State-Space Model and Observer/Kalman Filter Gain Identification by a Superspace Method

P. Lin[1], M. Q. Phan[2], and S. A. Ketcham[3]

Abstract: This paper describes a superspace method to identify a state-space model (A,B,C,D) and its associated observer/Kalman filter gain K from input-output measurements. The input and output noise covariances are unknown. The identified state-space model and the associated observer/Kalman filter gain can be used in general modeling, prediction, and control applications.

A superstate is defined at each time step as a vector consisting of input and output measurements at a sufficient number of previous time steps. Instead of finding the system states by intersecting two higher-dimensional state spaces as in a subspace method, the superspace method uses these superstates directly for identification. It is found that in the superstate space, the observer/Kalman system matrix (A+KC), its input influence matrix [B+KD, -K] which includes the Kalman filter gain matrix K, are matrices of 1's and 0's. These matrices are independent of the system dynamics and the input and output noise statistics. They are known before hand, and do not need to be identified. Instead, all the dynamics of the model and the associated observer/Kalman filter are contained in the output influence matrix C, and the direct transmission term D, both of which can also be directly identified from input-output measurements. Standard model reduction can be applied to reduce the model dimensions as needed.

This paper presents the mathematical formulation for the proposed superspace identification method together with a proof of optimality. Examples are used to illustrate the superspace method, and its comparison to a standard subspace identification method (N4SID) involving both simulated and experimental data.

[1,2] Thayer School of Engineering, Dartmouth College
Hanover, NH 03755, USA
ping.lin@dartmouth.edu, minh.q.phan@dartmouth.edu

[3] Signature Physics Branch
Cold Regions Research and Engineering Laboratory
Hanover, NH 03755, USA
stephen.a.ketcham@erdc.usace.army.mil