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Poster presentation

Decoding the population dynamics underlying ocular following response using a probabilistic framework

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Introduction

The machinery behind the visual perception of motion and the subsequent sensorimotor transformation, such as in Ocular Following Response (OFR), is confronted with uncertainties, which the primate's visual system efficiently resolves. We may understand this response as an ideal observer in a probabilistic framework by using Bayesian theory [1] that we previously proved to be successfully adapted to model the OFR for different levels of noise with full field gratings or with disk of various sizes and the effect of a flickering surround [2]. More recent experiments of OFR have used disk gratings and bipartite stimuli that are optimized to study the dynamics of center-surround integration. We quantified two main characteristics of the global spatial integration of motion from an intermediate map of possible local translation velocities: (i) a finite optimal stimulus size for driving OFR, surrounded by an antagonistic modulation and (ii) a direction selective suppressive effect of the surround on the contrast gain control of the central stimuli [3]. Herein, we extended in the dynamical domain the ideal observer model to simulate the spatial integration of the different local motion cues within a probabilistic representation. We present analytical results showing that the hypothesis of independence of local measures can describe the initial segment of spatial integration of motion signal. Within this framework, we successfully accounted for the dynamic contrast gain control mechanisms observed in the behavioral data for center-surround stimuli. However, another inhibitory mechanism had to be added to account for suppressive effects of the surround.

We explore here a hypothesis where this could be understood as the effect of a recurrent prediction of information in the velocity map. In fact, in previous models, the integration step assumes independence of the local information while natural scenes are very predictable: due to the rigidity and inertia of physical objects in visual space, neighboring local spatiotemporal information is redundant and one may introduce this *a priori* knowledge of the statistics of the input in the ideal observer model. We implement this in a realistic model of a layer representing velocities in a map of cortical columns, where predictions are implemented by lateral interactions within the cortical area. First, raw velocities are estimated locally from images and are propagated to this area in a feed-forward manner. Using this velocity map, we progressively learn the dependence of local velocities in a second layer of the model. Results show that this simple model is sufficient to disambiguate characteristic patterns such as the Barber-Pole illusion. Due to the recursive network that modulates the velocity map, it also explains that the representation may exhibit some "memory," such as when an object suddenly disappears or when presenting a dot followed by a line (line-motion illusion). We will relate this emergent property of the motion perception system to the concept of second-order motion.

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