NETWORK OF NEURONS WITH NONLINEAR CURRENTS FOR THE COMPARISON OF EFFECTS OF STATIC AND ADAPTIVE SYNAPSES

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Replacing static synapses with the adaptive ones can affect the behavior of neuronal network. Several network setups containing synapses modelled by alpha-functions, called here static synapses, are compared with corresponding setups containing more complex synapses, called here dynamic, or adaptive. The dynamic synapses have four state variables and the time constants are of different orders of magnitude.

What is the advantage for neuronal networks to use dynamic synapses changing their strength within milliseconds or seconds over the usage of static ones? We tried to answer this question using a computer model of neural network. The response of the network to modelled stimulations was studied together with effects of neuronal interconnectivity, the effects of axonal delays and the the effects of the proportion of excitatory and inhibitory neurons on the network output. Considering transitions between output regimes – bursting, synchronous firing, firing with weak or no synchrony – we found that dynamic synapses enable networks to be more sensitive to the changes in their input in comparison to the static networks requiring broader spectrum of inputs to produce similar outputs. Dependency of synaptic strength on synaptic activity was also studied.

We found that dynamic synapses enable network to exhibit broader spectrum of responses to given input and that they make the network more sensitive to changes of network parameters. As a step towards memory modelling, retention of input sequences in the network with static and dynamic synapses was studied. The network with dynamic synapses was found to be more flexible in reducing the interference between adjacent inputs in comparison to the network containing static synapses.

Individual neurons in the network contain the nonlinear, Hodgkin-Huxley type of biophysically realistic ionic currents described in neocortical neurons. Also the connectivity of the network is modeled following the descriptions of neocortex. Details of the simulation setups with all the parameters are available on request and they can be also found in (KURISCAK E and MARSALEK P, 2004).

On a sample **Figure** from our simulation we show that two types of bursting, which build up along the longer time of network simulation (here 5 seconds, 5000 ms), exhibit different type of bursting, as is demonstrated in the two insets in Figure. One can notice that in a network with dynamic synapses, the cross-correlation Rxy corresponding to given proportion of excitatory connectivity is higher, compared to the network with static synapses.

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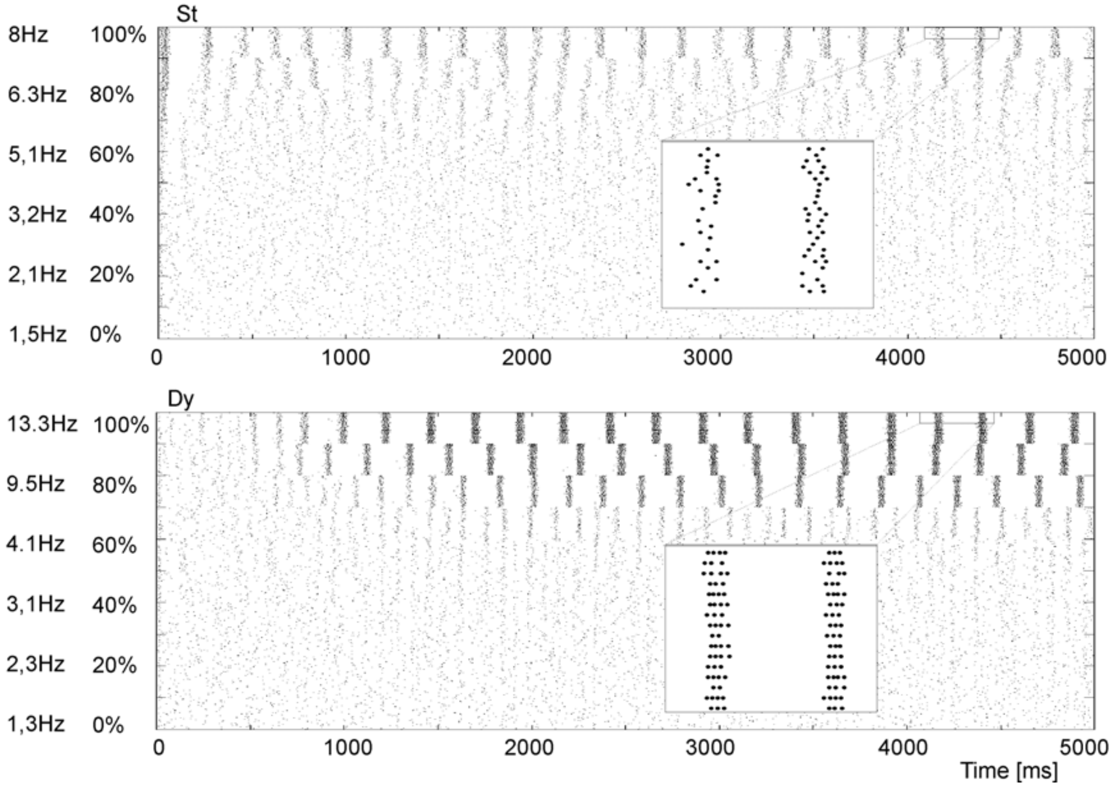

Figure. Sample output spike trains. The two panels show gradual synchronization of the static (St) and dynamic (Dy) networks, when the proportion of excitatory synapses is varied. The variation of the percentage of excitatory synapses together with the mean firing frequency in the network is on the y-axis left, cross-correlation Rxy is on the y-axis right. 20 sample spike trains are shown for each of the 10 successive variations of parameters. On the x-axis is time in ms. Note the initial 1000ms period of "adaptation like" process in the adaptive, (dynamic, Dy) network.

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