



# Optimal filtering and the dual process

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We link optimal filtering for hidden Markov models to the notion of duality for Markov processes. We show that when the signal is dual to a process that has two components, one deterministic and one a pure death process, and with respect to functions that define changes of measure conjugate to the emission density, the filtering distributions evolve in the family of finite mixtures of such measures and the filter can be computed at a cost that is polynomial in the number of observations. Hence, for models in this framework, optimal filtering reduces to a version of the Baum-Welch filter. Special cases of our framework are the Kalman filter, but also models where the signal is the Cox-Ingersoll-Ross process and the one-dimensional Wright-Fisher process, which have been investigated before in the literature. The duals of these two processes that we identify in this paper appear to be new in the literature. We also discuss the extensions of these results to an infinite-dimensional signal modelled as a Fleming-Viot process, and the connection of the duality framework we develop here and Kingman's coalescent.

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