Automatica (2004), vol. 40, no. 6, pp. 957-975.

Set Membership identification of nonlinear systems

Mario Milanese* and Carlo Novara*

*Dipartimento di Automatica e Informatica, Politecnico di Torino, Italy

Abstract - In the paper the problem of identifying nonlinear dynamic systems, described in nonlinear regression form, is considered, using finite and noise-corrupted measurements. Most methods inthe literature are based onthe estimationof a model within a finitely parametrized model class describing the functional form of involved nonlinearities. A key problem in these methods is the proper choice of the model class, typically realized by a search, from the simplest to more complex ones (linear, bilinear, polynomial, neural networks, etc.). In this paper an alternative approach, based on a Set Membership framework is presented, not requiring assumptions on the functional form of the regression function describing the relations between measured input and output, but assuming only some information on its regularity, given by bounds on its gradient. In this way, the problem of considering approximate functional forms is circumvented. Moreover, noise is assumed to be bounded, in contrast with statistical methods, which rely on assumptions such as stationarity, ergodicity, uncorrelation, type of distribution, etc., whose validity may be difficult to test reliably and is lost in presence of approximate modeling. In this paper, necessary and suffcient conditions are given for the validation of the considered assumptions. An optimal interval estimate of the regression function is obtained, providing its uncertainty range for any assigned regressor values. The set estimate allows to derive an optimal identification algorithm, giving estimates with minimal guaranteed Lp error onthe assigned domainof the regressors. The properties of the optimal estimate are investigated and its worst-case Lp identication error is evaluated. The presented approach is tested and compared with other nonlinear methods on the identification of a water heater, a mechanical system with input saturation and a vehicle with controlled suspensions.