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Peak Frequencies in the Collective Membrane Potential of a Hindmarsh-Rose Small-World Neural Network

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Abstract : As discussed extensively in many studies, noise in neural networks have an important role in the functioning and time evolution of the system. The mechanism by which noise induce stochastic resonance enhancing and influencing certain operations is not clarified nor is the mechanism of information storage and coding. With the present research we want to study the role of noise, especially focusing on the frequency peaks in a three variable Hindmarsh−Rose Small−World network. We investigated the behaviour of the network to external noises. We demonstrate that a variation of signal to noise ratio of about 10 dB induces an increase in membrane potential signal of about 15%, averaged over the whole network. We also considered the integral of the whole membrane potential as a paradigm of internal noise, the one generated by the brain network. We showed that this internal noise is attenuated with the size of the network or with the number of random connections. By means of Fourier analysis we found that it has distinct peaks of frequencies, moreover, we showed that increasing the size of the network introducing more neurons, reduced the maximum frequencies generated by the network, whereas the increase in the number of random connections (determined by the small-world probability p) led to a trend toward higher frequencies. This study may give clues on how networks utilize noise to alter the collective behaviour of the system in their operations.

Keywords : neural networks, stochastic processes, small-world networks, discrete Fourier analysis
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