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Neuronal avalanches and learning

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ABSTRACT OF THE TALK

Neuronal networks may exhibit diverse patters of activity. Recently it has been shown that a novel mode of activity is neuronal avalanches, experimentally found *in vitro* and *in vivo*. Moreover, experimental studies of morphology indicate that neurons develop a complex network of connections, with the possibility of very high connectivity degrees. We will discuss a recent model based on self-organized criticality, which consists of an electrical network with threshold firing and activity-dependent synapse strengths. The model is implemented on regular networks, on small world lattices and on the scale-free networks.

The system exhibits an avalanche activity with a power law distribution of sizes and durations. The power spectra of the electrical signal reproduce very robustly the power law behaviour with the exponent 0.8, experimentally measured in electroencephalogram (EEG) spectra. The exponents are quite stable with respect to lattice type, neuronal parameters and strength of plastic remodelling, indicating that universality holds for a wide class of neural network models.

Next we address the classical enigma of how such a chaotic system can ever learn or respond in a controlled and reproducible way. Learning in the model occurs via plastic adaptation of synaptic strengths by a non-uniform negative feedback mechanism. The system is able to learn all the tested rules, in particular the exclusive OR and a random rule with three inputs. The learning dynamics exhibits universal features. We find that the learning performance

and the average time required to learn are controlled by the strength of plastic adaptation, in a way independent of the specific task assigned to the system. Even complex rules can be learned provided that the plastic adaptation is sufficiently slow.