

## 组合导航系统滤波器截断误差抑制方法

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摘要:

组合导航系统作为重要的定位和测姿传感器, 其基本设计思想是将GPS和SINS等导航设备输出的信息经过滤波器进行最优估计。但在采用Riccati方程更新协方差矩阵和计算Kalman增益过程中, 截断误差随着迭代次数的增大而累积, 降低了滤波器计算的数值稳定性, 严重时可能破坏协方差矩阵的正定性, 导致组合系统故障发散。本文建立了Riccati方程一阶误差模型, 在理论层面分析了截断误差对滤波器估计性能的影响, 介绍了基于改进平方根分解的Bierman-Thorton算法更新Riccati方程抑制截断误差的原理, 并介绍了组合导航系统的设计方法。通过强实时半物理仿真系统验证, 基于改进平方根滤波器的组合导航系统相比于基于Kalman滤波器的系统有更强的数值稳定性和较高的导航精度。

关键词: 组合导航系统, 截断误差, Kalman滤波器, Bierman-Thorton算法, 半物理仿真

## Roundoff Error Restraining Method of Integrated Navigation System

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**Abstract:**

As the most important sensor for positioning and attitude measuring, the integrated navigation system is made use of SINS and GPS information for optimal estimation by Kalman filtering. We reviewed that the roundoff error accumulating would undermine the numerical stability of the filter, when we updated the estimation covariance matrix by virtue of Riccati equation. Severely, it ruined the property of positive-definite of covariance matrix, leading the navigation system to divergence. We presented the one order model of roundoff error propagation of Riccati equation, and analyzed how roundoff error affect Kalman filtering in theory. We introduced the Bierman-Thorton algorithm, and described the element of the algorithm to solve the numerical stability problem due to roundoff error in integrated navigation system. Consequently, it is proved that Riccati equation updating by Bierman-Thorton algorithm has better numerical stability and accuracy than which by conventional Kalman filtering, which is borne on hardware-in-the-loop simulation.

**Keywords:** integrated navigation system; roundoff error; Kalman filtering; Bierman-Thorton

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