The Emergence of Time from Structure in Models of Neuronal Activity

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Abstract

In this talk, we will illustrate with two examples how temporal activity naturally emerges from the structure of what is a priori atemporal models. The two examples are (i) the process of rate selection in a history-dependent manner in a neuron and (ii) the occurrence of temporal associative memory, where the time falls out naturally as a result of noise in the system. The first example presents the elements of a mathematical computational model that re ects the experimental finding that the time scale of a neuron is not fixed; but rather varies with the history of its stimulus. Unlike most physiological models, there is no predetermined rates associated with transitions between states of the system nor are there predetermined constants associated with adaptation rates; instead the model is a kind of "modulating automata" where the rates emerge from the history of the system itself. We focus here on the temporal dynamics of a neuron and show how a simple internal structure will give rise to complex temporal behavior. The internal structure modeled here is an abstraction of physiological structure reasonably well understood. We also suggest that this behavior can be used to transform a "rate" code to a "temporal one". The second example (to be presented as time allows) shows that in a complex memory system such as Albus' CMAC model of (static) associative memory; the natural assumption of a certain level of fallibility inthe mechanism leads in a natural way to temporal storage and retrieval. This analysis leads to a specific physiological prediction.