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Synchronization-based parameter estimation of fractional-order neural networks

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Abstract: This paper focuses on the parameter estimation problem of fractional-order neural network. By combing the adaptive control and parameter update law, we generalize the synchronization-based identification method that has been reported in several literatures on identifying unknown parameters of integer-order systems. With this method, parameter identification and synchronization can be achieved simultaneously. Finally, a numerical example is given to illustrate the effectiveness of the theoretical results.

Keywords: Parameter estimation; Synchronization; Fractional-order; Neural networks

1 Introduction

As a generalization of the ordinary differentiation and integration to arbitrary non-integer-order, fractional calculus dates from the 17th century. Though fractional calculus has as a long history as integer-order one, its application in physics and engineering has just attracted increasing interest of many researchers. Fractional-order systems can provide an excellent instrument for the description of memory and hereditary properties of various materials and processes. Because of the properties, fractional calculus has been well used in the study of neural networks. The fractional-order differentiation provides neurons with a fundamental and general computational ability that contributes to efficient information processing, stimulus anticipation and frequency-independent phase shifts in oscillatory neuronal firings [1]. The common capacitance in the continuous-time integer-order neural network can be replaced by the fractance, giving birth to the so-called fractional-order neural network model [2].

Many results on fractional-order neural networks have been obtained [3–18]. Some sufficient conditions were established to ensure the existence and uniqueness of the nontrivial solution for the fractional-order neural networks in [6]. The α-stability and α-synchronization for fractional-order neural networks were investigated in [8]. The stability of fractional-order Hopfield neural networks with constant or time-dependent external inputs was studied in [9], and complete synchronization and quasi-synchronization for different kinds of fractional-order Hopfield neural networks were investigated. The conditions on the global Mittag-Leffler stability and synchronization were established by using Lyapunov method for memristor-based fractional-order neural networks in [10]. The projective synchronization of fractional-order memristor-based neural

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