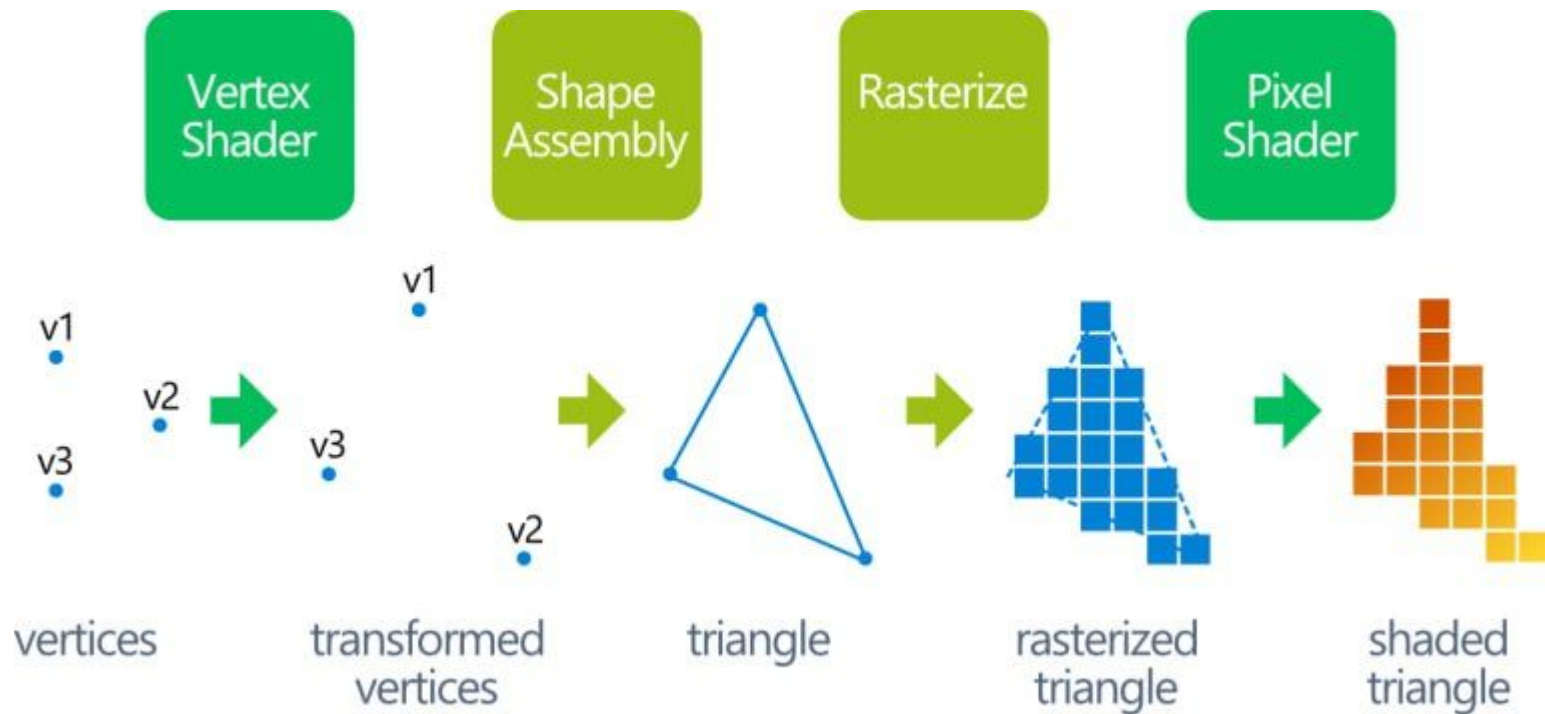


GPU

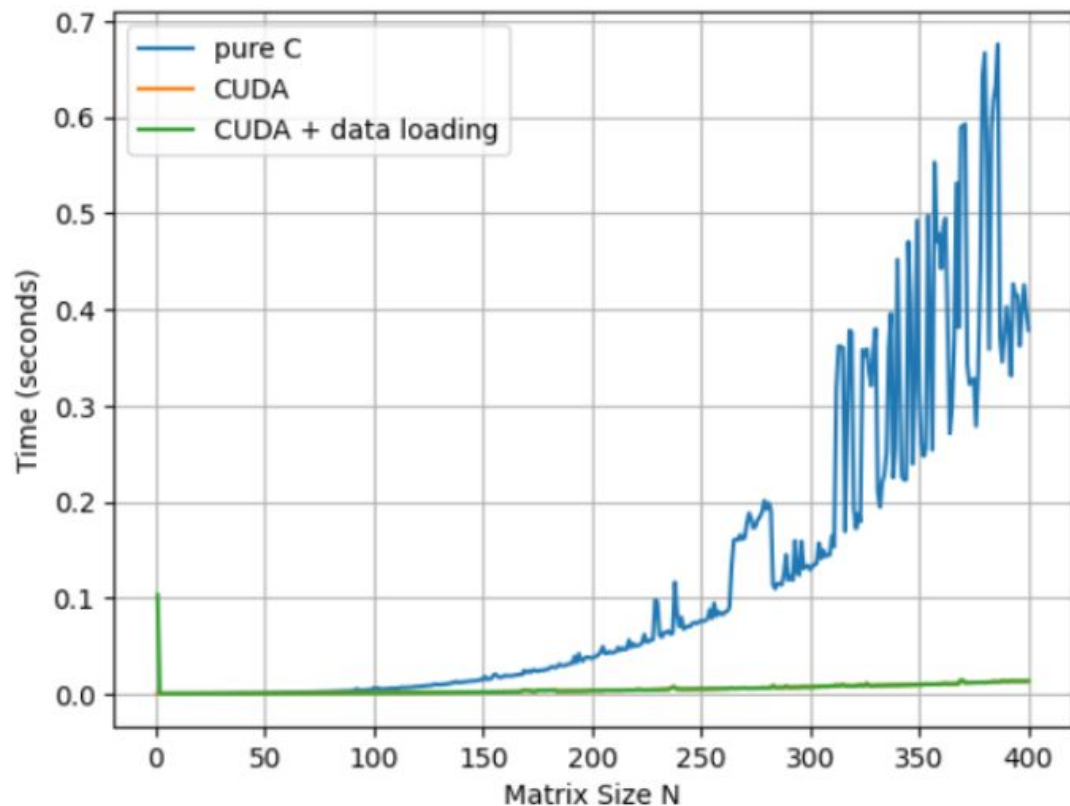


Processing flow
on CUDA

GRAPHICS



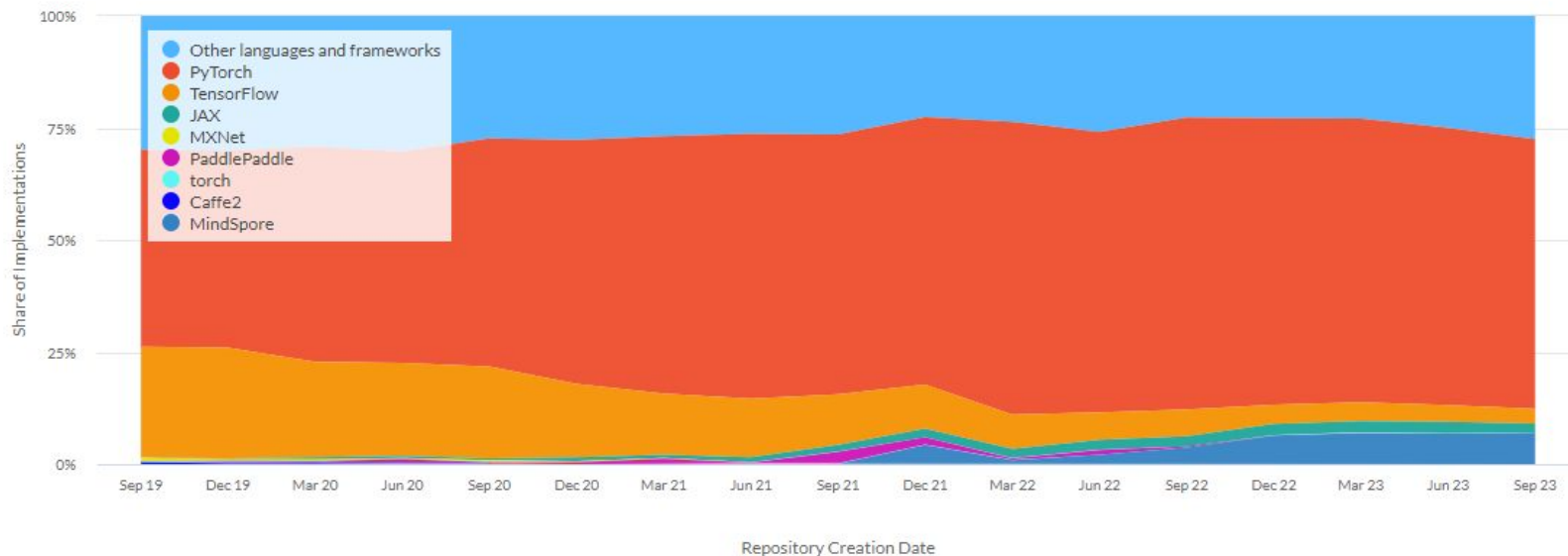
BENCHMARKING MATRIX MULTIPLICATION



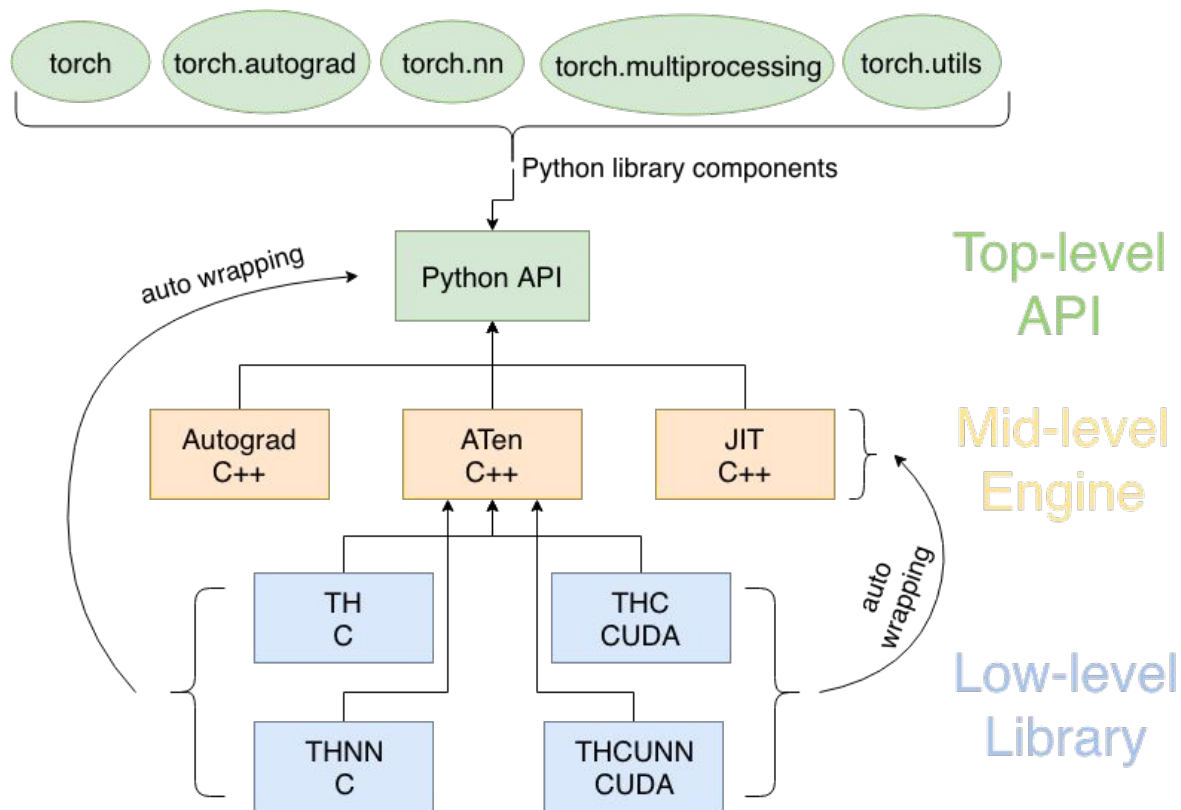
NN

Frameworks

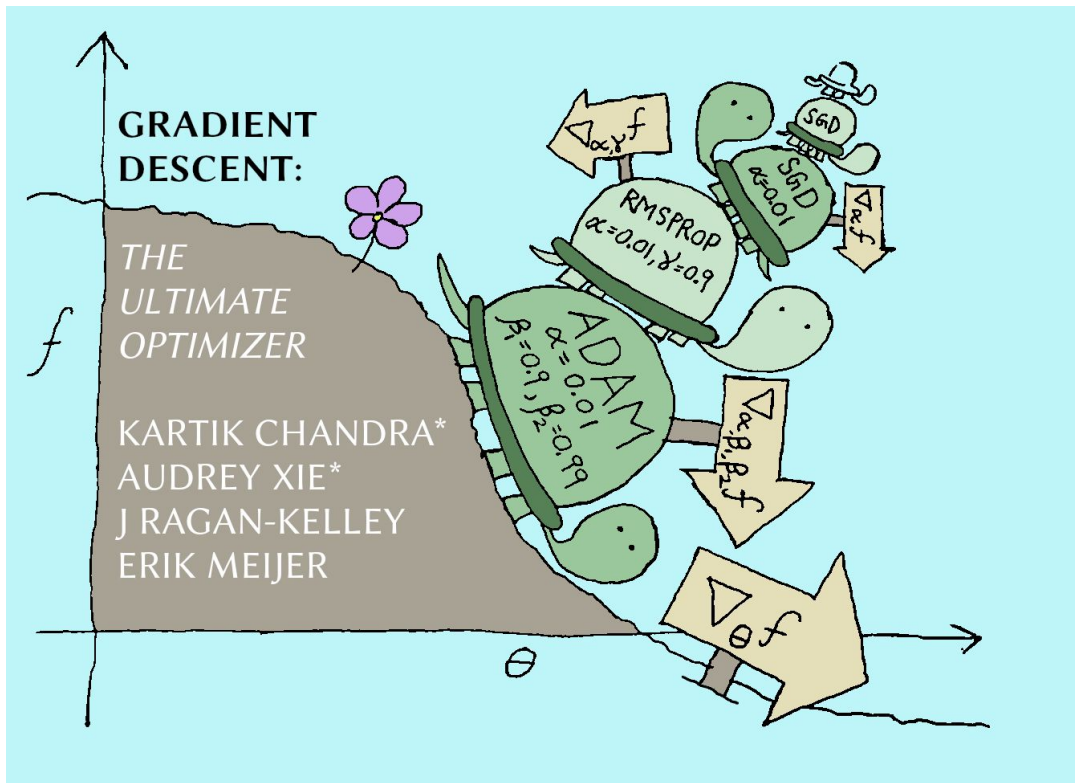
Paper Implementations grouped by framework



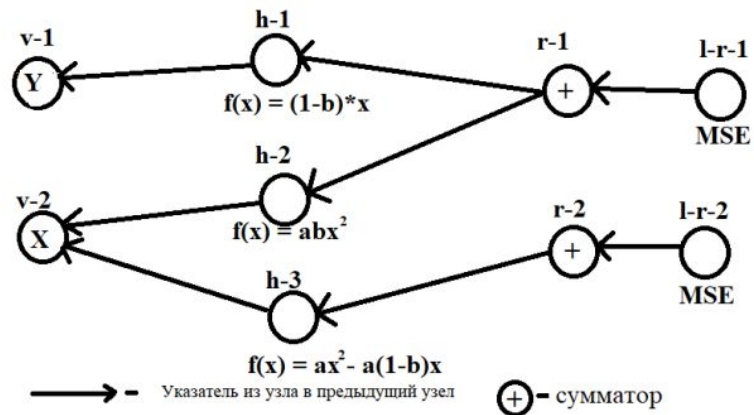
NN



COMPUTATIONAL GRAPH

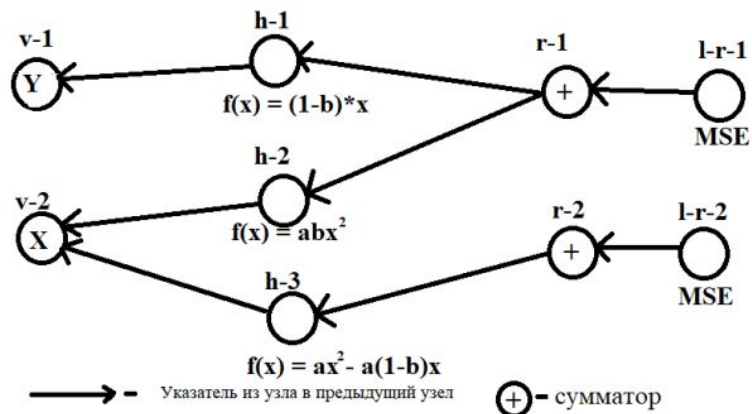


$$\begin{cases} abX^2 + (1-b)Y - a + (1-b)^2 = 0 \\ a^2X^2 - a(1-b)X - b = 0 \end{cases}$$



(Рис. архитектура сети)

BENCHMARKING NN



(Рис. архитектура сети)

	CompGraph	PyTorch	TensorFlow
Скорость выполнения (в секундах)	0.06	1	1

Таблица 1. Результаты сравнения библиотек для решения системы (1)

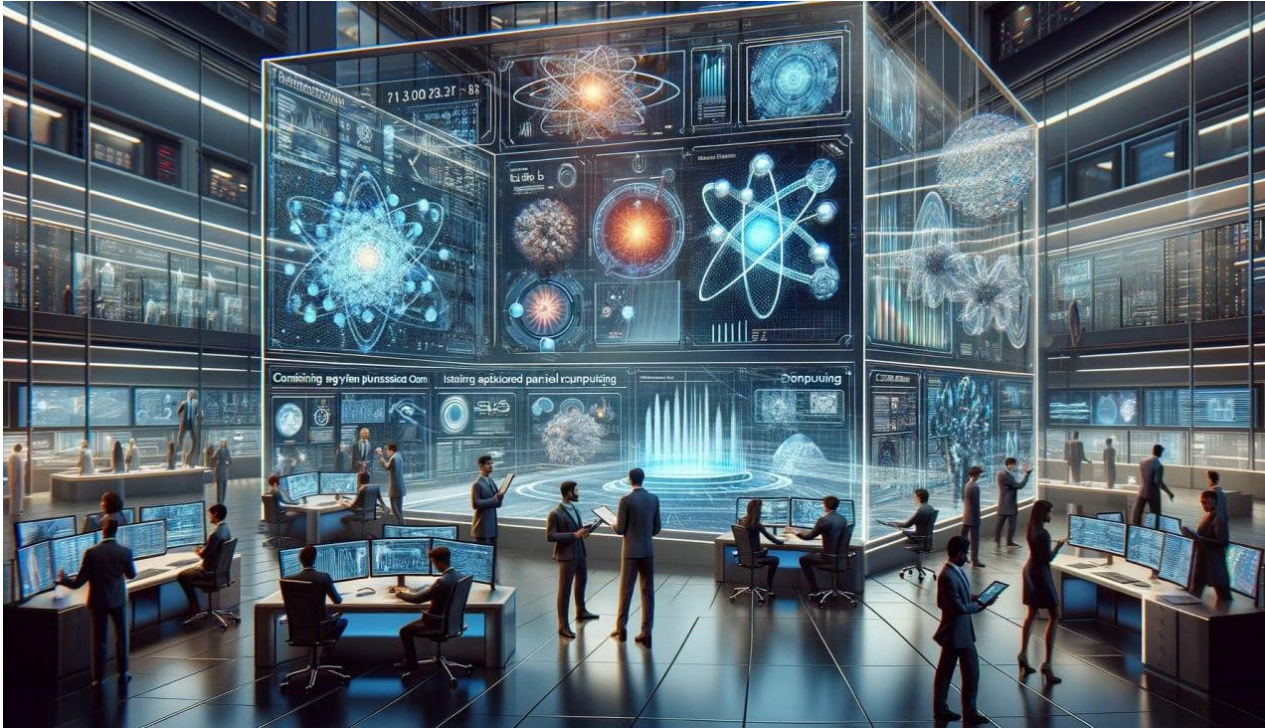
BENCHMARKING NN

```
class NeuralNetwork(nn.Module):  
    def __init__(self):  
        super().__init__()  
        self.network = nn.Sequential(  
            nn.Linear(3, 4),  
            nn.LeakyReLU(),  
            nn.Linear(4, 8),  
            nn.LeakyReLU(),  
            nn.Linear(8, 4),  
            nn.LeakyReLU(),  
            nn.Linear(4, 2),  
        )  
  
    def forward(self, x):  
        output = self.network(x)  
        return output
```

	CompGraph	TensorFlow	PyTorch
Скорость выполнения (в секундах)	0.027	0.092	0.2

Таблица 2. Результаты сравнения библиотек машинного обучения

FUTURE OF PARALLEL COMPUTATIONS



Sources

- <https://github.com/VasixG/ComputationalGraph>
 - <https://paperswithcode.com/>
 - <https://github.com/kach/gradients-descent-the-ultimate-optimizer>
 - <https://developer.nvidia.com/blog/even-easier-introduction-cuda/>
 - <https://www.nvidia.com/en-us/on-demand/session/gtcspring22-s41487/>
 - <https://developer.chrome.com/blog/webgpu-io2023/>
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 - <https://theneuralblog.com/forward-pass-backpropagation-example/>
 - <https://habr.com/ru/companies/dbtc/articles/498374/>
- 

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- <https://ya.zerocoder.ru/pgt-parallelnoe-programmirovaniye-i-parallelnye-vychisleniya/>
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- <https://hpc.llnl.gov/documentation/tutorials/introduction-parallel-computing-tutorial##LimitsCosts>