Learning with Temporal Derivatives in Pulse-Coded Neuronal Systems

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Abstract: A number of learning models have recently been proposed which involve calculations of temporal differences (or derivatives in continuous-time models). These models. like most adaptive network models. are formulated in tenns of frequency (or activation), a useful abstraction of neuronal firing rates. To more precisely evaluate the implications of a neuronal model. it may be preferable to develop a model which transmits discrete pulse-coded information. We point out that many functions and properties of neuronal processing and learning may depend. in subtle ways. on the pulse-coded nature of the informa(cid:173) tion coding and transmission properties of neuron systems. When com(cid:173) pared to formulations in terms of activation. computing with temporal derivatives (or differences) as proposed by Kosko (1986). Klopf (1988). and Sutton (1988). is both more stable and easier when refor(cid:173) mulated for a more neuronally realistic pulse-coded system. In refor(cid:173) mulating these models in terms of pulse-coding. our motivation has been to enable us to draw further parallels and connections between real-time behavioral models of learning and biological circuit models of the substrates underlying learning and memory.