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Maximum Likelihood Principle and Moving Horizon Estimation based Adaptive Unscented Kalman Filter

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Abstract

The classical unscented Kalman filter (UKF) requires prior knowledge on statistical characteristics of system noises for state estimation of a nonlinear dynamic system. If the statistical characteristics of system noises are unknown or inaccurate, the UKF solution will be deteriorated or even divergent. This paper presents a novel adaptive UKF by combining the maximum likelihood principle (MLP) and moving horizon estimation (MHE) to overcome this limitation. This method constructs an optimization based estimation of system noise statistics according to MLP. Subsequently, it further establishes a moving horizon strategy to improve the computational efficiency of the MLP based optimization estimation. Based on above, a new expectation maximization technique is developed to iteratively compute the MLP and MHE based noise statistic estimation by replacing complex smoothed estimates with filtering estimates for further improvement of the computational efficiency. The proposed method can achieve the online estimation of system noise statistic and enhance the robustness of the classical UKF. The efficacy of the proposed adaptive UKF is demonstrated through simulations and practical experiments in the INS/GPS integrated navigation.

Keywords: unscented Kalman filter; noise statistic estimation; maximum likelihood principle;

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