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Particle filtering using continuous guiding as proposal

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Particle filtering in high-dimensional system is seriously hampered by the large amount of independent observations that lead to strongly different likelihoods of the particles. Because some particles are much more likely than others, the number of statistically significant particles is strongly reduced. This results in filter divergence. A possible solution is to try to guide the particles to future observations. The so-called Guided particle filter, that has been introduced a few years ago, brings at certain times the observations back to that time and applies importance sampling, using enhanced observational errors. The likelihoods thus obtained are used in a re-sampling step at that time, and only the high-likelihood particles are propagating further in time. The extra weights introduced in this procedure are easily compensated for. However, gathering the all particles to calculate the likelihoods is relatively expensive, so the extra guiding steps have to remain low in number.

A new guiding method is proposed in which differences from the observations are used as extra forcing at each time step. Using Ito calculus a stochastic differential equation for each particle is generated with this extra forcing in place. The ensemble of particles is run up to the actual observation time, at which the ensemble is used as a proposal density in importance sampling using Bayes theorem. In this way one can assure that no assumptions enter the fully nonlinear particle filter problem. Applications to highly nonlinear low-dimensional dynamical systems and to (multi-layer) shallow water models are discussed.