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"Computational Chaos" in Massively Parallel Neural Networks

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Abstract

A fundamental issue which directly impacts the scalability of current theoretical neural network models to massively parallel embodiments, in both software as well as hardware, is the inherent and unavoidable concurrent asynchronicity of emerging fine-grained computational ensembles and the possible emergence of chaotic manifestations. Previous analyses attributed dynamical instability to the topology of the interconnection matrix, to parasitic components or to propagation delays. However, we have observed the existence of "emergent" computational chaos in a "concurrently asynchronous" framework, independent of the network topology. In this paper we present a methodology enabling the effective asynchronous operation of large-scale neural networks. Necessary and sufficient conditions guaranteeing concurrent asynchronous convergence are established in terms of contracting operators. Lyapunov exponents are computed formally to characterize the underlying nonlinear dynamics. Simulation results are presented to illustrate network convergence to the correct results, even in the presence of "large" delays.