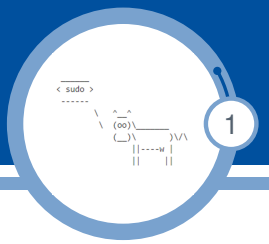
Sudo-ku

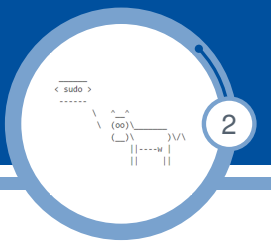
Energieffektivgruppen

November 23, 2016

Content



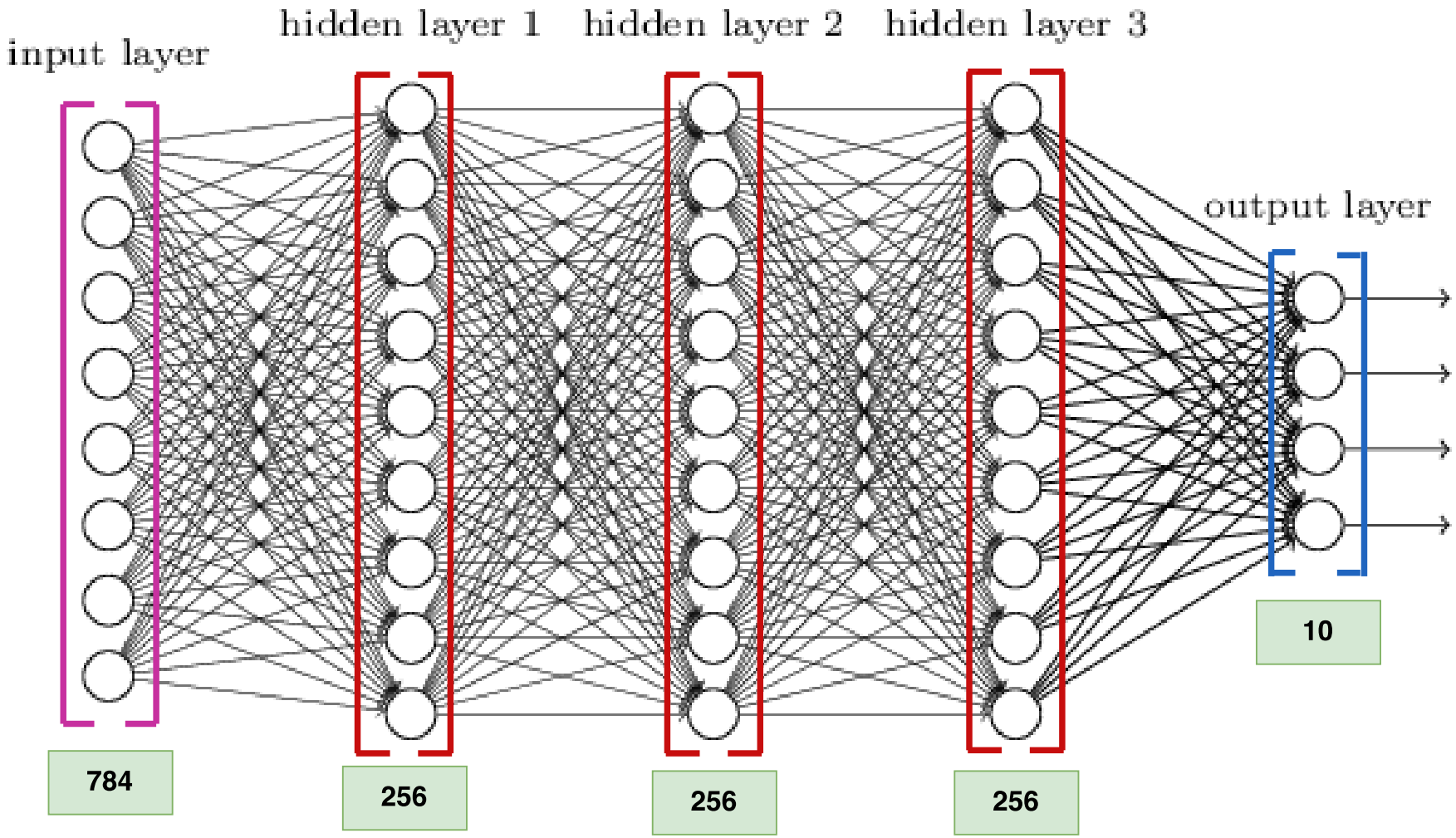
The task



- Construct a computer that makes use of binarized neural network deployed on an FPGA
- The BNN should recognize digits
- Computer must be battery powered
- Maximize battery life
- Sudoku solver that displays the board and correctness

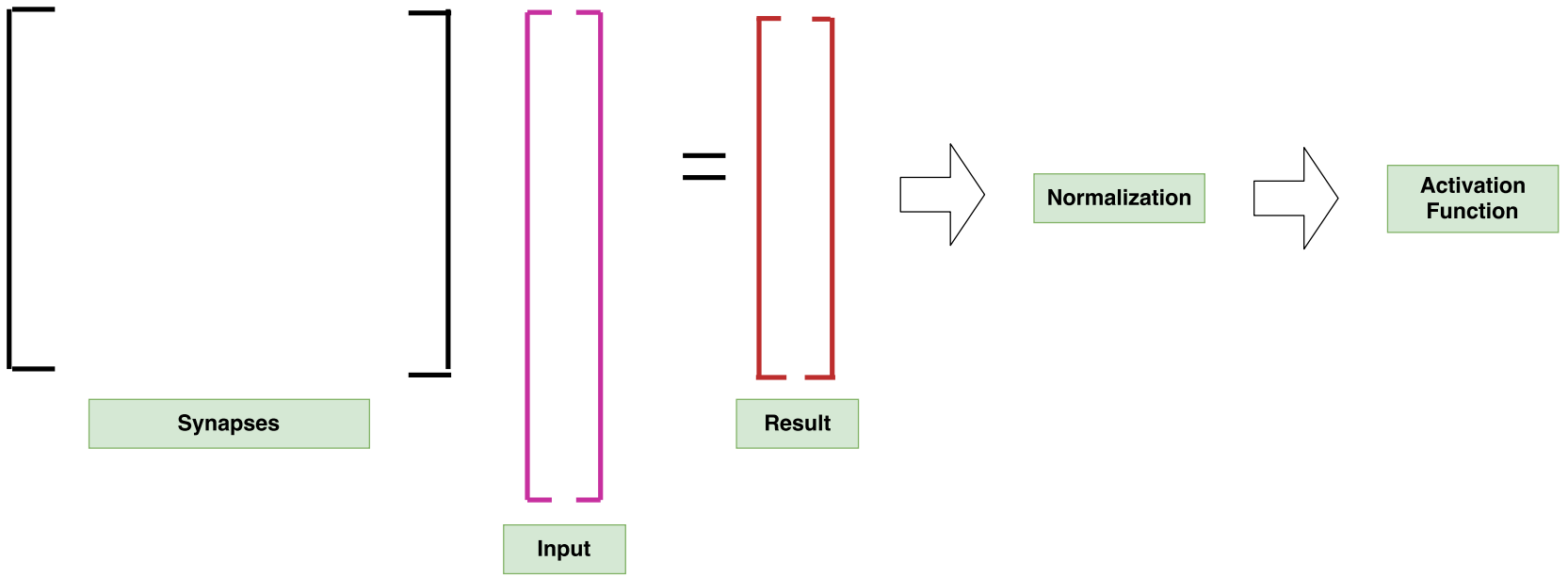
Binarized Neural Network

A neural network



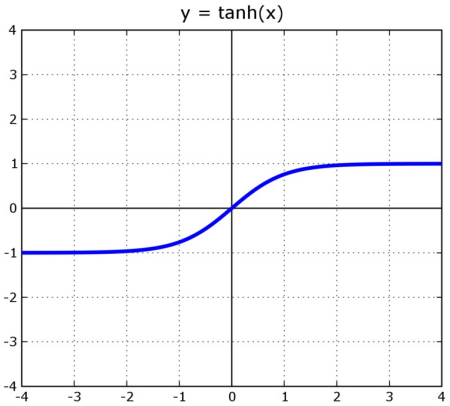
Binarized Neural Network

Inside one layer

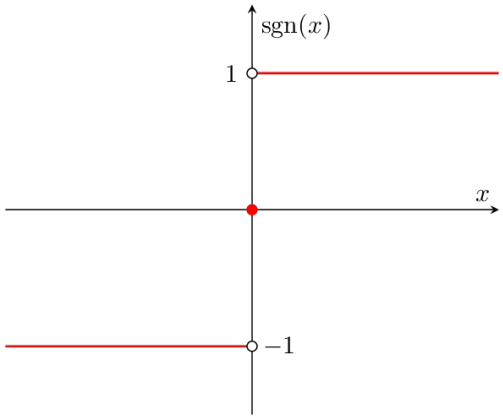


Binarized Neural Network

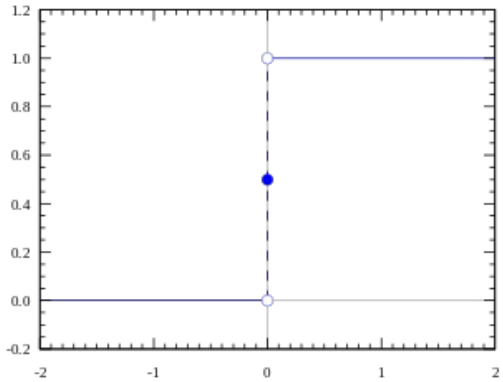
Binarizing the activation function



tanh



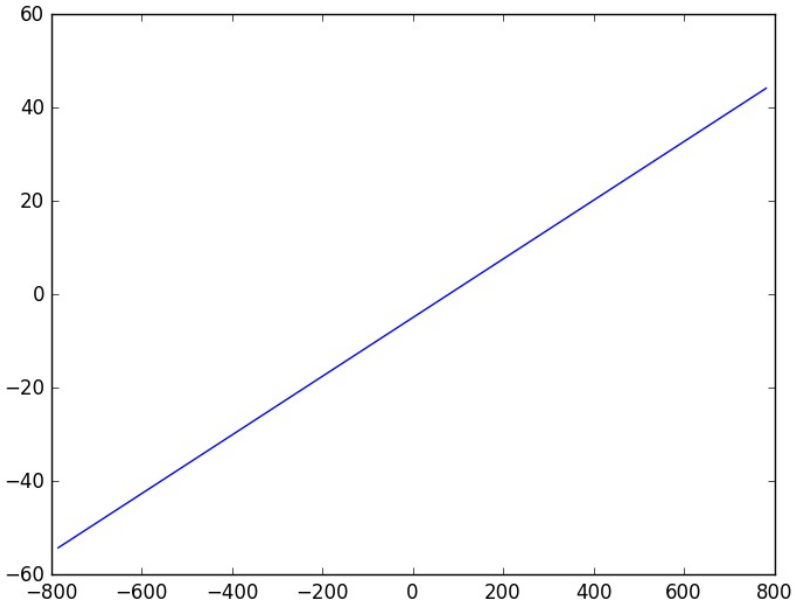
sign



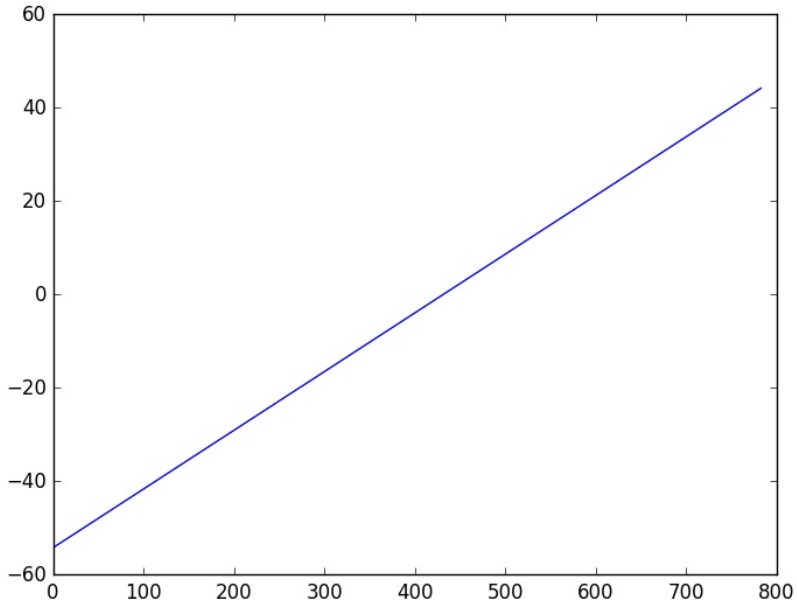
step function

Binarized Neural Network

Binarizing the normalization



-1 to 1

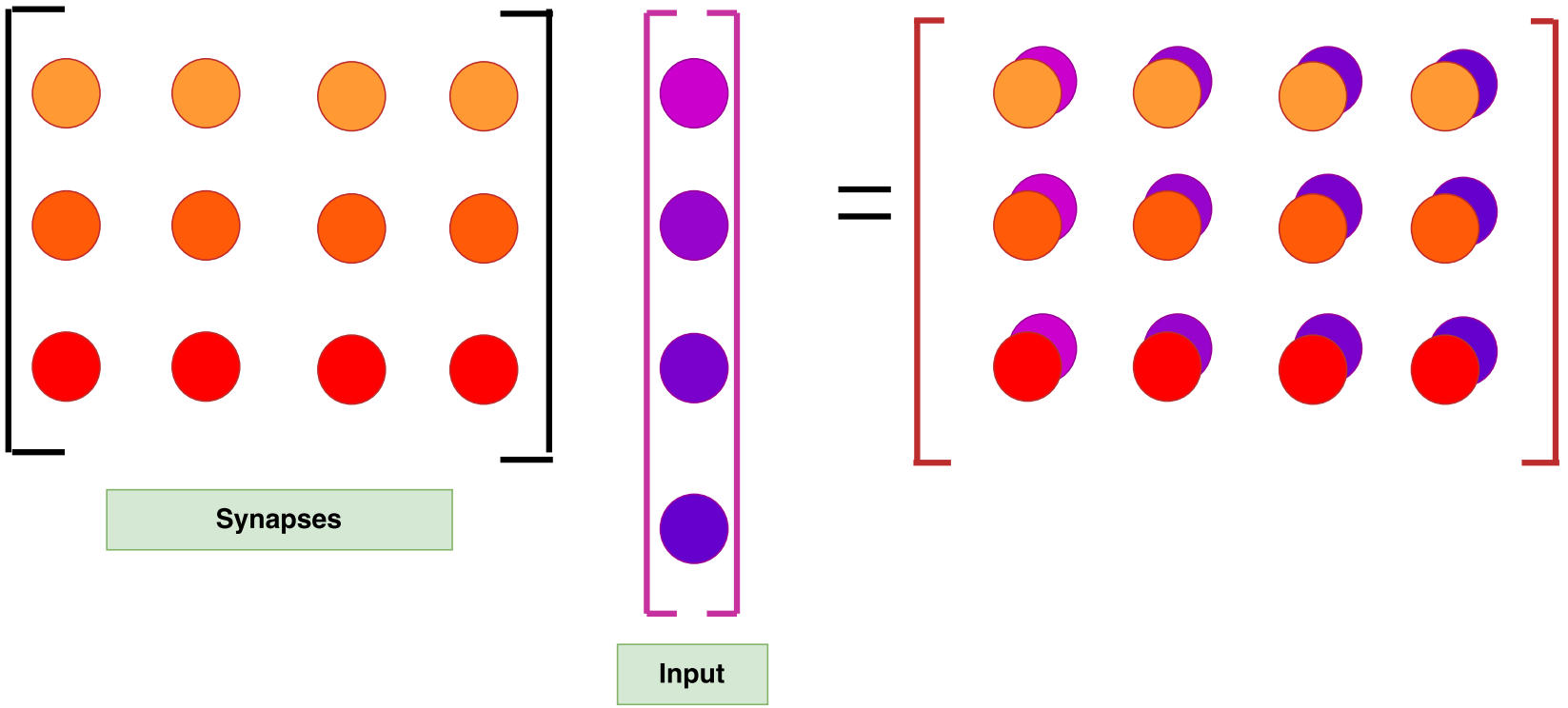


0 to 1

We find and use the threshold values

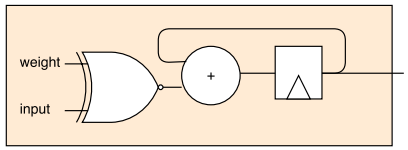
Binarized Neural Network

Splitting the layer

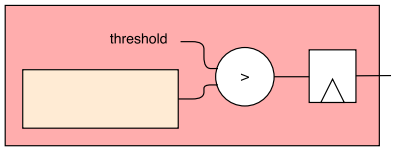


Binarized Neural Network

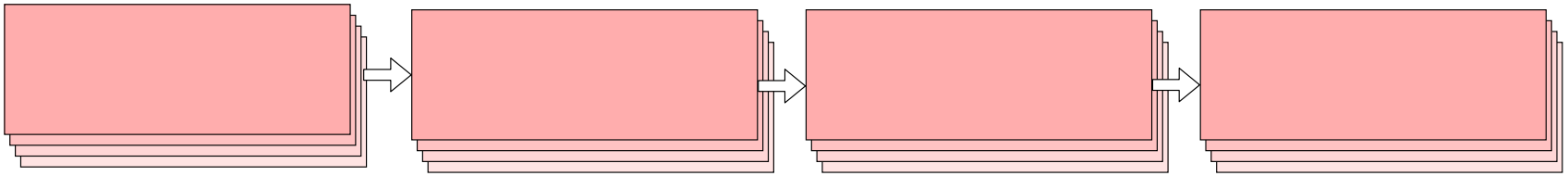
Overview of the network



Input for one neuron

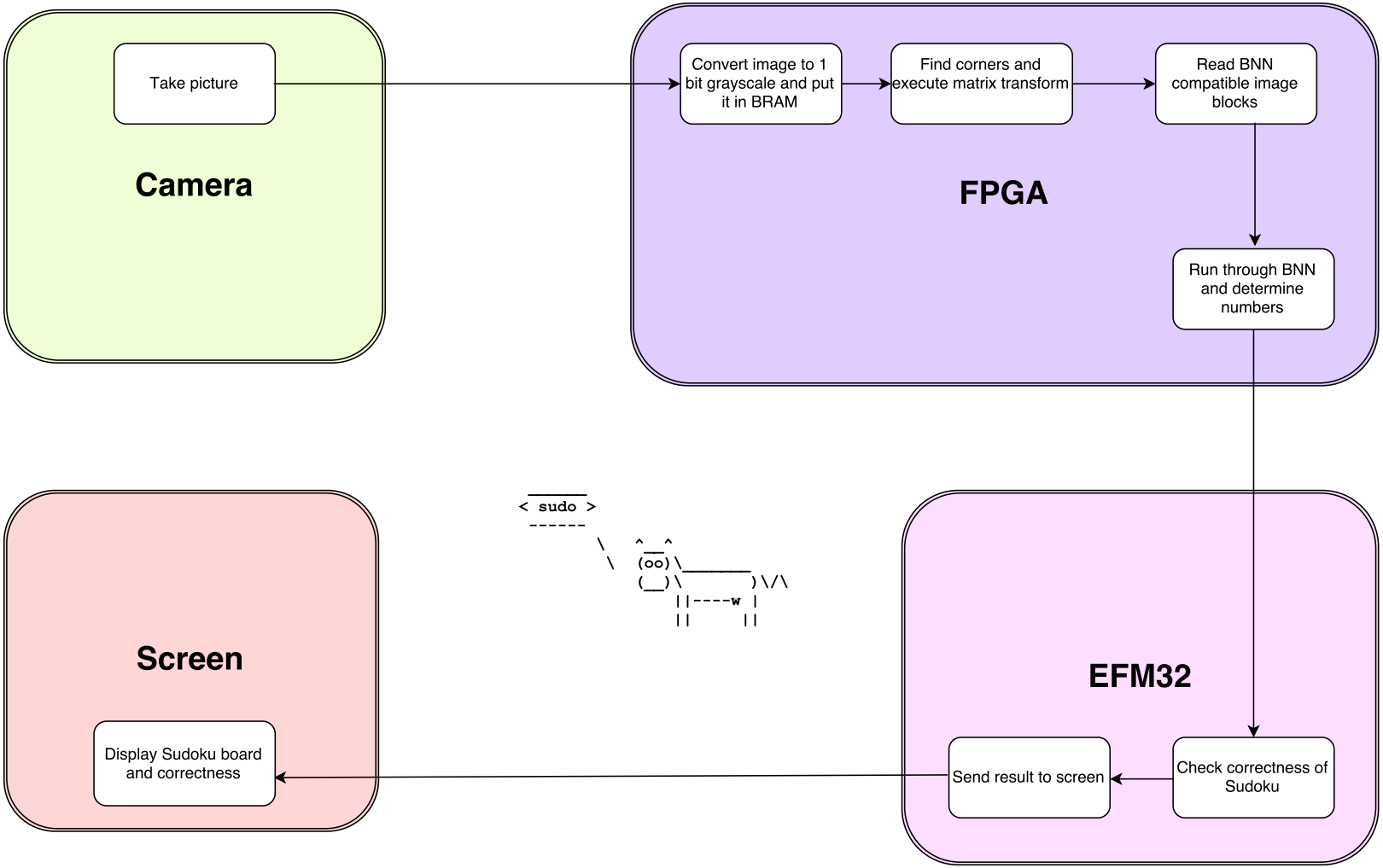


One neuron



256 neurons **256 neurons** **256 neurons** **10 neurons**

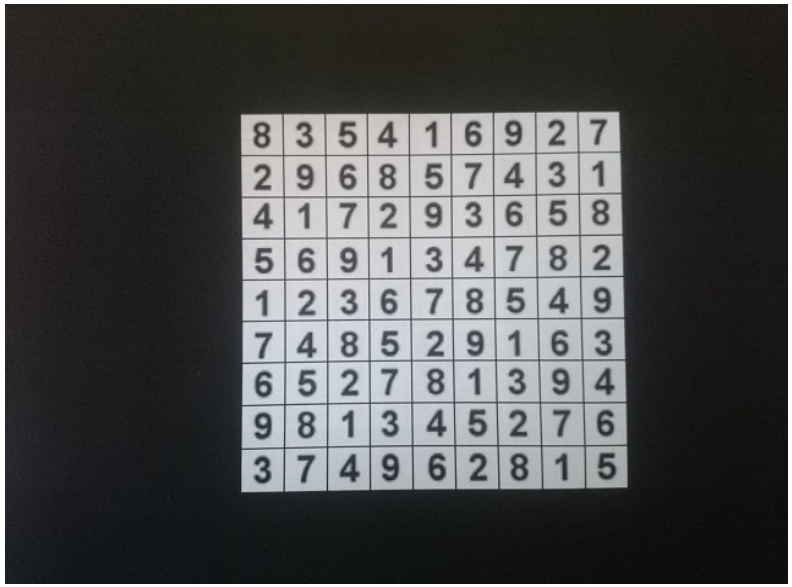
The Operation of Sudo-ku



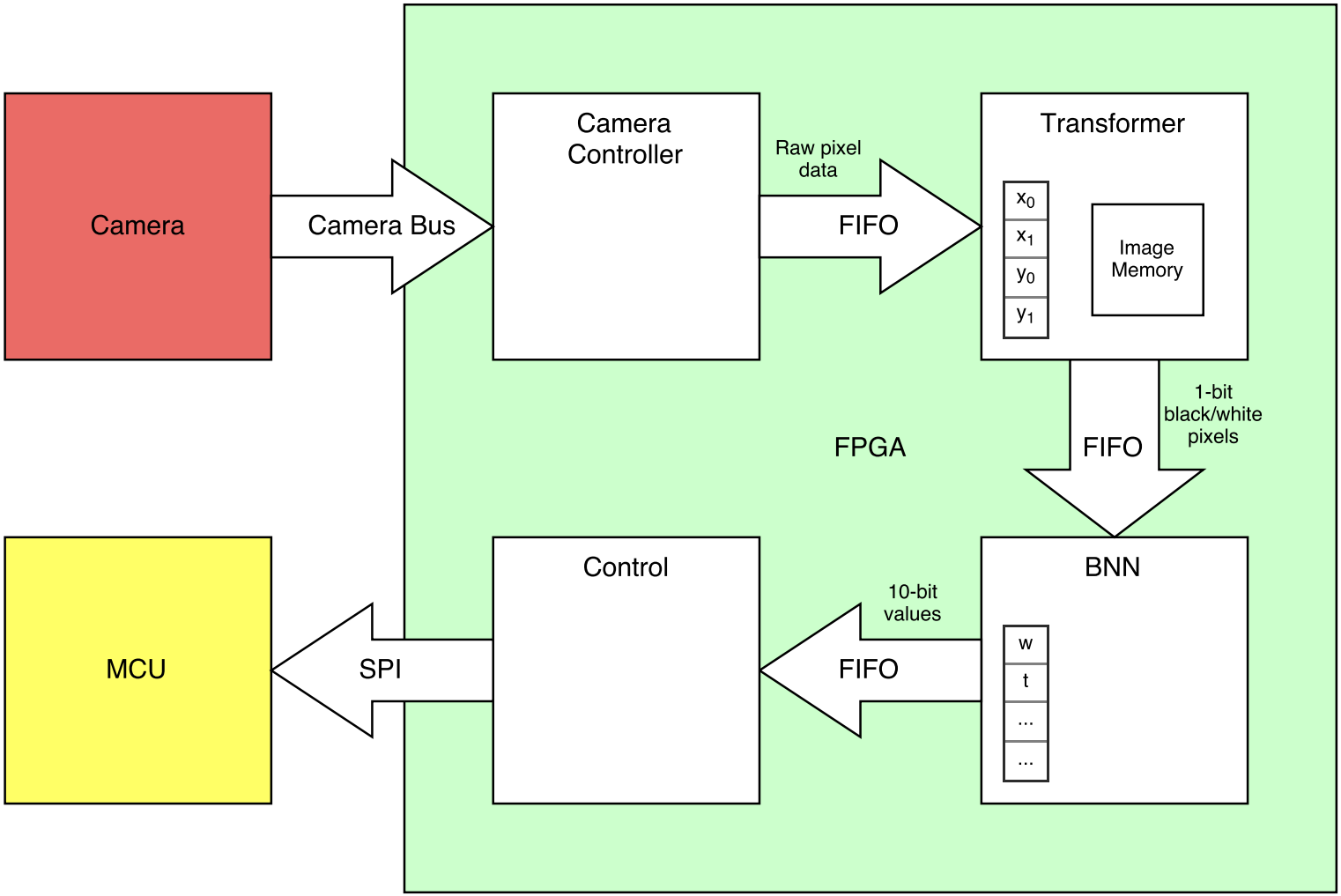
The operation of sudo-ku

Image restraints

- White Sudoku board on black background
- Not rotated more than 45 degrees in any direction
- Square board

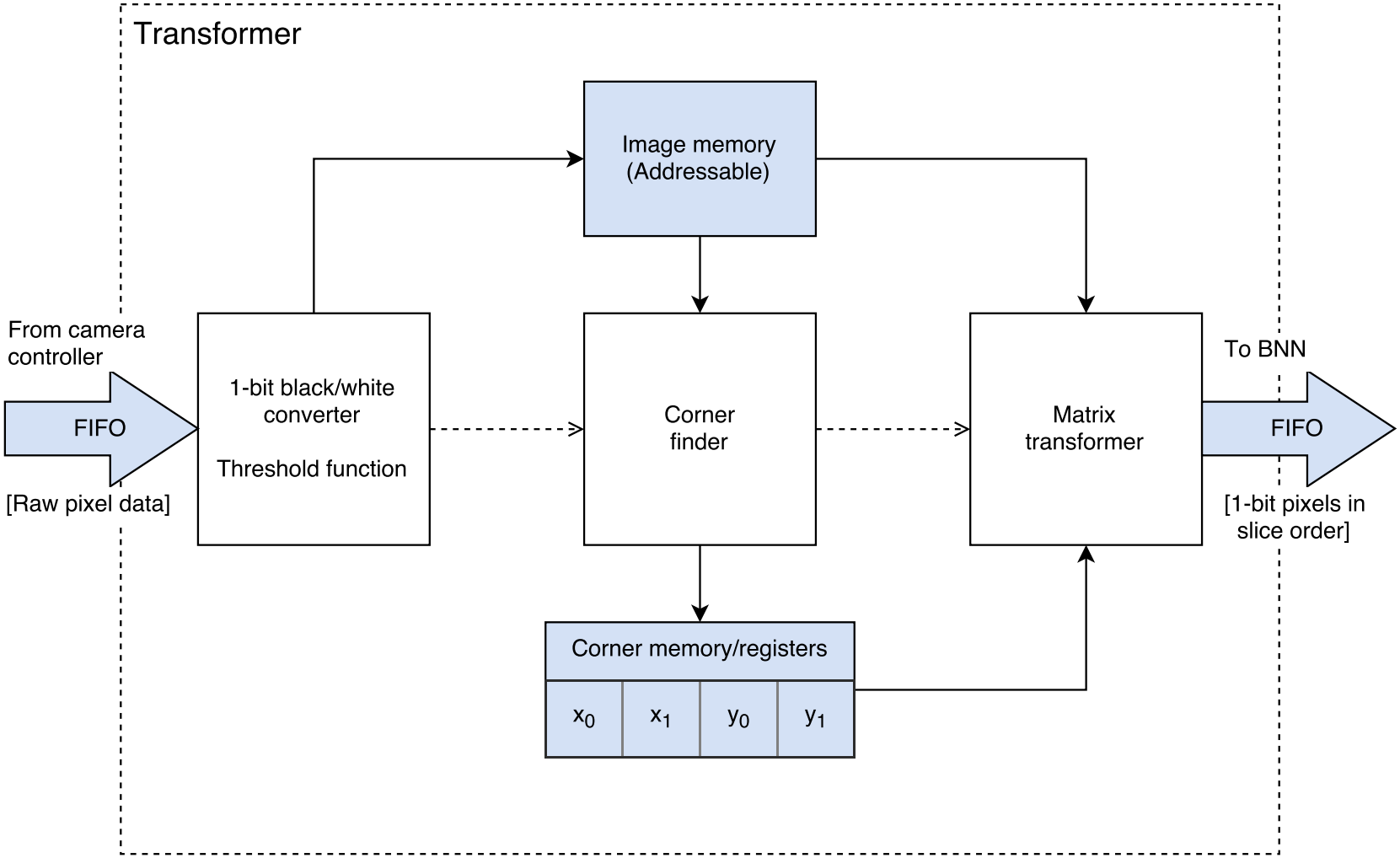


Data flow and memory
On the FPGA

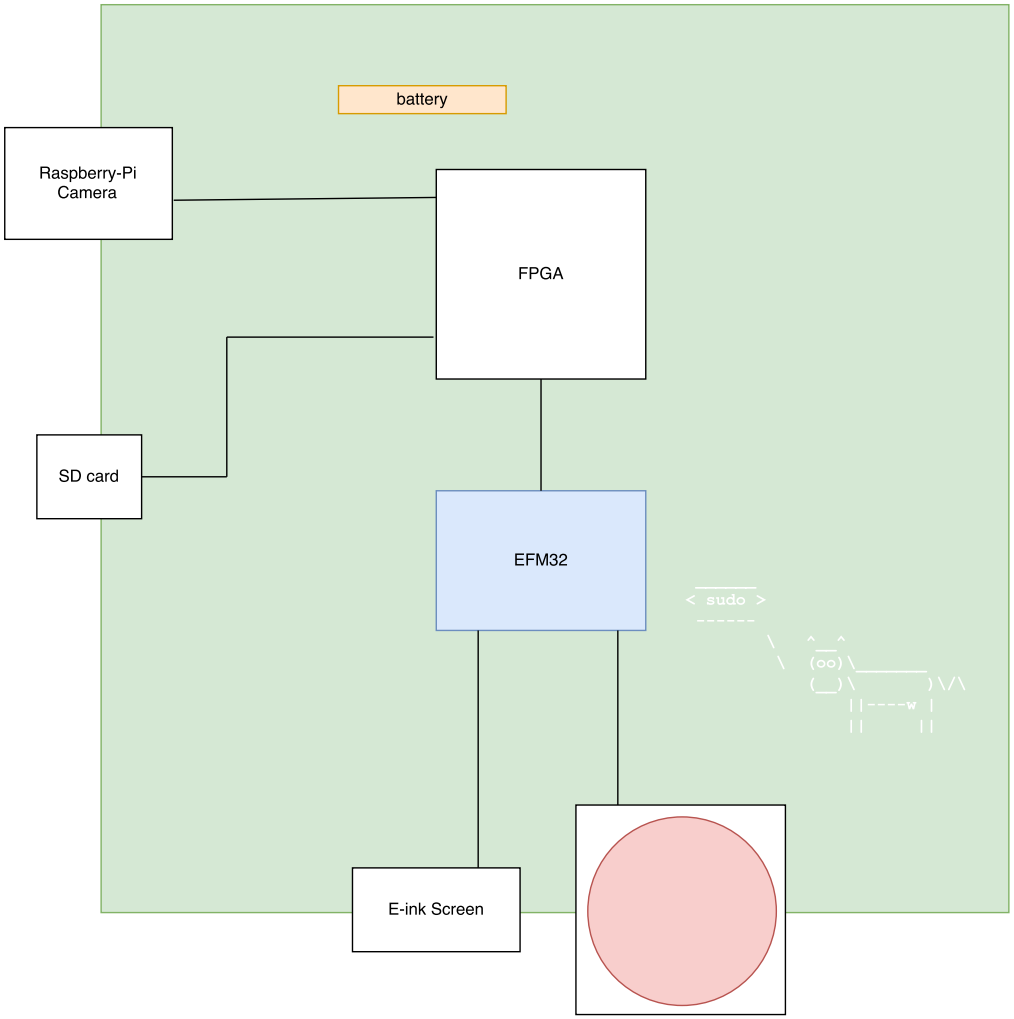


Data flow and memory

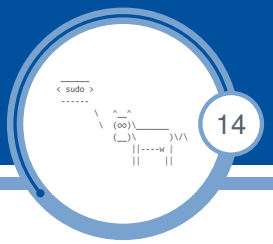
In the Transformer-module



PCB Design
High Level Schematic



PCB Design
Energy estimates



	Idle	Load
Estimated	0,36W	0,48W
Measured	0,77W	0,81W

PCB Design
3D Drawing