

Subspace Identification of a Distillation Column

Peter Dolietis, Kurt-Erik Häggblom, Hannu Toivonen and Jari Böling

Process Control Laboratory, Faculty of Technology

Åbo Akademi University, FIN-20500 Åbo, Finland

Abstract

Identification data of a MIMO system is often treated as a number of MISO systems, *i.e.*, each output is considered separately. However, this approach is suboptimal if there are system parameters affecting more than one output. For distillation columns, for example, the dynamics in the high-gain direction tend to be similar for all outputs. Therefore, all outputs should be treated simultaneously.

Subspace-based identification methods are well suited for the identification of MIMO systems because a state-space model formulation is employed. Thus, it is quite straightforward simultaneously to consider multiple inputs and outputs. Another advantage is that the numerical algorithms are not based on optimization, with possible convergence problems or even instability. Instead, the calculations are purely algebraic. As a consequence of this, the methods do not give information about the goodness of the obtained model (*e.g.*, parameter accuracies).

There are various numerical algorithms (*e.g.*, CVA, N4SID, MOESP) which all require a singular value decomposition (SVD) of a matrix. For ill-conditioned systems, this matrix will also be ill-conditioned. Since the SVD is used for model order selection based on the number of significant singular values, the smallest singular value(s) for an ill-conditioned system might easily be neglected, although it would be important to retain them in the model. This is a potential problem of subspace-based identification methods, which is studied in this work.

The N4SID method is probably the most well-known subspace identification method. In this work, we apply it to the identification of a pilot-scale distillation column, which is a typical example of an ill-conditioned system (although only moderately ill-conditioned in the actual case). As it is known that the experimental design is crucial for a successful identification of an ill-conditioned system, we used various experimental designs, where the directionality properties of such systems were taken into account. However, we also tested identification from data obtained by “unstructured” identification designs, both simple ones and more advanced ones, where the directionality was not taken into account. An example of the latter type is simultaneous uncorrelated PRBS perturbations.

As was expected based on previous research, the unstructured identification designs could not deliver good models even for an advanced identification method such as subspace identification. The structured designs, on the other hand, resulted in good models. The minimum singular value, needed in the model, was not a problem. Probably the large excitations used in the low-gain direction were crucial in this respect.

An interesting observation was that well-designed step excitation experiments seemed to produce better models than well-designed PRBS experiments. In a previous identification study, using the same data, it was found that they were about equal. However, in that study the output errors were minimized one at a time. Thus, the overall model did not contain (structural) information about the interplay between the outputs. Such information is automatically included in a state-space formulation, which is used in subspace identification. This could be one reason why step excitation outperformed PRBS excitation in the study.