An Active Efficient Coding Model of Optokinetic Nystagmus

Bertram Shi

Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology, Hong Kong, China

E-mail: eebert@ee.ust.hk

Optokinetic nystagmus (OKN) is an involuntary eye movement responsible for stabilizing retinal images in the presence of relative motion between an observer and the environment. Fully understanding the development of optokinetic nystagmus requires a neurally plausible computational model that accounts for the neural development and the behavior. To date, work in this area has been limited. We propose a neurally plausible framework for the joint development of disparity and motion tuning in the visual cortex and of optokinetic and vergence eye movement behavior. To our knowledge, this framework is the first developmental model to describe the emergence of OKN in a behaving organism. Unlike past models, which were based on scalar models of overall activity in different neural areas, our framework models the development of the detailed connectivity both from the retinal input to the visual cortex, as well as from the visual cortex to the motor neurons. This framework accounts for the importance of the development of normal vergence control and binocular vision in achieving normal monocular OKN (mOKN) behaviors. Because the model includes behavior, we can simulate the same perturbations as performed in past experiments, such as artificially induced strabismus. The proposed model agrees both qualitatively and quantitatively with a number of findings from the literature on both binocular vision as well as the optokinetic reflex. Finally, our model also makes quantitative predictions about OKN behavior using the same methods used to characterize OKN in the experimental literature.