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Chapter 1.
CAFFE2 OVERVIEW

The NVIDIA Deep Learning SDK accelerates widely-used deep learning frameworks such as Caffe\textsuperscript{2}™.

Caffe2 is a deep-learning framework designed to easily express all model types, for example, convolutional neural networks (CNNs), recurrent neural networks (RNNs), and more, in a friendly Python-based API, and execute them using a highly efficiently C++ and CUDA\textsuperscript{®} backend.

Caffe2 includes a flexible API that lets users define models for inference or training using expressive, high-level operations. The Python interface allows easy control and visualization of the inference or training process.

Caffe2 supports single and multi-GPU execution, along with support for multi-node execution.

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 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/caffe2:18.05-py<x>
   ```

   Where `<x>` is the version of Python you want to pull.

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. A typical command to launch the container is:

   ```
   nvidia-docker run -it --rm --v local_dir:container_dir nvcr.io/nvidia/caffe2:<xx.xx>
   ```

   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.

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

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

   - `<xx.xx>` is the tag. For example, 18.01.
You might want to pull in data and model descriptions from locations outside the container for use by Caffe2™ 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.

In order to share data between ranks, NVIDIA® Collective Communications Library™ (NCCL) may require shared system memory for IPC and pinned (page-locked) system memory resources. The operating system’s limits on these resources may need to be increased accordingly. Refer to your system’s documentation for details.

In particular, Docker containers default to limited shared and pinned memory resources. When using NCCL inside a container, it is recommended that you increase these resources by issuing:

```
--shm-size=1g --ulimit memlock=-1
```

in the command line to

```
nvidia-docker run
```

4. See `/workspace/README.md` inside the container for information on customizing your Caffe2 image.

For more information about Caffe2, including tutorials, documentation, and examples, see:

- Caffe2 tutorials
- Caffe2 project
Chapter 4. CAFFE2 RELEASE 18.05

The NVIDIA container image of Caffe2, release 18.05, is available.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04

  Container image 18.05–py2 contains Python 2.7; 18.05–py3 contains Python 3.5.

- 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Caffe2 container image version 18.05 is based on Caffe2 0.8.1.
- No new upstream changes in Caffe2 for April
- Ubuntu 16.04 with April 2018 updates
Announcements

Starting with the next major version of CUDA release, we will no longer provide Python 2 containers and will only maintain Python 3 containers.

Caffe2 is now merged into PyTorch. Due to lack of upstream changes in the separate Caffe2 container and merges into a separate repository with PyTorch, we will discontinue updates at the next version of CUDA. Until we discontinue, we will continue to update NVIDIA libraries and base OS updates.

Known Issues

There are no known issues in this release.
Chapter 5. CAFFE2 RELEASE 18.04

The NVIDIA container image of Caffe2, release 18.04, is available.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04

  Container image 18.04-py2 contains Python 2.7; 18.04-py3 contains Python 3.5.

- 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Caffe2 container image version 18.04 is based on Caffe2 0.8.1.
- Fixed a bug in nvidia-examples/seq2seq that was reported in the 18.03 Release Notes. This bug caused executing the wrong number of iterations or epochs when loading snapshots.
‣ Caffe2 runtime binary compiled with NVTX support.
‣ Support NVTX ranges for CPU operators (GPU operators were already supported).
‣ Latest version of NCCL 2.1.15
‣ Ubuntu 16.04 with March 2018 updates

**Announcements**

Starting with the next major version of CUDA release, we will no longer provide Python 2 containers and will only maintain Python 3 containers.

**Known Issues**

There are no known issues in this release.
Chapter 6.
CAFFE2 RELEASE 18.03

The NVIDIA container image of Caffe2, release 18.03, is available.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04
- 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Caffe2 container image version 18.03 is based on Caffe2 0.8.1.
- When using ImageNet training scripts in nvidia-examples on multiple GPUs, the printed metrics in the log for weak scaling was wrong. Also, the number of epochs the model is trained for was wrong. Both of these issues are fixed in the this release.
Gradient clipping used to be done by executing a series of small operators that compute a ratio by which the learning rate gets scaled, which has the same effect as gradient clipping for SGD optimizers. However, that method is wrong with optimizers that use momentum or history such as AdaGrad and Adam. In this release, we added a new operator `ClipByGlobalNorm` that explicitly clips the gradient. This operator also supports mixed precision for inputs and outputs.

Caffe2 already supported cuDNN RNN, however that integration does not provide enough features and flexibility to use cuDNN RNN in seq2seq. We improved this integration and also enabled using cuDNN RNN in the seq2seq example in `nvidia-examples`.

Incorporated GitHub Caffe2 code as of February 16, 2018.

- Latest version of cuBLAS 9.0.333
- Latest version of cuDNN 7.1.1
- Ubuntu 16.04 with February 2018 updates

**Announcements**

Starting with the next major version of CUDA release, we will no longer provide Python 2 containers and will only maintain Python 3 containers.

**Known Issues**

In `nvidia-examples/seq2seq`, there is a bug that causes training to skip one epoch in case of loading a snapshot. This bug will be fixed in 18.04.
Chapter 7. 
CAFFE2 RELEASE 18.02

The NVIDIA container image of Caffe2, release 18.02, is available.

Caffe2 container image version 18.02 is based on Caffe2 0.8.1.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries, lib] directories 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) 9.0.282 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™)
  - OpenMPI™ 1.10.3

Driver Requirements

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

This Caffe2 release includes the following key features and enhancements.

- Enhanced debug mode in `nvidia-examples/seq2seq`
- Added `nvidia-examples/onnx-inference` for testing ONNX
- Enabled FP16 in `TransposeOp` that uses cuDNN
- 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 8.
CAFFE2 RELEASE 18.01

The NVIDIA container image of Caffe2, release 18.01, is available.
Caffe2 container image version 18.01 is based on Caffe2 0.8.1.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories in the container image.

The container also includes the following:

- Ubuntu 16.04
- Container image 18.01–py2 contains Python 2.7; 18.01–py3 contains Python 3.5.
- 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Addition of Python 3 container
- Addition of ONNX package for inference
- FP16 and Tensor Core support for RNNs
- 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.
The NVIDIA container image of Caffe2, release 17.12, is available. Caffe2 container image version 17.12 is based on Caffe2 0.8.1.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 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.
The NVIDIA container image of Caffe2, release 17.11, is available.

Caffe2 container image version 17.11 is based on Caffe2 0.8.1.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in `/opt/caffe2`. It is pre-built and installed into the `/opt/caffe2/[binaries,lib]` directories 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™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Reworked mixed precision optimizers and fused mixed precision-aware optimization operators
- 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 11.
CAFFE2 RELEASE 17.10

The NVIDIA container image of Caffe2, release 17.10, is available. Caffe2 container image version 17.10 is based on Caffe2 0.8.1.

Contents of Caffe2
This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories 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
- NCCL 2.0.5 (optimized for NVLink™)
- OpenMPI™ 1.10.3

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

Key Features and Enhancements
This Caffe2 release includes the following key features and enhancements.

- Improved data pipeline using libturbojpeg for faster JPEG decoding
- Enhanced and fixed bugs in nvidia-examples/seq2seq
- Added GradientSlice support to MultiPrecisionSGD
- Added FP16 support to gradient clipping
- 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.
The NVIDIA container image of Caffe2, release 17.09, is available.

Caffe2 container image version 17.09 is based on Caffe2 0.8.1.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,lib] directories 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
- NCCL 2.0.5 (optimized for NVLink™)
- OpenMPI™ 1.10.3

Driver Requirements

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

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Support Tensor Core Operations for Volta
- Improved the ImageNet training script in nvidia-examples
- Data input pipeline improvements - use of libturbojpeg directly for JPEG decode, and resize work-saving improvements.
- Improved the sequence-to-sequence (seq2seq) example in caffe2/python/models/seq2seq
- Added FP16 support for RNNs via the updated seq2seq example
Latest version of CUDA
Latest version of cuDNN
Latest version of NCCL
Ubuntu 16.04 with August 2017 updates

Known Issues

There are no known issues in this release.
Chapter 13.
CAFFE2 RELEASE 17.07

The NVIDIA container image of Caffe2, release 17.07, is available.
Caffe2 container image version 17.07 is based on Caffe2 0.7.0.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,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
- NCCL 2.0.3 (optimized for NVLink™)
- OpenMPI™ 1.10.3

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Updated version of the imagenet script in the nvidia-examples directory.
- Ubuntu 16.04 with June 2017 updates

Known Issues

You may come across unexpected behavior, including a runtime cash, when using the predictor_exporter.py script to save or load models or checkpoints. However, in this release, there may be cases where the script can save or load a model incorrectly. The imagenet script at nvidia-examples/imagenet/train.py uses the predictor_exporter.py script, therefore, when using the imagenet script, you
may come across unexpected behavior. Alternatively, use the `SaveOp` and `LoadOp` operations, with the correct argument, to save and load the models and checkpoints.
Chapter 14. CAFFE2 RELEASE 17.06

The NVIDIA container image of Caffe2, release 17.06, is available. Caffe2 container image version 17.06 is based on Caffe2 0.7.0.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries, 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
- NCCL 1.6.1 (optimized for NVLink™)
- OpenMPI™ 1.10.3

Key Features and Enhancements

This Caffe2 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.
In some cases, the use of GPU transforms in the `ImageInput` operator can cause out-of-bound memory accesses. To avoid this, set `use_gpu_transform=False` in the `ImageInput` operator of your network definition.
Chapter 15. CAFFE2 RELEASE 17.05

The NVIDIA container image of Caffe2, release 17.05, is available.

Caffe2 container image version 17.05 is based on Caffe2 0.5.0+.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in /opt/caffe2. It is pre-built and installed into the /opt/caffe2/[binaries,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
- NCCL 1.6.1 (optimized for NVLink™)
- OpenMPI™ 1.10.3

Key Features and Enhancements

This Caffe2 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.
Chapter 16.
CAFFE2 RELEASE 17.04

The NVIDIA container image of Caffe2, release 17.04, is available. Caffe2 container image version 17.04 is based on Caffe2 0.5.0+.

Contents of Caffe2

This container image contains the complete source of the version of Caffe2 in \opt\caffe2. It is pre-built and installed into the \opt\caffe2\[binaries,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
- NCCL 1.6.1 (optimized for NVLink™)
- OpenMPI™ 1.10.3

Key Features and Enhancements

This Caffe2 release includes the following key features and enhancements.

- Examples that support multi-GPU using NCCL for computer vision, such as, image classification, segmentation, and more:
  - MNIST, CIFAR-10, and IMAGENET datasets

IMAGENET is the dataset on which neural networks, such as, AlexNet, VGG, OverFeat, ResNet, and Inception are trained on. These neural networks are comprised of different depths and complexities.

The complete list of examples are in the /workspace/nvidia-examples directory.
Ubuntu 16.04 with March 2017 updates

**Known Issues**

There are no known issues in this release.
Notice

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