New particle filters for underwater terrain-aided navigation using multi-sensor fusion

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Résumé :

The goal of this thesis is to develop robust particle filters for underwater terrain aided navigation.The studied filters allow the control of the Monte Carlo approximation errors that are created by the evaluation of the integrals and to the resampling step.

The first strategy consists in maintaining the consistency between the likelihood and the prior density by adapting the support of the likelihood function. In that way, the particles' weights degeneracy is slowed down, which reduces the resampling frequency and thus the cases of divergence. This approach is called Adaptive Approximate Bayesian Computation (A2BC) and is integrated within the Regularized Particle Filter (RPF) and the Rao-Blackwellized Particle Filter (RBPF).

The second strategy is based on the choice of the importance density whose support overlaps the conditional density. The proposed filter is called the Interacting Weighted Ensemble Kalman Filter (IWEnKF), and is based on the Weighted Ensemble Kalman Filter (WEnKF). IWEnKF analytically computes the support of the importance density to ensure an optimal overlap with the conditional density, therefore reducing Monte Carlo fluctuations.

The proposed filters (A2BC-Particle Filters and IWEnKF) were applied to an underwater terrain-aided navigation case. The underwater vehicle was equipped with a multi-beam telemeter, an atomic gravimeter, and numerical maps associated with the sensors stored in an on-board computing system. The results show an improvement of the accuracy and of the robustness to non-linearities for the A2BC-Particle Filters and the IWEnKF compared to conventional particle filters (RPF, RBPF, and WEnKF).

Mots clés :
Underwater navigation, Particle filters, Multi-sensor fusion, Terrain-aided navigation.