ROBUST IDENTIFICATION TOOLBOX

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Abstract— **In this paper we present a brief tutorial and a Toolbox for the area of Robust Identification, i.e. deterministic, worst-case identification of dynamic systems. The uncertain models obtained fit exactly the framework of Robust control, specially $\mathcal{H}_\infty$ procedures, if the control of the system is the objective. The use of several of the identification algorithms are illustrated by means of a simulated example of a flexible structure.**

Keywords— **Robust Identification, two stage algorithms, $\mathcal{H}_\infty$ identification, ℓ_1 identification, Mixed time/frequency identification, parametric/non-parametric identification.**

I. INTRODUCTION

The area of Robust Identification has been originally proposed by Zames in the Plenary talk at ACC 1988, and the first papers appeared in Gu *et al.* (1989) for approximation and in Helmicki *et al.* (1991) for Identification. This methodology allows the computation of a family of models (the so called uncertain model) from experimental data and *a priori* information, which can be used as a first step in a Robust Control framework. It is therefore a deterministic, worst-case approach which describes families of models in terms of $\mathcal{H}_\infty$ or ℓ_1 errors. In particular, frequency domain Robust Identification methods produce a set of models with additive dynamic uncertainty (Sánchez Peña and Sznaier (1998); Zhou *et al.* (1996)) which can be used directly as the representation of a physical system which may be controlled by an $\mathcal{H}_\infty$ controller. To produce structured dynamic uncertain models, these Robust identification procedures should be used over different input-output sets. In this case, control design methods as μ–synthesis (Sánchez Peña and Sznaier (1998); Zhou *et al.* (1996)) may be used. If time domain Robust identification is applied to the physical system, ℓ_1 controllers (Sánchez Peña and Sznaier (1998)) could be designed.

In this context model uncertainty stems from two different sources: measurement noise and lack of knowledge ot the system itself due to the limited information supplied by the experimental data.

Different types of identification algorithms have been developed in this framework. The case where the available experimental data are generated by frequency domain experiments leads to $\mathcal{H}_\infty$ based identification procedures (see Gu and Khargonekar (1992), Chen *et al.* (1995) and references therein). Instead, if the available experimental data originate from time domain experiments ℓ_1 identification procedures (see Jacobson *et al.* (1992) and references therein) are used. In Parrilo *et al.* (1996, 1998), a new Robust Identification framework that takes into account *both* time and frequency domain experiments has been proposed. Thus, the problem where "good" frequency response fitting (small $\mathcal{H}_\infty$ error norm) leads to "poor" fitting in the time domain is prevented. Finally, in Parrilo *et al.* (1999) an extension of this mixed time/frequency identification procedure to the case of systems with a parametric component is presented.

This paper presents a Robust Identification toolbox which implements many of the different techniques available in this framework. As an example there is an application to the problem of a flexible structure. The toolbox has been developed for MatLab, and is freely available from the Web Site of GICOR (Robust Identification and Control Group) at the University of Buenos Aires: `//www.fi.uba.ar/laboratorios/gicor/`. The uncertain models obtained from this methodology are compatible with the different synthesis methods available in the *Robust Control*, *LMI* and μ*–Analysis* toolboxes.

This toolbox implements almost all the state of the art methods in this area, although it inherits a few practical limitations from the theory and the algorithms used to implement it. In the first place, a common weakness of the Robust Identification framework is the conservativeness of the error bounds. Better bounds are possible by using optimization methods, at the expense of a heavier computational load. Also, the LMI based approach, which is related to interpolation methods, is limited by the number of experimental data points. A strong research effort is devoted to the area of optimization methods, in particular LMI's, therefore larger practical problems are expected to be solved in a reasonable time, in the future.

An extense bibliography has been devoted to this subject during the last years. A complete survey of the area can be found in Mäkilä *et al.* (1995); Sánchez Peña and Sznaier (1998) and Chen and Gu (2000). Next section presents a brief tutorial on this subject, and sections III, IV and V provide a more detailed explanation of frequency and time domain identification algorithms as well as interpolatory procedures, respectively. Section VI details the Toolbox commands, and section VII illustrates the use of all previ-