Automatica (2009), vol. 45, no. 10, pp. 2350-2357.

The filter design from data (FD2) problem: Nonlinear Set Membership approach

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Abstract - In the paper, we consider the problem of designing a filter that, operating on noisy measurements of input u and output y of a dynamical system, gives estimates (possibly optimal in some sense) of some other variable of interest z. A large body of literature exists, which investigates this problem assuming that the system equations relating u, y and z are known. However, in most practical situations, the system equations are not (completely) known, but a data set composed of noisy measurements of u, y and z is available. In such situations, a two-step procedure is typically adopted: a model is identified from the set of measured data, and the filter is designed on the basis of the identified model. In this paper, we propose an alternative solution, which uses the available data set of measured u, y and z not for the identification of system dynamics, but for the direct design of the filter. Such a direct design is investigated within the Nonlinear Set Membership framework. In the case of full observability, an almost optimal filter is derived, where optimality refers to minimizing a worst-case estimation error. In the case of partial observability, conditions are given for which the direct design is guaranteed to give bounded estimation error. Three examples are presented, related to the Lorenz chaotic system the first two, and to an automotive application the third one.