VISUAL MOTION ESTIMATION AND OPTIMAL SENSORY PROCESSING IN THE FLY

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Sense organs are usually subject to a very complex high dimensional stream of stimuli, especially during natural behavior of the animal that they belong to. As an animal moves through the world, for instance, the photoreceptors in its eyes receive a complicated, fluctuating spatiotemporal pattern of signals, blurred by optics, and corrupted by photon shot noise. This data stream forms the input to the information processing machinery in the brain, which must make sense of this complex high-dimensional input, typically in real time. Many animals, flies certainly among them, rely on visual motion estimation for navigation. Because of its importance in the fly's behavior and survival, it seems reasonable to assume that neural computation of motion estimates is under strong evolutionary pressure to be as fast and reliable as possible. We are interested in how the fly computes motion from visual input, aiming to understand this particular example of sensory processing within the wider context of optimal processing of natural signals.

I will present two approaches to this question. First, I will discuss a direct sampling strategy, which aims at quantifying the joint distribution of rotational motion and visual input in natural conditions. From that distribution we derive certain characteristics of the optimal motion estimator. These predictions are compared to the behavior of a fly motion sensitive neuron under comparable conditions. Second, I will present data from a fly motion sensitive neuron recorded during motion with approximately natural dynamics in a fully natural environment. The findings from both sets of experiments suggest that motion estimation by the fly's brain approaches an optimal strategy within the context of real world visual statistics. The ramifications of this conclusion will be discussed.