

A SIMPLE DELAYED NEURAL NETWORK WITH LARGE CAPACITY FOR ASSOCIATIVE MEMORY

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ABSTRACT. We consider periodic solutions of a system of difference equations with delay arising from a discrete neural network. We show that such a small network possesses a huge amount of stable periodic orbits with large domains of attraction if the delay is large, and thus the network has the potential large capacity for associative memory and for temporally periodic pattern recognition.

1. Introduction. Multistability in a dynamical system refers to the coexistence of multiple stable patterns such as equilibria and periodic orbits. It has been shown that the coexistence of multiple equilibria/fixed points in a neural network lies at the basis of the mechanism for associative content-addressable memory storage and retrieval [15, 21, 22, 28, 32]. It has also been known that stable periodic orbits and limiting cycle attractors are important for memory storage and other neural activities as some form of memories are encoded as temporally patterned spike trains [8, 15, 16] (see also limiting cycle attractors in excitable cells [24] and in neural circuits constructed from invertebrate neurons [23]). According to Milton and Black [30], there are over 30 diseases of the nervous system in which recurrence of symptoms or the appearance of oscillatory signs are a defining feature. It was also noted in [29] that more than 25 years of experimental and theoretical work indicates that the onset of oscillations in neurons and in neuron populations is characterized by multistability.

Time delays are intrinsic properties of the nervous systems and unavoidable in electronic implementations due to axonal conduction times, distances of interneurons and the finite switching speeds of amplifiers. See, for example, [2, 3, 4, 5, 15, 16, 17, 18, 19, 20, 26, 27, 42]. Periodic orbits for delay differential equations and systems have been extensively studied in the literature. In particular, for a system of two coupled delay differential equations describing the information processing of two identical neurons with delayed feedback, the series of papers [9, 10, 11, 12, 13, 14] established the coexistence of multiple periodic orbits and gave detailed description of their domains of attraction and the structure of the global attractor

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