Pursuit Eye Movements

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Abstract

When viewing objects, primates use a combination of saccadic and pursuit eye movements to stabilize the retinal image of the object of regard within the high-acuity region near the fovea. Although these movements involve widespread regions of the nervous system, they mix seamlessly in normal behavior. Saccades are discrete movements that quickly direct the eyes toward a visual target, thereby translating the image of the target from an eccentric retinal location to the fovea. In contrast, pursuit is a continuous movement that slowly rotates the eyes to compensate for the motion of the visual target, minimizing the blur that can compromise visual acuity.

This brief review outlines a new framework for understanding the sensorimotor processing and control strategy of the pursuit eye-movement system. Control theory models and small spot experiments have helped frame some of the basic principles of organization of the pursuit system, but the essentially linear models that have been proposed cannot account for more recent behavioral and physiological data obtained with more complex stimuli. The growing evidence that inherently non-linear processes such as image segmentation, selective motion integration, target identification and selection, prediction, and even cognitive and attentional factors play critical roles in pursuit, highlights the need for models that transcend the traditional linear or quasilinear system theory modeling. Furthermore, two independent and apparently unrelated recent findings, the fact that cerebellar output provides for plant compensation and that the primary sensory drive for pursuit appears to be object motion (or trajectory) and not mere retinal error, both logically imply a pursuit control strategy based on object motion, not image motion. If pursuit is guided by a 3D estimate of object motion provided by the cerebral cortex, then a brainstem-cerebellar loop is not needed for velocity memory. Conversely, if the cerebellum compensates for the dynamics of the eye plant, then the descending control signal should be the desired eye trajectory, not retinal image motion.