Uniform Stability of a Particle Approximation of the Optimal Filter Derivative

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Sequential Monte Carlo methods, also known as particle methods, are a widely used set of computational tools for inference in non-linear non-Gaussian state-space models. In many applications it may be necessary to compute the sensitivity, or derivative, of the optimal filter with respect to the static parameters of the state-space model; for instance, in order to obtain maximum likelihood model parameters of interest, or to compute the optimal controller in an optimal control problem. In Poyiadjis et al. [2011] an original particle algorithm to compute the filter derivative was proposed and it was shown using numerical examples that the particle estimate was numerically stable in the sense that it did not deteriorate over time. In this paper we substantiate this claim with a detailed theoretical study. Lp bounds and a central limit theorem for this particle approximation of the filter derivative are presented. It is further shown that under mixing conditions these Lp bounds and the asymptotic variance characterized by the central limit theorem are uniformly bounded with respect to the time index. We demon- strate the performance predicted by theory with several numerical examples. We also use the particle approximation of the filter derivative to perform online maximum likelihood parameter estimation for a stochastic volatility model.

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