ICA with spiking neurons?

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Overview
- Intrinsic plasticity (IP): homeostatic regulation of neuronal properties [ZhangLinden2003].
- IP may contribute to efficient coding, under a limited energy constraint [StemmlerKoch99].
- Combined with synaptic learning, IP discovers heavy tailed distributions in the input [Triesch2007].
- STDP can result in weight changes similar to Hebbian learning [Izhikevich2003].

ICA with IF neurons
Find one IC by IP and Hebbian learning

Rate neuron model:
\[ y = \delta_0(x) = \frac{1}{1 + \exp(-ax + b)} \]

STDP and Hebbian learning
- Nearest-neighbor interactions
- Weak input-output correlations
- Learning window [Izhikevich]

ICA with IP neurons
Leaky integrate-and-fire neuron:
\[ \tau \frac{dy}{dt} = -y(t) + w(t) + RI(t) \]

IP rule:
- match the first 2 moments of the output distribution \( (m_1, m_2) \) to that of an exponential:
\[ m_1 = \langle y \rangle \]
\[ m_2 = \langle y^2 \rangle \]
\[ \Delta R = \lambda_R \cdot (m_1 - m_1) \]
\[ \Delta rC = \lambda_C \cdot (m_2 - m_2) \]

Learning different ICs

Conclusions
- New IP model for integrate-and-fire neurons.
- Combination of IP and STDP allows the neuron to learn one IC for the bars problem.
- The neuron outputs can be decorrelated by lateral inhibition and anti-Hebbian learning.
- ICA can be implemented using only simple biologically-plausible mechanisms.

References

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