A hierarchical model of complex cells in visual cortex for the binocular perception of motion-in-depth

Silvio P. Sabatini, Fabio Solari, Giulia Andreani, Chiara Bartolozzi, and Giacomo M. Bisio
Department of Biophysical and Electronic Engineering
University of Genoa, I-16145 Genova, ITALY
sibio@dile.unige.it

Abstract

A cortical model for motion-in-depth selectivity of complex cells in the visual cortex is proposed. The model is based on a time extension of the phase-based techniques for disparity estimation. We consider the computation of the total temporal derivative of the time-varying disparity through the combination of the responses of disparity energy units. To take into account the physiological plausibility, the model is based on the combinations of binocular cells characterized by different ocular dominance indices. The resulting cortical units of the model show a sharp selectivity for motion-in-depth that has been compared with that reported in the literature for real cortical cells.

1 Introduction

The analysis of a dynamic scene implies estimates of motion parameters to infer spatio-temporal information about the visual world. In particular, the perception of motion-in-depth (MID), i.e. the capability of discriminating between forward and backward movements of objects from an observer, has important implications for navigation in dynamic environments. In general, a reliable estimate of motion-in-depth can be gained by considering the dynamic stereo correspondence problem in the stereo image signals acquired by a binocular vision system. Fig. 1 shows the relationships between an object moving in the 3-D space and its geometrical projections in the right and left retinas. In a first approximation, the positions of corresponding points are related by a 1-D horizontal shift, the disparity, along the direction of the epipolar lines. Formally, the left and right observed intensities from the two eyes, respectively $I^L(x)$ and $I^R(x)$, result related as $I^L(x) = I^R[x + \delta(x)]$, where $\delta(x)$ is the horizontal binocular disparity. If an object moves from $P$ to $Q$ its disparity changes and projects different velocities ($v_L$, $v_R$) on the retinas.