$\mathcal{H}_\infty$ Filtering for Discrete-time Nonlinear Singularly-Perturbed Systems

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Abstract: In this paper, we consider the $\mathcal{H}_\infty$ filtering problem for discrete-time singularly-perturbed (two time-scale) nonlinear systems. Two types of filters, namely, (i) decomposition; and (ii) aggregate, are discussed, and sufficient conditions for the approximate solvability of the problem in terms of discrete-time Hamilton–Jacobi–Isaacs equations (DHJIEs) are presented. In addition, for each type of filter above, reduced-order filters are also derived in each case. The results are also specialized to linear systems, in which case the HJIEs reduce to a system of linear-matrix-inequalities (LMIs) which are computationally efficient. An example is also given to demonstrate the approach.

Keywords: *discrete-time nonlinear filtering; $\mathcal{H}_\infty$-norm; discrete-time singularly-perturbed nonlinear system; decomposition filters; aggregate filters; discrete-time Hamilton–Jacobi–Issacs equations (DHJIEs).*

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1 Introduction

The optimal control problem for linear and nonlinear discrete-time singularly-perturbed systems has been considered by several authors [8–10], [16, 18]. On the other hand, the filtering problem for linear singularly-perturbed systems has received little attention [5, 18, 22]. Kalman filtering techniques have generally been considered, and various types of filters have been proposed, including composite and reduced-order filters. However, to the best of our knowledge, the nonlinear filtering problem and in particular the problem for affine nonlinear singularly-perturbed systems has not been considered by any authors.

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