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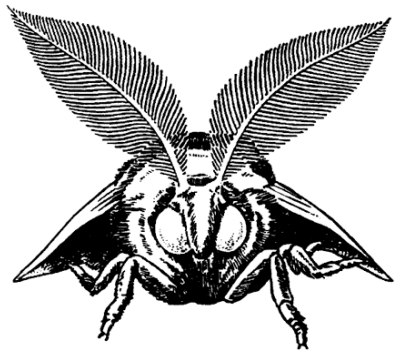

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Single unit (SUA) and group activity (MUA) in simulated populations of impulse coupled neurons with lateral inhibition

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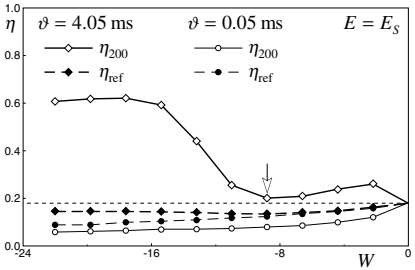
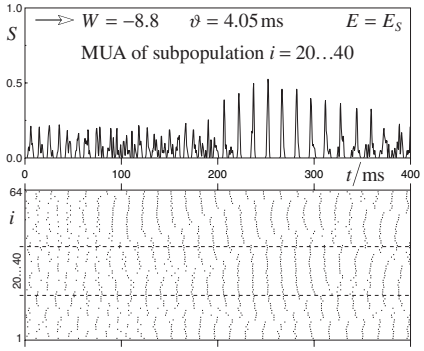
We studied the temporal fine structure of spike activity in networks that so far have not received much theoretical attention, namely local lateral inhibition with transmission delay between noisy "leaky integrate & fire" model neurons [1; 2]. For this purpose we ran computer simulations (temporal resolution: 0.1 ms) of chains of $n=64$ units, each coupled to its ±8 neighbours by inhibitory links. The units integrate with $\tau=10\,\text{ms}$ and emit spikes (1 ms) when the potential surpasses the threshold. Noise is added to simulate fluctuations of the somatic potentials. At the start of every run, the unit's potentials are chosen at random while the mean stimulation E (input current) is the same for all units (for details of the model neuron and the network see [3]).

We exemplify the network behaviour for remarkable settings of coupling strength W, transmission delay ϑ, and stimulation $E = const$ as well as $E = E(t)$. The results are displayed and quantified by spatio-temporal spike patterns (n SUAs), spike densities S (integral spike activity of λ units in a running window of 1 ms duration; ≈ MUA), and qualities of spike synchrony η (mean over 50 runs of $\max\{S(150 < t \le 200\,\text{ms})\}$).

We observed good and stable synchronization in the whole population for transmission delays $\vartheta > 2\,\text{ms}$ and strong coupling $W < -15$, desynchronization, i.e. $\eta < \eta_{\text{ref}}$ (η_{ref}: synchrony by chance) for $\vartheta \approx 0\,\text{ms}$, dynamic spatial clustering (see Figure) for weak coupling $-12 < W < 0$ and moderate stimulation, and destructive interference, i.e. low synchrony, for delays around about multiples of the period of an uncoupled unit.

[1] Kirillov A.B. and Woodward D.J. (1993) In: Int. Neural Network Society (ed.) *Proc. of the WCNN 1993* (Portland/OR, 11.-15.07.1992). Erlbaum, Hillsdale/NJ, pp. 594-597.
[2] Nischwitz A., Glünder H., von Oertzen A. and Klausner P. (1992) In: Aleksander I. and Taylor J. (eds.) *Artificial Neural Networks 2*. Elsevier, Amsterdam, pp. 851-854.
[3] Glünder H. and Nischwitz A. (1993) In: Aertsen A. (ed.) *Brain Theory. Spatio-Temporal Aspects of Brain Function*. Elsevier, Amsterdam, pp. 251-258.





- Quality of synchrony $\eta(W)$ for moderate stimulation
- Spike density $S(t)$ (MUA) for the units $i = 20\ldots40$
- Spatio-temporal spike pattern of 64 laterally weakly inhibited units (64 SUAs)