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高超声速滑翔再入飞行器弹道估计的自适应卡尔曼滤波

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Adaptive Kalman Filtering for Trajectory Estimation of Hypersonic Glide Reentry Vehicles

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摘要 参考文献 相关文章

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摘要

采用传统状态增广法对高超声速滑翔再入飞行器(HGRV)进行弹道估计,存在模型简化误差过大和过程噪声方差难以构造的问题。依据目标运动特性和模型简化误差定量分析结果,状态方程改进为采用圆形地球模型和拟合大气模型并考虑哥氏力。采用一阶Markov过程描述气动力参数,将过程噪声方差构造为气动力参数方差和机动时间常数的函数,时变气动力参数方差采用"渐消记忆"的统计估计法由气动力参数估计值序列统计获得,而存在跳变的机动时间常数则作为运动模式采用变结构交互多模型法与运动状态一起估计。仿真结果表明,所提算法对位置、速度和气动力参数的估计精度优于传统算法,具有较好的工程实用性、鲁棒性和效费比。

关键词： 高超声速飞行器 目标跟踪 自适应滤波 变结构交互多模型 增加期望模式

Abstract:

The trajectory estimation of a hypersonic glide reentry vehicle (HGRV) usually uses traditional state augment methods, which have very large model simplification errors and the process noise variance of which are hard to build. In this study, based on the quantitative analysis results of the target movement property and the model simplification errors, the state equations are refined by using the spherical gravity model and fitting atmosphere model and considering the Coriolis force. The aerodynamic parameters are described using the first-order Markov process, and then the process noise variance is formulated as a function of the aerodynamic parameter variance and maneuvering time constant. Moreover, the time-varying aerodynamic parameter variance is obtained using the statistical result of the aerodynamic parameter estimate sequence based on the "fading memory" method, while the maneuvering time constant, as a target movement mode, is estimated along with the target base state by using a multi-model method of expected model augmentation. The simulation results show that the proposed algorithm can identify the time-varying variance of process noise effectively, and demonstrates better performance than traditional algorithms in the estimation precision of position, velocity and aerodynamics parameters, and has better engineering application value, robustness, and effectiveness-cost ratio.

Keywords: hypersonic vehicles target tracking adaptive filtering variable structure interacting multiple model expected-mode augmentation

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