

The H_∞ Identification in the Presence of Generalized Disturbance

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Abstract: In this paper a class of algorithms for the problem of H_∞ system identification are investigated. The disturbance is modeled as the sum of uniformly bounded and stochastic (possibly unbounded) processes. For system modeling we use general orthonormal bases which generalize the common finite impulse response (FIR), Laguerre and two-parameter Kautz models. The algorithms has two-stage structure and involve a window functions. In the form of theorems the conditions characterizing the robust convergence of the algorithms are derived.

Key words: H_∞ identification, Orthonormal base, Bounded disturbance, Stochastic disturbance, Robust convergence

I. INTRODUCTION

Constructing models from observed data is a fundamental problem in science. The identification area consists of results around the concept of information, estimation (learning) and validation (generalization) [2]. Influence of control community to system identification theory development have been described in [7]. One of the key result is control –oriented system identification [7]- [10], [13] and [20]. The important part of the panorama in control –oriented identification is H_∞ identification.

Traditionally, the vast amount of research on system identification has been dominated by the consideration of stochastic measurement errors and the development of stochastic approximation or least squares method. So given estimates are base for adaptive control [1]. In the robust control paradigm [3] a controller is designed on the basis of a nominal model of the plant with the associated parametric and unstructured model uncertainties which are explicitly taken into account. Using combination of adaptive control and robust control design we have adaptive robust control [12]. In that case key interest is robust identification (or control-oriented identification).

In reference [4] has been considered algorithm possessing a low sensitivity to distribution noise uncertainty. Robust estimation in the presence of noise uncertainty and unmodeled dynamic is presented in [5]. In last reference, under the standard conditions imposed on the modeled system part, has been shown that the estimation error converges to a limit which explicitly depends on the unmodeled dynamics in such a way that when the unmodeled dynamics decays the estimation error tends to zero.

Next step in identification was estimation of nominal model and explicit bound on the plant uncertainty in a form compatible with a robust control design. For H_∞ robust

control design has been developed robust H_∞ identification [8-10]. The algorithms are characterized by a two-stage structure: the first stage involves taking the inverse discrete Fourier transform and multiplication by a suitable window function and second stage involves finding the best analytic approximation using Nehari theorem [24] to the function obtained of stage 1. Also, under the general conditions on the window function the resulting two-stage nonlinear algorithm is robustly convergent.

In [18] the H_∞ identification, when noise is stochastic (zero mean stationary stochastic process with bounded spectral density) has been considered. Algorithms are linear in the data. The parallels between classical stochastic estimation (Kalman filtering) and the deterministic robust estimation is presented in [13].

Original FIR model has been modified using general orthonormal base [19] (special cases are Laguerre and Kautz forms [22-23]). The benefits are achievement of improved numerical conditioning and the provision of efficient parameterizations that allow decreased variance error while still minimizing bias error. The identification algorithms are characterized by a two-stage structure and involve a class of window functions. Some conditions are derived which guarantee robust convergence of the algorithms.

II. SYSTEMS AND DISTURBANCES MODELING

We will suppose that the system under consideration has a form [15-16]

$$y_k = hu_k + v_k, \quad k = 0, 1, \dots, N-1 \quad (1)$$

where y_k , u_k and v_k output, input and noise respectively. The transfer function h has the form

$$h = \sum_{k=0}^{\infty} h_k^1 q^{-k} \quad (2)$$

That is transfer function for discrete – time linear models with impulse response sequences h_k and shift operator $q^{-1}x(t) = x(t-1)$.

Typically, in the robust identification context, finite impulse response (FIR) model structure are employed so that transfer function has the form

