Optimal linear estimation of self-motion -- a real-world test of a model of fly tangential neurons

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The tangential neurons in the fly brain are sensitive to the typical optic flow patterns generated during self-motion (see example in Fig.1). We examine whether a simplified linear model of these neurons can be used to estimate self-motion from the optic flow. We present a theory for the construction of an optimal linear estimator incorporating prior knowledge both about the distance distribution of the environment, and about the noise and self-motion statistics of the sensor. The optimal estimator is tested on a gantry carrying an omnidirectional vision sensor that can be moved along three translational and one rotational degree of freedom. The experiments indicate that the proposed approach yields accurate results for rotation estimates, independently of the current translation and scene layout. Translation estimates, however, turned out to be sensitive to simultaneous rotation and to the particular distance distribution of the scene. The gantry experiments confirm that the receptive field organization of the tangential neurons allows them, as an ensemble, to extract self-motion from the optic flow.

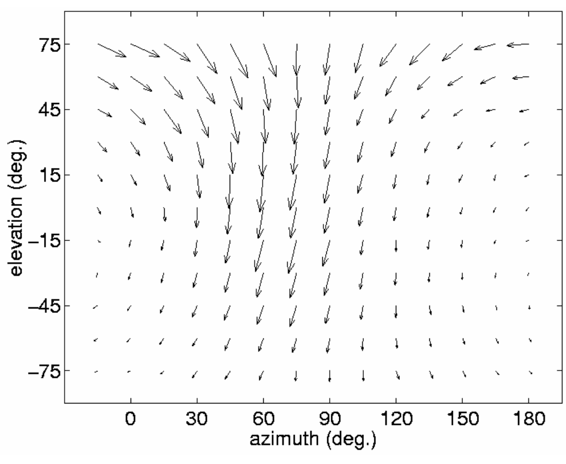

Fig.1. Mercator map of the response field of the tangential neuron VS4. The orientation of each arrow gives the local preferred motion direction, and its length denotes the local motion sensitivity (redrawn after Krapp et al., *J. Neurophysiol*. **79**, 1902-1917, 1998).