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Robust real-time identification of linear systems with correlated noise

BRANKO D. KOVAČEVIĆ† and VOJISLAV Ž. FILIPOVIĆ†

The problem of recursive robust identification of linear discrete-time single-input single-output dynamic systems with correlated disturbances is considered. Problems related to the construction of optimal robust stochastic approximation algorithms in the min-max sense are demonstrated. Since the optimal solution cannot be achieved in practice, several robustified stochastic approximation algorithms are derived on the basis of a suitable non-linear transformation of normalized residuals, as well as step-by-step optimization with respect to the weighting matrix of the algorithm. The convergence of the developed algorithms is established theoretically using the ordinary differential equation approach. Monte Carlo simulation results are presented for the quantitative performance evaluation of the proposed algorithms. The results indicate the most suitable algorithms for applications in engineering practice.

1. Introduction

The presence of large unmodelled errors may severely degrade the performances of optimal statistical estimation methods. Many convincing examples can be found in areas such as flight control, electric power systems, telecommunications, industrial process control, econometrics (e.g. Merrill and Schweppe 1971, Handschin *et al.* 1975, Bierens 1981, Martin and Thomson 1982, Tsytkin and Lototsky, 1985; Puthenpura and Sinha 1985). Estimation algorithms based on the gaussian model have been found to be especially inefficient when the real distribution belongs to the heavy-tailed variety, giving rise to occasionally very large outliers (e.g. Poljak and Tsytkin 1976, 1979, 1980, Barnet and Lewis 1978). Considerable efforts have been oriented towards the design of robust estimation algorithms possessing a low sensitivity to distribution changes, usually valid locally within a prespecified distribution class. A precise mathematical treatment of this problem may be found in Huber (1964, 1981), Hampel (1971), Rey (1977) or Papantoni-Kazakos (1977). Numerous robust algorithms have been proposed starting from simple ad hoc modifications of the parametric estimates, reducing the effect of extreme disturbances (see surveys by Ershov 1978, Hogg 1979). The fundamental contribution to the field of robust estimation has been given by Huber (1964), who introduced the concept of min-max robust estimation. Further developments of this idea and applications to different types of problems, including system identification, signal processing and adaptive control, have led to many valuable achievements (e.g. Barnet and Lewis 1978, Ershov 1978, Huber 1981, Tsytkin 1984, 1986, Kassam and Poor 1985). However, modest efforts have been oriented towards systematic practical verifications of the developed concepts and robust algorithms. The achievement of robustness in practice requires a more profound understanding of possible criteria and ways of choosing the form of algorithms, their parameters and initial conditions. This problem is particularly acute in the case of robust identification of dynamic systems, owing to the correlation

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