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Chapter 1.
PYTORCH OVERVIEW

The NVIDIA Deep Learning SDK accelerates widely-used deep learning frameworks such as PyTorch.

PyTorch is a GPU accelerated tensor computational framework with a Python front end. Functionality can be easily extended with common Python libraries such as NumPy, SciPy and Cython. Automatic differentiation is done with a tape-based system at both a functional and neural network layer level. This functionality brings a high level of flexibility and speed as a deep learning framework and provides accelerated NumPy-like functionality.

PyTorch also includes standard defined neural network layers, deep learning optimizers, data loading utilities, and multi-gpu and multi-node support. Functions are executed immediately instead of enqueued in a static graph, improving ease of use and a sophisticated debugging experience.

This document describes the key features, software enhancements and improvements, any known issues, and how to run this container.
Chapter 2.
PULLING A CONTAINER

You can access NVIDIA’s GPU accelerated containers for all three products, the NVIDIA DGX-1™, NVIDIA DGX Station™, and the NVIDIA® GPU Cloud™ (NGC). If you own a DGX-1 or DGX Station then you should use the NVIDIA® DGX™ container registry at https://compute.nvidia.com. This is a web interface to the Docker hub, nvcr.io (NVIDIA DGX container registry). You can pull the containers from there and you can also push containers there into your own account in the registry.

If you are accessing the NVIDIA containers from the NVIDIA® GPU Cloud™ (NGC) container registry via a cloud services provider such as Amazon® Web Services™ (AWS), then you should use the NGC container registry at https://ngc.nvidia.com. This is also a web interface to the same Docker repository as for the DGX-1 and DGX Station. After you create an account, the commands to pull containers are the same as if you had a DGX-1 in your own data center. However, currently, you cannot save any containers to the NGC container registry. Instead, you have to save the containers to your own Docker repository that is either on-premise or in the Cloud.

The containers are exactly the same, whether you pull them from the NVIDIA DGX container registry or the NGC container registry.

For all three products, the DGX-1, DGX Station, and the NVIDIA NGC Cloud Services, the location of the framework source is in /opt/<framework> in the container.

Before you can pull a container from the NGC container registry, you must have Docker and nvidia-docker installed as explained in Preparing to use NVIDIA Containers Getting Started Guide. You must also have access and logged into the NGC container registry as explained in the NGC Getting Started Guide.

For step-by-step instructions, see Container User Guide.
Before running the container, use the `docker pull` command to ensure an up-to-date image is installed. Once the pull is complete, you can run the container image.

1. Issue the command for the applicable release of the container that you want. The following command assumes you want to pull the latest container.

   ```
docker pull nvcr.io/nvidia/pytorch:18.07
   ```

2. Open a command prompt and paste the pull command. The pulling of the container image begins. Ensure the pull completes successfully before proceeding to the next step.

3. Run the container image. To run the container, choose interactive mode or non-interactive mode.

   a) **Interactive mode:** Open a command prompt and issue:

      ```
nvidia-docker run -it --rm -v local_dir:container_dir
                     nvcr.io/nvidia/pytorch:<xx.xx>
      ```

   b) **Non-interactive mode:** Open a command prompt and issue:

      ```
nvidia-docker run --rm -v local_dir:container_dir
                     nvcr.io/nvidia/pytorch:<xx.xx> <command>
      ```

Where:

- `-it` means interactive
- `--rm` means delete the container when finished
- `-v` means mount directory
- `local_dir` is the directory or file from your host system (absolute path) that you want to access from inside your container. For example, the `local_dir` in the following path is `/home/jsmith/data/mnist`.

   ```
-v /home/jsmith/data/mnist:/data/mnist
   ```

If you are inside the container, for example, `ls /data/mnist`, you will see the same files as if you issued the `ls /home/jsmith/data/mnist` command from outside the container.
Running PyTorch

» **container_dir** is the target directory when you are inside your container. For example, */data/mnist* is the target directory in the example:

```bash
-v /home/jsmith/data/mnist:/data/mnist
```

» **<xx.xx>** is the tag. For example, 18.01.

» **<command>** is the command you want to run in the image.

If you use multiprocessing for multi-threaded data loaders, the default shared memory segment size that the container runs with may not be enough. Therefore, you should increase the shared memory size by issuing either:

```bash
--ipc=host
```

or

```bash
--shm-size=<requested memory size>
```

in the command line to

```bash
nvidia-docker run
```

You might want to pull in data and model descriptions from locations outside the container for use by PyTorch or save results to locations outside the container. To accomplish this, the easiest method is to mount one or more host directories as Docker® data volumes.

You have pulled the latest files and run the container image.

4. See */workspace/README.md* inside the container for information on customizing your PyTorch image.

For more information about PyTorch, including tutorials, documentation, and examples, see:

» PyTorch website

» PyTorch project
The NVIDIA container image of PyTorch, release 18.07, is available.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in `opt/pytorch`. It is pre-built and installed in the `pytorch-py3.6` Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 (see Errata section and 2.1) including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.425
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.1.4
- NCCL 2.2.13 (optimized for NVLink™)
- Caffe2 0.8.1
- DALI 0.1 Beta

Driver Requirements

Release 18.07 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- PyTorch container image version 18.07 is based on PyTorch 0.4.0 upstream master branch post commit cca2476.
- Clip grads can be used on a single tensor directly.
- The precision of MSELoss with half inputs has been improved.
- PyTorch’s JIT (still in Alpha) now supports FP16 inputs and outputs, comparisons, the exp operator, and ReLU gates.
- Added support for DALI 0.1 Beta.
- Latest version of CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.425.
- Ubuntu 16.04 with June 2018 updates

**Known Issues**

There are no known issues in this release.
Chapter 5.
PYTORCH RELEASE 18.06

The NVIDIA container image of PyTorch, release 18.06, is available.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py3.6 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 (see Errata section and 2.1) including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.333 (see section 2.3.1)
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.1.4
- NCCL 2.2.13 (optimized for NVLink™)
- Caffe2 0.8.1

Driver Requirements

Release 18.06 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- PyTorch container image version 18.06 is based on PyTorch 0.4.0 upstream master branch post commit 0e9613c.
- Improved data loader pipeline in the ImageNet example, see /opt/pytorch/examples/imagenet within the container.
- Data loader pipeline now uses pillow-simd and jpeg-turbo.
- Improved FP16 support, specifically, reductions like sum() are now more accurate when using FP16.
• Improved distributed performance, specifically, gradient communication can now overlap with gradient computation in `backwards()`.
• Compatibility changes, specifically, Magma 1 is no longer supported.
• Ubuntu 16.04 with May 2018 updates

**Known Issues**
There are no known issues in this release.
The NVIDIA container image of PyTorch, release 18.05, is available.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in `opt/pytorch`. It is pre-built and installed in the `pytorch-py3.6` Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 (see Errata section and 2.1) including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.333 (see section 2.3.1)
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.1.2
- NCCL 2.1.15 (optimized for NVLink™)
- Caffe2 0.8.1

Driver Requirements

Release 18.05 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- PyTorch container image version 18.05 is based on PyTorch 0.4.0.
- Includes Caffe2 0.8.1. For more information, see PyTorch and Caffe2 repos getting closer together.
- APEX, an extension providing utilities for FP16 and multi-gpu training. For more information, see APEX: A PyTorch Extension and APEX.
- Ubuntu 16.04 with April 2018 updates
Known Issues

- Some mixed-precision models might encounter a crash due to a new FP16 overflow check added in PyTorch. We have an upstream fix submitted with PR 7382 and should be resolved in a future container.

- There is a minor performance regression with the imagenet sample in `/opt/pytorch/examples/imagnet` for some network architectures on multi-gpu cases. This regression will be fixed in the next release.
The NVIDIA container image of PyTorch, release 18.04, is available.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in `/opt/pytorch`. It is pre-built and installed in the `pytorch-py3.6` Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 (see Errata section and 2.1) including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.333 (see section 2.3.1)
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.1.1
- NCCL 2.1.15 (optimized for NVLink™)

Driver Requirements

Release 18.04 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- PyTorch container image version 18.04 is based on PyTorch 0.3.1.
- Incorporated all upstream changes from the PyTorch master branch, specifically up to and including commit 2f27c1b5.
- Latest version of NCCL 2.1.15
- Ubuntu 16.04 with March 2018 updates
Known Issues

Some mixed-precision models might encounter a crash due to a new FP16 overflow check added in PyTorch. We have an upstream fix submitted with PR 7382 and should be resolved in a future container.
The NVIDIA container image of PyTorch, release 18.03, is available.

**Contents of PyTorch**

This container image contains the complete source of the version of PyTorch in `opt/pytorch`. It is pre-built and installed in the `pytorch-py3.6` Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 (see Errata section and 2.1) including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.333 (see section 2.3.1)
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.1.1
- NCCL 2.1.2 (optimized for NVLink™)

**Driver Requirements**

Release 18.03 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

**Key Features and Enhancements**

This PyTorch release includes the following key features and enhancements.

- PyTorch container image version 18.03 is based on PyTorch 0.3.0.
- Incorporated all upstream changes from the PyTorch master branch, specifically, PR 5327.
- Latest version of cuBLAS 9.0.333
- Latest version of cuDNN 7.1.1
- Ubuntu 16.04 with February 2018 updates
Known Issues

There are no known issues in this release.
Chapter 9.
PYTORCH RELEASE 18.02

The NVIDIA container image of PyTorch, release 18.02, is available. PyTorch container image version 18.02 is based on PyTorch 0.3.0.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py3.6 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 including:
  - CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.282 Patch 2 which is installed by default
  - cuBLAS 9.0.234 Patch 1 as a debian file. Installing Patch 1 by issuing the dpkg -i /opt/cuda-cublas-9-0_9.0.234-1_amd64.deb command is the workaround for the known issue described below.
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.5
- NCCL 2.1.2 (optimized for NVLink™)

Driver Requirements

Release 18.02 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Improved multi-GPU performance on image networks shown in /opt/pytorch/examples/imagenet. You can run this example for multi-GPU by issuing the python -m multiproc main.py command.
- Latest version of cuBLAS
- Ubuntu 16.04 with January 2018 updates

**Known Issues**

cuBLAS 9.0.282 regresses RNN seq2seq FP16 performance for a small subset of input sizes. This issue should be fixed in the next update. As a workaround, install cuBLAS 9.0.234 Patch 1 by issuing the `dpkg -i /opt/cuda-cublas-9-0_9.0.234-1_amd64.deb` command.
Chapter 10.
PYTORCH RELEASE 18.01

The NVIDIA container image of PyTorch, release 18.01, is available.
PyTorch container image version 18.01 is based on PyTorch 0.3.0.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py3.6 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04 including Python 3.6 environment
- NVIDIA CUDA 9.0.176 including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.282
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.5
- NCCL 2.1.2 (optimized for NVLink™)

Driver Requirements

Release 18.01 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Latest version of cuBLAS
- Latest version of cuDNN
- Latest version of NCCL
- Ubuntu 16.04 with December 2017 updates
Known Issues

cuBLAS 9.0.282 regresses RNN seq2seq FP16 performance for a small subset of input sizes. As a workaround, revert back to the 11.12 container.
Chapter 11.
PYTORCH RELEASE 17.12

The NVIDIA container image of PyTorch, release 17.12, is available. PyTorch container image version 17.12 is based on PyTorch 0.2.0.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py35 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA 9.0.176 including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.234
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.5
- NCCL 2.1.2 (optimized for NVLink™)

Driver Requirements

Release 17.12 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Latest version of CUDA
- Latest version of cuDNN
- Latest version of NCCL
- Ubuntu 16.04 with November 2017 updates

Known Issues

There are no known issues in this release.
Chapter 12.
PYTORCH RELEASE 17.11

The NVIDIA container image of PyTorch, release 17.11, is available. PyTorch container image version 17.11 is based on PyTorch 0.2.0.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py35 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA 9.0.176 including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) 9.0.234
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.4
- NCCL 2.1.2 (optimized for NVLink™)

Driver Requirements

Release 17.11 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Tensor Op accelerated RNNs for Volta architecture
- Improved depthwise separable convolution performance
- Improved automatic differentiation engine latency
- Latest version of CUDA
- Latest version of cuDNN
- Latest version of NCCL
- Ubuntu 16.04 with October 2017 updates
Known Issues

There are no known issues in this release.
Chapter 13.  
PYTORCH RELEASE 17.10

The NVIDIA container image of PyTorch, release 17.10, is available.

PyTorch container image version 17.10 is based on PyTorch 0.2.0.

Contents of PyTorch
This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py35 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA® 9.0
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.3
- NVIDIA® Collective Communications Library™ (NCCL) 2.0.5 (optimized for NVLink™)

Driver Requirements
Release 17.10 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements
This PyTorch release includes the following key features and enhancements.

- Latest version of CUDA
- Latest version of cuDNN
- Latest version of NCCL
- Ubuntu 16.04 with September 2017 updates

Known Issues
There are no known issues in this release.
Chapter 14.
PYTORCH RELEASE 17.09

The NVIDIA container image of PyTorch, release 17.09, is available.
PyTorch container image version 17.09 is based on PyTorch 0.2.0.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed in the pytorch-py35 Conda™ environment in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA® 9.0
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 7.0.2
- NVIDIA® Collective Communications Library™ (NCCL) 2.0.5 (optimized for NVLink™)

Driver Requirements

Release 17.09 is based on CUDA 9, which requires NVIDIA Driver release 384.xx.

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Supports Tensor Core operations for convolutions and GEMMs on Volta hardware
- The examples directory contains examples of ImageNet and LSTM training scripts that use FP16 data, as well as show how to train with FP16
- Matrix multiplication on FP16 inputs uses Tensor Core math when available
- A custom batch normalization layer is implemented to use cuDNN for batch normalization with FP16 inputs
- Latest version of CUDA
Latest version of cuDNN with support for Tensor Core math when available
Latest version of NCCL
Ubuntu 16.04 with August 2017 updates

Known Issues
There are no known issues in this release.
Chapter 15.
PYTORCH RELEASE 17.07

The NVIDIA container image of PyTorch, release 17.07, is available. PyTorch container image version 17.07 is based on PyTorch 0.1.12.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed into the /usr/local/[bin,share,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA® 8.0.61.2 including CUDA® Basic Linear Algebra Subroutines library™ (cuBLAS) Patch 2
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 6.0.21
- NVIDIA® Collective Communications Library™ (NCCL) 2.0.3 (optimized for NVLink™)

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Support for advanced tensor indexing
- Support multi-node or multi-process mode on the same node
- Support for double backward for most functions, including convolution
- Ubuntu 16.04 with June 2017 updates

Known Issues

There are no known issues in this release.
Chapter 16.
PYTORCH RELEASE 17.06

The NVIDIA container image of PyTorch, release 17.06, is available.
PyTorch container image version 17.06 is based on PyTorch 0.1.12.

Contents of PyTorch

This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed into the /usr/local/[bin,share,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA® 8.0.61
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 6.0.21
- NVIDIA® Collective Communications Library™ (NCCL) 1.6.1 (optimized for NVLink™)

Key Features and Enhancements

This PyTorch release includes the following key features and enhancements.

- Ubuntu 16.04 with May 2017 updates

Known Issues

The NCCL library version 1.6.1 included in this image, modifies the output buffers on all GPUs during in-place ncclReduce() operations, whereas normally only the "root" (target) device's output buffer should be modified. This is fixed in later versions of NCCL, as will be packaged in later versions of this image. As a workaround, either use ncclAllReduce(), which correctly modifies output buffers of all GPUs to the same values, or use out-of-place ncclReduce(), wherein the output buffer is distinct from the input buffer.
Chapter 17.
PYTORCH RELEASE 17.05

The NVIDIA container image of PyTorch, release 17.05, is available.
PyTorch container image version 17.05 is based on PyTorch 0.1.12.

Contents of PyTorch
This container image contains the complete source of the version of PyTorch in /opt/pytorch. It is pre-built and installed into the /usr/local/[bin,share,lib] directories in the container image.
The container also includes the following:

- Ubuntu 16.04
- NVIDIA CUDA® 8.0.61
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 6.0.21
- NVIDIA® Collective Communications Library™ (NCCL) 1.6.1 (optimized for NVLink™)

Key Features and Enhancements
This PyTorch release includes the following key features and enhancements.

- Latest cuDNN release
- Ubuntu 16.04 with April 2017 updates

Known Issues
The NCCL library version 1.6.1 included in this image, modifies the output buffers on all GPUs during in-place `ncclReduce()` operations, whereas normally only the "root" (target) device's output buffer should be modified. This is fixed in later versions of NCCL, as will be packaged in later versions of this image. As a workaround, either use `ncclAllReduce()`, which correctly modifies output buffers of all GPUs to the same
values, or use out-of-place `ncclReduce()`, wherein the output buffer is distinct from the input buffer.
The NVIDIA container image of PyTorch, release 17.04, is available.
PyTorch container image version 17.04 is based on PyTorch 0.1.10.

Contents of PyTorch
This container image contains the complete source of the version of PyTorch in `/opt/pytorch`. It is pre-built and installed into the `/usr/local/[bin,share,lib]` directories in the container image.

The container also includes the following:
- Ubuntu 16.04
- NVIDIA CUDA® 8.0.61
- NVIDIA CUDA® Deep Neural Network library™ (cuDNN) 6.0.20
- NVIDIA® Collective Communications Library™ (NCCL) 1.6.1 (optimized for NVLink™)

Key Features and Enhancements
This PyTorch release includes the following key features and enhancements.
- Reduce DataParallel overhead on more than 4 GPUs
- cuDNN v6 integration
- Synced to upstream PyTorch version as of March 2017
- Ubuntu 16.04 with March 2017 updates

Known Issues
There are no known issues in this release.
Notice

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