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Homotopy Particle Filter and Data Assimilation

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A homotopy schedule is proposed, wherein from a known probability distribution the normalization constant for an improper probability density function can be found. An improper distribution is one for which the normalization is not known, but its functional form is. In the statistical mechanics constant this amounts to finding the canonical ensemble for the improper distribution. Along the way, the method will generate samples from the target distribution.

This homotopy schedule can be adopted to particle filters used for Bayesian estimation with the aim of improving estimates of the mean path and the uncertainty of a noisy dynamical system, for which noisy observations are available. The method is useful when the dynamics are highly nonlinear, especially if the observations that inform the likelihood have low uncertainty. In the context of data assimilation we require that the stochastic dynamics of the system have an asymptotic stationary distribution, which we use as a the known distribution in the homotopy procedure.

In this talk we present the methodology, apply it to the estimation of canonical ensembles and present numerical comparisons of the standard particle filter estimates with those of the homotopy data assimilation.