Doursat, R. (2007e) Of tapestries, ponds and RAIN: Toward mesoscopic neurodynamics on excitable media. *International Workshop on Nonlinear Brain Dynamics for Computational Intelligence*, as part of the *10th Joint Conference of Information Systems (JCIS 2007)*, July 20, 2007, Salt Lake City, UT.

Of Tapestries, Ponds and RAIN: Toward Mesoscopic Neurodynamics on Excitable Media

René Doursat

Institut des Systèmes Complexes, CNRS & Ecole Polytechnique, Paris, France
Brain Computation Laboratory, Department of Computer Science, University of Nevada, Reno
http://doursat.free.fr

***Abstract*—** Bridging the lingering gap between symbol-based AI architectures and node-based neural computation requires an intermediate, or *mesoscopic*, scale of description of cognitive functions. Representations at this scale are embodied in local but large-scale *dynamical states* of bioelectrical activity forming quasi-discrete entities. These dynamical entities are (a) endogenously produced by the neuronal substrate, (b) exogenously perturbed under the influence of stimuli and (c) interactively binding to each other. Understanding the laws of self-organization, and induced organization, of the neural signals supporting those entities should become the main topic of *neurodynamics*. In recent years, encouraged by multi-electrode recordings, brain imaging and increased computing power, this discipline has greatly progressed through the large-scale modeling and simulation of biologically realistic *spiking* neuron networks. Taking into account the fine timing of membrane potentials has revealed a great diversity of possible, and plausible, *spatiotemporal* regimes of cortical activity in large cell populations: synchronization and phase locking, delayed correlations and traveling waves, rhythms and chaos, etc. All these regimes are candidates for supporting the above-mentioned mesoscopic entities of cognition. After outlining a new theoretical framework of mesoscopic neurodynamics, I illustrate it with three studies. These works construe the cortical substrate of neuronal units and synaptic contacts as an *excitable medium*, and have potential applications in designing artificial systems for perceptual, linguistic or behavioral tasks: (i) the “self-made tapestry” of neocortex, a model of neural self-structuration into synfire motifs (Doursat & Bienenstock 2006); (ii) the “morphodynamic pond” interface between perception and language, a model of traveling waves on lattices of quasi-oscillatory units (Doursat & Petitot 2005); and (iii) the “RAIN lock-and-key” mechanisms of spatiotemporal pattern recognition, a model of perturbation and coherence induction among Recurrent Asynchronous Irregular Networks (Doursat & Goodman 2006, Goodman, Doursat et al. 2007).