# Maratyszcza / NNPACK



Acceleration package for neural networks on multi-core CPUs

neural-network neural-networks convolutional-layers inference high-performance high-performance-computing simd cpu multithreading fast-fourier-transform winograd-transform matrix-multiplication

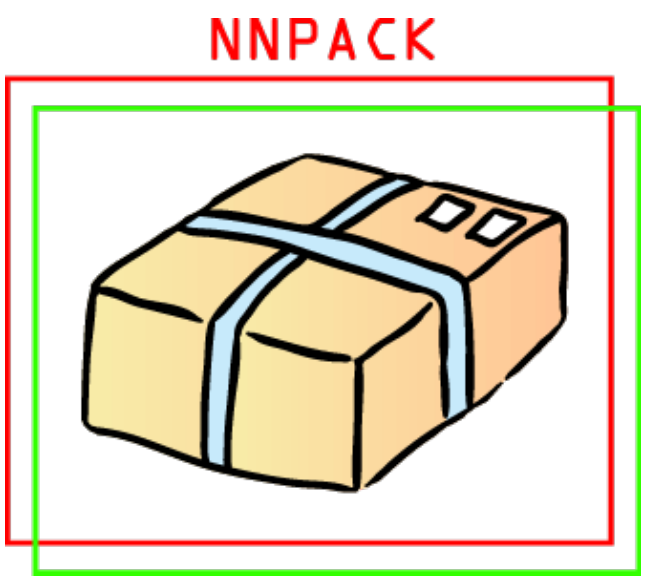
**227** commits **3** branches **0** releases **3** contributors BSD-2-Clause



**Maratyszcza** Android: support MIPS/MIPS64 ABI. Close #66 Latest commit `3ada270` 5 days ago

| | | |
|---|---|---|
| bench | Convolution: support pre-allocated buffer in all modes | 5 days ago |
| include | Android: support MIPS/MIPS64 ABI. Close #66 | 5 days ago |
| jni | Android: support MIPS/MIPS64 ABI. Close #66 | 5 days ago |
| logo | Public release | a year ago |
| src | Android: support MIPS/MIPS64 ABI. Close #66 | 5 days ago |
| test | Convolution: support pre-allocated buffer in all modes | 5 days ago |
| web | Configure.py: switch to confu | 2 months ago |
| .gitignore | Configure.py: switch to confu | 2 months ago |
| .travis.yml | Travis-CI: always specify $BACKEND | 2 months ago |
| LICENSE | License: update year | 2 months ago |
| README.md | README: document ReLU integration into Caffe | 8 days ago |
| benchmark.py | Convolution inference: implicit GEMM algorithm | 10 months ago |
| configure.py | Convolution: support pre-allocated buffer in all modes | 5 days ago |
| confu.yaml | Fully-connected inference: add mixed-precision scheme | 2 months ago |

**README.md**




# NNPACK

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NNPACK is an acceleration package for neural network computations. NNPACK aims to provide high-performance implementations of convnet layers for multi-core CPUs.

NNPACK is not intended to be directly used by machine learning researchers; instead it provides low-level performance primitives to be leveraged by higher-level frameworks, such as Caffe, Torch, MXNet, Theano, Tensorflow, and Mocha.jl.

# Requirements

## Host system

- Linux or OS X host system
- x86-64 processor with AVX2 instruction set
  - NNPACK is optimized for Intel Skylake, but can run on Haswell & Broadwell processors too
  - SSE2 instruction set can be targeted using `--backend=psimd` or `--backend=scalar` configuration options, but for performance reasons it is not recommended for production use
- ARMv7 processor with NEON instruction set
  - VFP instruction set (including ARMv6 systems with VFPv2) can be targeted using `--backend=scalar` configuration option, but for performance reasons it is not recommended for production use.

## Cross-compilation options:

- Android with x86/x86-64 (SSE2), ARMv7 with NEON, or ARM64 architecture
- WebAssembly for next-generation Web browsers
- Emscripten/Asm.js to run inside any modern Web browser
- Portable Native Client to run inside Google Chrome (no packaging required)
- Native Client (x86-64) to run as a packaged Google Chrome App

# Features

- Fast convolution algorithms based on Fourier transform and Winograd transform.
  - Forward propagation performance on Intel Core i7 6700K vs BVLC Caffe master branch as of March 24, 2016 (protobufs from convnet-benchmarks, integration via caffe-nnpack):

| Library | Caffe | NNPACK | NNPACK | NNPACK |
|---|---|---|---|---|
| **Algorithm** | **im2col + sgemm** | **FFT-8x8** | **FFT-16x16** | **Winograd F(6x6, 3x3)** |
| AlexNet:conv2 | 315 ms | 129 ms | **86** ms | N/A |
| AlexNet:conv3 | 182 ms | 87 ms | **44** ms | 70 ms |
| AlexNet:conv4 | 264 ms | 109 ms | **56** ms | 89 ms |
| AlexNet:conv5 | 177 ms | 77 ms | **40** ms | 64 ms |
| VGG-A:conv1 | **255** ms | 303 ms | 260 ms | 404 ms |
| VGG-A:conv2 | 902 ms | 369 ms | **267** ms | 372 ms |
| VGG-A:conv3.1 | 566 ms | 308 ms | **185** ms | 279 ms |
| VGG-A:conv3.2 | 1091 ms | 517 ms | **309** ms | 463 ms |
| VGG-A:conv4.1 | 432 ms | 228 ms | **149** ms | 188 ms |
| VGG-A:conv4.2 | 842 ms | 402 ms | **264** ms | 329 ms |
| VGG-A:conv5 | 292 ms | 141 ms | **83** ms | 114 ms |
| OverFeat:conv2 | 424 ms | 158 ms | **73** ms | N/A |
| OverFeat:conv3 | 250 ms | 69 ms | 74 ms | **54** ms |
| OverFeat:conv4 | 927 ms | 256 ms | 272 ms | **173** ms |
| OverFeat:conv5 | 1832 ms | 466 ms | 524 ms | **315** ms |

- Built-in expert-tuned kernels with very high performance:
  - Fast Fourier transform
  - Winograd transform

    - Matrix-matrix multiplication (GEMM)
    - Matrix-vector multiplication (GEMV)
    - Max-pooling.
- Multi-threaded SIMD-aware implementations of neural network layers.
- Implemented in C99 and Python without external dependencies.
- Extensive unit tests using C++ and Google Test.
- Supports Native Client target and outperforms native Caffe/CPU when running inside Chrome.

## Layers

- Convolutional layer
    - Training-optimized forward propagation ( `nnp_convolution_output` )
    - Training-optimized backward input gradient update ( `nnp_convolution_input_gradient` )
    - Training-optimized backward kernel gradient update ( `nnp_convolution_kernel_gradient` )
    - Inference-optimized forward propagation ( `nnp_convolution_inference` )
- Fully-connected layer
    - Training-optimized forward propagation ( `nnp_fully_connected_output` )
    - Inference-optimized forward propagation ( `nnp_fully_connected_inference` )
- Max pooling layer
    - Forward propagation, both for training and inference, ( `nnp_max_pooling_output` )
- ReLU layer (with parametrized negative slope)
    - Forward propagation, both for training and inference, optionally in-place, ( `nnp_relu_output` )
    - Backward input gradient update ( `nnp_relu_input_gradient` )
- Softmax layer
    - Forward propagation, both for training and inference, optionally in-place ( `nnp_softmax_output` )

## Building

NNPACK can be build on OS X and Linux.

Install ninja build system

```
sudo apt-get install ninja-build || brew install ninja
```

Install PeachPy assembler and confu configuration system

```
[sudo] pip install --upgrade git+https://github.com/Maratyszcza/PeachPy
[sudo] pip install --upgrade git+https://github.com/Maratyszcza/confu
```

Then clone NNPACK, install dependencies, configure, and build

```
git clone https://github.com/Maratyszcza/NNPACK.git
cd NNPACK
confu setup
python ./configure.py
ninja
```

### Cross-compilation for Android

- Download and setup Android NDK
- Add `ndk-build` to `PATH` variable
- Navigate to NNPACK directory and setup dependencies ( `confu setup` )
- Build NNPACK with `ndk-build` build system.

### Cross-compilation for Emscripten/WebAssembly

- Download and setup upstream version of Emscripten SDK

- Using `emsdk`, download, build and activate `incoming` version of Emscripten and Binaryen, and setup environment variables. `$EMSCRIPTEN` should specify the path to activated Emscripten environment.
- Configure NNPACK with `--target=wasm` option.

### Cross-compilation for Emscripten/Asm.js

- Download and setup Emscripten SDK
- Using `emsdk`, download, build and activate one of the environments, and setup environment variables. `$EMSCRIPTEN` should specify the path to activated Emscripten environment.
- Configure NNPACK with `--target=asmjs` option.

### Cross-compilation for Portable Native Client

- Download and setup Native Client SDK
- Set `NACL_SDK_ROOT` variable to a versioned SDK directory (e.g. `/opt/nacl_sdk/pepper_49`).
- Configure NNPACK with `--target=pnacl` option.

### Cross-compilation for Native Client

- Download and setup Native Client SDK
- Set `NACL_SDK_ROOT` variable to a versioned SDK directory (e.g. `/opt/nacl_sdk/pepper_49`).
- Configure NNPACK with `--target=x86_64-nacl-newlib` (recommended) or `--target=x86_64-nacl-gnu` option.

## Testing

NNPACK contains extensive test suite for transformation and neural network layers.

After configuration type `ninja smoketest` to run a set of quick tests, or `ninja test` to additionally NNPACK layers with parameters from AlexNet, VGG-A, and Overfeat-Fast networks (this will take a while).

## Packaging

Binary packages need to distribute two files: `include/nnpack.h` and `lib/libnnpack.a` (also `lib/libnnpack.so` or `lib/libnnpack.dylib` if NNPACK was configured with shared library support).

## Bindings

### Deep Learning Frameworks

- Caffe2 natively supports NNPACK
- MXNet - supports NNPACK for inference in convolutional layers, fully-connected, and max-pooling layers. See MXNet wiki for configuration instructions and performance benchmarks).
- szagoruyko/nnpack.torch - integration of NNPACK into Lua Torch via ffi
- tiny-dnn - header-only deep learning framework in C++11, which natively supports NNPACK.
- darknet-nnpack - fork of Darknet framework with NNPACK support.
- Maratyszcza/caffe - up-to-date integration of NNPACK (convolutional, fully-connected, max-pooling, and ReLU layers) into Caffe based on `nnpack-pr` branch in ajtulloch/caffe.
- Maratyszcza/caffe-nnpack - older and unmaintained integration of NNPACK (convolutional layers only) into Caffe.
- See also discussion in Issue #1

### Languages and Environments

- node-nnpack - Node.js bindings
- peterhj/libnnpack - Rust bindings

### Users

- Facebook uses NNPACK in production.
- Prisma uses NNPACK in the mobile app.

## Acknowledgements


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