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Estimation for discrete-time systems with multiple packet dropouts using covariance information

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ABSTRACT

The problem is considered of estimating a signal based on measurements with multiple packet dropouts when the probability of data arrival at a processing unit is known. Assuming that the equation which describes the signal is unknown, we derive recursive algorithms for the prediction, filtering and smoothing problems using the information provided by the covariance functions of the processes involved in the measurement equation.

1. Introduction

Recently, the trend to utilize networks for transmitting measurement data has gained ground over traditional systems of communication. This form of transmission has several advantages, such as low cost, simple installation and maintenance, and flexibility. However, in many practical situations, its use may bring about problems such as the loss of data or packet dropouts due to unreliable features of networks.

Packet dropouts are a kind of uncertainty, and can occur randomly, due to failures in transmission or to network congestion. This problem is common in network systems and so, in the last few years, estimation and control problems in systems with multiple packet dropouts has received a lot of attention.

The estimation problem in multiple packet dropouts systems has been studied using different approaches, for example, by considering switched systems (see [1]), modeling packet dropouts by Markov chains (see, for example, [2–4]) or assuming that the packet dropouts are realizations of independent Bernoulli random variables. Under this latter assumption, Sinopoli et al. [5] obtained the Kalman filter with intermittent observations by using "dummy" observations with a given variance when the real observations do not arrive; they also analyzed the stability of the proposed filter. Other authors, under the framework of packet dropouts modeled by independent Bernoulli random variables, have studied the estimation problem of the signal by transforming the original system into a stochastic parameter system and by augmenting the state and measurement. Specifically, Sahebsara et al. [6] solved the filtering problem for systems with multiple packet dropouts as well as other typical problems of networks such as random sensor delay and uncertain observations through the same framework, using the stochastic H_2-norm for systems with stochastic parameters. In [7] the problem of optimal H_∞ filtering in the network with multiple packet dropouts was addressed by generalizing the H_∞-norm for systems with stochastic parameters. Adopting a similar model to that used in [6], Sun et al. [8,9] derived the optimal linear estimator, including the filter, predictor and smoother in the minimum variance sense using an innovation approach.

The aforementioned papers study the estimation problem in multiple packet dropout systems considering that the state-space model is fully known; however, in many practical contexts, the equation which describes the state is unknown. In this

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