

Lessons from neurobiology and physics: pseudobackprop & more

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Spike-based computation is inspired by neurobiology and is implemented in physical devices. Spike-based computation can also be inspired by methods from theoretical physics where overarching principles are formulated to capture the dynamics of charges, masses and more abstract variables. We consider the principle of Least Action and show how this can be applied to the neurobiology of cognition. The key notion is the one of an error. Errors can be defined at the level of the behaviour, the microcircuits and the single neurons. I will show how a rigorous application of this Neural Least Action (NLA) principle leads to a cortical version of error-backpropagation, namely pseudobackprop. Pseudobackprop naturally emerges when error representations are learned by cortical microcircuits and made available at the dendritic sites. Performance-wise, pseudobackprop outperforms feedback-alignment, is comparable with backpropagation, and has distinct advantages. The NLA principle potentially offers generalizations to spike-based computation, conductance-based computation, and natural gradients (covered by other talks at NICE 2021). As a physical theory that deals with continuous time it may give hints to actually implement it by real-time physical devices.