ICA with spiking neurons?

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Overview

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

ICA with rate neurons

Find one IC by IP and Hebbian learning

Leaky integrate-and-fire neuron:
\[ \tau \frac{du}{dt} = u(t) - u(t) + RI(t) \]
\[ \tau = RC \]

IP rule:
- match the first 2 moments of the output distribution to that of an exponential
- IP can discover heavy-tailed distributions in the input [Triesch2007] - Combined with synaptic learning, IP can discover heavy-tailed distributions in the input [Triesch2007]

ADP and Hebbian learning

AMPA synapses
- nearest-neighbor interactions
- weak input-output correlations
- BCM-like threshold between potentiation and depression
- learning window [Izhikevich]:
\[ A_i > |A_{ij}| \quad |A(C_i) > A_{ij} + \alpha \]

With Hebbian learning:
- Input distribution:
- Output distribution:

Learning one IC

Model parameters:
- Moments learning rate: \( \alpha_t = 0.01 \)
- IP learning rate: \( J = 10^{-3} \cdot \lambda = 10^{-1} \)
- Synapse amplitude: \( A_0 = 0.18 \)
- STDP: \( A_i = 1.0 \cdot 10^{-6} \)
- \( \lambda = 1.0 \cdot 10^{-6} \)
- Bin size: 10

With STDP:
- Weight histogram
- Rate histogram

Conclusions

- New IP model for integrate-and-fire neurons
- When combined with STDP or Hebbian learning the neuron is able to learn one IC for the bars problem
- For the full IC basis, the neuron outputs can be decorrelated by lateral inhibition
- ICA can be implemented using only simple biologically-plausible mechanisms

References


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