Identification of criticality in neuronal avalanches

Luc Berthouze

Sussex Neuroscience, University of Sussex, Brighton, UK

The notion that the brain may operate at, or close to, a critical state is receiving much attention in the neuroscience community. Much of the work to date has been focused on finding empirical evidence of operation at this regime through the characterisation of power law in some observable of the system, e.g., avalanche size, fluctuation of amplitude, inter-burst interval. Such characterisation is fraught with difficulties, however. In the first part of my presentation, I will describe our study of a simple model of a purely excitatory non-driven neural network that, by construction, operates at a critical point. This model allows us to consider various markers of criticality and illustrate how they should perform in a finite-size system. By calculating the exact distribution of avalanche sizes we are able to show that, over a limited range of avalanche sizes which we precisely identify, the distribution has scale free properties but is not a power law. We consider other possible markers, such as the divergence of susceptibility as the critical point of the system is approached. In the second part, I will present results when the same network is driven by a continuous external input, i.e., when the model does not have a separation of timescales. Derivation of the distributions of waiting times between neuronal avalanches shows that as the system approaches the critical state by two alternative `routes', different markers of criticality (partial scale-free behaviour and long-range temporal correlations) are displayed. This suggests that signatures of criticality exhibited by a particular system in close proximity to a critical state are dependent on the region in parameter space at which the system (currently) resides.