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Experimental evaluation of the combined global and local LPV system identification approach

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1 Abstract

This work focuses on identifying a linear parameter-varying (LPV) model of an XY-motion system by combining two seemingly antagonizing identification approaches. One extreme of the approach results in a model optimal - in terms of accuracy - under varying scheduling parameter conditions, while the other returns a model with optimal behavior for fixed scheduling parameter. Ideally, the combined approach retains advantages of the two extremes, with the possibility to emphasize one or the other (as shown in [1]). Practically, various difficulties may appear, one of which is overparameterization.

2 Experimental validation

2.1 Setup description

The system under test is a mechatronic XY-motion system (Fig.1), used for fast positioning of the end-effector. The system consists of two perpendicularly mounted linear stages and a flexible cantilever beam. The length of this beam is changed by the position of the Y-motor, such that system resonances and hence the dynamics of the XY-motion system in the X-direction depends on the position of the Y-motor [2]. The position of the Y-motor can thus be seen as a scheduling parameter of the system we aim to identify. The referent velocity for the X-motor is considered to be the system input, while the acceleration of the end-effector in the same direction represents the system output.

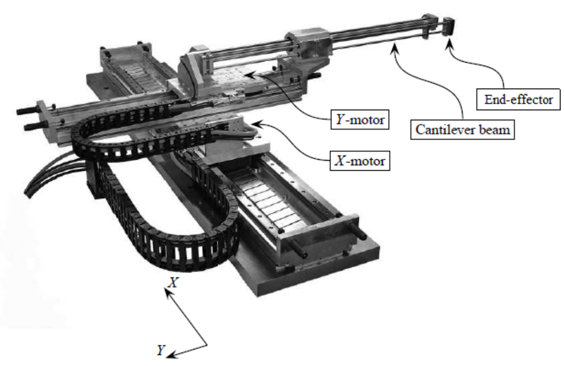

Figure 1: XY-motion system

2.2 Identification procedure

The model to be identified is a fully-parameterized, discrete-time LPV model in the state-space form:

$$\begin{cases} x(t+1) = \mathscr{A}(p(t)) \cdot x(t) + \mathscr{B}(p(t)) \cdot u(t) \\ y(t) = \mathscr{C}(p(t)) \cdot x(t) + \mathscr{D}(p(t)) \cdot u(t), \end{cases} \tag{1}$$

where $x(t) \in \mathbb{R}^3$, $u(t) \in \mathbb{R}^1$, $y(t) \in \mathbb{R}^1$, $p(t) \in \mathbb{R}^1$, and

$$\mathscr{A}(p(t)) = A^{(0)} + \sum_{i=1}^{3} A^{(i)} p(t)^i. \tag{2}$$

The data gathered in an experiment where the system input and the scheduling parameter were simultaneously excited, are combined with four frequency response functions resulting from experiments with fixed scheduling parameter. All together forms a nonlinear least squares optimization problem, solved by the Levenberg-Marquardt algorithm.

2.3 Results

Figure 2 shows the parameter dependent frequency response function (FRF) of one of the identified LPV models. During the optimization, the model has been gaining on accuracy in the local and global sense, but only for the data points involved in the identification. The model FRF is experiencing undesirable bumps and folds in-between, which indicates the need for regularization.

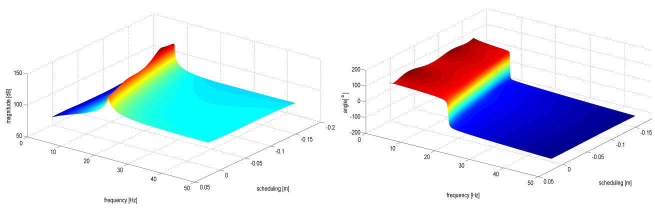

Figure 2: Magnitude (left) and phase response (right) of the obtained LPV model

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[2] De Caigny, Jan 2009. *Contributions to the Modeling and Control of Linear Parameter-Varying Systems*. Ph.D thesis, KU Leuven.