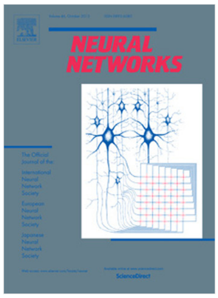
Accepted Manuscript



Global exponential stability of nonautonomous neural network models with unbounded delays

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PII: S0893-6080(17)30208-3
DOI: http://dx.doi.org/10.1016/j.neunet.2017.09.006
Reference: NN 3817

To appear in: *Neural Networks*

Received date : 30 January 2017
Revised date : 4 September 2017
Accepted date : 4 September 2017

Please cite this article as: Oliveira, J.J., Global exponential stability of nonautonomous neural network models with unbounded delays. *Neural Networks* (2017), http://dx.doi.org/10.1016/j.neunet.2017.09.006

Global exponential stability of nonautonomous neural network models with unbounded delays

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Abstract

For a nonautonomous class of n-dimensional differential system with infinite delays, we give sufficient conditions for its global exponential stability, without showing the existence of an equilibrium point, or a periodic solution, or an almost periodic solution. We apply our main result to several concrete neural network models, studied in the literature, and a comparison of results is given. Contrary to usual in the literature about neural networks, the assumption of bounded coefficients is not need to obtain the global exponential stability. Finally, we present numerical examples to illustrate the effectiveness of our results.

Keywords: Cohen-Grossberg neural networks, Infinite distributed delays, Infinite discrete delays, Global exponential stability, Unbounded coefficients.

Mathematics Subject Classification: 34K20, 34K25, 39A30, 92B20.

1 Introduction

In 1983, Cohen and Grossberg [8] presented and studied the well-known neural network model described by the following system of ordinary differential equations

$$x_i'(t) = -a_i(x_i(t))\left[b_i(x_i(t)) - \sum_{j=1}^{n} c_{ij} f_j(x_j(t)) + I_i\right], \quad t \geq 0,\ i = 1, \dots, n, \tag{1.1}$$

where $a_i(u)$ are the amplification functions, $b_i(u)$ are the self-signal functions, $f_j(u)$ are the activation functions, c_{ij} represent the connection weights, and I_i denote the inputs from outside of the system. As particular situation of (1.1), we have the well-known Hopfield neural network model

$$x_i'(t) = -b_i(x_i(t)) + \sum_{j=1}^{n} c_{ij} f_j(x_j(t)) + I_i, \quad t \geq 0,\ i = 1, \dots, n, \tag{1.2}$$

studied by Hopfield [16, 17] in 1982 and 1984 respectively.

Due to the finite switching speed of the amplifiers and the communication time between neurons, differential equations describing neural networks should incorporate time delays. In 1989, Marcus and Westervelt [22] introduced for the first time a discrete delay in the Hopfield model (1.2), and they observed that the delay can destabilize the system. In fact, the delays can affect the dynamic behavior of neural network models [3, 22] and, for this reason, stability of delayed neural network models has been investigated extensively (see [1, 2, 4, 6, 7, 9, 11, 18, 19, 20, 23, 25, 26, 27, 28, 29, 30], and the references therein). Another relevant fact to take into account is that the neuron charging time, the interconnection weights, and the external inputs often change as time proceeds. Thus, neural network models with temporal structure of neural activities should be introduced and investigated (see [7, 25]).

For neural network models with time-varying coefficients, many authors derive sufficient conditions ensuring that all solutions converge exponentially to zero or to an equilibrium point [9, 19, 30]. Other authors assume periodic, or almost periodic, coefficient functions and derive sufficient conditions ensuring the existence of a periodic, or almost periodic, solution and its global exponential stability