Lehrstuhl für Schaltungsentwurf
Fakultät für Elektrotechnik und Informationstechnik
Technische Universität München

Circuits for Brain Inspired Analog Computing: Scalable Design and Layout of an Analog Spiking Neural Network

Master Thesis Offering at the Chair for Circuit Design
(Can be combined with 'Research Internship')

Motivation:
Driven by digitalization, the internet of things (IoT) and other digital megatrends, a massive amount of data is collected these days and artificial intelligence is more and more necessary to generate value out of these large data sets. Throughput and efficiency in today's integrated circuits and systems for artificial intelligence are strongly limited by the available – only slightly optimized – computer systems. Those have originally been developed for completely different, math centric calculation and control tasks. Compared to the efficiency of a human brain these systems are many orders of magnitude worse. At the chair for circuit design we will approach this problem from a different angle which is inspired by the human brain: the human nerve system and its structure as well as its function is operating very slow but heavily parallel with much more connections compared to modern central processing units. Similar to the human brain a Spiking Neural Network (SNN) is used. The human brain arranges its connections between neurons in a three-dimensional manner. This allows the brain to build up to 10000 synaptic connections for one neuron. Modern CMOS processes allow 2.5- or 3-D stacking of designs but this is still very cost-intensive and sometimes not possible. It is a complex problem to layout an analog SNN because the synapses between two layers scales with the number of input- and output-neurons. A kind of automated process would help a lot to scale up the design process. Also the area needed is a huge problem and must be tackled.

What does the work look like?
The work will be done at the chair of circuit design for a time duration 6 months (fulltime). Starting from some literature research on ANNs/SNNs and the problem of a scalable layout. Then a proper benchmark dataset should be chosen (e.g. MNIST) and according to this the neural network must be designed. The design of the circuits for basic blocks (neurons and synapses) is finished but small changes will be necessary. Noise and mismatch effects must be considered. Effective layout styles must be found to solve this problem. All the circuits will be designed and layouted in a very modern process node of 22nm. The final goal of this thesis is to design and layout the SNN and maybe to find an easy way of implementing an automization process.

What are good pre-requisites for starting this work?

- MSEI/MSCE/MSPE student with focus on circuit design
- Solid knowledge in analog and mixed-signal circuits (Lab/Lecture)
- Some experience of Cadence design environment (Design/Layout) is desired
- Some Python programming can be helpful
- Knowledge in AI, neural networks (especially SNNs) would be desirable
- Highly interested in biologically inspired systems and its learning algorithms

Interested?	→ contact:	Matthias Ochs Matthias.ochs@tum.de Room N5323