Rao-Blackwellized Particle Filtering for Statistical Estimation of Large Predator Population

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The aim is to describe the statistical model and the computational method used in a recently developed system (Särkkä et al., in preparation) for estimating the number of large predators in Finland from a database of sightings and field-signs. The system uses Tassu database which is owned and maintained by the Finnish Game and Fisheries Research Institute. In the method, we reformulate the problem of estimating the number of animals as a multiple target tracking problem with an unknown number of targets, which can be solved by using Bayesian optimal filtering methodology called Rao-Blackwellized particle filtering (Särkkä et al. 2007; Särkkä, 2013). The framework also enables the use of dynamic models in form of stochastic differential equations (SDE) for accounting for the movement of animals.

We calibrate the SDE and noise parameters using data collected via GPS collars as well by using a Rao-Blackwellized version of the particle Markov chain Monte Carlo (PMCMC) method (Andrieu et al., 2010). Due to the use of PMCMC, we can directly account for the uncertainty in parameter values by numerically integrating over them. The posterior distribution provided by the PMCMC is also used to investigate the identifiability of the model parameters from the present data. We apply the method to field-sign and direct sighting datasets collected in Finland during years 2009 and 2012. The results are well aligned with the results from manual counting methods. The advantage of the present method over manual counting is that the result is less subjective and an estimate of the uncertainty in the result is available.

Keywords: Animal population estimation, multiple target tracking, particle filtering, Bayesian filtering.

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