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# A Novel Square-Root Adaptive Unscented Kalman Filtering Method for Accurate State-of-Charge Estimation of Lithium-ion Batteries

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The accurate state-of-charge estimation of the lithium-ion battery is one of the key technologies to benchmark the rapid development of new energy vehicles. Unscented Kalman filtering abandons the traditional way of forcing the system to linearize, selects the symmetric sampling strategy to obtain sampling points, and uses Unscented Transformation to deal with the nonlinear transfer of mean and covariance. Then calculate the statistical properties of nonlinear functions with the corresponding weights of each sampling point. However, the traditional unscented Kalman filtering has accumulated errors due to a large number of calculations, the covariance matrix is easy to diverge due to the inability to perform QR decomposition, and the system has deviations caused by unknown noise, resulting in low stability and easy divergence of the state-of-charge estimation results. Based on the second-order RC equivalent circuit model, a square-root adaptive unscented Kalman filtering is proposed, which replaces the state error covariance matrix with the square root of the state error covariance matrix. The noise covariance is updated in real-time to improve the tracking and convergence of state-of-charge estimation results. The algorithm is verified by the Hybrid Pulse Power Characterization test (HPPC) and Beijing Bus Dynamic Stress Test (BBDST) working conditions. The results show that square-root adaptive unscented Kalman filtering can improve the estimation accuracy of state-of-charge under complex working conditions.

**Keywords:** Lithium-ion battery; Second-order RC equivalent circuit model; State of Charge; Square-Root Adaptive Unscented Kalman Filtering

FULL TEXT