SaturnLab

Tsinghua iCenter

TensorFlow 机器学习库

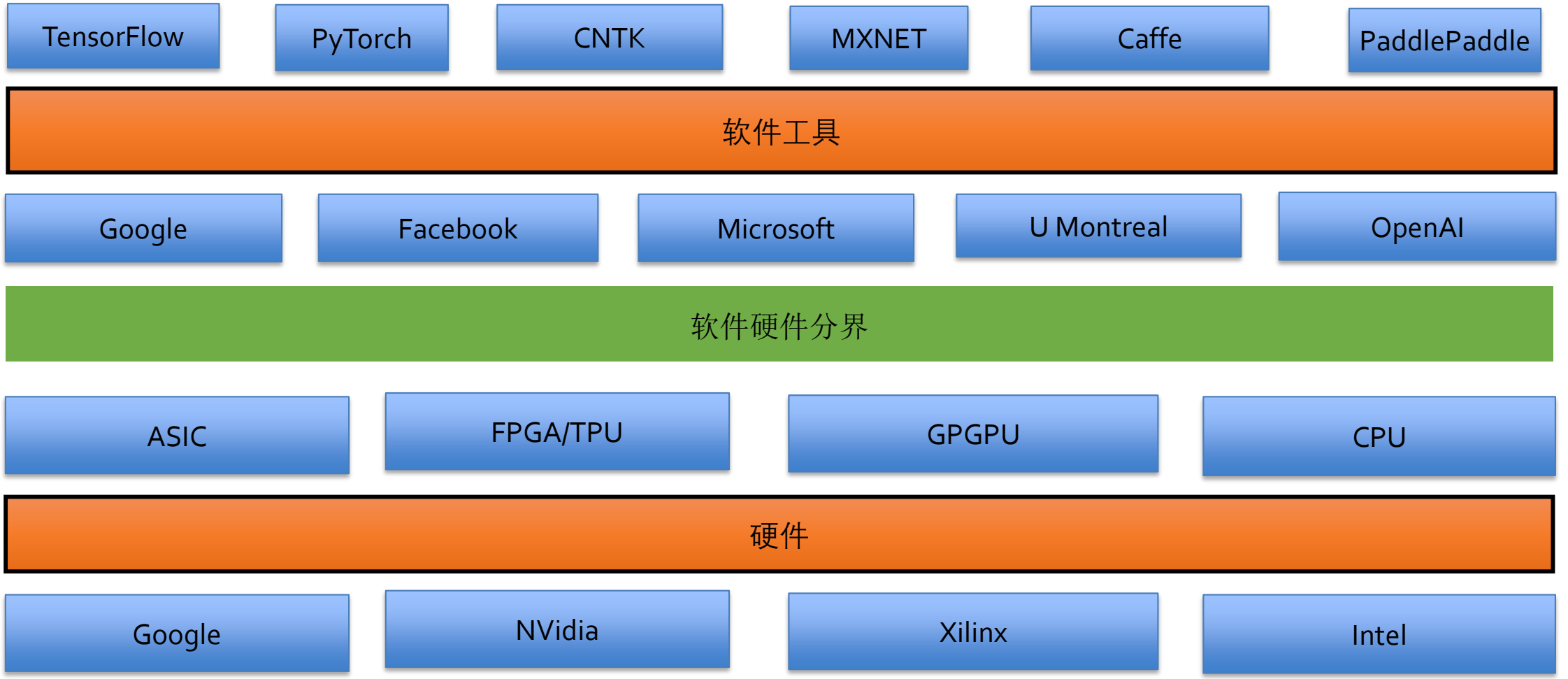
TensorFlow - Machine Intelligence Library

智能系统实验室

清华大学基础工业训练中心

深度学习软硬件布局

- 相关的硬件与软件及其产业公司



深度学习框架

- **Tensor Flow:** ***Google*** *Deep Learning Library*
  - Supports general deep learning with symbolic diff.
  - Python on top of C++ (Easy + Fast)
  - GPU, cluster, and mobile implementations
- **pyTorch:** ***Facebook*** *AI research*
  - Tensor Library
  - File I/O Interface Library
- **Berkeley Caffe:** *GPU accelerated Computer Vision*
  - Focused on computer vision and GPU acceleration
  - C++ with Python support (Very Fast + somewhat easy)
  - Rich library of pre-trained models (Caffe Model Zoo)
- **DMLC/MXNET**
- **Microsoft/CNTK**
- **Baidu/PaddlePaddle/Brain++/Jitor**

PYTORCH

mxnet

PaddlePaddle

深度学习框架是什么？

- 深度学习框架（Deep Learning Framework）是描述多层网络模型及训练推断的编程语言及工具类库。
  - 过程式语言Python / C 不同
  - 申明式编程语言Prolog 类似
- 深度学习框架包括:
  - 编程语言，解释器，编译器。
- 深度学习框架的不同，对应着编程语言内部的不同设计。
  - 动态语言和静态语言的差别，对应着 TensorFlow和PyTorch 的动态计算图和静态计算图的区别。

TensorFlow深度学习框架

- TensorFlow中的“计算图”，类似对应为编译器中的 data-flow graph 或者 control-flow graph

- TensorFlow会自动求导AD，优化权重参数，使得损失函数最小。可以称为一种“可求导编程语言”（differentiable programming language）。

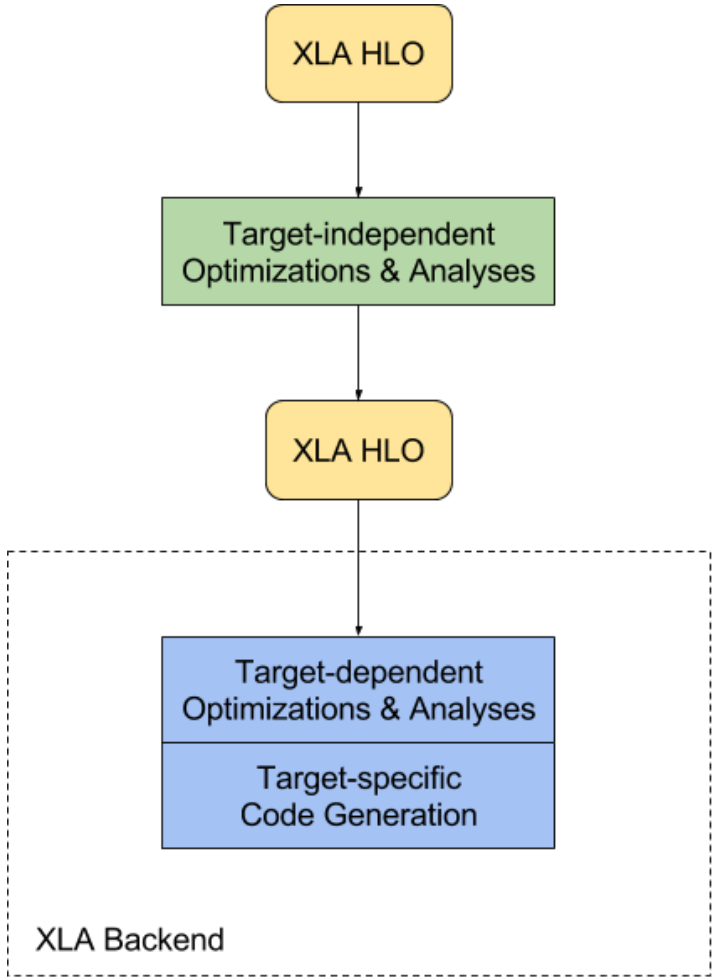
- TensorFlow的编译器XLA (Accelerated Linear Algebra) 优化TensorFlow计算图

编译器

- 深度学习编译器
  - TensorFlow XLA,
  - Facebook Glow,
  - TVM

- 软硬协同设计
  - 解释器、编译器
  - 算子库
  - AI芯片

TensorFlow XLA

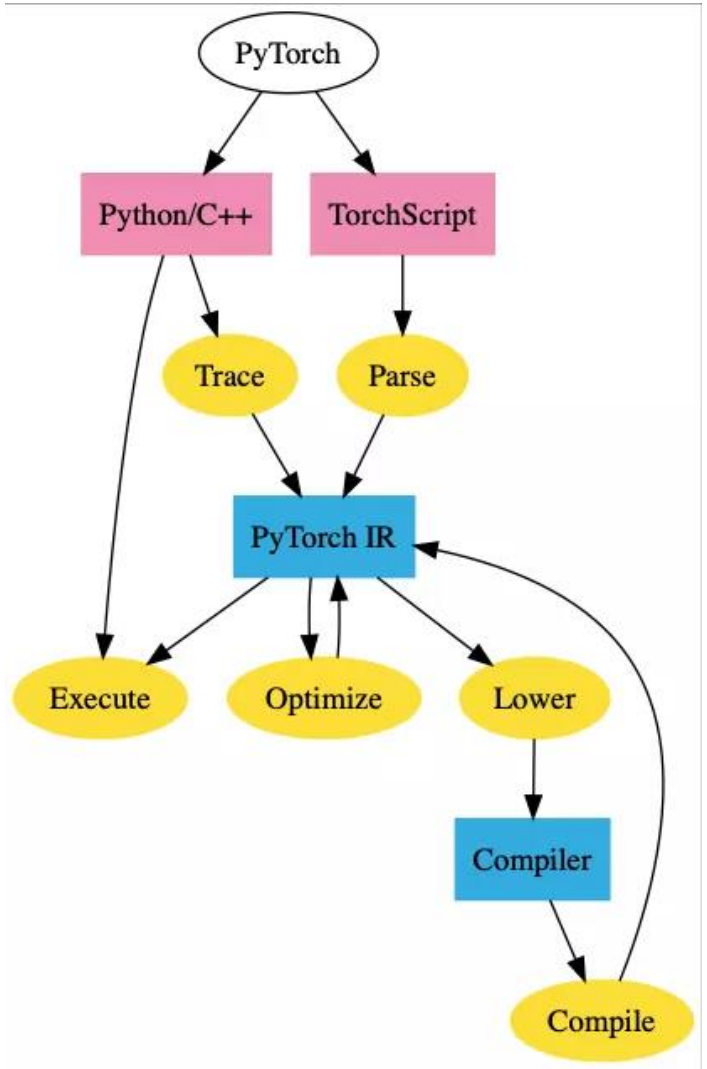


- XLA(Accelerated Linear Algebra 加速线性代数)
- XLA是一种能够优化 TensorFlow 计算的编译器

PyTorch compiler stack

- PyTorch
  - PyTorch IR
  - Execution Code
  - Pytorch Glow
- Glow是pyTorch的编译器和执行引擎，基于LLVM项目进行了开发的。

https://github.com/pytorch/glow



TVM compiler stack

https://tvm.ai

TensorFlow 简介

- 谷歌大脑团队出品，
- 在谷歌内部应用广泛，2015年11月开源
- http://www.tensorflow.org/
- http://tensorflow.googe.cn

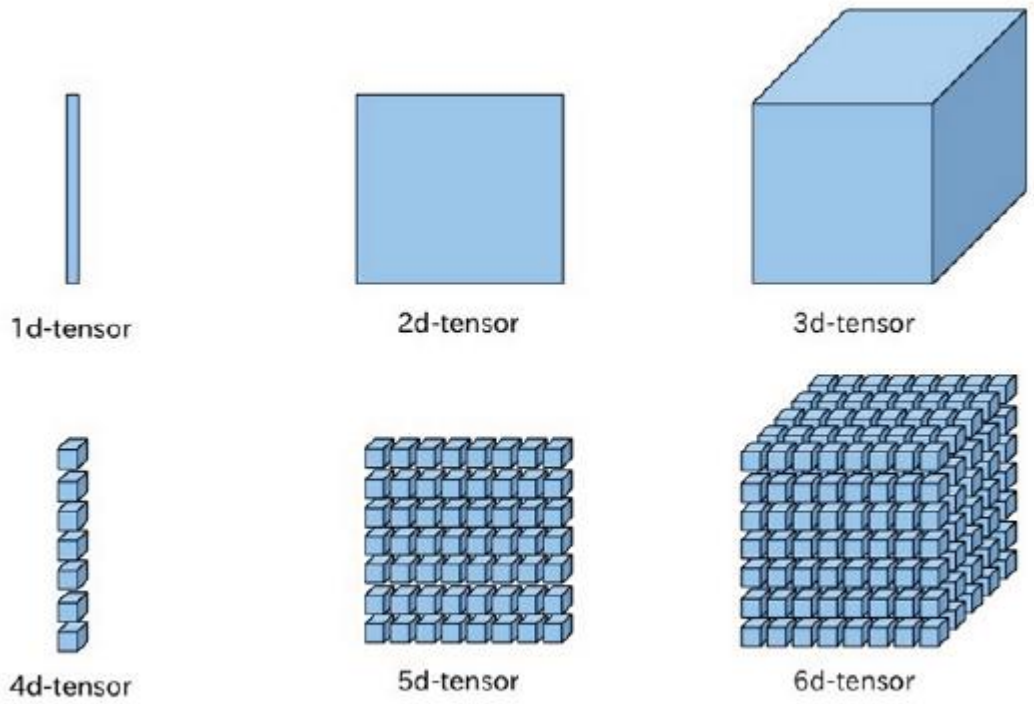
谷歌大脑，Google Brain，https://research.googleblog.com/

TensorFlow简介

- 开发者：Google Brain Team（Google Research）
- 历史：
  - DistBelief: 第一代深度学习系统：DistBelief: First Generation Deep Learning System
  - TensorFlow: 第二代深度学习系统：TensorFlow: Second Generation Deep Learning System
- 网址：http://www.tensorflow.org/
- 源代码：https://github.com/tensorflow/tensorflow
- 论文与白皮书：http://tensorflow.org/whitepaper2015.pdf
- OSDI论文
  - TensorFlow: A system for large-scale machine learning

Tensor简介

- Tensor（张量）意味着N维数组。
- 1维Tensor的形式是向量;
- 2维Tensor的形式是矩阵;
- 3维Tensor的形式是彩色图像，可以用（行，列，颜色）来表示。



TensorFlow名称来历

- TensorFlow是一个用数据流图进行数值计算的软件库。图中的节点表示的数学运算，而图的边代表它们之间传送的多维数据阵列（张量）。
- 张量Tensor从图的一端流动到另一端，这就是“TensorFlow”（张量流）名称来源。
- Tensor是TensorFlow的核心
- 在TensorFlow框架中，
  - Tensor的形式有三种：constant, placeholder, variables
  - Tensor的属性有：rank， shape，datatype

TensorFlow 1.0版本

- Release 1.13
  - Support for **Python3.7 on all operating** systems.
  - TensorFlow Lite has moved from contrib to core.
  - TensorFlow GPU binaries are now built against CUDA 10 and TensorRT 5.0.
  - Moved NCCL to core.
- Release 1.14.0 （2019.8.19）
  - Turn on MKL-DNN contraction kernels by default. MKL-DNN dynamically dispatches the best kernel implementation based on CPU vector architecture.
- Release 1.15.0 (2019.10.23)

TensorFlow安装与使用（1.0版本）

- 安装
  - ‘$pip install tensorflow’
  - ‘$pip install tensorflow-gpu’
- 使用，运行python
  - >>>import tensorflow as tf
  - >>>a=tf.constant(1.0)
  - >>>b=tf.constant(3.0)
  - >>> c=a+b
  - >>> sess = tf.Session()
  - >>> sess.run(c)

TensorFlow 简单示例（1.0版本）

- # tensorflow
- >>> a = tf.placeholder(tf.int8)
- >>> b = tf.placeholder(tf.int8)
- >>> sess =tf.Session()
- >>> sess.run(a+b, feed_dict={a: 10, b: 32})

Tensorflow_basics-operation.ipynb

TensorFlow 2.0版本

- TensorFlow 2.0 focuses on simplicity and ease of use, featuring updates like:
  - Easy model building with Keras and eager execution
  - Robust model deployment in production on any platform
  - Powerful experimentation for research
  - API simplification by reducing duplication and removing deprecated endpoints
- http://tf.wiki

Eager execution in TensorFlow 2.0

- A call to a function f(g(x+y), 2*x).
- In a language with eager evaluation, you'd first compute the values of the parameters and only invoke the function after the parameters had been computed.
  - You'd compute g(x+y) and 2*x before invoking f; and when you were computing g(x+y), you'd first compute x+y before invoking the function g.
  - This is the way that many familiar languages actually work: for example, this is how C, Java, JavaScript, and Python work.
- In lazy evaluation, you don't compute the value of any expression until you need to.
  - You'd invoke f first. You wouldn't invoke g(x+y) until f tried to use the value of that expression. If f never specifically used the value of the parameter expression g(x+y), then it would never get computed and g would never get invoked.
  - This kind of evaluation turns out to be really useful, and it's the basis of languages like Haskell and Miranda.

TensorFlow 2.2版本

- Replaced the scalar type for string tensors from std::string to tensorflow::tstring which is now ABI stable.
- A new Profiler for TF 2 for CPU/GPU/TPU.
- Export C++ functions to Python using pybind11
- tf.keras:
  - Model.fit major improvements:
- tf.lite:
  - Enable TFLite experimental new converter by default.
- XLA
  - XLA now builds and works on windows.

TensorFlow 2.0版本

- 安装
  - ‘$pip install tensorflow’
  - ‘$pip install tensorflow-gpu’
- 使用，运行python
  - >>>import tensorflow as tf
  - >>>a=tf.constant(1.0)
  - >>>b=tf.constant(3.0)
  - >>> c=a+b
  - >>> print(c.numpy())

TensorFlow 2.0版本Keras示例

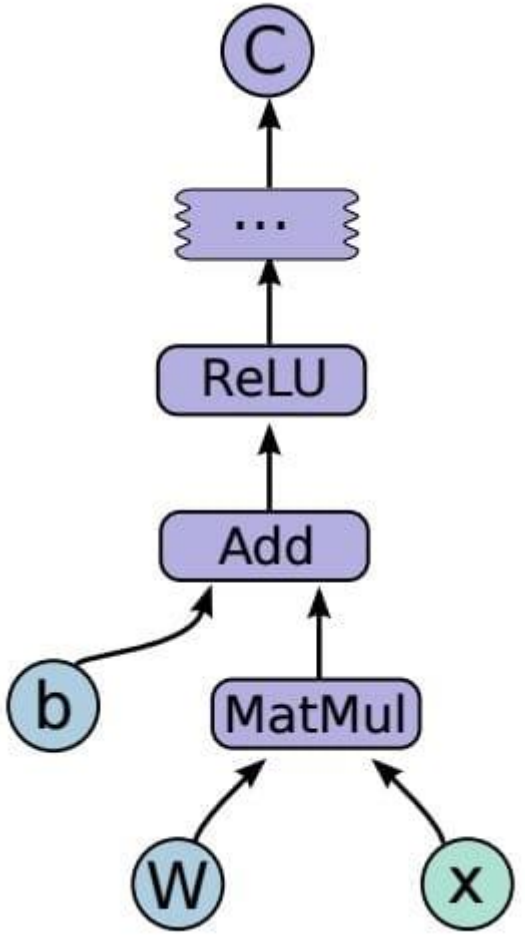
```
import tensorflow as tf

mnist = tf.keras.datasets.mnist

(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential()

model.add(tf.keras.layers.Flatten(input_shape=(28, 28)))
model.add(tf.keras.layers.Dense(128, activation='relu'))
model.add(tf.keras.layers.Dropout(0.2))
model.add(tf.keras.layers.Dense(10, activation='softmax'))

model.compile(optimizer='adam',loss='sparse_categorical_crossentropy', metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)

model.evaluate(x_test,  y_test, verbose=2)
```

Keras-mnist.ipynb

TensorFlow计算图CG（1.0版本）

- TensorFlow是一种元编程（meta programming），构建计算图的语言
- 基本人工神经元的代码分析:

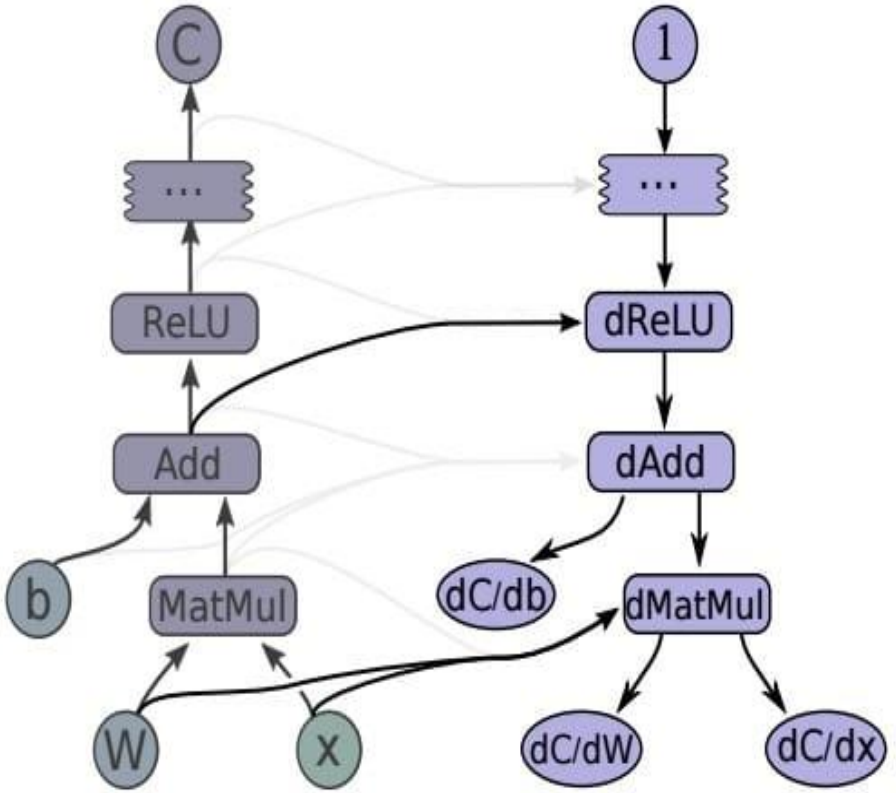
```
import tensorflow as tf

b = tf.Variable(tf.zeros([100]))  # 100-d vector, init to zeroes
W = tf.Variable(tf.random_uniform([784,100],-1,1))  # 784x100 matrix w/rnd vals
x = tf.placeholder(name="x")  # Placeholder for input
relu = tf.nn.relu(tf.matmul(W, x) + b)  # Relu(Wx+b)
C = [...]        # Cost computed as a function of Relu

sess = tf.Session()
for step in xrange(0, 10):
    input = ...construct 100-D input array ... # Create 100-d vector for input
    result = sess.run(C, feed_dict={x: input}) # Fetch cost, feeding x=input
    print step, result
```



TensorFlow求导

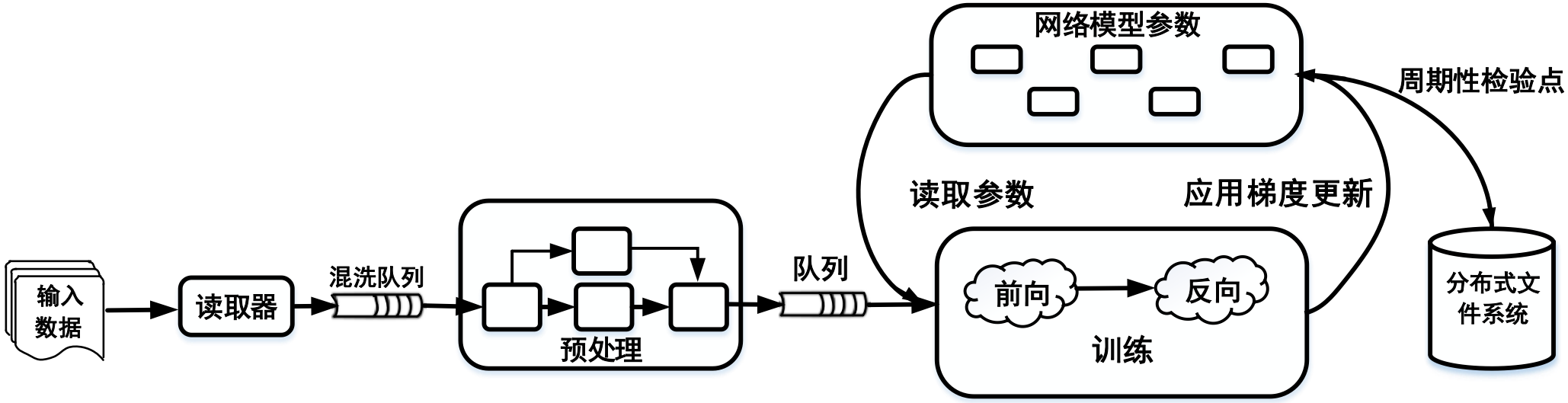
- TensorFlow求导采用符号微分方法

- 在图g上，由后向前：
  - 从结果C开始，查找C的所有依赖节点I，并计算C的梯度，插入新的计算图中
  - 递归地从I开始，查找I的所有依赖节点I'，并计算I的梯度，插入新的计算图中
- 最终，自顶向下地形成梯度的计算图g'。



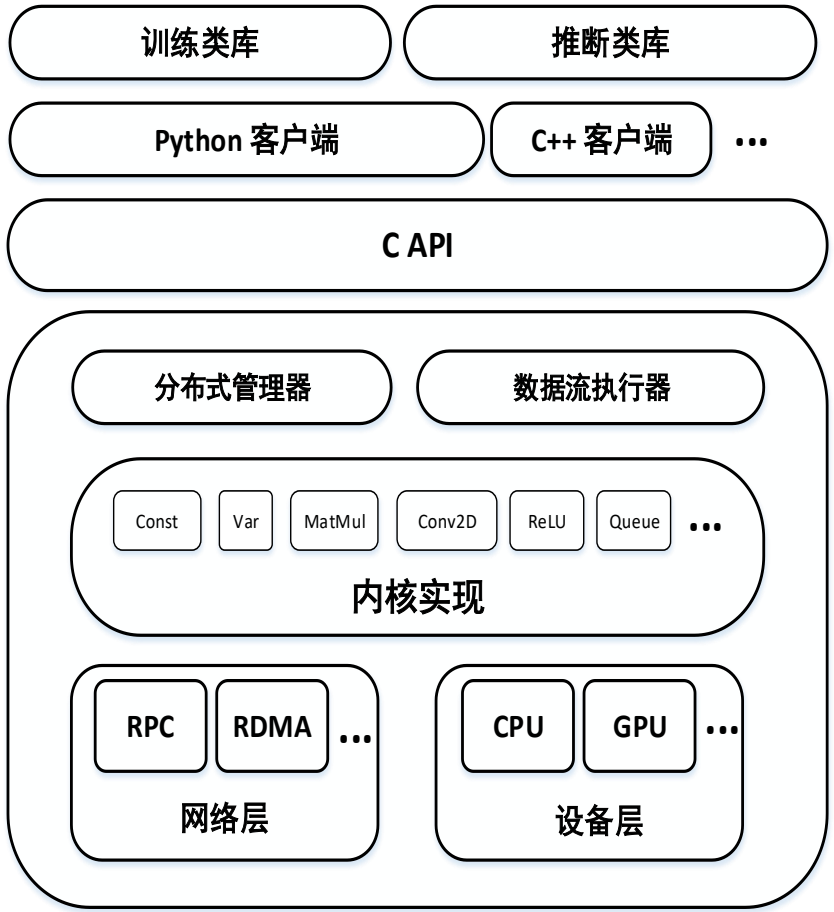
TensorFlow数据流图

- TensorFlow用于模型训练过程的数据流图，包括训练数据的读取和转换，队列，参数的更新以及周期性监测点生成。
- 图中的操作都是并发执行的，图中的节点的可变状态（Mutable states）在图的执行中是可以共享的。



TensorFlow架构

- 上层是训练库（Training library）和推断库（Inference libs），部署最终的生成模型在不同的设备上。
- 中间层是Python和C++接口，方便程序员进行调用。
- 底层是网络层和设备层，TensorFlow可以灵活的运行在通过网络连接的不同计算设备上。
- 统一API（Python、C++等）调用，部署在一个或多个CPU或GPU的桌面电脑、服务器或移动设备。



https://www.tensorflow.org/guide/extend/architecture

TensorFlow底层

- Eigen is a C++ template library for linear algebra: matrices, vectors, numerical solvers, and related algorithms.

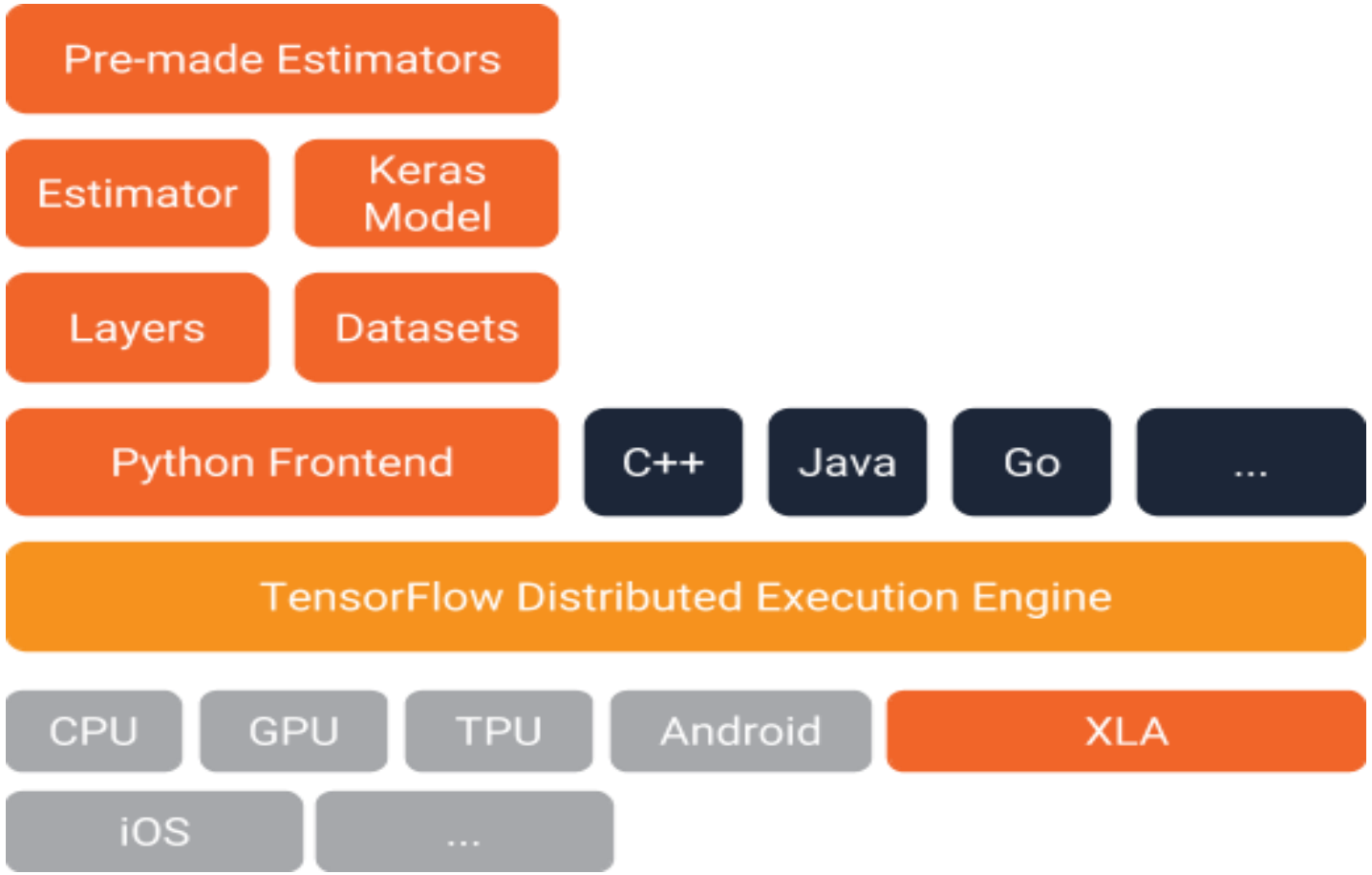
http://eigen.tuxfamily.org/

- Eigen::Tensor实现的Tensor定义和运算主要是调用

- gemmlowp (Low-precision matrix multiplication)低精度矩阵库加快量化计算

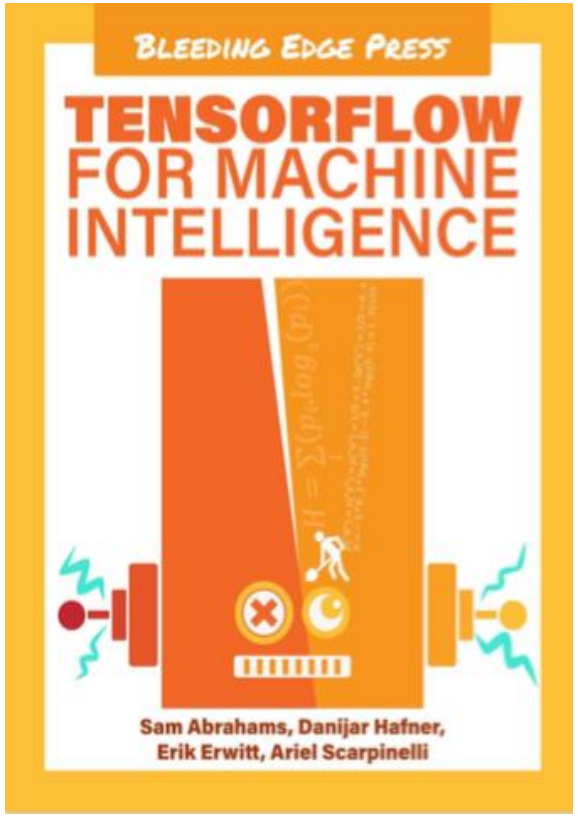
https://github.com/google/gemmlowp

TensorFlow 编程模型



参考书

- Abrahams, Sam, Danijar Hafner, Erik Erwitt, and Ariel Scarpinelli. TensorFlow for Machine Intelligence: A Hands-on Introduction to Learning Algorithms. Bleeding Edge Press, 2016.



谢谢指正！

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万物皆数

- “万物皆数”是毕达哥拉斯学派（*the Pythagoreans*）的观点，毕达哥拉斯学派融合了数学和神秘主义的观点
- “… in all nature numbers are the first, they supposed the elements of numbers to be the elements of all things.”

- 毕达哥拉斯定理和无理数的发现

- https://en.wikipedia.org/wiki/Pythagoreanism