Paper Review : Towards Spike Based Machine Intelligence

Kartik Srinivas
IIT Hyderabad, India
Hyderabad, India
es20btech11015@iith.ac.in

I. General Notes

The paper [RJP19] gives a comprehensive overview of the development of Neuromorphic computing in both algorithms and hardware. It systematically goes through all the types of approaches that have been taken towards building hardware and Algorithms that attempt to simulate how the brain works, while also showing the shortcomings of today's technology. The explanations have well made diagrams that assist the layman reader and there is also a historical 'Tinge' to the paper that tells the reader about the motivation behind these ideas.

II. Pros

- The Hardware section of the paper is very broad and gives a very good overview of the hardware that has been built in order to simulate Synaptic Plasticity and the STDP paradigm.
- Clarity: The paper gives good clarity to the reader because it is well organized.
- The paper also mentions open problems in Neuromorphic Computing and also gives the reader a good idea about the challenges that are being faced in this field.
- The paper actively compares accuracies with the performance of DNN's to give the reader a clear idea of the actual ability of SNN's.

III. Cons

1) The paper assumes that there is some level of separation in the brain where all the operation can be performed using a Turing machine, i.e there is some level after which the brain's processes can be seen as a 'mental program' running on the Brain Hardware. This may not be the case, and this assumption should be mentioned. Please see [Bel99].
2) No intuition has been provided for STDP updates of the weights during the training of SNN's. The diagram mentions that

$$\Delta w = a_+ \exp(\frac{-\Delta t}{\tau_+})$$

   But no explanation is given for choosing such a weight update. I understand that this is probably derivable from one of the LIF models (or through some approximation of the derivative of the spiking neuron) , but this should be explicitly mentioned.
3) In the section on "Other unexplored Directions", the author claims, but does not give any reason for the failure on NLP tasks, even though the data is sequential in nature which is almost perfect for the spatio-temporal SNN's.
4) Repeated claiming of 'Energy-efficient' SNN models but very less examples to back it up. I understand that event driven Nature of computations will reduce the cost of computation, but very less examples of success in this field have been shown. The author needs to be more convincing about why this is the case, and show the reader, how the present problems may be mitigated in the future.
5) Less info about the routing algorithms that are used in Neurogrid and TrueNorth chips.
6) There should be more explanation for the AER communication system. The only explanation for the working of the AER is present under the image caption of Fig 5b.

IV. Question

I am concerned about the existence of '3 - dimensional' connectivity-based chips. The paper does not mention any attempts in the past that tried to create such architectures and repeatedly shows this shortcoming. Have there been any attempts at creating such an architecture.? What are the difficulties? Or is this an unexplored area?.

V. Rating

Overall Paper rating : 8/10
Confidence: 3

References

[Bel99] Anthony J Bell. Levels and loops: the future of artificial intelligence and neuroscience. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 354(1392):2013–2020, 1999.

[RJP19] Kaushik Roy, Akhilesh Jaiswal, and Priyadarshini Panda. Towards spike-based machine intelligence with neuromorphic computing. *Nature*, 575:607–617, 11 2019.