Solving Problems from Systems and Control by Root-Seeking Method for Functions

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Abstract

The talk provides a solution route for many problems arising from systems and control that are reduced to estimating an unknown vector or matrix parameter x^0. For example, in system identification x^0 may be the parameters characterizing the system to be identified, in stochastic adaptive regulation x^0 may be the optimal regulation control, and the similar situation may also take place in problems from iterative learning control, adaptive filtering, signal processing and many others. The problem under consideration may further be transformed to a root-seeking problem for some function $g(\cdot)$ with $g(x^0) = 0$ on the basis of the available observations $\{O_k\}$. As a matter of fact, any available data O_{k+1} may be considered as an observation on $g(x_k)$ with observation error $\epsilon_{k+1} \triangleq O_{k+1} - g(x_k)$, where x_k denotes the estimate for x^0 at time k. This is the topic of stochastic approximation (SA). Thus, as the first step the solution route proposes to transform the problem in question to the one solved by SA.

However, the classical stochastic approximation algorithm, the Robbins-Monro (RM) algorithm, may not lead to a satisfactory result, because in most of the problems from systems and control with selected $g(\cdot)$ and $\{O_k\}$, the resulting $\{\epsilon_k\}$ can hardly meet the conditions required for convergence of the RM algorithm. To overcome the difficulty the RM algorithm is then modified, and the resulting algorithm is called the stochastic algorithm with expending truncations (SAAWET). The general convergence theorem of SAAWET is given in the talk.

As the second step, the solution route proposes to adequately select $g(\cdot)$ and $\{O_k\}$, because, otherwise, the resulting $\{\epsilon_k\}$ may still not be appropriate for SAAWET. Finally, according to the solution route one has to verify conditions required for convergence of SAAWET for selected $g(\cdot)$ and $\{O_k\}$.

The proposed solution route has successfully been realized in solving a series of problems from systems and control. The estimates derived in such a way are recursive and convergent with probability one. Identification of ARMA processes and adaptive regulation for Hammerstein systems are demonstrated to serve as examples of realization of the proposed solution route.