■ R-Wonc'19

というのを聴講.

https://usability-research.r-ccs.riken.jp/r-wonc19/

Giacomo Indiveri, Neural processing and learning electronic circuits for building neuromorphic cognitive agents

- intro
  - driven by AI
  - driven by Big-Data https://www.nature.com/articles/d41586-018-01683-1
- Bee brain specs
  - 1mg, 1mm^3, 960,000 neurons, 10^{-15} J/spike energy/op
- Neuromorphic processor chips
  - spikes in, and spikes out
  - analog subthreshold circuits
  - inhomogeneous, imprecise, and noisy,
  - massively parallel
- DYNAP-SEL-Dynamic Neuromorphic Asynch Processor with Self Learning
- Adaptive CardioRespiratory Pacemaker EU project

Mike Davies, A New Era of Neuromorphic Computing

- cf. https://newsroom.intel.com/editorials/intel-creates-neuromorphic-research-community/
- Background (pict.)
- The Engineering Perspective (pict.)
- LOIHI: https://www.computer.org/csdl/magazine/mi/2018/01/mmi2018010082/13rRUIJcWtw
  - https://www.researchgate.net/publication/322548911_Loihi_A_Neuromorphic_Manycore_Processor_with_On-Chip_Learning
  - 128 neuromorphic cores, 128k neurons, 128M synapses
  - 14nm FinFET
  - cf. http://niceworkshop.org/wp-content/uploads/2018/05/Mike-Davies-NICE-Loihi-Intro-Talk-2018.pdf
- Loihi systems
  - wolf mountain, Nahuku, Kapoho Bay, ...
    - cf. https://converge360.com/Blogs/Future-Tech-Blog/2018/12/NeuroBiological-USB-Intel.aspx
    - cf. https://www.top500.org/news/intel-ramps-up-neuromorphic-computing-effort-with-new-research-partners/
- SNN algorithms discovery and development
- Speech Recognition: Keyword spotting
  - https://arxiv.org/abs/1812.01739
- Spiking LCA dynamics
- Spike-based LSTMs LSNN
  - cf. Long short-term memory and learning-to-learn in networks of spiking neurons https://arxiv.org/abs/1803.09574
  - cf. Biologically inspired alternatives to back-propagation through time for learning in recurrent neural nets https://arxiv.org/abs/1901.09049
  - cf. Adaptive Control of a Robot Arm using Loihi https://royalsocietypublishing.org/doi/full/10.1098/rspb.2016.2134
- Graph search
- Olfacton-Inspired One Shot Learning
  - cf. olfaction inspired machine learning https://arxiv.org/pdf/1802.05405.pdf
- Why Spikes: (pic.)

Cerebellum

- a little brain
  - cf. Cerebellar ataxia - https://www.youtube.com/watch?v=Txlvuu2byUY
- simulation by CPU, GPU, FPGA, PEZY
  - GPU, FPGA, PEZY - realtime simulation
- human-scale cerebellum on K
  - 68 billion neurons on 82,944 nodes
  - MONET (in-house simulator)
  - 600 time slower than realtime (10min. for 1s)
- application
  - arm control
  - reinforcement learning in cerebellum
    - reinforcement learning can go in parallel (massively)
    - - cf. Hybrid Reward Architecture for Reinforcement Learning https://arxiv.org/abs/1706.04208
    - - cf. Hybrid Reward Architecture https://github.com/Maluuba/hra

A Benchmarking and Programming Framework for Spiking Neuromorphic Computing Systems

A Survey of Neuromorphic Computing and Neural Networks in Hardware - https://arxiv.org/abs/1705.06963

- 3 examples (pict.)
- TENNLab sotware framework
  - https://www.semanticscholar.org/paper/The-TENNLab-Exploratory-Neuromorphic-Computing-Plank-Schuman/
  - http://neuromorphic.eecs.utk.edu/publications/2018-08-17-the-tennlab-exploratory-neuromorphic-computing-framework-submission/
- Types of Neuromorphic Implementations
  - DANNA 2- fuly digital https://dl.acm.org/citation.cfm?id=3229894
  - mr DANNA - mixed analog-digital
  - SOEN - optoelectronic

VLSI Research for Neuromorphic Computing in IBM Research

- spiking/non-spiking neural network, digital/analog implementation
  - spiking/digital - TrueNorth
  - non-spiking/digital - GPGPU, FPGA, FPU arrays
  - spiking/analog - Spiking neural network chips w/ non-volatile memory arrays
  - non-spiking/analog -
- A Scalable Multi-TeraOPS Deep Learning Processor Core for AI Training and Inference - https://ieeexplore.ieee.org/document/8502276, https://xpressdrivein.org/glo16/pdf/C04-2.PDF
  - approximate computing by reduced precision computations
- A million spiking-neuron integrated circuit with a scalable communication network and interface - http://science.sciencemag.org/content/345/6197/668 http://paulmerolla.com/merolla_main_som.pdf
  - 1M neurons, 256M synapses tileable 2D-onchip
- NVM synaptic array - eg. phase change memory (pict.)
- Analog multiply accumulation with non-volatile memory array
- NVM Weight Variation Imact on Analog Spiking Neural Network Chip - https://link.springer.com/chapter/10.1007/978-3-030-04239-4_61

- Lightweight Refresh Method for PCM-based Neuromorphic Circuits - https://www.semanticscholar.org/paper/Lightweight-Refresh-Method-for-PCM-based-Circuits-Ito-Ishii/5ae6ddfcf182

AI on the Edge: Frontiers for Energy-Efficient Hardware Architectures

- "Structure" is a key
- Binary/Ternary DNN accelerator VLSI 2017
  - Binary/Ternary, Reconfigurable in Memory
  - cf. https://www.researchgate.net/publication/321930684_BRein_Memory_A_Single-Chip_BinaryTernary_Reconfigurable_in-Memory_Deep_Neural_Network_Accelera
- Log-Quantized DNN accelerator with 3D SRAMs
  - QUEST(Log QUantization, MIMD Parallel Engine, Die-STacking with SRAMs)
  - cf. Convolutional Neural Networks using Logarithmic Data Representation - https://arxiv.org/pdf/1603.01025.pdf
- Dynamically reconfigurable processor with AI-MAC engine
  - DRP(96-core, 333MHz) + AI-MAC(1024, 500MHz)
- The Era of "Intelligence at the Edge" will Begin
  - Common Key Features: Mostly static, dataflow rich, (self) evolvable
  - Procedure Oriented Computing -> Structure Oriented Computing: Reconfigurable HW, "Virtualized" Reconfigurable HW (post FPGA), Dataflow Oriented Machine (w/ reduced synth. cost)

Towards biologically plausible learning of spike-based cognition

- CT-AuGMEnt

Stochastic Computing for Brainware LSI

関連する？

- Large-Scale Neuromorphic Spiking Array Processors: A Quest to Mimic the Brain - https://www.frontiersin.org/articles/10.3389/fnins.2018.00891/full
- Adaptive motor control and learning in a spiking neural network realised on a mixed-signal neuromorphic processor - https://arxiv.org/pdf/1810.10801.pdf
- Dual Supervised Learning - https://arxiv.org/abs/1707.00415
- Implementation of a Liquid State Machine with Temporal Dynamics on a Novel Spiking Neuromorphic Architecture - https://www.osti.gov/servlets/purl/1405258