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Variational formulation to spiking neural networks: A top-down approach

We bring new insights to better understand the link between spiking neural networks and variational approaches. To do so, we consider two simple visual tasks formulated as variational approaches, related to linear/non-linear filtering [1] and input selection: Image denoising via edge-preserving smoothing, and focus of attention via a winner-take-all mechanism. Variational approaches, which refer to an energy minimization formulation, are defined in a continuous setting. Our goal is to show how spiking neural networks can be used to minimize those energies. Based on some recent advances [2,3], including spiking neurons [4], the key point is to understand the relation between smoothness constraints and cortical activity diffusion (as observed with extrinsic optical imaging). In particular, we will focus on the two following issues:

Diffusion

Depending on the task, and given the underlying neural circuitry and computational power, how far, and how fast should local information be transmitted (e.g., intensity, local gradient, local movement)?

Feedback

How can different information pathways, associated with different processing tasks, interact?

Results and discussion

Input images, encoded by means of a simple latency code, are processed by a network of spiking neurons generated from the variational description of the task. A simple temporal coding scheme is used in this initial study, the underlying idea being to analyze the possible role of synchrony as a support for diffusing information [5]. A step further, this relates to more general forms of computation in the brain, in terms of propagation of information, neural coding. It has also being linked [3] to modulation of a feed-forward processing track by various feedback mechanisms.

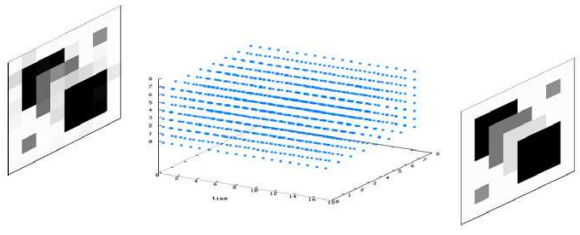

Figure 1
Image denoising by a spiking neural network with local interactions (nearest neighbors).

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