Generalized Framework of OKID for Linear State-Space Model Identification

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Abstract: This paper presents the complete framework of Observer/Kalman Filter Identification (OKID), recently established as a general and unified approach for the simultaneous identification of a dynamic system from measured input-output data and its associated optimal state observer.

OKID was originally developed at NASA as an algorithm known as OKID/ERA (OKID followed by Eigensystem Realization Algorithm). The initial motivation was the identification of lightly damped structures but OKID/ERA can indeed be applied to any linear system. Subsequent development revealed how, in the presence of white process and measurement noise, the observer underlying OKID corresponds to the Kalman filter. The presence in its formulation of the Kalman filter makes of OKID a method capable of minimizing the effect of the noise on the estimated state-space model matrices, as opposed to other methods formulated without taking into account the noise. Therefore, the latter methods are referred to as deterministic system identification methods whereas OKID is classified as a stochastic (or combined) system identification method. Recently it was demonstrated that ERA is not the only option to complete the OKID identification process.

In this paper we illustrate all the methods that can be devised within the OKID framework, raising OKID from a single algorithm (OKID/ERA) to a general approach to linear system identification. The key intuition behind this generalization establishes the Kalman filter embedded in the OKID core equation as a filter converting the original stochastic identification problem into an equivalent deterministic identification problem, which can be solved via any existing method for deterministic system identification. Hence OKID is also shown to be a unified approach as any deterministic identification method can be converted within the OKID framework into stochastic. The presented theory also inspired the extension of OKID to output-only identification, where the system is driven by white noise and only the output is measured, and to nonlinear system identification, in particular for bilinear systems, establishing OKID as an even more general approach to system identification.

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