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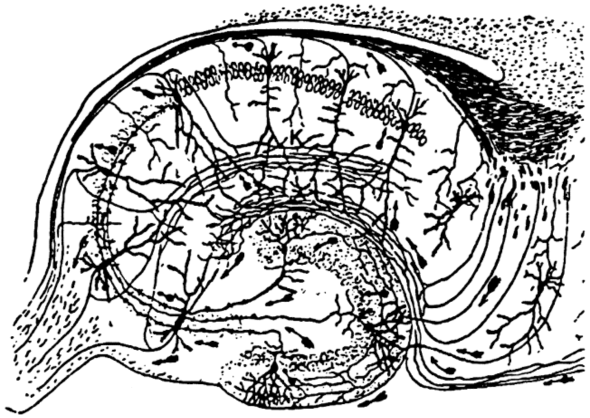

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Same network – different formal neurons

Two network implementations for competitive motion analysis

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We compared the behaviour of a biologically inspired artificial neural network when implemented with either “threshold logic”(1) or “leaky integrate & fire”(2) model neurons. Implementation (1) reliably approximates the solution of the correspondence problem in visual motion analysis for rigid objects that translate in the plane [1]. For two reasons this structured network is appealing for the desired comparison: It shows a non-trivial competitive, i.e. excitatory and inhibitory interconnection scheme, and its function is based on relaxation, i.e. results evolve in time. – In the sequel to our detailed investigations of populations of type (2) units with local, purely excitatory or inhibitory, and delayed recurrent coupling [2] the first argument was decisive during our search for a reasonable network with mixed interconnections. Moreover, the interplay between the spike-related temporal fine structure and the global temporal relaxation process promised essential insights to competitive neural processing.

The here considered analysis of two-frame motion selects plausible correspondences between object pixels from the possible ones. For images with n pixels, the network consists of $n(n-1)$ units, each representing a pixel correspondence (velocity vector). In its most basic form, every unit of the network inhibits units representing different vectors that originate from the same pixel and excites units that represent the same vector at neighbouring pixels. All units characterizing possible vectors of object pixels are initially activated. With implementation (1) and owing to the interconnection scheme, the activity of some units will be reduced and the corresponding vectors discarded. Repeatedly applied, this procedure results in the desired velocity estimates.

The nonlinear dynamics of implementation (2) appears too complex for useful theoretical predictions. Thus, we performed elaborate simulations and gained first answers to the crucial question about the behaviour of this implementation. For this purpose, activated type (2) units (time constant 10 ms) received a constant input current that produces a spike rate of $100/\text{s}$ in an uncoupled unit. The PSP amplitude $\pm w$ in percent of the “resting potential to threshold”-range and the transmission delays ϑ_{exc} and ϑ_{inh} were free parameters. Inhibition was not mediated by interneurons.

- With physiological parameter values, it appears impossible to significantly alter or even suppress the spiking activity of units representing incorrect vectors.
- The spiking activity could be synchronized within groups representing the same vectors at different pixels. These group activities differed by arbitrary phase shifts.
- This behaviour was observed for $\vartheta_{inh} = 2\,\text{ms}$ with $|w| < 15\%$ and $\vartheta_{exc} < 0.6\,\text{ms}$.
- The parameter choice is delicate and group synchronization can hardly be deduced from the behaviour of networks with purely excitatory or inhibitory coupling.

[1] Glünder H. and Lehmann A. (1992) Relaxation in 4D state space – A competitive network approach to object-related velocity vector-field correction. In: Aleksander I. and Taylor J. (eds.) *Artificial Neural Networks 2*. Elsevier, Amsterdam, pp. 509-512.

[2] Glünder H. and Nischwitz A. (1993) On spike synchronization. In: Aertsen A. (ed.) *Brain Theory – Spatio-Temporal Aspects of Brain Function*. Elsevier, Amsterdam, pp. 251-258.