Models of low-level vision: linking probabilistic models and neural masses

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Correlating Excitation and Inhibition in Visual Cortex

Stimulus

Drifting Grating

Spikes

Trial

Membrane Potential

MP (mV)

MP (mV)

Time (s)

Time (s)

Natural Image + Eye mvt

(Jens Kremkow, PhD.)
Models of unsupervised learning of natural images
Models of unsupervised learning of natural images

\[ C(s|x, A) = \frac{1}{2\sigma^2} \| x - \sum_j s_j A_j \|^2 + \lambda \| s \|_0 \]  (Perrinet, 2010, Neural Comp.)
Macroscopic effect of microscopic patches connections

(Nicole Voges)
Implementing an association field: Markov Random Field

\[ I(\vec{x} + \vec{v} \cdot dt, t + dt) \approx I(\vec{x}, t) \]

\[ \nabla I \cdot V + \Delta t I \propto N_I \]
Implementing an association field: Markov Random Field

\[ \frac{\mathbf{I}(\mathbf{x}+\mathbf{v}.dt, t+dt)}{\mathbf{I}(\mathbf{x}, t)} \approx \nabla \mathbf{I}.\mathbf{V} + \Delta t \mathbf{I} \propto \mathcal{N}_I \]

\[ \nabla \mathbf{V}.\mathbf{V} + \Delta t \mathbf{V} \propto \mathcal{N}_V \]
Implementing an association field: Markov Random Field

\[ \nabla l \cdot v + \Delta_t l \propto \mathcal{N}_l \]

\[ \nabla V \cdot v + \Delta_t V \propto \mathcal{N}_V \]

\[ P(V_t|l_{0:t}) \propto P(l_t|V_t)P(V_t|l_{0:t-1}) \text{ with} \]

\[ P(V_t|l_{0:t-1}) = \int dV_t P(V_t|V_{t-1})P(V_t|l_{t-1}) \]
Implementation of an association field: results
Implementation of an association field: results

input  early  motion  late  OFR

[Images and graphs related to the text]
Implementation of an association field: results

input  early  motion  late  OFR

eye velocity
time (ms)

0°  45°  90°  135°  180°  225°  270°  315°

hor  ver

0  5  10  15  20  25  30  35  40

time (ms)

0.0  0.1  0.2  0.3  0.4  0.5  0.6
Implementation of an association field: results

Input early motion late OFR

Eye velocity versus time for different directions.

0° 45° 90° 135° 180° 225° 270° 315°
Emergence of low-level visual computations
Emergence of low-level visual computations
Emergence of low-level visual computations
Emergence of low-level visual computations
Emergence of low-level visual computations
Take-home message

\[ P(V,x-V\cdot dt|t-dt) \times P(V,x|t) \]

\[ P(V,x|t,I(t)) \]
Take-home message

\[
P(V,x-V.dt|t-dt) \odot P(V,x|t) = P(V,x|t,I(t))
\]
Take-home message
For more information: http://www.incm.cnrs-mrs.fr/LaurentPerrinet/Publications/Perrinet10facets.
latency effect

sharpening of CRF

surround suppression
Figure 5. One time-step in the CONDENSATION algorithm: Each of the three steps—drift-diffuse-measure—of the probabilistic propagation process of Fig. 2 is represented by steps in the CONDENSATION algorithm.
Figure 1. Probability distribution of contrasts, (a), in the fly environment from the measurements of Laughlin (1981). The contrast–response predicted by information theory is the cumulative probability map in (b). (c) is a comparison between the predicted response and that actually measured by Laughlin (1981) in the LMC.