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Motion processing in the primary visual cortex – Networks and their spatio-temporal receptive fields

Helmut Glünder

Institut für Medizinische Psychologie, LMU, Gœthestraße 31, 80336 München
Bureau G2 für wiss.-techn. Dienstleistungen, Amalienstraße 71, 80799 München

Despite the huge collection of details about the primary visual cortex, little is known about the relation between its structure and its purpose. However, there are good reasons to conjecture that spatial (disparity) and spatio-temporal (velocity) correspondences are determined at the level of simple cells. Recently, we showed how competitive networks – that resemble the hypercolumnar organization with its selective lateral interconnections – can compute velocity vector fields from motion detector signals [1;2] and that they are related to networks for the estimation of binocular disparities [3;4].

The purpose of our schemes is to select the plausible spatio-temporal correspondences (velocity vectors) between picture points from the possible ones. Moving retinal images stimulate spatio-temporal coincidence detectors and activate cortical cells that represent possible vectors. Essentially, we now assume every neuron to inhibit cells representing different vectors that originate from the same location (intra-hypercolumnar inhibition) and to excite cells representing the same vector originating from surrounding points. This competitive interaction causes the activity of certain neurons, i.e. the plausibility of the velocity vectors they represent, to decline and finally even to stop. Consequently, the network relaxes to an estimate of the actual vector field.

Receptive Fields (RFs) of cells in such populations have two remarkable properties: They change during relaxation and they are characterized by motion vectors – not by purely spatial organizations. The simplified spatio-temporal RF of a cell of the above described system (without preprocessing, on/off-computation, etc.) with its isotropic spatial surround is shown in Fig. 1. The neuron is tuned to the bold vector. Its activity is increased by collinear (solid) and decreased by divergent (dotted) vectors (only two pairs drawn). Compliance to deviations from purely translatory motion (dashed Fig. 2) might be expected from a system characterized by the RF sketched in Fig. 2, but its actual performance is disappointing. However, networks of cells with RFs that have oriented spatial surrounds (vertical in Fig. 3) produce reasonably convincing results.

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[4] Mayhew J.E.W. and Frisby J.P. (1980) *Perception* **9**: 69-86.

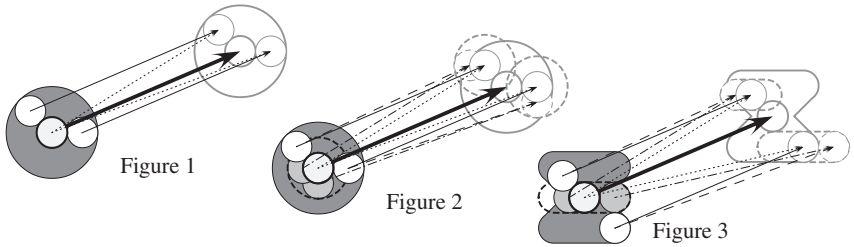

Figure 1 Figure 2 Figure 3