

Smoothing algorithms for state–space models

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Abstract Two-filter smoothing is a principled approach for performing optimal smoothing in non-linear non-Gaussian state–space models where the smoothing distributions are computed through the combination of ‘forward’ and ‘backward’ time filters. The ‘forward’ filter is the standard Bayesian filter but the ‘backward’ filter, generally referred to as the backward information filter, is not a probability measure on the space of the hidden Markov process. In cases where the backward information filter can be computed in closed form, this technical point is not important. However, for general state–space models where there is no closed form expression, this prohibits the use of flexible numerical techniques such as Sequential Monte Carlo (SMC) to approximate the two-filter smoothing formula. We propose here a *generalised* two-filter smoothing formula which only requires approximating probability distributions and applies to any state–space model, removing the need to make restrictive assumptions used in previous approaches to this problem. SMC algorithms are developed to implement this generalised recursion and we illustrate their performance on various problems.

Keywords Sequential Monte Carlo · Two-filter smoothing · State–space models · Rao-Blackwellisation · Non-linear diffusion · Parameter estimation