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Existence of an exponential periodic attractor of a class of impulsive differential equations with time-varying delays☆

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ABSTRACT

By using the continuation theorem due to Mawhin and Gaines, some analysis techniques and the Lyapunov functional method, the sufficient conditions ensuring the existence of an exponential periodic attractor of a class of impulsive differential equations with time-varying delays are established. The results are interesting and very different from previously known results [Xia and Wong, 2009 [7]; Tan and Tan, 2009 [19]; Huang et al., 2005 [20]; Liu and Huang, 2006 [22]]. Finally, applications and an example are given to illustrate the effectiveness of the results.

1. Introduction

It is well-known that the properties of stability and convergence are important in design and application in neural networks. In recent years, the dynamics of delayed neural networks has been studied deeply due to its application in image processing, signal processing and patten recognition problem. the reader is referred to Refs. [1–6]. On the other hand, in many cases, the impulsive effect exists in a variety of evolutionary processes where states are changed abruptly at certain moments. Neural networks are often subject to impulsive perturbations which can affect the dynamic behavior of the system just as time delays. Many results on the impulsive effect have been obtained in Refs. [7–18]. For example, in [7], Xia and Wong proposed a class of retarded functional impulsive differential equations as follows:

$$\begin{cases} x_i'(t) = -a_i x_i(t) + f_i(x_1(t), x_2(t), \ldots, x_n(t), x_1(t-\tau_{i1}), \ldots, x_n(t-\tau_{in})) + I_i(t), & t \neq t_k, \\ \Delta x_i(t_k) = x_i(t_k^+) - x_i(t_k^-) = J_k(x_i(t_k)), & t = t_k. \end{cases} \tag{1.1}$$

By using the Banach fixed point theorem and spectral theory, they obtained the existence and stability of the equilibrium point of system (1.1). Actually, both a delayed differential equation and a BAM neural network can be contained in a functional differential equation (1.1), which can be seen in [7].

However, in real world, the delays in neural networks are usually time-varying [19–26]. In addition, it is well-known that an equilibrium point can be seen as a special periodic solution with an arbitrary period [27]. In this sense, the analysis of periodic solutions of neural networks with time-varying delays is more general than that of an equilibrium point [11,15–19].

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