# TensorFlowOnACL

User Manual

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OPEN AI LAB

# Reversion Record

| Date | Rev | Change Description | Author |
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| 2017-12-25 | 0.1.0 | Initial | Yuming Cheng<br>Yu Wang |
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# catalog

# 1 Purpose

This guide help developers to use the code of TensorFlowOnACL (TensorFlow+ACL) to improve the performance of their applications based on the TensorFlow framework.

# 2 Terminology

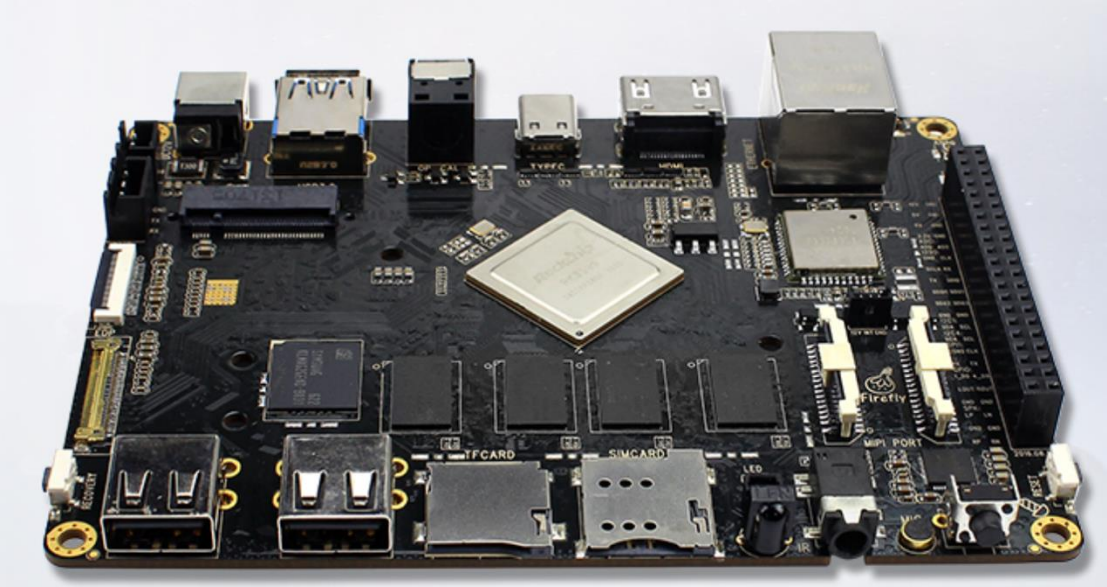
- **ACL:** Arm Compute Library
- **TensorFlow**: A deep learning library or framework.
- **TensorFlowOnACL:** optimized Tensorflow on Arm platform with ACL.
- **ACL/GPU**: In the below tables, it is specialized to mean using GPU by Arm Compute Library to test. (Mali: GPU from Arm)
- **ACL/Neon**: In the below tables, it is specialized to mean using Neon by Arm Compute Library to test. (Neon: ARM coprocessor supporting SIMD)
- **NCHW, NHWC**: Tensor format for input/output activations used in convolution operations.
  The mnemonics specify the meaning of each tensor dimension sorted from largest to smallest memory stride. N = Batch, H = Image Height, W = Image Width, C = Number of Channels. NHWC is the default format in TensorFlow. NCHW often improves performance on GPUs.
- **OIHW, HWIO**: Tensor format for convolutional filters. The mnemonics specify the meaning of each tensor dimension sorted from largest to smallest memory stride. H = Kernel Height, W = Kernel Width, I = Input Channels, O = Output Channels. HWIO is the default filter format in TensorFlow. OIHW often improves performance on GPUs.
- **1st :** The first test loop**;** In the test applications ”classification_profiling” and “classification_ profiling_gpu” include all the process
- **2nd~11th :** the 2nd to 11th test loops, unlike the first test loop, aren’t guaranteed to use all the allocation and config processes.
- TPI : The total time for per inference

# 3 Environment

## 3.1 Hardware Platform

SoC : Rockchip RK3399

- GPU : Mali T864 (800MHz)
- CPU : Dual-core Cortex-A72 up to 2.0GHz (real frequency is 1.8GHz); Quad-core Cortex-A53 up to 1.5GHz (real frequency is 1.4GHz)




## 3.2 Software platform

Operating System : Ubuntu 16.04

# 4 Install Guide

## 4.1 Download code

```
git clone https://github.com/ARM-software/ComputeLibrary.git
git clone https://github.com/OAID/TensorflowOnACL.git
```

## 4.2 Compiled Environment Prepared

### 4.2.1 Setup build server

1. Update build server to add arm64 architecture and backup apt sources.list.

```
sudo dpkg --add-architecture arm64
sudo mv  /etc/apt/sources.list  /etc/apt/sources.list.bak
```

2. create file tsinghua.list in /etc/apt/sources.list.d/ with following content.

```
deb [arch=amd64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ xenial main restricted
```

```
universe multiverse
    deb [arch=amd64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ xenial-updates main
restricted universe multiverse
    deb [arch=amd64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ xenial-security main
restricted universe multiverse
    deb [arch=amd64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ xenial-backports main
restricted universe multiverse

    deb [arch=arm64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu-ports/ xenial main restricted
universe multiverse
    deb [arch=arm64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu-ports/ xenial-updates main
restricted universe multiverse
    deb [arch=arm64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu-ports/ xenial-security main
restricted universe multiverse
    deb [arch=arm64] https://mirrors.tuna.tsinghua.edu.cn/ubuntu-ports/ xenial-backports main
restricted universe multiverse
```

### 4.2.2 Install crossbuild tools

```
    sudo apt-get update
    sudo apt-get install gcc-aarch64-linux-gnu g++-aarch64-linux-gnu scons rsync
    sudo apt-get install python-numpy python-dev python-pip python-wheel
    sudo apt-get install libpython2.7-dev:arm64
```

### 4.2.3 Install bazel (release 0.7.0 or above)

Tensorflow uses bazel to build. If bazel is not installed on your system, install it now by following guide at https://docs.bazel.build/versions/master/install.html.

### 4.2.4 Setup RK3399 device

```
    sudo apt-get update
    sudo apt-get install rsync
    sudo apt-get install python-numpy python-dev python-pip python-wheel
    sudo pip install pip enum34 mock
```

## 4.2.5 Compile ACL on build server

```
cd ~/project/ComputeLibrary
mkdir build
aarch64-linux-gnu-gcc opencl-1.2-stubs/opencl_stubs.c -Iinclude -shared -o build/libOpenCL.so
scons Werror=1 -j8 debug=0 asserts=1 neon=1 opencl=1 embed_kernels=1 os=linux arch=arm64-v8a
```

## 4.2.6 Compile Tensorflow Example

1. Update cross build setting for ACL
   Modify following 3 lines in “TensorflowOnAcl/tools/aarch64_compiler/CROSSTOOL” to ACL path in build server.
   35: linker_flag: "-L/home/cym/project/ComputeLibrary/build"
   36: linker_flag: "-L/home/cym/project/ComputeLibrary/build/opencl-1.2-stubs/"
   44: cxx_builtin_include_directory: "/home/cym/project/ComputeLibrary"
2. Run Tensorflow configure

```
cd ~/project/TensorflowOnAcl
./configure
WARNING: Running Bazel server needs to be killed, because the startup options are different.
You have bazel 0.7.0 installed.
Please specify the location of python. [Default is /usr/bin/python]:


Found possible Python library paths:
  /usr/local/lib/python2.7/dist-packages
  /usr/lib/python2.7/dist-packages
Please input the desired Python library path to use.  Default is [/usr/local/lib/python2.7/dist-packages]

Do you wish to build TensorFlow with jemalloc as malloc support? [Y/n]:
jemalloc as malloc support will be enabled for TensorFlow.

Do you wish to build TensorFlow with Google Cloud Platform support? [Y/n]: n
No Google Cloud Platform support will be enabled for TensorFlow.

Do you wish to build TensorFlow with Hadoop File System support? [Y/n]: n
No Hadoop File System support will be enabled for TensorFlow.

Do you wish to build TensorFlow with Amazon S3 File System support? [Y/n]: n
No Amazon S3 File System support will be enabled for TensorFlow.
```

```
    Do you wish to build TensorFlow with XLA JIT support? [y/N]: n
    No XLA JIT support will be enabled for TensorFlow.

    Do you wish to build TensorFlow with GDR support? [y/N]: n
    No GDR support will be enabled for TensorFlow.

    Do you wish to build TensorFlow with VERBS support? [y/N]: n
    No VERBS support will be enabled for TensorFlow.

    Do you wish to build TensorFlow with OpenCL SYCL support? [y/N]: n
    No OpenCL SYCL support will be enabled for TensorFlow.

    Do you wish to build TensorFlow with CUDA support? [y/N]: n
    No CUDA support will be enabled for TensorFlow.

    Do you wish to build TensorFlow with MPI support? [y/N]: n
    No MPI support will be enabled for TensorFlow.

    Please specify optimization flags to use during compilation when bazel option "--config=opt"
is specified [Default is -march=native]:


    Add "--config=mkl" to your bazel command to build with MKL support.
    Please note that MKL on MacOS or windows is still not supported.
    If you would like to use a local MKL instead of downloading, please set the environment
variable "TF_MKL_ROOT" every time before build.
    Configuration finished
```

## 4.3 Run bazel build command

*NOTE： needs to change ComputeLibrary path*

```
    cd ~/project/TensorflowOnAcl

    bazel build -c opt \
    --incompatible_load_argument_is_label=false \
    --cxxopt=-fexceptions --copt="-I/home/cym/project/ComputeLibrary/" \
    --copt="-I/home/cym/project/ComputeLibrary/include" \
    --cpu=aarch64 \
    --crosstool_top=//tools/aarch64_compiler:toolchain \
    --host_crosstool_top=@bazel_tools//tools/cpp:toolchain \
    --copt="-DUSE_ACL=1" --copt="-DTEST_ACL=1" \
    --verbose_failures //tensorflow/examples/label_image/...
```

If there is a following build error :

```
    /home/xxxx/.cache/bazel/_bazel_xxxx/xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx/external/nsync/BUILD:402:13: Configurable attribute "copts" doesn't match this configuration (would a default condition help?).
    Conditions checked:
     @nsync//:android_arm
    ...
     @nsync//:msvc_windows_x86_64.
```

*Solution:*

Open “/home/xxx/.cache/bazel/_bazel_xxxx/xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx/external/nsync/BUILD”,  Add a default conditions there as marked as red line below:

```
    NSYNC_OPTS_GENERIC = select({
        # Select the CPU architecture include directory.
        # This select() has no real effect in the C++11 build, but satisfies a
        # #include that would otherwise need a #if.
        ":gcc_linux_x86_64_1": ["-I" + pkg_path_name() + "/platform/x86_64"],
        ":gcc_linux_x86_64_2": ["-I" + pkg_path_name() + "/platform/x86_64"],
        ":gcc_linux_aarch64": ["-I" + pkg_path_name() + "/platform/aarch64"],
        ":gcc_linux_ppc64": ["-I" + pkg_path_name() + "/platform/ppc64"],
        ":clang_macos_x86_64": ["-I" + pkg_path_name() + "/platform/x86_64"],
        ":ios_x86_64": ["-I" + pkg_path_name() + "/platform/x86_64"],
        ":android_x86_32": ["-I" + pkg_path_name() + "/platform/x86_32"],
        ":android_x86_64": ["-I" + pkg_path_name() + "/platform/x86_64"],
        ":android_armeabi": ["-I" + pkg_path_name() + "/platform/arm"],
        ":android_arm": ["-I" + pkg_path_name() + "/platform/arm"],
        ":android_arm64": ["-I" + pkg_path_name() + "/platform/aarch64"],
        ":msvc_windows_x86_64": ["-I" + pkg_path_name() + "/platform/x86_64"],
        "//conditions:default": [],
    }) + [
```

## 4.4 Compile Unit test

Type the following commands :

```
    cd ~/project/TensorflowOnAcl

    bazel build -c opt \
    --incompatible_load_argument_is_label=false \
    --cxxopt=-fexceptions \
    --copt="-I/home/cym/project/ComputeLibrary/" \
    --copt="-I/home/cym/project/ComputeLibrary/include" \
```

```
    --cpu=aarch64 \
    --crosstool_top=//tools/aarch64_compiler:toolchain \
    --host_crosstool_top=@bazel_tools//tools/cpp:toolchain \
    --copt="-DUSE_ACL=1" --copt="-DTEST_ACL=1" –verbose_failures \
    //tensorflow/python/kernel_tests:<TEST_CASE>

    TEST_CASE list:
    acl_conv_ops_test
    acl_lrn_op_test
    acl_relu_op_test
    acl_matmul_op_test
    acl_softmax_op_test
    acl_cwise_ops_test
    acl_pooling_ops_test
    acl_softplus_op_test
```

## 4.5 Run Tests

```
    Run Tensorflow label_image :

    cd ~/project/TensorflowOnAcl

    rsync -avL –progress \
        bazel-bin/tensorflow/examples/label_image/label_image*  \
        firefly@192.168.3.211:/home/firefly/

    ssh firefly@192.168.3.211
    mkdir -p tensorflow/examples/label_image/data/
    curl -L \
    "https://storage.googleapis.com/download.tensorflow.org/models/inception_v3_2016_08_28_frozen.pb.tar.gz" | \
    tar -C tensorflow/examples/label_image/data -xz
```

copy “tensorflow/examples/label_image/data/grace_hopper.jpg” from TensorflowAcl source code tree and run following command in RK3399.

```
    ./label_image
```

output message :

```
    2017-12-28 10:18:43.381239: I tensorflow/examples/label_image/main.cc:250] military uniform (653): 0.734324
    2017-12-28 10:18:43.382520: I tensorflow/examples/label_image/main.cc:250] mortarboard (668): 0.0430416
    2017-12-28 10:18:43.382583: I tensorflow/examples/label_image/main.cc:250] academic
```

```
gown (401): 0.0220961
    2017-12-28 10:18:43.382630: I tensorflow/examples/label_image/main.cc:250] pickelhaube
(716): 0.00787005
    2017-12-28 10:18:43.382720: I tensorflow/examples/label_image/main.cc:250] bow tie
(458): 0.00745112
```

Run Unit test :

```
    cd ~/project/TensorflowOnAcl

    rsync -avL --progress \
        bazel-bin/tensorflow/python/kernel_tests/<TEST_CASE>*  \
        192.168.3.211:/home/firefly/test/
    Example:
        rsync -avL --progress \
        bazel-bin/tensorflow/python/kernel_tests/acl_conv_ops_test*  \
        192.168.3.211:/home/firefly/test/
```

output message:

```
    ./acl_conv_ops_test

    testInceptionFwd_0 [4, 5, 5, 124] [1, 1, 124, 12] [4, 5, 5, 12] 1
    testInceptionFwd_1 [4, 8, 8, 38] [1, 1, 38, 38] [4, 8, 8, 38] 1
    testInceptionFwd_2 [4, 8, 8, 38] [1, 1, 38, 38] [4, 8, 8, 38] 1
    ...
    Testing InceptionFwd %s ([4, 8, 8, 176], [1, 1, 176, 19], 1, 'SAME')
    Testing InceptionFwd %s ([4, 8, 8, 176], [1, 1, 176, 19], 1, 'SAME')
    ......
    ----------------------------------------------------------------------
    Ran 62 tests in 2.735s

    OK
```

# 5 Configuration Guide

## 5.1 Enable ACL In Compile Time

- ✧ Enable ACL functions by “-DUSE_ACL=1” in bazel build command
- ✧ Disable it without define “USE_ACL” in build command.

*The TensorflowOnACL disable ACL by default.*