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КОСМИЧЕСКИЕ НАВИГАЦИОННЫЕ СИСТЕМЫ И ПРИБОРЫ. РАДИОЛОКАЦИЯ И РАДИОНАВИГАЦИЯ

Cubature Kalman Filter in the Task of Spacecraft Autonomous Navigation

V. A. Filimonov, *post-graduate student, vladimir.a.filimonov@tusur.ru*
Tomsk State University of Control Systems and Radioelectronics, Russia

V. I. Tislenko, *Dr. Sci (Engineering.), wolar1491@yandex.ru*
Tomsk State University of Control Systems and Radioelectronics, Russia

V. Yu. Lebedev, *Cand. Sci. (Engineering), Ibk@bk.ru*
Tomsk State University of Control Systems and Radioelectronics, Russia

V. V. Shavrin, *post-graduate student, svv281088@gmail.com*
Tomsk State University of Control Systems and Radioelectronics, Russia

A. P. Kravets, *post-graduate student, aleksei.p.kravets@tusur.ru*
Tomsk State University of Control Systems and Radioelectronics, Russia

Abstract. A key element of the algorithm to evaluate informative processes (a state vector of a dynamical system) by the Markov (Bayesian) theory of nonlinear filtration is in calculating a current mathematical expectation of the state based on a posteriori density of probability distribution of states at the set observations. Realization of the algorithm for processing of observations assumes formation of the current estimates of a state and observations extrapolated to one step. Hence, calculation of the integrated expressions defining the corresponding estimates in the form of expected values is necessary. The task considered in article belongs to the class of conditionally Gaussian that is caused by existence of additive Gaussian noise of disturbances in nonlinear model of states and observations. Calculation of the corresponding multidimensional integrals is carried out by the method of numerical integration based on spherically-radial cubature rule — the algorithm of the cubature Kalman filter (cubature Kalman filter, CKF). The paper analyses an RMS error of the assessment of an 8-dimensional state vector in the onboard autonomous navigation system of the space user. The results are received for an algorithm of CKF and a traditionally used algorithm of the expanded Kalman filter (extended Kalman filter, EKF). It is shown that the algorithm of CKF allows one to receive an RMS error of spacecraft positioning in HEO equal to 2.24 m and an RMS error of the speed module equal to 0.075 ms/s at the C/N0 35 dB-Hz ratio.

Keywords: autonomous navigation system, spacecraft, estimation of coordinates, onboard timescale shift, Kalman filter, numerical integration, cubature form, statistical simulation