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H_2 AND H_∞ FILTERING FOR LINEAR SYSTEMS WITH UNKNOWN INPUTS AND POLYTOPIC UNCERTAINTY

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Abstract. *State estimation of linear systems under the influence of both unknown deterministic time varying disturbance inputs and Gaussian noise is considered. Two new filters are developed. The first is based on H_2 estimation while the second is based on H_∞ estimation. Extension to the case of real convex parametric uncertainties in the system matrices is presented. Performance of the developed filters is numerically illustrated using a fifth order dynamic system.*
Keywords: Linear systems, Unknown inputs, Polytopic uncertainty, H_2/H_∞ filtering, Fault tolerant estimation, Fault detection and isolation

1. **Introduction.** The ever increasing demand of improving the reliability and safety of automated processes has put an increasing emphasis on designing fault tolerant systems. This requires effective fault detection and isolation schemes, fault tolerant control and fault tolerant state estimation strategies. System faults are commonly modeled as unknown disturbance inputs acting on the healthy system as in [3, 4, 12] or as parameter variations of the nominal (i.e. healthy) system [3]. Unknown disturbance inputs resulting from system faults are, in general, time varying and may not be considered as stochastic inputs with known statistics. Such disturbance inputs can have severe adverse effects on the state estimation accuracy and thus must be accounted for properly when estimating the system states. This problem is of vital importance in fault detection, identification and isolation as mentioned earlier [3] and [4], and also has application in state estimation of large-scale interconnected systems [6, 8]. The problem of state estimation under the influence of unknown inputs has been previously treated in a deterministic setting based on Luenberger's observer theory, e.g. [9, 10, 11]. There are few published results which treat the problem in a stochastic setting under special conditions on the system structure and/or assumptions on the unknown inputs, e.g. [13, 14, 17, 18]. Also, in a stochastic setting, an augmented Kalman filter can be employed to provide estimates of the states as well as the unknown inputs. Such an approach requires an *a priori* identified linear stochastic model of the unknown inputs and results in a state estimation problem of increased dimension. In [16], a hypothesized stochastic model of the unknown inputs