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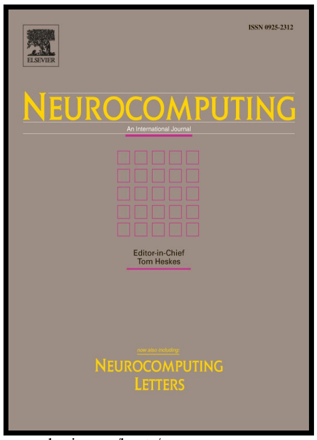

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Distributed State Estimation for Periodic Systems with Sensor Nonlinearities and Successive Packet Dropouts

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***Abstract*—In this paper, distributed state estimators are designed for periodic systems with sensor nonlinearities and successive packet dropouts. In consideration of large quantity of sensors work in harsh environment, the sensor nonlinearities are considered. By using the Bernoulli processes, a new model is introduced to describe the randomly occurred packet dropouts in transmission of neighbors' information. In terms of property of periodic systems, N-periodic distributed state estimators are proposed to estimate the target plant. Then sufficient conditions are established to ensure that the augmented estimation error system is globally asymptotically stable with the prescribed l_2-l_∞ performance index γ in average sense. Finally, a numerical example is utilized to illustrate the effectiveness of the proposed new method.**

***Index Terms*—Periodic systems, distributed state estimator, packet dropouts, sensor nonlinearities.**

I. Introduction

Periodic phenomenon is a common case in personal life, from periodic rotation of crops in agriculture to magnetic attitude control of a satellite in aerospace engineering, from time-periodic control of a multi blade helicopter in engineering to natural seasonal phenomena in environmental area. Therefore, periodic systems modeled by differential/difference equations with periodic coefficients have received extensive attention [1]–[6].

Due to the prolonged exponential growth in semiconductor technology and wireless communications, the low-cost, low-power and multi-functional small size sensor nodes become widely available, followed by the development of sensor networks [7]. Sensor networks have a wide range of applications and mainly focus on military [8], environment and habitat monitoring [9], health monitoring [10], and home area [11]. It is worthy to note that how to estimate the state of target plant by a collaborative way from densely deployed sensor nodes known as distributed state estimation is a representative problem in sensor networks. The distributed state estimation problem requires each sensor node to estimate the state from not only its own measurement but also its neighboring sensors' measurements. Along with the cooperative effectiveness comes some challenges: 1) the complicated coupling between sensor nodes; 2) the nonlinearities induced by inherent characteristics of sensors and network-induced phenomena; 3) some negative phenomena in networks especially as packet dropouts.

Considerable contributions have been done to overcome the complicated coupling problem. The distributed Kalman filtering problem is concerned for a class of networked multi-sensor fusion systems with communication bandwidth constraints [12]. For unstable time-varying random fields, a novel distributed filter, which includes a new type dynamic consensus on pseudo-observations algorithm, has been proposed [13]. H_∞ performance, stochastic parameters and nonlinearities have been considered simultaneously over a finite horizon [14]. Distributed state estimators have been designed for a class of uncertain discrete-time systems with Markov jumping parameters and distributed time-delays [15]. A distributed filtering scheme for sensor networks has been proposed considering some network-induced phenomena [16]. Although innumerable great achievements have been reached by researchers, there still some interesting and meaningful problems such as the l_2-l_∞ distributed estimation for periodic systems need to be investigated.

In sensor networks, most of the sensor nodes work in harsh and changeable environment such as drastic variations of flow rates, pressures, and temperatures. These conditions may bring some negative effect on sensor performance, result in the nonlinear characteristic of sensors. Therefore, considerable researches focus on new filter and controller design method based on nonlinear measurements [17]–[24]. Specifically, in sensor networks, sensor nonlinearity is a necessary factor to take into account due to the large quantity of sensors in harsh environment. Some network-induced problems such as packet dropouts, time delays, and quantization are widespread in network situation, which have caused great concerns for researchers [25]–[31]. Especially in sensor networks, network-induced packet dropouts is a typical problem due to the channel bandwidth capacity constraint. Different from [32], [33] using Bernoulli distribution and [34]–[36] applying Markov chains to model the packet dropouts, the successive packet dropouts model has been proposed by [37]. This novel model has been extended to fault detection [38] and distributed filtering [16] to reflect a more realistic transmission phenomenon. It is worth noting that this packet dropouts model can be well

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