TENSORFLOW AMPERE® OPTIMIZED FRAMEWORK Documentation

v.1.3.1

AMPERE COMPUTING

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RELEASE NOTES

V1.3.1:

- Updated to use Ampere Optimized Deep Learning Stack 0.4.0
- Bug Fixes

V1.2.0:

- TensorFlow framework updated to 2.7.1 from 2.7.0
- Updated to use Ampere Optimized Deep Learning Stack 0.3.0
    - Misc models speed up like BERT and UNET
    - New Ops: Expand dims
- If TF intra_op is 0, set Ampere Optimized TensorFlow num threads to 1

V1.1.0

- TensorFlow framework is updated to 2.7.0 from 2.4.1.
- Updated to use Ampere Optimized Deep Learning Stack 0.2.1
- AIO_NUM_THREADS no longer needed to set Ampere Optimized TensorFlow threads, inherits TensorFlow intra-op thread count.

OVERVIEW

Ampere Optimized TensorFlow inference acceleration engine is fully integrated with the TensorFlow framework. TensorFlow models and software written with the TensorFlow API can run as-is, without modifications.

TENSORFLOW FRAMEWORK

Python is installed with Ampere Optimized TensorFlow and all dependencies. No additional installation steps are needed.

Versions Compatibility

This release is based on TensorFlow 2.7.1. Refer to TensorFlow version compatibility documentation, found at https://www.tensorflow.org/guide/versions, to check the compatibility of models built with older versions of TensorFlow.

PYTHON

TensorFlow 2.7.1 is built for Python 3.8. Regarding other Python versions, contact your Ampere sales representative. If you are using the software through a third party, contact their customer support team for help. You can also contact the Ampere AI team at ai-support@amperecomputing.com.

CONFIGURATIONS

Ampere Optimized TensorFlow inference engine can be configured by a set of environment variables for performance and debugging purposes. They can be set in the command line when running TensorFlow models (e.g., AIO_NUM_THREADS=16 python run_tf_resnet50.py) or set in the shell initialization script.

AIO_PROCESS_MODE

This variable controls if Ampere Optimized TensorFlow inference engine is used in running the TensorFlow model.

- 0: disabled
- 1: enabled (Default)

AIO_CPU_BIND

Enables core binding. If enabled, each Ampere Optimized TensorFlow thread will bind itself to a single core.

- 0: Core binding disabled
- 1: Core binding enabled (Default)

AIO_MEM_BIND

Bind memory to NUMA (Non-uniform memory access) node 0. For optimal performance, numactl (https://linux.die.net/man/8/numactl) is preferred. numactl bind will affect both the Tensorflow framework and the optimized framework buffers, while the optimized framework is unable to affect buffers allocated by the TensorFlow framework.

- 0: Membind disabled
- 1: Membind to node 0 (Default)

AIO_NUMA_CPUS

Select cores that Ampere Optimized TensorFlow should bind to (if CPU_BIND is enabled).

- Not set: use the first N cores of the machine, excluding hyper-threaded machines (Default)
- Set: try to use N first cores from the list of cores for N threads. The list is in space-separated, 0-based number format. For example, selecting cores 0 to 1: AIO_NUMA_CPUS="0 1"

AIO_DEBUG_MODE

Control verbosity of debug messages.

- 0: No messages
- 1: Errors only
- 2: Basic information, warnings, and errors (Default)
- 3: Most messages
- 4: All messages

QUICKSTART

The following instructions run on Altra/Altra Max Linux machines installed **with Docker**. To initialize Ampere Optimized TensorFlow environment run:

```
$ wget -O aio-tf.tar.gz "<your_unique_url>"
$ docker load < aio-tf.tar.gz
$ docker run --privileged=true --rm --name tf-aio --network host -it aio-tf-2.7.1:1.3.0
```

Skip the above steps if running **without a Docker** container.

You can try Ampere Optimized TensorFlow by either running the Jupyter Notebook examples or Python scripts on the CLI level.

To run the Jupyter Notebook QuickStart examples follow the instructions below:

Set AIO_NUM_THREADS to the requested value first.

```
$ export AIO_NUM_THREADS=16; export OMP_NUM_THREADS=16
$ cd /workspace/aio-examples/
$ bash download_models.sh
$ bash start_notebook.sh
```

If you run the Jupyter Notebook QuickStart on a cloud instance, make sure your machine has port 8080 open and on your local device run:

```
$ ssh -N -L 8080:localhost:8080 -I <ssh_key> your_user@xxx.xxx.xxx.xxx
```

Use a browser to point to the URL printed out by the Jupyter Notebook launcher.

You will find the Jupyter Notebook examples (examples.ipynb) under the */classification* and */object* detection folders.

The examples run through several inference models, visualize results they produce and present the performance numbers.

To use CLI-level scripts:

Set AIO_NUM_THREADS to the requested value first.

```
$ export AIO_NUM_THREADS=16; export OMP_NUM_THREADS=16
$ cd /workspace/aio-examples/
$ bash download_models.sh
```

Go to the directory of choice, e.g.

```
$ cd classification/resnet_50_v15
```

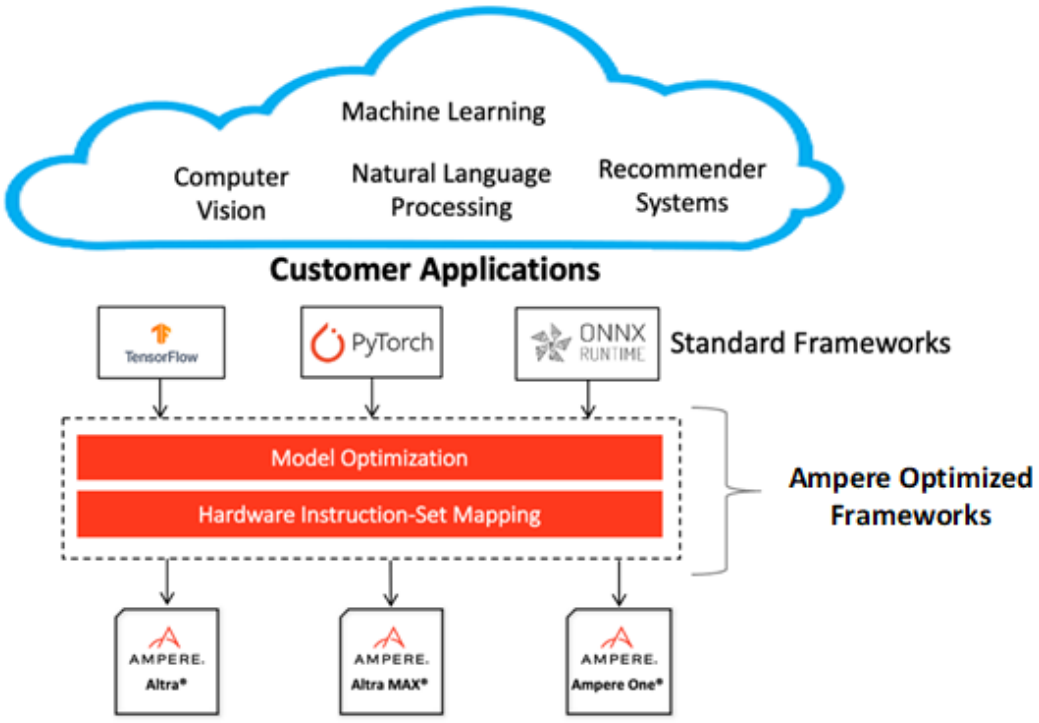
Evaluate the model.

```
$ python3 run.py -m resnet_50_v15_tf_fp32.pb -p fp32
$ python3 run.py -m resnet_50_v15_tflite_int8.tflite -p int8
```

AMPERE OPTIMIZED FRAMEWORKS PROGRAMMING GUIDE

Overview

Ampere Optimized TensorFlow is powered by Ampere® AI backend which accelerates Deep Learning (DL) operations on the Ampere® Altra family of processors. Ampere Optimized Frameworks accelerate DL operations through model optimization, highly vectorized compute kernels and multi-thread operations that are automatically tuned to deliver the best latency and throughput on Ampere Altra processors. It delivers 2-5x gains over alternative backend solutions.



Supported Inference Ops

Ampere Optimized Tensorflow accelerates most common Tensorflow ops that are used in various types of models. Here is a list of accelerated ops and formats (Note: non-accelerated ops will still run without a problem, at the original framework operator speed):

	FP32	FP16	Remarks
Conv2D	Y	Y	
Conv3D	Y	N	NDHWC only
_FusedConv2D	Y	Y	
FusedBatchNorm	Y	N	NHWC only
FusedBatchNormV2	Y	N	
FusedBatchNormV3	Y	N	
MaxPool	Y	Y	NHWC only 2D Max Pooling only
AvgPool	Y	Y	NHWC only 2D Average Pooling only
MatMul	Y	Y	transpose_a == 0 only
_FusedMatMul	Y	Y	transpose_a == 0 only
BatchMatMul	Y	Y	adj_x == 0 only
BatchMatMulV2	Y	Y	adj_x == 0 only
Mean	Y	Y	
Mul	Y	Y	
Add	Y	Y	
AddV2	Y	Y	
BiasAdd	Y	Y	
Sub	Y	Y	
Pow	Y	Y	
Div	Y	Y	
RealDiv	Y	Y	
Tanh	Y	Y	
Sqrt	Y	Y	
Square	Y	Y	
Rsqrt	Y	Y	
SquaredDifference	Y	Y	
Relu	Y	Y	
Relu6	Y	Y	
LeakyRelu	Y	Y	
Softmax	Y	Y	
AddN	Y	Y	
Pad	Y	Y	
Concat	Y	Y	axis_constant only
ConcatV2	Y	Y	axis constant only

Gather	Y	N	indices int32 only axis constant only
GatherV2	Y	N	indices int32 only axis constant only batch_dim = 0 only
StridedSlice	Y	N	index int32 only begin_mask and end_mask only
Squeeze	Y	Y	
DepthwiseConv2dNative	Y	Y	
Reshape	Y	Y	
ExpandDims	Y	Y	
Transpose	Y	Y	perm constant only
Erf	Y	Y	
SplitV	Y	Y	axis constant only
Conv3dBackpropInputV2	Y	N	NDHWC only

Ampere AI continues to expand the coverage of TensorFlow ops. If your model has any op that is not listed in the table or custom ops that need acceleration, please contact ai-support@amperecomputing.com.

Ampere Optimized TensorFlow also supports acceleration of TensorFlow Lite int8 models. Please contact us for information about TensorFlow Lite model support.

TensorFlow Eager Execution and Graph Execution

While TensorFlow Eager Execution provides excellent model building, programming, and debugging experience, it is slower than graph execution. So, graph execution is typically used for inference deployment. In current version Ampere Optimized TensorFlow only accelerates Graph Execution mode.

After building your model in Eager mode, you can use tf.function() to compile you eager function into callable graph. More details can be found in TensorFlow documentation at: https://www.tensorflow.org/api_docs/python/tf/function.

Ampere model library also provides some sample code in how to run eager model efficiently, access AML at:
https://github.com/AmpereComputingAI/ampere_model_library/blob/main/natural_language_processing/extractive_question_answering/electra_large/run.py.

Threading

Ampere Optimized TensorFlow controls the number of intra_op threads of Ampere Optimized Tensofrlow with tensorflow.config.threading.set_intra_op_parallelism_threads() (Or in the case of TF v1 session, set config.intra_op_parallelism_threads). This controls both the number of threads used for ops delegated to Ampere Optimized Tensorflow as well as the ops running on default CPU backend.

Some default CPU backend ops (non-AIO) also need to set OMP_NUM_THREADS environment variable to control the intra_op threads.

Programming Tips

- In the first inference pass, Ampere Optimized Tensorflow performs runtime compilation of TF graphs. So, the latency of the first pass is expected to be longer. Subsequent passes will be accelerated.
- Frozen TF models will provide slightly better performance. Please see TF documentations in how to generate frozen graphs.
- Ampere Optimized TensorFlow provides much better latency scaling as core count increase, comparing to other platforms. You can easily try the optimal number of cores with the above intra_op_parallelism_threads configurations that can give you the best performance/$, while meeting your latency requirements.
- If any issues occur, Ampere AI team is ready to help. Typically, the first step is to get more debug logs and send it to ai-support@amperecomputing.com. Please set environment variable AIO_DEBUG_MODE=5 to capture low level logs.

We can also provide more in-depth profiling of your model to help enhancing performance to meet your needs.

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