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Dynamical behavior of impulsive and periodic Cohen–Grossberg neural networks

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ABSTRACT

This paper investigates the existence and global stability of the periodic solution $\mathring{x}(t)$ to Cohen–Grossberg neural networks with periodic coefficients and impulses. By using comparison results for impulsive differential equations and the method of Lyapunov, we describe the asymptotic behavior of all solutions. In addition, we give an explicit formula for the rate of exponential decay at infinity of the Euclidean norm $\|x(t) - \mathring{x}(t)\|$, where $x(t)$ is any solution of our model. Such a formula involves the jumps and the average of a suitable periodic function depending on the other parameters of the neural networks.

1. Introduction

The dynamics of artificial neural networks has received considerable attention because neural networks have demonstrated a great range of applications in different areas of research such as optimization, pattern recognition, associative memory, robotics and computer vision. It has been observed that many evolutionary processes, including those related to neural networks, may exhibit impulsive effects. From a mathematical point of view, the impulsive differential equations [1,2] are appropriate tools to investigate phenomena characterized by abrupt changes of states. In such situations, the solutions are not continuous but present jumps which could cause instability in the dynamical systems. Hence, it is interesting to investigate the influence of the jumps on the asymptotic behavior of the differential system. An increasing number of papers concerning the subject of global stability of neural networks has been published [3–10]. Among the nonautonomous neural networks models, we consider the following Cohen–Grossberg one

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

which includes Hopfield-type neural networks as a special case.

Sometimes neural networks present periodic oscillations so that their appropriate models are differential equations with periodic properties. In this article we study the existence and attractivity of the periodic solution to system (1.1), with periodic coefficients and impulses at instant time t_k, in the form

$$x_i(t_k^+) - x_i(t_k^-) = \gamma_{ik} x_i(t_k), \quad i = 1, \dots, n,\ k \in \mathbf{N}. \tag{1.2}$$

Some recent results on the dynamics of Cohen–Grossberg neural networks, with impulses or delays, have been obtained [11–13]. Such results require suitable assumptions making the jumps sufficiently small. As a consequence, the influence of impulses on the convergence dynamics of (1.1), (1.2) becomes less significant. In this article, for the existence of a periodic

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