Receptive Field Dynamics Underlying MST Neuronal Optic Flow Selectivity

Chen Ping Yu[1], William K. Page[2], Roger Gaborski[1], and Charles J. Duffy[2]

[1]Departments of Computer Sciences, Rochester Institute of Technology

Rochester, New York 14623

[2]Departments of Neurology, Neurobiology and Anatomy, Ophthalmology, Brain and Cognitive Sciences, and The Center for Visual Science,

The University of Rochester Medical Center

Rochester, New York 14642

Brief Title: Modeling Optic Flow Selectivity

40 pages, 10 figures

Title 71 chars, Abstract 243 words, Introduction 493 words, Discussion 1,558 words

Key words: receptive fields, computational models, optic flow, visual motion, extrastriate cortex, MST

Address correspondence to:

Charles J. Duffy, M.D., Ph.D.

Department of Neurology

University of Rochester Medical Center

601 Elmwood Avenue

Rochester, New York 14642-0673

Phone: (585) 273-1696

Fax: (585) 442-8766

charles_duffy@urmc.rochester.edu

ABSTRACT

Optic flow informs moving observers about their heading direction. Neurons in monkey medial superior temporal (MST) cortex show heading selective responses to optic flow and planar direction selective responses to patches of local motion. We recorded MST neuronal responses to a 90^{o} X 90^{o} optic flow display, and to a 3 X 3 array of local motion patches covering the same area. Our goal was to test the hypothesis that the optic flow responses reflect the sum of the local motion responses. The local motion responses of each neuron were modeled as a mixture of Gaussians, derived using a genetic algorithm, and then used to predict that neuron's optic flow responses. Although some neurons showed good correspondence between the local motion model and the optic flow responses, others showed substantial differences.

We then used the genetic algorithm to modulate the relative strength of each local motion segment's responses to accommodate multiplicative interactions during their co-activation by the global patterns of optic flow. These gain modulated models showed uniformly better fits to the optic flow responses, suggesting that co-activation of receptive field segments alters neuronal response properties. We tested this hypothesis by simultaneously presenting local motion stimuli at two different sites. These two-segment stimulus studies revealed that interactions between response segments have direction and location specific effects that can account for aspects of optic flow selectivity. We conclude that MST's optic flow selectivity reflects dynamic interactions between spatially distributed local planar motion response mechanisms.