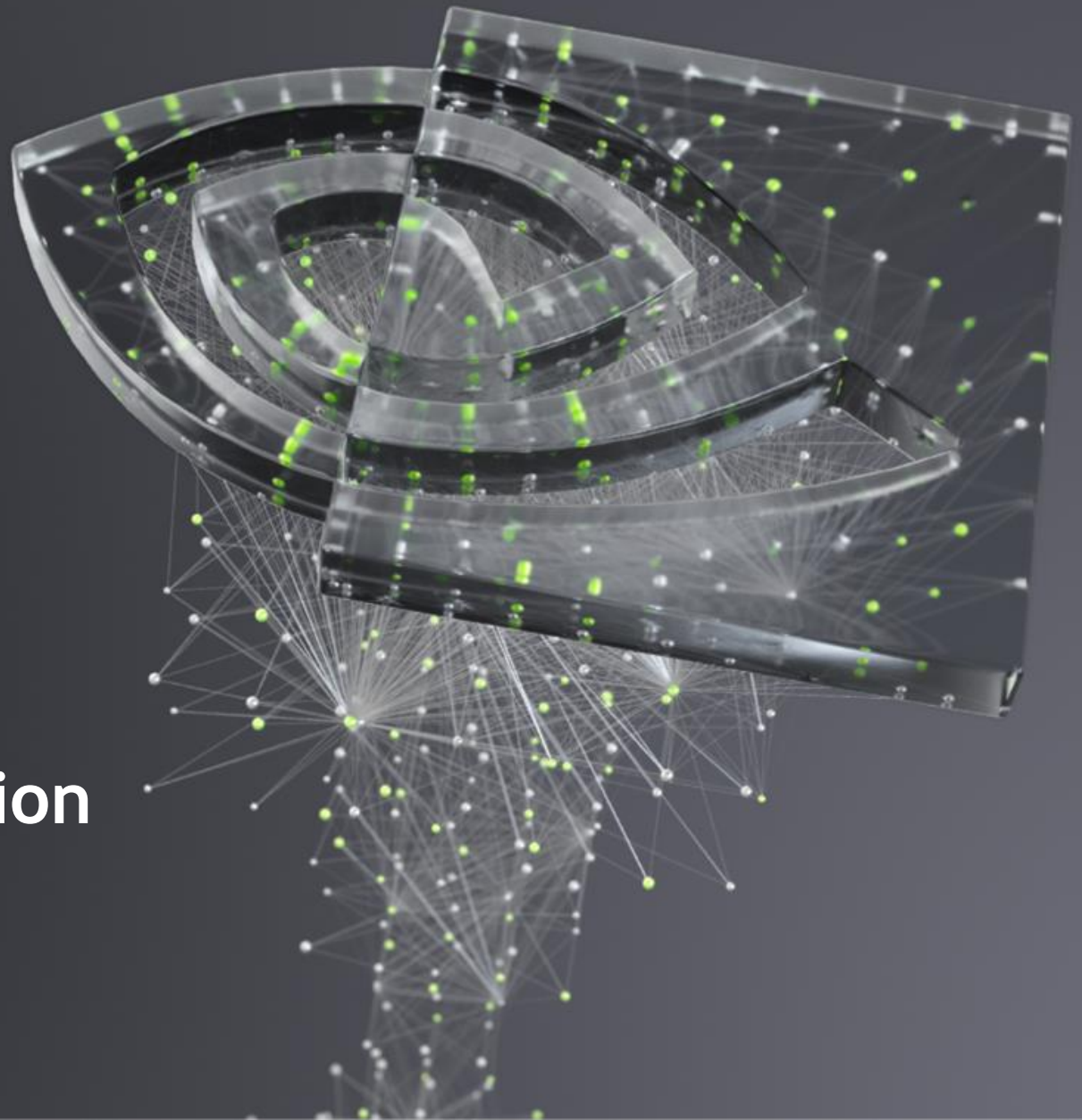


Train Faster: A Guide to Tensorflow Performance Optimization

Shriya Balaji Palsamudram, 04-12-2021

INTRODUCTION

Is optimization worth your time?

- Utilize resources optimally
- Get results faster
- Apply simple strategies to most models
- Add very few lines of code

Automatic Mixed Precision

Do we really need FP32 everywhere?

- Uses lower precision (e.g. FP16) where applicable (e.g. convolutions, matrix multiplies)
- Keeps certain operations in FP32
- Achieves the same accuracy as FP32 training using all the same hyper-parameters
- Reduces memory requirements
- Accelerates memory-intensive operations

Code Snippets

TF 1.x

```
opt = tf.train.experimental.enable_mixed_precision_graph_rewrite(opt)
```

TF 2.x

```
policy = tf.keras.mixed_precision.Policy('mixed_float16')
tf.keras.mixed_precision.set_policy(policy)
```

use mixed_bfloat16 when training with TPUs

NHWC

Which is the faster data format?

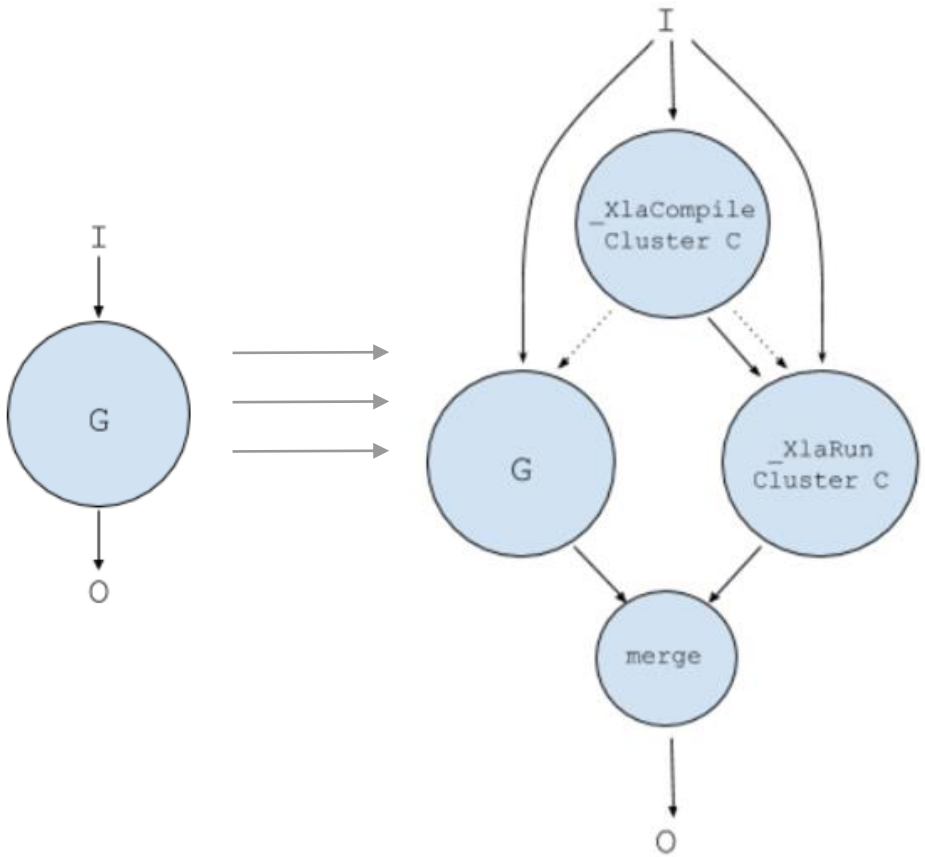
NCHW vs NHWC

- Are you using AMP?
- Do you have convolutions in your model?
- Do you want to improve your tensor core utilization?
- Do you want to eliminate unnecessary data layout transposes?

```
tf.keras.layers.Conv2D(...,data_format="channels_last")
```

Auto-clustering

Why run only one node at a time?



Use XLA to fuse kernels!

```
TF_XLA_FLAGS=--tf_xla_auto_jit=<level>
```

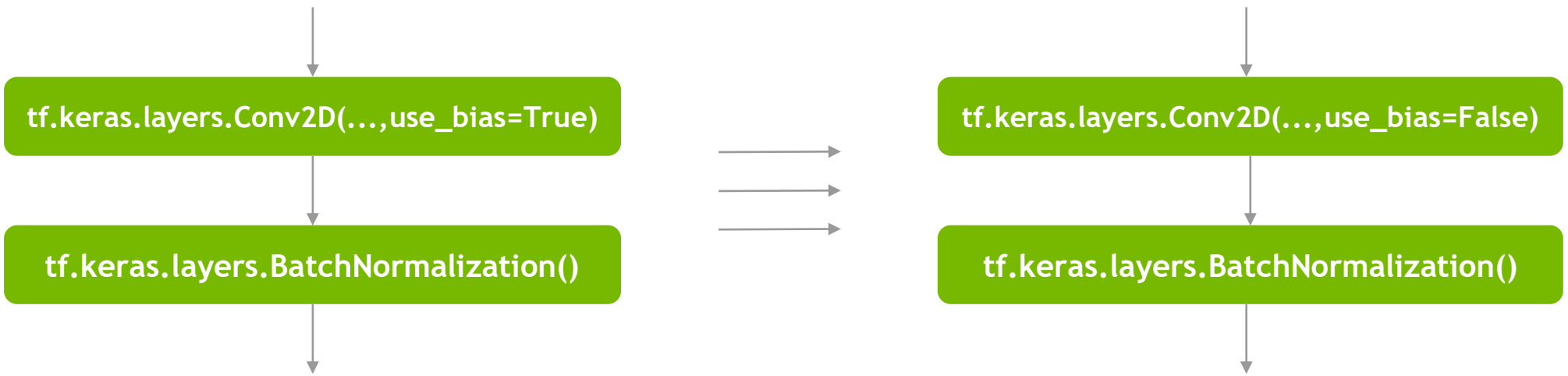
- Levels: -1 (disable), 1, 2
- Higher level = XLA is more aggressive

Note: XLA does not perform well for models with dynamic shapes (example: transformer) as XLA would have to compile a new kernel for every shape

More information: XLA Best practices

Bias

Why add bias when you do not need it?



Batch norm basically shifts the values by their mean and this shift removes the need to have a constant bias term

Batch Size

Why not utilize your resources well?

Training Efficient-Det D0 on a Tesla V100 32GB machine	Case #1	Case #2	Case #3
Batch size	1	16	64
Training speed (frames per second)	2 FPS	22 FPS	70 FPS
Training time for 1 coco epoch	**16 hours**	**1.5 hours**	**28 mins**

Note: Increasing batch size will change the model's accuracy so the model needs to be scaled by tuning hyper parameters like learning rate, etc to meet the target accuracy.

Use nvidia-smi query to investigate memory utilization

```
nvidia-smi --query-gpu=utilization.memory,memory.total,memory.free,memory.used --format=csv
```

Threading

Why not use threads to improve performance?

Intra-op: Multiple threads → One operation

Inter-op: Independent operations → Run concurrently

Note: These threads depend on the number of CPU threads available

GPU Thread mode: Reduces kernel launch time during training

GPU Thread count: # Threads per GPU

Code Snippets

Parallel Threads

```
import multiprocessing
config.intra_op_parallelism_threads = 1
config.inter_op_parallelism_threads = max(2,(multiprocessing.cpu_count() // hvd.size()) - 2)
```

GPU Threads

```
TF_GPU_THREAD_MODE=gpu_private
TF_GPU_THREAD_COUNT=1
```

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

Use tf.data API !!!!!

Note: Benchmark only the data loader without the training and backpropagation steps to quantify the effect of the optimizations independently

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

tf.data.Dataset.interleave

Read TFRecords in parallel

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

num_parallel_calls=tf.data.experimental.AUTOTUNE

Run operations in parallel

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

dataset.shard()

Shard very early on

(While listing TFrecords)

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

dataset.prefetch(batch_size)

Prefetch right before returning the dataset

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

dataset.cache()

Only if the entire dataset can fit in memory

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

tf.data.Options()

```
options = tf.data.Options()
options.experimental_optimization.map_vectorization.enabled = True
options.experimental_optimization.map_parallelization = True
options.experimental_optimization.parallel_batch = True
```

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

Do not use this!

from_generator()

Use TF operations instead to get better performance

Data Pipeline Optimization

Why not demystify the biggest bottleneck?

Do not use this!

py_func()

It cannot be serialized

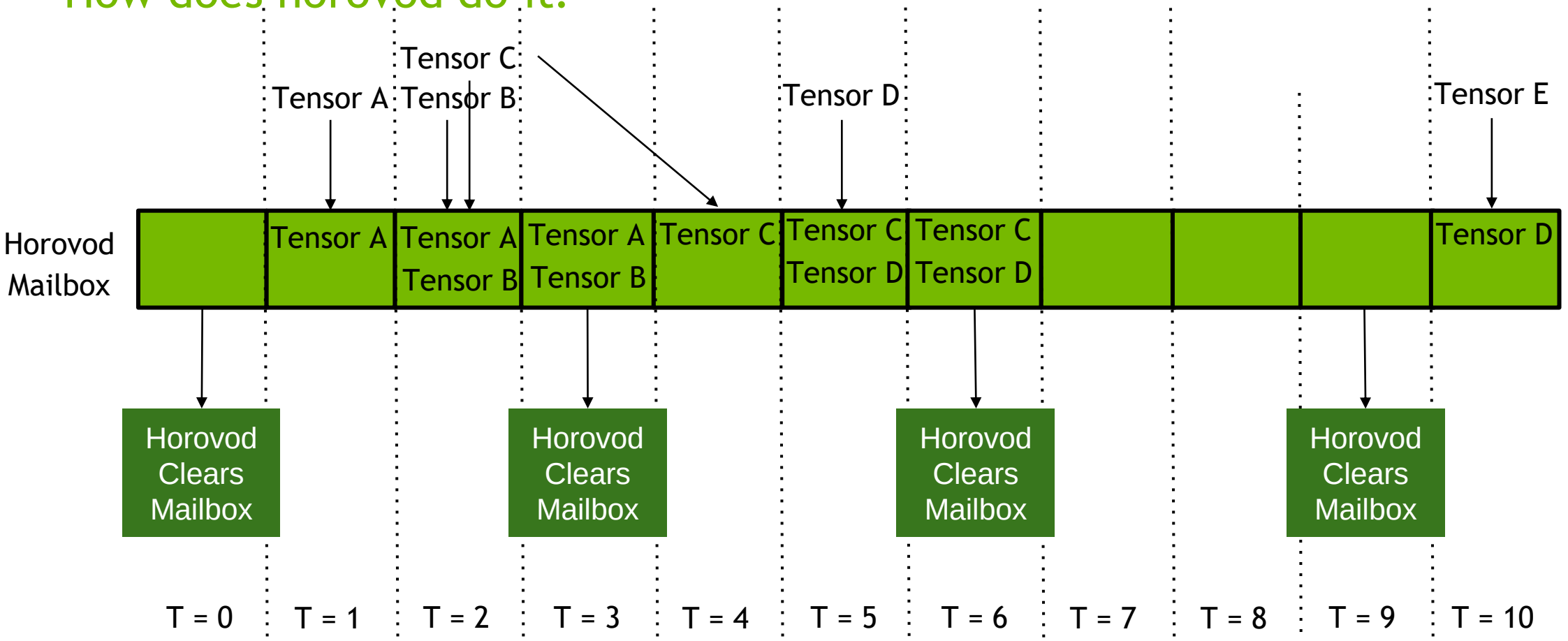
Horovod

Why not make distributed training simple?

- Scale models easily
- Very few code changes
- Uses MPI model
- Its fast!

Understanding Horovod

How does horovod do it?



Horovod Flags

How to get boost in performance?

HOROVOD_CYCLE_TIME

Set based on complexity of the model and training step duration

Horovod Flags

How to get boost in performance?

HOROVOD_TENSOR_THRESHOLD_FUSION

Buffer size to reduce multiple tensors

Horovod Flags

How to get boost in performance?

HOROVOD_AUTOTUNE

Let horovod find the best values based on your model

Note: Do not enable autotuning in production code as it affects the performance

Horovod Tensors

How to avoid time spent on transformation?

Convert sparse tensors to dense before allreduce

```
optimizer = hvd.DistributedOptimizer(optimizer, sparse_as_dense=True)
```

Summary

Or is it the introduction again?

- Get results faster
- Utilize resources optimally
- Apply simple strategies to all models
- Add very few lines of code

Further Information

What next?

https://www.tensorflow.org

Further Information

What next?

PyTorch Performance Tuning Guide [S31831]

Algorithmic and Software Techniques to Optimize BERT Training and Inference [S31140]

Profiling and Optimizing Deep Neural Networks with DLProf and PyProf [S31341]

Deep Learning Performance Optimization with Profiling Tools [S31228]

Fast, Accurate, Scalable: Building a Benchmark to Test Neural Time Series Models [S31950]

Segmenting 3D Medical Images with nnU-Net and DGX A100, Using Tensor Cores [S31315]


Thank You