Multivariable Least Squares Frequency Domain Identification for Models described by Fractional Polynomial Descriptions

R.A. de Callafon

Mechanical Engineering Systems and Control Group,
Delft University of Technology, Mekelweg 2, 2628 CD Delft, The Netherlands.
e-mail: `callafon@tudw03.tudelft.nl`

Abstract

A commonly used approach in the identification of linear models is the usage of complex frequency domain data for performing a curve fit procedure to obtain a transfer function of a linear model that approximates the frequency domain data using e.g. a least squares minimization (Pintelon *et al.* 1994). This approach is favourite especially in applications where huge amounts of noisy experimental data of the process to be identified can be obtained at a low price relatively easily. Additional features and motivating examples can be found in e.g. (Pintelon *et al.* 1994) whereas an analysis based on Fourier transforms in (Ljung 1993) shows the connection of the frequency domain approach with a time domain prediction error approach.

The idea to estimate a linear model on the basis of frequency domain data (using a 2-norm minimization) is not new, see e.g. (Sanathanan and Koerner 1963). However, only recently the research is focused on finding multivariable extensions (Lin and Wu 1982, Bayard 1994). Although the problem formulation remains principally the same, these multivariable extensions differ mainly in the way the multivariable model is being parametrized. Moreover, similar iterative linear least squares minimization steps as proposed in (Sanathanan and Koerner 1963) are used to tackle or start up the (non-linear) 2-norm minimization.

The aim of this presentation is to present a procedure for performing an approximate identification on the basis of frequency domain data using a weighted input/output least squares minimization wherein the model is parametrized in a multivariable either left or right fractional polynomial description. The multivariable 2-norm minimization is handled by an iterative approach of weighted input/output multivariable linear least squares minimization problems that can be characterized and solved relatively easily by using Kronecker calculus. The parametrization being used generalizes the usage of a common denominator as used in e.g. (Bayard 1994), while the estimation procedure itself can be considered to be a multivariable extension of (Sanathanan and Koerner 1963) and will be illustrated by an example.

References

Bayard, D.S. (1994). High order multivariable transfer function curve fitting: algorithms, sparse matrix methods and experimental results. *Automatica,* Vol. *30.* pp. 1439–1444.

Lin, P.L. and Y.C. Wu (1982). Identification of multi–input multi–output linear systems from frequency response data. *Journal of Dynamic Systems, Measurement and Control.* pp. 58–64.

Ljung, L. (1993). Some results on identifying linear systems using frequency domain data. In *Proc. 32nd IEEE Conference on Decision and Control.* San Antonio, USA. pp. 3534–3538.

Pintelon, R., P. Guillaume, Y. Rolain, J. Schoukens and H. Van hamme (1994). Parametric identification of transfer functions in the frequency domain – a survey. *IEEE Trans. on Automatic Control, AC-39.* pp. 2245–2260.

Sanathanan, C.K. and J. Koerner (1963). Transfer function synthesis as a ratio of two complex polynomials. *IEEE Trans. on Automatic Control, AC-8.* pp. 56–58.