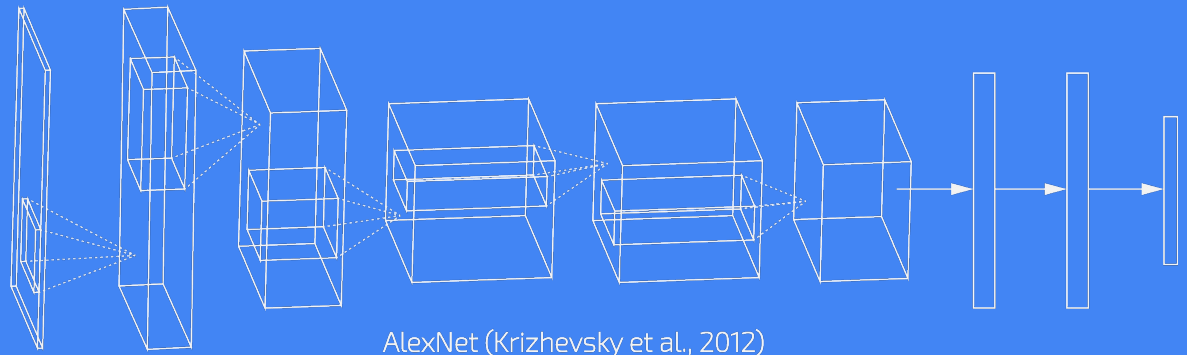
EPSRC Centre for Doctoral Training in
Pervasive Parallelism

Optimization of neural computations using a functional data-parallel language

Or making neural networks performance-portable



AlexNet (Krizhevsky et al., 2012)

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Problem

Neural networks (NNs) depend on hardware-specific low-level optimizations.

Manual approach:

- Requires expertise in both machine learning and performance programming
- Costly to develop and maintain
- Hard to port to new platforms

Automated approaches:

- *Caffe*, *Tensorflow*, *Theano*, *Torch* have limited functional and performance portability
- *Autotuners* are not performance-portable because of no structural optimizations

Solution

- ***Lift***, a functional data-parallel language
  - Abstracted from hardware, pure and safe

Lift code example:

```
fully_connected(f, weights, bias, inputs) :=
    Map((neuron_weights, neuron_bias) → f() o Reduce(add, neuron_bias) o
        Map(mult) $ Zip(inputs, neuron_weights)) $ Zip(weights, bias)
```

Solution

- ***Lift***, a functional data-parallel language
  - Abstracted from hardware, pure and safe

- Introduce NN-specific primitives such as *conv*, *norm*, *pool*, *fully_connected*
- Implement fine-grained generic optimizations such as:
  - Parallel mappings space exploration
  - Memory tiling & coalescing
  - Float quantization
  - Neuron pruning
  - Training batch size autotuning
  - Varying precision across layers
  - Vectorization

- Optimize based on NN configuration, input dimensions and target hardware
- Generate OpenCL code for any OpenCL-supporting target hardware

The end

Questions?