Dynamics of a probabilistic motion field with predictive inference

Laurent U. Perrinet and Guillaume S. Masson
CNRS / Université de la Méditerrannée, Marseille, France

Spatio-Temporal Integration in Ocular Following Response

This allows to compute a probabilistic representation which may be used to model spatial integration of the different local motion cues. First, we consider cues to be independent and the density of neurons pooling responses for the OFR as a centered Gaussian and a surround inhibition similar to the Ratio-Of-Gaussian (ROG) model [Sceniak et al., 1999; Cavanaugh et al., 2002]. We proved that this model is successfully adapted to model the OFR [Perrinet and Masson, 2007].

Predictive coding and the integration of motion information

This leads to the auto-advective term in the Navier-Stokes equations and adds-up to the equation for intensity conservation (see Eq. 1).

Figure 3: Writing the velocity field as a vector field, velocity is conserved along path-lines:
\[ \nabla \cdot V + \Delta V = 0 \]

1D motion early vel. pdf 1D spatial map 2D motion late vel. pdf OFR

Figure 4: To implement Eq. 1 and 2, we use particle filtering [Degond and Mas-Galic, 1989; Isard and Blake, 1998]. Particles are generated as a weighted set of particles by importance sampling using Eq. 1 and propagated according to Eq. 2. We show processing steps for a moving dot (2D motion color code: blue= early, red=late).

Figure 5: The internal noise introduced in the propagation of particles, as defined in [Doucet et al., 2000; Doucet and Johansen, 2008], is an important parameter for the stability of results.

Dynamical emergence of 2D motion feature detectors

Figure 6: Results obtained with various stimuli. Although no explicit model of 2D motion as [Wilson et al., 1992] is introduced, the predictive coding constraint (see Eq. 2) is sufficient to let 2D motion feature detectors emerge from the dynamics of the particles.

References


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