



PowerAI 使用指南

——Basic Guide

IBM System Lab Services(GCG)

通过经验，交流和反复试验，我们学会了感知我们周围的世界

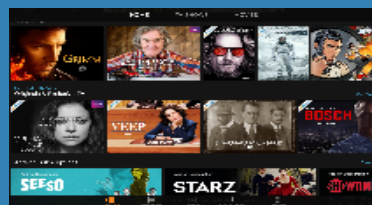


深度学习/人工智能词典

- 人工智能 > 机器学习 > 深度学习
- 深度学习 = 训练 (密集计算型, 数据中心计算) + 推断 (嵌入式、边缘计算... 更加贴近用户端)
- 训练 = 类似神经元方式 “灵感”, 由数百万的数据点馈送... 重复驱动器的加权和连接
- 平台 = 软件框架 + 支持的库 + 计算
- 计算 = 加速器 + 高带宽

- 期望成果: 在推断模型感知任务中具有更高的准确度

深度学习: 跨界跨领域应用



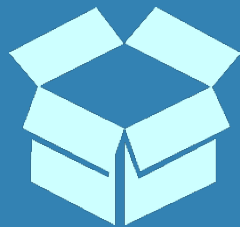
| 汽车和交通 | 国防, 安全, 公共安全 | 互联网, 手机, 零售消费者 | 生物医学 | 娱乐传媒 |
|--|---|--|---|---|
| <ul style="list-style-type: none">自动驾驶行人检测事故避免 | <ul style="list-style-type: none">视频监控图像分析面部识别和检测 | <ul style="list-style-type: none">图片标记语音识别自然语言处理建议和情绪分析 | <ul style="list-style-type: none">药物探索诊断帮助癌细胞检测 | <ul style="list-style-type: none">字幕搜索建议实时翻译 |

Power 人工智能/深度学习策略

- 拥抱扩展开源：增加创新，优化，新算法
- 增加系统级优化。利用NVLink Power平台，更好的集群（横向扩展）性能，简化入门过程
- 使用NVLink构建差异化的GPU加速系统解决方案



PowerAI介绍: 快速开始深度学习



预编译主要的深度学习框
架软件包



易于安装 & 开始使用企
业级支持的深度学习



利用NVLink优化性能

高性能计算基础设施使得这些变得可行

PowerAI 平台

深度学习框架

Caffe

NVCaffe

IBMCaffe

Torch

TensorFlow

DL4J

Theano

支持的函数库

OpenBLAS

Bazel

Distributed
Frameworks

NCCL

DIGITS

加速服务器和
基础架构

NVLink 服务器集群



高速并行文件系统



扩展到云



很快到来

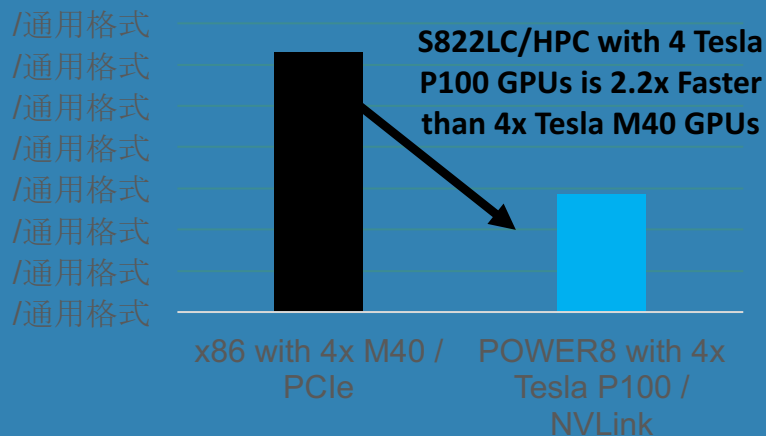
PowerAI 简化访问和安装

- 测试二进制构建的常见深度学习框架，以方便实施
- 简单完整安装的过程记录在ibm.biz/powerai
- 未来的重点是优化POWER的特定包：OpenBLAS，NVIDIA Caffe，TensorFlow和Torch

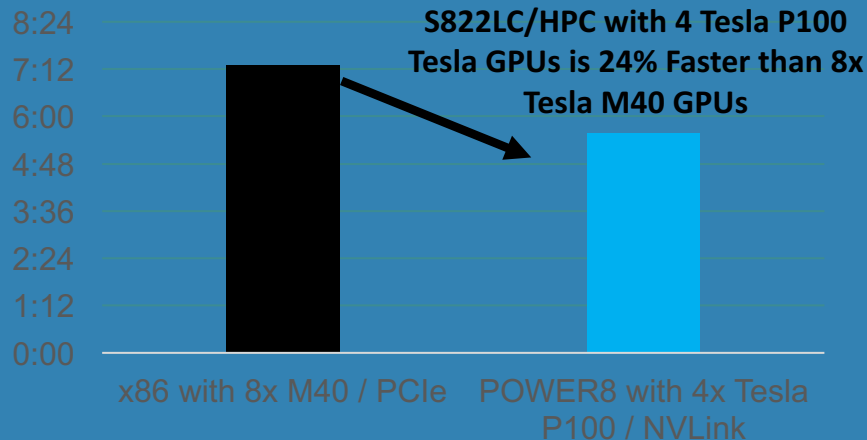
| | PowerAI |
|---------------|--------------------|
| OS | Ubuntu 16.04 |
| CUDA | 8.0 |
| cuDNN | 5.1 |
| Built w/ MASS | Yes |
| OpenBLAS | 0.2.19 |
| Caffe | 1.0 rc3 |
| NVIDIA Caffe | 0.14.5 |
| IBM Caffe | 1.0 rc3 |
| NVIDIA DIGITS | v5.0.0 |
| Torch | 7 |
| Theano | 0.8.2 |
| TensorFlow | v1.0.1 and v0.12.0 |
| GPU | 4 x P100 |
| Base System | S822LC/HPC |

PowerAI on S822LC for HPC: 2.2x Faster

Training time (minutes): AlexNet
and Caffe to top-1, 50% Accuracy
(Lower is better)



BVLC Caffe vs IBM Caffe / VGGNet
Time to Top-1 50% accuracy:
(Lower is better)

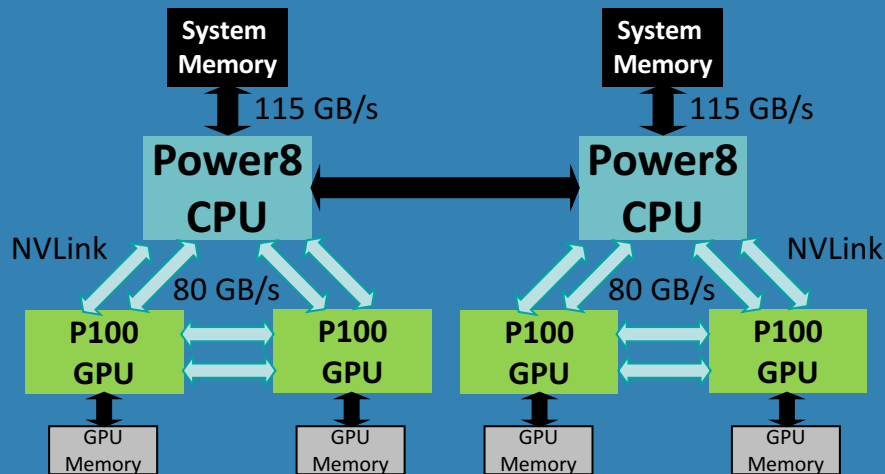


IBM S822LC 20-cores 2.86GHz 512GB memory / 4 NVIDIA Tesla P100 GPUs / Ubuntu 16.04 /
CUDA 8.0.44 / cuDNN 5.1 / IBM Caffe 1.0.0-rc3 / Imagenet Data

Intel Broadwell E5-2640v4 20-core 2.6 GHz 512GB memory / 8 NVIDIA TeslaM40 GPUs / Ubuntu 16.04 /
CUDA 8.0.44 / cuDNN 5.1 / BVLC Caffe 1.0.0-rc3 / Imagenet Data

PowerAI利用POWER8和P100之间的NVLink来提高系统带宽

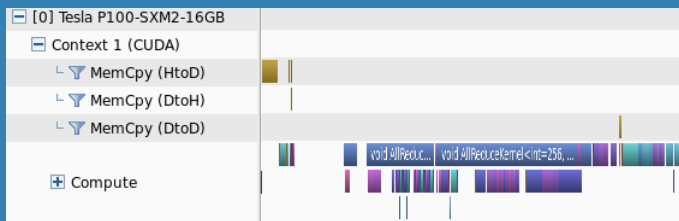
- CPU和GPU之间的NVLink支持跟大的带宽，可以快速访问系统内存中的大型数据集
- GPU和CPU-GPU之间的两个NVLink连接导致更快的数据交换



NVLink和P100 优势: 缩短通信时间，整合最快的GPU进行深度学习

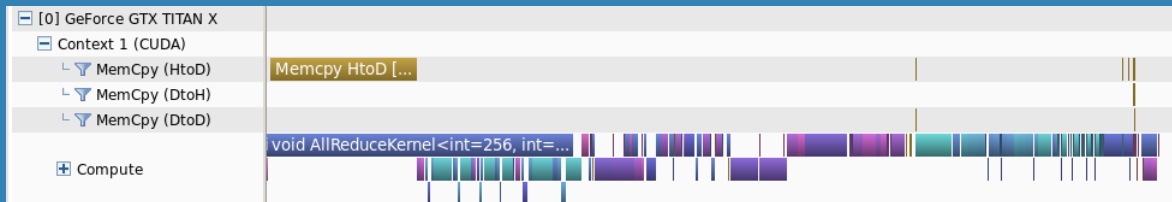
- NVLink减少通信时间和开销
 - GPU-GPU, Memory-GPU的数据获取更快，训练时间更短
- IBM 优势: 数据通信和GPU性能

POWER8 +
Tesla
P100+NVLink



78 ms

x86 based
GPU system



170 ms

ImageNet / Alexnet: Minibatch size = 128

PowerAI的应用场景示例

- 销售主管：
 - 更好地了解客户的观点，建议，提高互动性
- IT 主管：
 - 企业级支持，更好的性价比和共享基础设施
- 数据科学家和开发人员：
 - NVLink意味着新的创新机会，更快的访问更大的内存，执行更大的训练模型和更多的迭代...完善，提高
- 研究科学家：
 - 探索理解现有数据集的新方法

信息 – 深度学习

- 商业价值
 - 效率 – 减少的训练时间允许数据科学家快速迭代和改进模型
 - 准确 – 更高的性能: 更多的运行 (集合), 更大的数据集, 为什么不是两者皆有?
- 为什么是IBM?
 - 超越深度学习 - 运行其他加速工作负载 (模拟 , 分析 , HPC)
 - PowerAI 平台
 - 专为生产系统
 - 易于实施 – 经过完整测试和构建框架, 安装和配置详细的文档。
 - 软件包中包括应用程序, 库和其他系统组件意味着更快的部署速度。
 - 首先进入市场 - 竞争对手仍在用以往的模式进行销售, IBM首先推出基于Tesla P100 GPU的系统 ... 在深度学习领域取得先机。

S822LC for HPC: 2路Power8, 4个GPU NVLink系统的PowerAI的具体配置

- 包含的:
 - 2 POWER8 10 Core CPUs
 - 4 NVIDIA P100 "Pascal" GPUs
 - 256 GB System Memory
 - 2 SSD storage devices
 - High-speed interconnect (IB or Ethernet, depending on infrastructure)
-
- 可选的:
 - Up to 1 TB System Memory
 - PCIe attached NVMe storage



PowerAI入门

- 安装PowerAI在你现有的S822LC的高性能计算服务器上

<http://ibm.biz/powerai>

- 没有高性能服务器S822LC?
 - 参考架构/系统要求适用于使用POWER8 , NVLink和Tesla P100的第一个系统 (下一张幻灯片)
 - 访问IBM POWER HPC Cloud合作伙伴 , 以便今天在POWER8 / P100上测试这些框架
 - <https://power.jarvice.com/> (Nimbix HPC Cloud)

PowerAI安装介绍

- PowerAI可以通过两种方式安装，分别是网络和本地（ mldl-repo-local & mldl-repo-network ），两种方式的安装过程都是通过配置repository进行安装，过程基本类似。
- 下载PowerAI所需的repository package文件(.deb file)
from <https://public.dhe.ibm.com/software/server/POWER/Linux/mldl/ubuntu/>
- 安装repository package:
 - \$ sudo dpkg -i mldl-repo-*.deb
 - \$ sudo apt-get update

通过apt-get 进行安装

1、把所有的框架一次全部安装

All the Deep Learning frameworks can be installed at once using the power-mldl meta-package:

```
$ sudo apt-get install power-mldl
```

2、根据需要使用的框架选择安装

The Deep Learning frameworks can be installed individually if preferred. The framework packages are: caffe-bvlc caffe-ibm caffe-nv chainer digits tensorflow theano torch

Each can be installed with:

```
$ sudo apt-get install <framework>
```

更新旧版本的PowerAI

安装新版本的repository package :

使用本地repo的话直接安装 :

```
$ sudo dpkg -i mldl-repo-local_3.4.1_ppc64el.deb
```

使用网络repo的话需要先删除旧版本再安装 :

```
$ sudo apt-get purge mldl-repo-local
```

```
$ sudo dpkg -i mldl-repo-network_3.4.0_ppc64el.deb
```

更新repository meta-data

```
$ sudo apt-get update
```

更新过程

更新PowerAI全部系统环境：

```
$ sudo aptitude dist-upgrade
```

仅更新PowerAI相关框架：

```
$ sudo aptitude upgrade power-mldl
```

仅更新某个PowerAI环境中的包：

```
$ sudo aptitude upgrade tensorflow
```

PowerAI上手体验

每个框架提供了一个shell脚本用来激活当前的环境变量，可以自己修改bashrc里的参数达到设置效果，但建议使用对应目录下的配置脚本来设置当前的环境变量，比如：

```
$source /opt/DL/<framework>/bin/<framework>-activate
```

在每个框架的目录下，都提供了一个基础功能测试的脚本用以验证功能是否完善：

```
$ <framework>-test
```

Caffe alternatives

Packages are provided for upstream BVLC Caffe (/opt/DL/caffe-bvlc), IBM optimized BVLC Caffe (/opt/DL/caffe-ibm), and NVIDIA's Caffe (/opt/DL/caffe-nv). The system default Caffe (/opt/DL/caffe) can be selected using Ubuntu's alternatives system:

```
$ sudo update-alternatives --config caffe
```

There are 3 choices for the alternative caffe (providing /opt/DL/caffe).

```
There are 3 choices for the alternative caffe (providing /opt/DL/caffe).

  Selection    Path                                Priority  Status
  -----
* 0            /opt/DL/caffe-ibm                   100      auto mode
  1            /opt/DL/caffe-bvlc                  50      manual mode
  2            /opt/DL/caffe-ibm                   100      manual mode
  3            /opt/DL/caffe-nv                    75      manual mode

Press <enter> to keep the current choice[*], or type selection number: 1
update-alternatives: using /opt/DL/caffe-bvlc to provide /opt/DL/caffe (caffe) in manual mode
```

Users can activate the system default caffe:

```
source /opt/DL/caffe/bin/caffe-activate
```

Or they can activate a specific variant. For example:

```
source /opt/DL/caffe-bvlc/bin/caffe-activate
```

Attempting to activate multiple Caffe packages in a single login session will cause unpredictable behavior.

Tuning recommendations

Recommended settings for optimal Deep Learning performance on the S822LC for High Performance Computing are:

Enable Performance Governor

```
$ sudo apt-get install linux-tools-common linux-tools-generic linux-cloud-tools-generic cpufrequtils lsb-release
```

```
$ sudo cpupower -c all frequency-set -g performance
```

Enable GPU persistence mode

Use nvidia-persistenced (<http://docs.nvidia.com/deploy/driver-persistence/index.html>) or

```
$ sudo nvidia-smi -pm ENABLED
```

Set GPU memory and graphics clocks

```
$ sudo nvidia-smi -ac 715,1480
```

For TensorFlow, set the SMT mode

```
$ sudo ppc64_cpu --smt=2
```

MNIST 数据集训练过程——数据准备

1、进入caffe目录下

```
cd $CAFFE_HOME
```

2、下载Mnist 数据集

```
./data/mnist/get_mnist.sh
```

3、将其转换成Lmdb数据库格式，执行完此shell脚本后，会在./examples、mnist下增加两个新目录，mnist_test_lmdb和mnist_train_lmdb

```
./examples/mnist/create_mnist.sh
```

Mnist 数据集训练过程——训练模型

训练模型：

```
./examples/mnist/train_lenet.sh
```

打开train_lenet.sh可以看到，事实上通过caffe 命令，加上solver文件作为参数实现的训练

```
#!/usr/bin/env sh  
./build/tools/caffe train --solver=examples/mnist/lenet_solver.prototxt
```


\$CAFFE_ROOT/examples/mnist/lenet-solver.prototxt

```
# The train/test net protocol buffer definition
net: "examples/mnist/lenet_train_test.prototxt" #网络模型文件路径
test_iter: 100 #test的迭代次数，要和test layer中的batch_size结合起来理解
test_interval: 500 #训练时每迭代500次测试一次
base_lr: 0.01 #学习率
momentum: 0.9 #动量
weight_decay: 0.0005 #权重衰减
lr_policy: "inv" #学习率策略
gamma: 0.0001
power: 0.75
display: 100 #每迭代100次显示
max_iter: 10000 #最大迭代次数。这个数设置太小，会导致没有收敛，精确度很低。设置太大，会导致震荡，浪费时间
snapshot: 5000 #snapshot用于设置训练多少次后进行保存
snapshot_prefix: "examples/mnist/mnist-model/mymnist"
solver_mode: GPU
```

Ready? Let's train!

```
root@nova-eabf7820-3853-4ee8-90d5-565be95cbca3:/home/opuser/caffe-master-20150813# ./examples/mnist/train_lenet.sh
I0518 06:54:23.101384 24768 caffe.cpp:118] Use GPU with device ID 0
I0518 06:54:23.262435 24768 caffe.cpp:126] Starting Optimization
I0518 06:54:23.262526 24768 solver.cpp:36] Initializing solver from parameters:
test_iter: 100
test_interval: 500
base_lr: 0.01
display: 100
max_iter: 10000
lr_policy: "inv"
gamma: 0.0001
power: 0.75
momentum: 0.9
weight_decay: 0.0005
snapshot: 5000
snapshot_prefix: "examples/mnist/mnist-model/mymnist"
solver_mode: GPU
net: "examples/mnist/lenet_train_test.prototxt"
I0518 06:54:23.262779 24768 solver.cpp:74] Creating training net from net file: examples/mnist/lenet_train_test.prototxt
I0518 06:54:23.263417 24768 net.cpp:289] The NetState phase (0) differed from the phase (1) specified by a rule in layer mnist
I0518 06:54:23.263450 24768 net.cpp:289] The NetState phase (0) differed from the phase (1) specified by a rule in layer accuracy
I0518 06:54:23.263478 24768 net.cpp:44] Initializing net from parameters:
```

```
I0612 15:10:25.185286 1370 solver.cpp:456] Test net output #0: accuracy = 0.9887
I0612 15:10:25.185308 1370 solver.cpp:456] Test net output #1: loss = 0.036992 (* 1 = 0.036992 loss)
I0612 15:10:25.186771 1370 solver.cpp:251] Iteration 9500, loss = 0.0040812
I0612 15:10:25.186789 1370 solver.cpp:267] Train net output #0: loss = 0.00408101 (* 1 = 0.00408101 loss)
I0612 15:10:25.186800 1370 sgd_solver.cpp:106] Iteration 9500, lr = 0.00606002
I0612 15:10:25.187003 1370 solver.cpp:287] Time: 0.265889s/100iters
I0612 15:10:25.356017 1370 solver.cpp:251] Iteration 9600, loss = 0.00198696
I0612 15:10:25.356040 1370 solver.cpp:267] Train net output #0: loss = 0.00198677 (* 1 = 0.00198677 loss)
I0612 15:10:25.356050 1370 sgd_solver.cpp:106] Iteration 9600, lr = 0.00603682
I0612 15:10:25.356214 1370 solver.cpp:287] Time: 0.169183s/100iters
I0612 15:10:25.506953 1370 solver.cpp:251] Iteration 9700, loss = 0.00341411
I0612 15:10:25.506973 1370 solver.cpp:267] Train net output #0: loss = 0.00341392 (* 1 = 0.00341392 loss)
I0612 15:10:25.506983 1370 sgd_solver.cpp:106] Iteration 9700, lr = 0.00601382
I0612 15:10:25.507148 1370 solver.cpp:287] Time: 0.150913s/100iters
I0612 15:10:25.659124 1370 solver.cpp:251] Iteration 9800, loss = 0.00911176
I0612 15:10:25.659211 1370 solver.cpp:267] Train net output #0: loss = 0.00911158 (* 1 = 0.00911158 loss)
I0612 15:10:25.659222 1370 sgd_solver.cpp:106] Iteration 9800, lr = 0.00599102
I0612 15:10:25.659389 1370 solver.cpp:287] Time: 0.152221s/100iters
I0612 15:10:25.814558 1370 solver.cpp:251] Iteration 9900, loss = 0.00373757
I0612 15:10:25.814580 1370 solver.cpp:267] Train net output #0: loss = 0.00373739 (* 1 = 0.00373739 loss)
I0612 15:10:25.814590 1370 sgd_solver.cpp:106] Iteration 9900, lr = 0.00596843
I0612 15:10:25.814755 1370 solver.cpp:287] Time: 0.155347s/100iters
I0612 15:10:25.964187 1370 solver.cpp:506] Snapshotting to binary proto file examples/mnist/lenet_iter_10000.caffemodel
I0612 15:10:25.970006 1370 sgd_solver.cpp:273] Snapshotting solver state to binary proto file examples/mnist/lenet_iter_10000.solverstate
I0612 15:10:25.974470 1370 solver.cpp:357] Iteration 10000, loss = 0.00264752
I0612 15:10:25.974485 1370 solver.cpp:377] Iteration 10000, Testing net (#0)
I0612 15:10:26.090816 1370 solver.cpp:456] Test net output #0: accuracy = 0.9912
I0612 15:10:26.090837 1370 solver.cpp:456] Test net output #1: loss = 0.0286396 (* 1 = 0.0286396 loss)
I0612 15:10:26.090849 1370 solver.cpp:362] Optimization Done.
I0612 15:10:26.090864 1370 caffe.cpp:292] Optimization Done.

real    0m20.143s
user    0m30.636s
sys     0m5.188s
```

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