# SPIKE INDEPENDENCY IN FEED-FORWARD NETWORKS

Yutaka Sakai

Department of Information and Computer Sciences, Faculty of Engineering,
Saitama University,
Saitama, Saitama 338-8570, Japan.
sakai@bios.ics.saitama-u.ac.jp

**Abstract**

A cortical neuron puts thousands of synaptic contacts on other neurons. A spike event caused in a neuron is transmitted to a number of post-synaptic neurons. Each of them also conveys the effect of the spike event to a number of neurons. Thus, the effect of the spike event spreads over a large number of neurons So it is natural that spike timings are found to be correlated to each other. But there have been few reports of spike timing correlations, while some works reported somewhat longer time range correlations through mean spike rates. It is generally hard to find spike timing correlations. That is, in general, spike timings are statistically independent. Why do cortical neurons discharge spikes so independently? The present study attempts to determine whether a simple feed-forward neural network can reproduce spiking independency.

The spiking mechanism of each unit is assumed to be common and temporally independent. Namely, the stochastic law of spike events does not depend on the history of input, but depends on only the net input at the moment. The assumption can be applied if inter-spike intervals are highly variable and relatively long to the neuronal refractory period. In such a case, however, there practically exists a lower limit of time scale $\Delta t$ between which the spiking mechanism can be considered to be independent. So the present study adopts the discrete time separated by $\Delta t$. The network has only feed-forward connections with weights obeying a common distribution for all units. The number of units is large enough to discuss macroscopic statistical quantities.

If units in the previous layer are almost independent, then the input can be approximated to be Gaussian. Since symmetry, the state of a layer can be described by two variable: firing rate of the previous layer units, $\lambda$, and correlation coefficient of inputs, $\gamma$. Map of the $\ell$-layer state variables to layer $\ell+1$ can be defined,

$$\left(\lambda^{\ell},\gamma^{\ell}\right)\mapsto(\lambda^{\ell+1},\gamma^{\ell+1}).$$

Linear stability analyses are performed around $\gamma=0$ to obtain the condition that spike independency is stable. The case of threshold unit is applied for the analysis and the following results are obtained,

- the independency-stable parameter region contains a reasonable range,
- the independency-stable spike probability has a lower limit, $\lambda\Delta t \geq 0.0323$.

Thus, a simple feed-forward network is found to reproduce spike independency. The lower limit of spike probability prevents the operation of continuous limit of time, $\Delta t \to 0$. ut practically $\Delta t$ is finite, so it is no problem. For example, if $\Delta t$ is assumed to be 10msec, then the lower limit of spike frequency is about 3Hz. It may imply the role of spontaneous activities of neurons.