Accepted Manuscript

Robust two-stage rank filter for mars entry navigation under parameter uncertainties

Mengli Xiao, Yongbo Zhang, Huimin Fu, Qiang Xiao

PII: S1270-9638(17)31588-2
DOI: https://doi.org/10.1016/j.ast.2018.06.028
Reference: AESCTE 4642

To appear in: *Aerospace Science and Technology*

Received date: 1 September 2017
Revised date: 7 May 2018
Accepted date: 25 June 2018

Please cite this article in press as: M. Xiao et al., Robust two-stage rank filter for mars entry navigation under parameter uncertainties, *Aerosp. Sci. Technol.* (2018), https://doi.org/10.1016/j.ast.2018.06.028

Robust Two-Stage Rank Filter for Mars Entry Navigation under Parameter Uncertainties

Mengli Xiao[1], Yongbo Zhang[1*], Huimin Fu[1], Qiang Xiao[2]
[1] Research Center of Small Sample Technology, Beihang University, Beijing 100191, China
[2] Beijing Institute of Space Launch Technology, Beijing 100076, China
E-mail: zhangyongbo@buaa.edu.cn

Abstract: Future Mars landing missions require high-precision entry navigation capability, but the uncertainties lie in the Mars atmosphere density and aerodynamic coefficients may cause serious performance degeneration of conventional Kalman filters. This paper proposed a robust two-stage rank filter (RTSRF) out of augmented state rank filter by decoupling the covariance matrices and modifying the measurement update equations. Therefore, this filter could obtain an accurate state estimation by treating the parameter uncertainties as the unknown inputs even the prior knowledge of the inputs are completely unknown, a novel method to dealing with the parameter uncertainties. Then, it was applied for Mars entry navigation simulation, and the results show that the navigation accuracy is greatly improved, fulfilling the requirement of future Mars pinpoint landing missions.

Key words: Two-stage Kalman filter, rank filter, unknown inputs, nonlinear system, robust filter

1. Introduction

The pinpoint landing capability is required for future Mars exploration vehicle [1]. The critical stage of pinpoint landing mission is Mars entry, descent and landing phases, of which Mars entry is the most uncertain and dangerous period. During this period, there are uncertainties in the atmosphere density and vehicle aerodynamic characteristics which are the main difficulty of the high-precision autonomous Mars entry navigation [1, 2]. Thus to achieve the goal of landing a vehicle precisely and autonomously on Mars, navigation algorithm for reducing the effect of parameter uncertainties is dispensable [3-7].

Kalman filtering [8] is a well known method which has been widely used in many areas of control, signal processing and optimization, and others. However, Kalman