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飞行器气动参数估计不确定度评价方法研究

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Study on Uncertainty Evaluation Methods of Aerodynamic Parameter Estimation for Aircraft

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摘要

为了有效地利用飞行器气动参数估计结果,必须同时给出估计结果的不确定度,因此研究了不确定度评价方法。当试验样本较多时,样本标准差具有明确的统计含义,比分散度能够更好地描述参数估计的不确定度。对于单个试验样本,基于不确定度椭球导出的C-R(Cramer-Rao)界是参数估计不确定度最好的理论预测,但利用飞行实测数据得到的C-R界普遍比样本标准差小。鉴于此,通过在低频有色噪声的基础上构造白噪声的方法,得到了一种C-R界修正方法,并通过仿真算例验证了修正方法的正确性。最后,将C-R界修正方法应用于飞行实测数据,得到的修正C-R界与利用多次飞行试验参数估计结果计算的样本标准差比较一致,表明该修正方法能够较好地给出参数估计的不确定度区间。

关键词: 空气动力学 飞行力学 参数估计 不确定度评价 飞行试验 样本标准差 Cramer-Rao界

Abstract：

In order to make effective use of aerodynamic parameter estimation results for an aircraft, it is necessary to provide at the same time an aerodynamic parameter uncertainty interval, for which the uncertainty evaluation methods are studied in this paper. If test runs are sufficient in number, the sample standard deviation has a clear statistical significance. Therefore it is a good criterion for uncertainty evaluation. The C-R (Cramer-Rao) bound based on the uncertainty ellipsoid is the best theoretical prediction of uncertainty for a single flight test, but C-R bound is different from the sample standard deviation due to colored residuals. A correction method by constructing the Gauss noises based on colored noises is proposed, and the accuracy of the corrected C-R bound is validated through comparing it the with sample standard deviation. Finally the correction method of C-R bound is applied to flight test data, and the corrected C-R bound is found to be close to the sample standard deviation, which demonstrates that the uncertainty evaluation method is valid.

Keywords： aerodynamics flight dynamics parameter estimation uncertainty evaluation flight test sample standard deviation Cramer-Rao bound

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