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A box regularized particle filter for state estimation with severely ambiguous and non-linear measurements. (English) Zbl 1415.93265

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Summary: The first stage in any control system is to be able to accurately estimate the system’s state. However, some types of measurements are ambiguous (non-injective) in terms of state. Existing algorithms for such problems, such as Monte Carlo methods, are computationally expensive or not robust to such ambiguity. We propose the box regularized particle filter (BRPF) to resolve these problems. Based on previous works on box particle filters, we present a more generic and accurate formulation of the algorithm, with two innovations: a generalized box resampling step and a kernel smoothing method, which is shown to be optimal in terms of mean integrated square error. Monte Carlo simulations demonstrate the efficiency of BRPF on a severely ambiguous and nonlinear estimation problem, that of terrain aided navigation. BRPF is compared to the sequential importance resampling particle filter (SIR-PF), Monte Carlo Markov chain (MCMC), and the original box particle filter (BPF). The algorithm outperforms existing methods in terms of root mean square error (e.g., improvement up to 42% in geographical position estimation with respect to the BPF) for a large initial uncertainty. The BRPF reduces the computational load by 73% and 90% for SIR-PF and MCMC, respectively, with similar RMSE values. This work offers an accurate (in terms of RMSE) and robust (in terms of divergence rate) way to tackle state estimation from ambiguous measurements while requiring a significantly lower computational load than classic Monte Carlo and particle filtering methods.

MSC:

93E11 Filtering in stochastic control theory
93E10 Estimation and detection in stochastic control theory
93E25 Computational methods in stochastic control (MSC2010)
65C05 Monte Carlo methods

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box regularized particle filter; state estimation

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