

Deep Learning Frameworks



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Nils Reimers

Course-Website: www.deeplearning4nlp.com

Please have your Python environment up and running

Requirements for a Framework

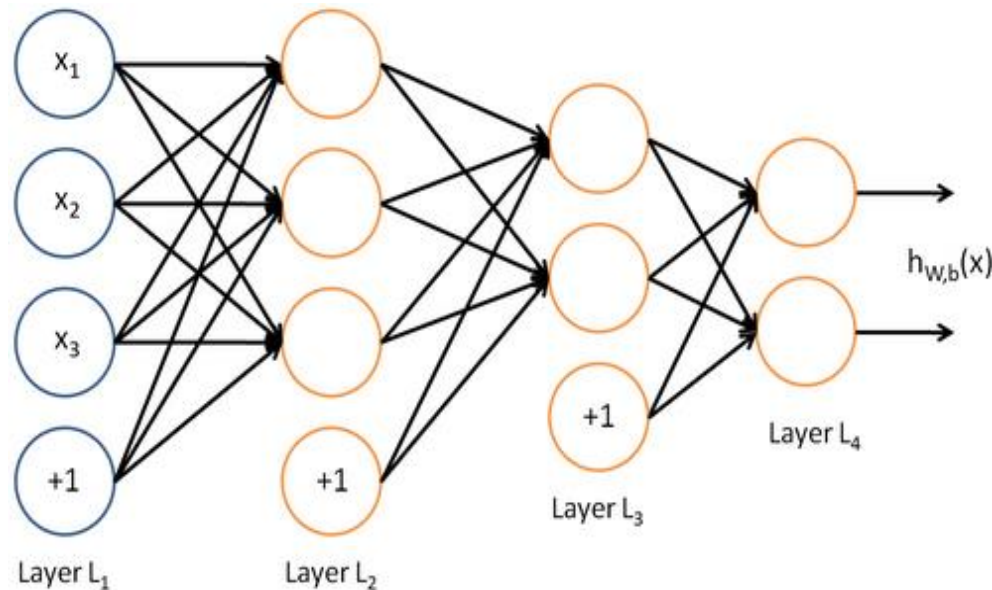
- To train Deep Neural Networks requires billions of operations
 - Google had trained some systems on up to 16.000 cores
 - Today on GPU-cluster (up-to 256 high-end GPUs)
- Performance in training time is **crucial**
 - More data = better results
 - Some times: Larger network = better results
 - Slow computation is not acceptable => Choose the framework that is the fastest
- Nearly all operations are matrix operations (multiplications, additions)
 - Easy syntax for matrices desired
 - Optimizing matrix multiplication for speed is hard, simple “two loop solution” is way too slow
- Must be runnable on a GPU
- Nice to have: Easy computation of gradients

Neural Network as One Long Function

- Neural Networks can be expressed as one long function of vector and matrix operations

$$output = \text{softmax}(b_3 + W_3 \tanh(b_2 + W_2 \tanh(b_1 + W_1 x)))$$

$$E(x, W, b) = -\log(\text{softmax}(b_3 + W_3 \tanh(b_2 + W_2 \tanh(b_1 + W_1 x))))_y$$



Img-Source: <http://ufldl.stanford.edu/wiki/>

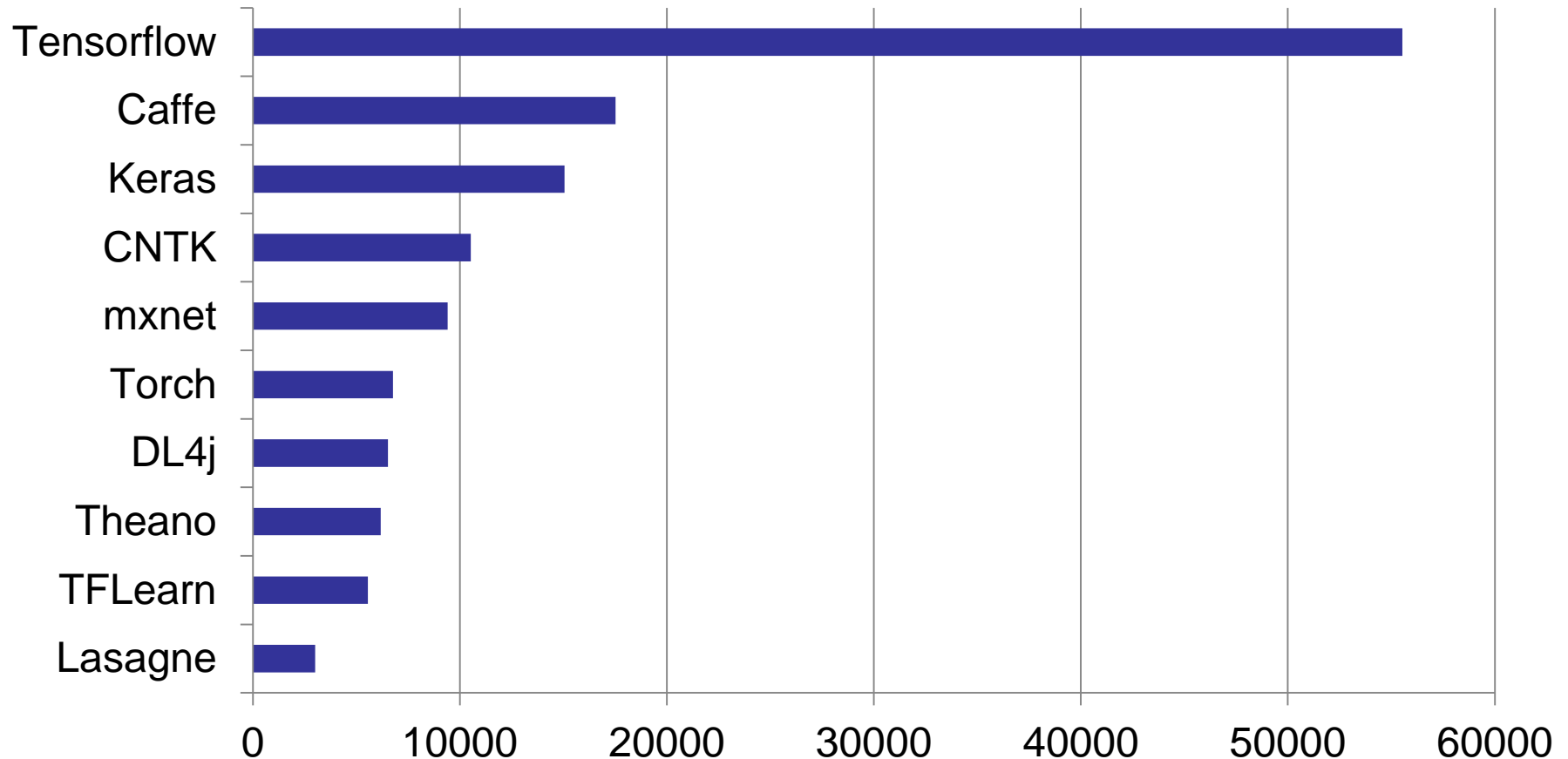
Deep Learning Tools

It's all open source



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Most popular on Github



- Theano
 - One of the oldest deep learning frameworks
 - Python based framework
 - Largely used in the research community
- TensorFlow
 - Deep Learning framework by Google
 - Written in C/C++, wrapper exists for various languages
 - Most people use the Python wrapper for TensorFlow
 - My recommendation for starters in deep learning – learn TF
- Keras
 - Provides modules for the most common network architectures
 - Uses Theano, TensorFlow (or CNTK) in the background

Introduction to Theano



TECHNISCHE
UNIVERSITÄT
DARMSTADT

- TensorFlow uses similar concepts and porting code is not too difficult

Advantages

- Python library with tight integration of NumPy
 - Easy syntax for matrix operations ✓
- Transparent use of GPU (speed-up of up to 140x) ✓
- Efficient symbolic differentiation (Theano computes the gradient) ✓
- Speed and stability optimizations ✓
- Calculations are dynamically mapped to C code
 - We do our computations as fast as we would have written it in C
 - Great performance (>10 faster than Java in my experiments) ✓

Disadvantages

- Debugging is really hard

Some note on the installation of Theano

- Theano utilizes BLAS (Basic Linear Algebra Subprograms)
 - Building blocks for fast vector and matrix operations
 - Often written in Fortran, sometimes in Assembler
- For performance optimization install a BLAS package
- Benchmark different BLAS packages
- I use a manually compiled OpenBlas implementation
 - Installation notes: http://deeplearning.net/software/theano/install_ubuntu.html

Theano – Flow

- The execution of a Theano script is a bit different

Python: Define a computation graph



Python: Tell Theano to compile the graph



Theano: Optimize the graph, generate C-Code and compile it



Python: Pass input data to the compiled graph



C: Compute the output, compute updates of weights, maybe run on GPU



Python: Get the final output

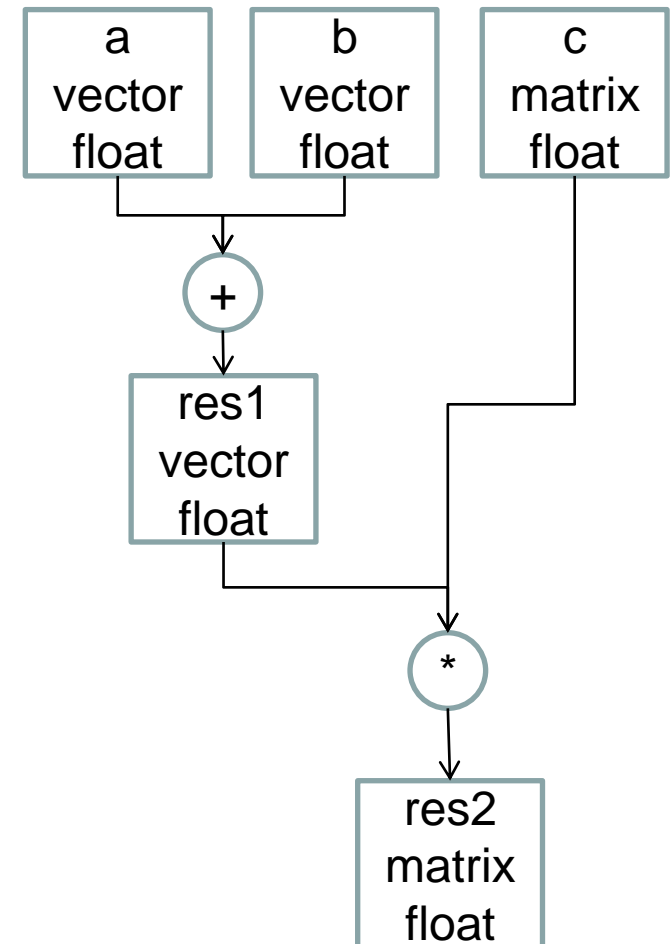
Theano – Computation Graph

- You write symbolic expression to define the computation graph

```
import theano
import theano.tensor as T
```

```
a = T.fvector()
b = T.fvector()
c = T.fmatrix()
```

```
res1 = a+b
res2 = T.dot(res1,c)
```



Introduction to Keras



TECHNISCHE
UNIVERSITÄT
DARMSTADT

One of the most popular Deep Learning Frameworks

- Builds on top of Theano and TensorFlow
 - You can easily switch the backend without needing to change your code
 - As of Keras 1.1.1, TensorFlow the default backend
- Keras implements tons of useful Neural Network moduls:
 - Feed Forward Layers, Convolutional Layers, Recurrent Layers
 - Different optimization functions
 - Different loss functions
 - Storage and loading of models
 -
- Building your deep learning models becomes quite easy with Keras
 - ... at least as long as it is already implemented in Keras