

编程范式



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关于本内容

1. 内容背景

- AI框架的基础介绍

2. 具体内容

- AI框架作用：深度学习基础 – AI框架的作用 - AI框架的目的
- AI框架之争：第一代框架 – 第二代框架 – 第三代框架
- 编程范式：声明式编程 - 命令式编程

Programming Language and Programming Model

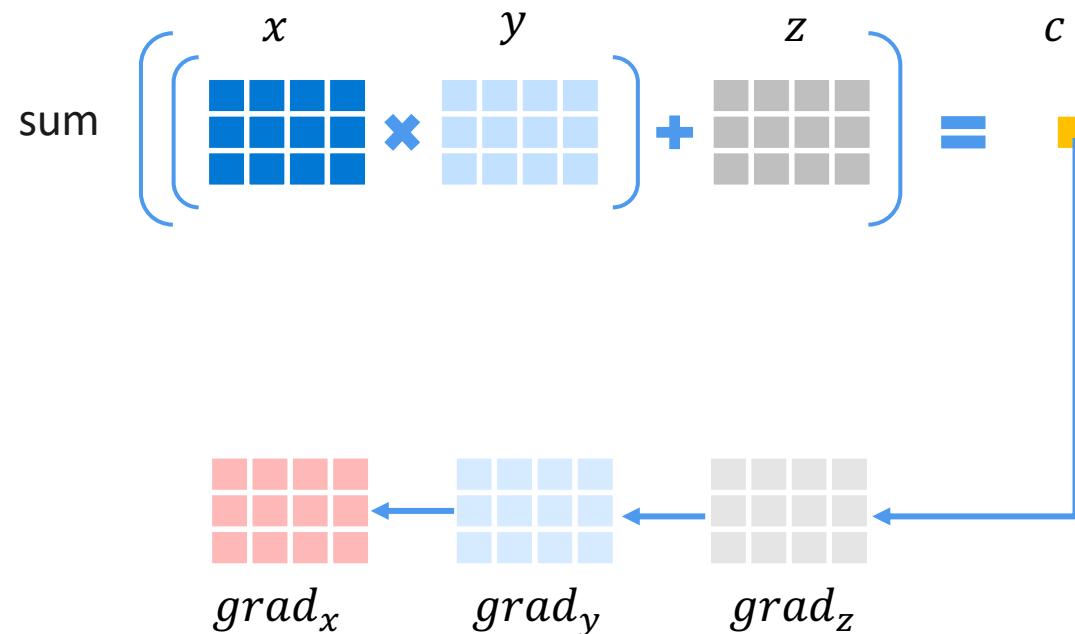
Numpy

```
import numpy as np

N, D = 3, 4
x = np.random.randn(N, D)
y = np.random.randn(N, D)
z = np.random.randn(N, D)

a = x * y
b = a + z
c = np.sum(b)
```

```
grad_c = 1.0
grad_b = grad_c * np.ones((N, D))
grad_a = grad_b.copy()
grad_z = grad_b.copy()
grad_x = grad_a * y
grad_y = grad_a * x
```



Programming Language and Programming Model

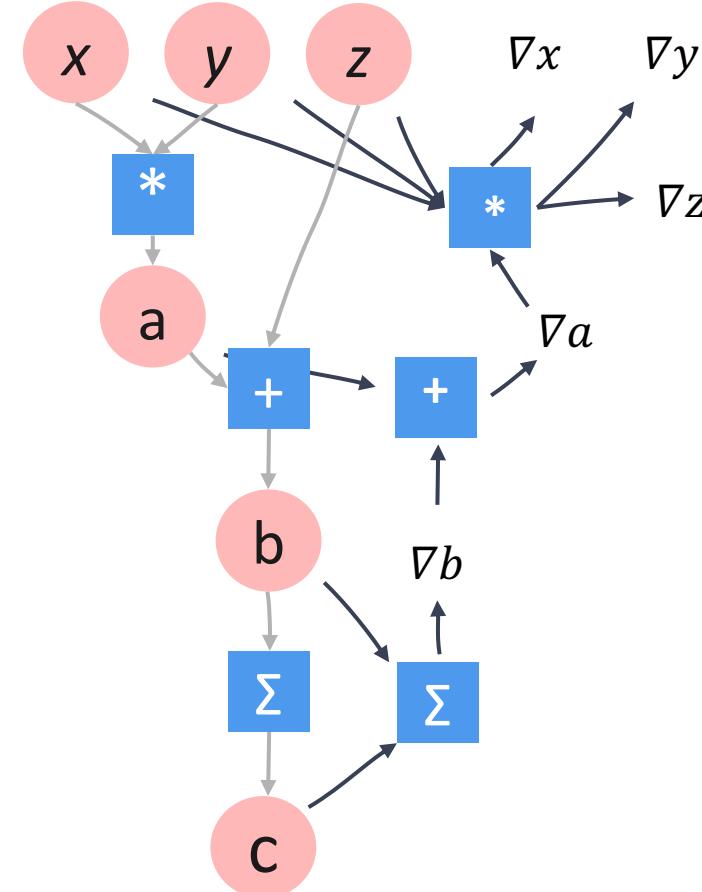
PyTorch

```
import torch

N, D = 3, 4
x = torch.randn(N, D)
y = torch.randn(N, D)
z = torch.randn(N, D)
```

```
a = x * y
b = a + z
c = torch.sum(b)
```

```
c.backward(retain_graph=True)
```



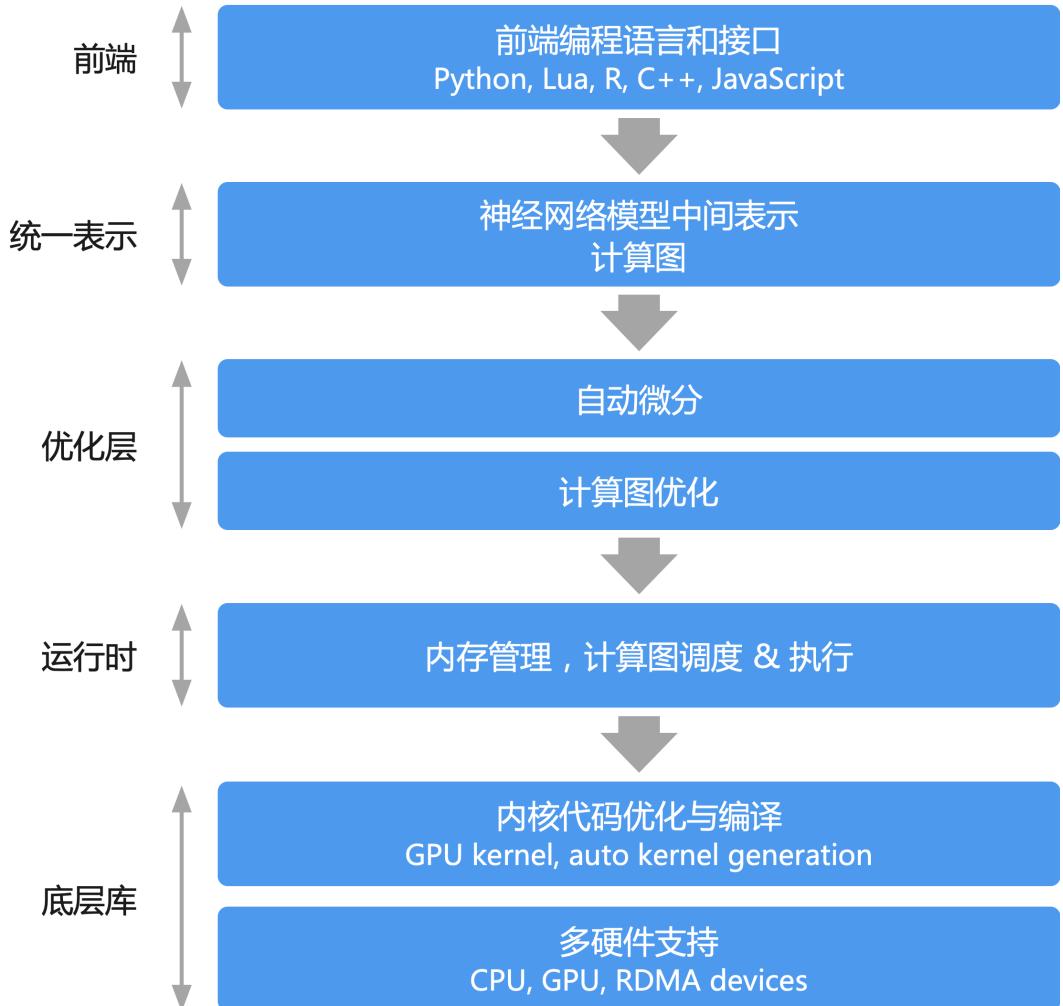
Programming Method

前端：

- 以高层次语言如Python作为前端
- 提供脚本式的编程体验

后端：

- 提供更低层次的编程模型和编程语言开发
- 后端高性能可复用模块与前端深度绑定
- 通过前端驱动后端方式执行



Imperative programming

命令式编程

- define-by-run or 动态图

执行方式

- 前端语言直接驱动后端算子执行
- 用户表达式会立即被求值

优点

- 方便调试
- 灵活性高

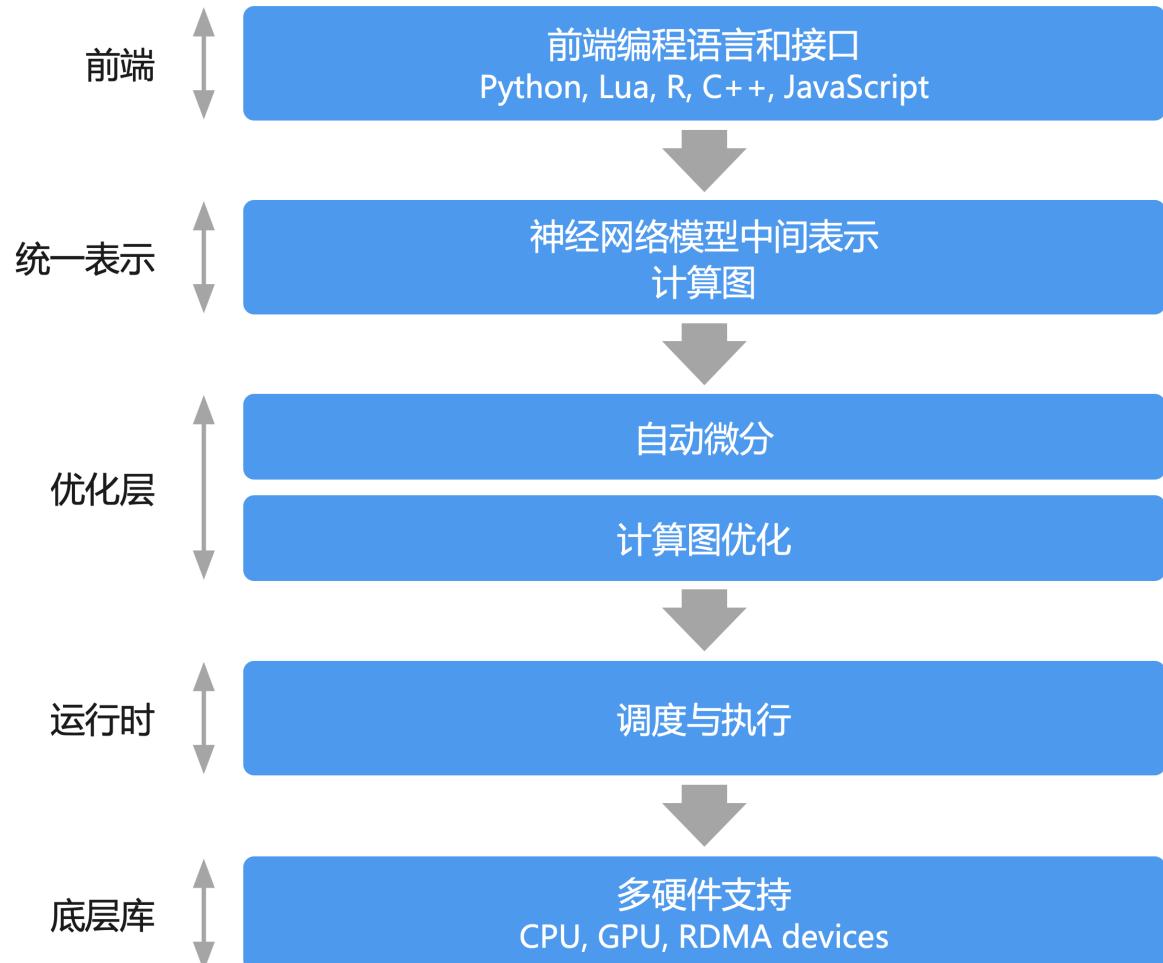
缺点

- 缺少对算法的统一描述
- 缺乏编译期优化

代表



PyTorch



Declarative programming

声明式编程

- define-and-run or 静态图

执行方式

- 前端语言中的表达式不直接执行
- 构建一个完整前向计算过程表示
- 对数据流图经过优化然后再执行

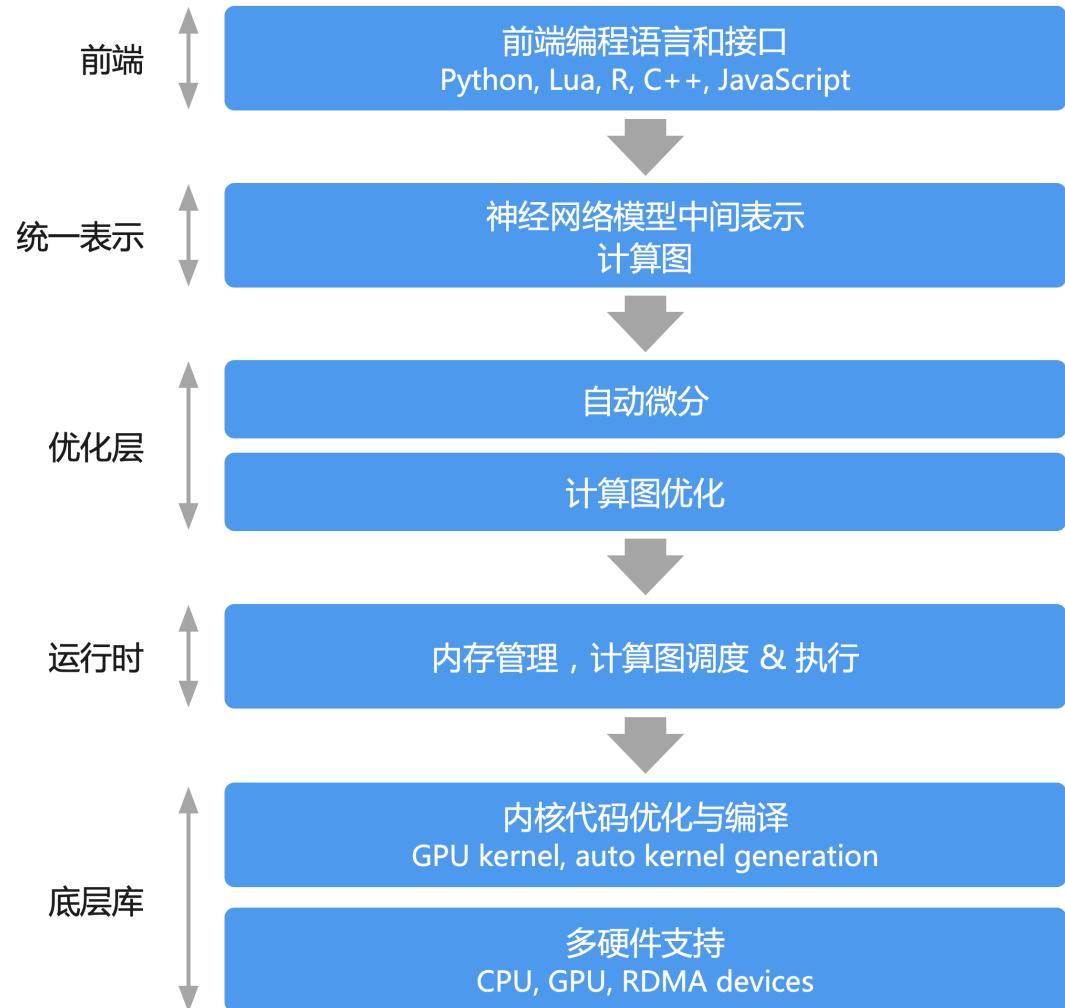
优点 • 执行之前得到全程序描述

- 运行前编译优化
- 极致性能优化

缺点 • 数据和控制流限制强

- 不方便调试
- 灵活性低

代表  TensorFlow



Fusion

- 分阶段编程 (Multi-stage)
- 及时编译 (Just-in-time, JIT)

代表  MindSpore

 PyTorch JIT

 TF Eager

Summary

1. 回顾了深度学习的编程方式
2. 了解了什么是声明式编程和命令式编程
3. 未来以命令式编程易用性为主，结合声明式编程的优化方式相融合



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