Mathematics > Optimization and Control

Robust and Trend Following Student's t Kalman Smoothers

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We present a Kalman smoothing framework based on modeling errors using the heavy tailed Student's t distribution, along with algorithms, convergence theory, open-source general implementation, and several important applications. The computational effort per iteration grows linearly with the length of the time series, and all smoothers allow nonlinear process and measurement models.

Robust smoothers form an important subclass of smoothers within this framework. These smoothers work in situations where measurements are highly contaminated by noise or include data unexplained by the forward model. Highly robust smoothers are developed by modeling measurement errors using the Student's t distribution, and outperform the recently proposed L1-Laplace smoother in extreme situations with data containing 20% or more outliers.

A second special application we consider in detail allows tracking sudden changes in the state. It is developed by modeling process noise using the Student's t distribution, and the resulting smoother can track sudden changes in the state.

These features can be used separately or in tandem, and we present a general smoother algorithm and open source implementation, together with convergence analysis that covers a wide range of smoothers. A key ingredient of our approach is a technique to deal with the non-convexity of the Student's t loss function. Numerical results for linear and nonlinear models illustrate the performance of the new smoothers for robust and tracking applications, as well as for mixed problems that have both types of features.

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