Neural Responses to Moving Natural Scenes

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Abstract

Visual movement is important to most animals that move quickly, and even some that do not. What *neural computations* do animals use to see visual motion in their natural environment?

The visual stimulus used to perform experiments on such questions is critical, and has historically limited the ability to perform experiments asking critical questions about responses to naturalistic moving scenes. The ability to display, at high frame rates, moving natural panoramas and other stimuli distorted to compensate for projection onto a flat screen was important to the experiments described here. I therefore created a software library called the 'Vision Egg' that allows creation of motion stimuli with recent, inexpensive computer hardware, and was used for the experiments described here.

Additionally, I developed a mathematical model to determine the quality of motion simulation possible with computer displays. This model was applied to reach an understanding of the 'ghosting' artifact sometimes perceived on such apparent motion displays. Psychophysical experiments on human observers confirmed model predictions and allowed testing of synthetic motion blur for simulation of smooth motion and elimination of the ghosting artifact. I show this synthetic motion blur is optimal in the sense of creating the closest perception possible to that of smooth motion experienced in natural settings. Experiments on humans and flies show that such synthetic 'motion blur' has no effect on motion detection *per se*. However, ghosting in sampled displays results in information not present in smooth motion at high velocities, permitting inappropriate discrimination of rapidly moving features.

I performed experiments measuring the responses of hoverfly wide-field motion detecting neurons (HS cells) in adapted and unadapted states to the velocity of natural scenes. Responses to natural images of varied intrinsic contrast depend little on the choice of image. Artificially reducing contrast, however, does reduce response magnitudes. Finally, the greatest component of response variation to natural scenes is directly related to local structure in the scenes, and could thus be called 'pattern noise.'

The large receptive field of HS cells arises from a (non-linear) spatial summation of numerous elementary motion detectors. I measured spatial and temporal contrast sensitivity of small patches in the large receptive field. As predicted from the presence of a frontal optical acute zone, spatial tuning is highest frontally. A sexually dimorphic 'bright zone' in the fronto-dorsal eye is correlated with enhanced contrast sensitivity and faster temporal tuning in HS cells with receptive fields in this region of male flies.