Accepted Manuscript

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PII: S1270-9638(16)30833-1
DOI: http://dx.doi.org/10.1016/j.ast.2017.04.025
Reference: AESCTE 4008

To appear in: *Aerospace Science and Technology*

Received date: 11 October 2016
Revised date: 11 April 2017
Accepted date: 25 April 2017

Please cite this article in press as: W. Yun-jie et al., Optimal discretization of feedback control in missile formation, *Aerosp. Sci. Technol.* (2017), http://dx.doi.org/10.1016/j.ast.2017.04.025

Optimal Discretization of Feedback Control in Missile Formation

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Abstract:

This paper develops a missile formation algorithm. The general form of time-varying formation constraints in three-dimensional space for missiles is deduced, and the formation control under time-varying position constraints is transformed into constrained optimization problem. Based on discretization of trajectory and optimization of control outputs, an approach to design optimal feedback control algorithm is presented. The three degree of freedom simulation results of the missiles obtained by constraint optimization show that the formation strategy proposed in this paper is feasible in missile formation control under complex time-varying constraint.

Keywords:

Aircraft Formation; Cooperative Guidance; Optimal Feedback Control; Constrained Optimization

1 Introduction

This paper proposes a discrete optimal feedback guidance law for multi-missile formation to achieve formation shape stabilization. The design of a three-dimensional formation controller is based on time-varying kinematical constraints. This guidance law assumes that the vehicle model provides sufficient aerodynamic overload and computational resources.

1.1 Literature review

There is a large body of work on formation control in multi-missile systems literature, including formation structure, formation control style, and constrain type for a very small sample of works. The most widely investigated content of formation control is control strategy. Numerous vehicle formation control strategies employ leader-follower method [1-2], virtual structure method [3-4], and behavior based approach [5-6]. These three methods have limitations [7]. With the development of consensus theory, the consensus method can overcome the defects of these three methods by unifying them in the general framework of consensus building [8]. Based on consensus theory, reference [9] researches VTOL aircraft formation control with delayed communication, but the main difficulty in the application is that the intermediary control input needs to be a priori bounder and satisfy the extraction algorithm condition. Reference [10] researches time-varying formation consensus protocol, but practical implementation needs to consider control input saturation in the protocol.

Another class of formation methods is artificial potential field based formation control. Olfati-Saber and Murry first propose artificial potential field based formation control [11]. Then Ogren, Fiorelli and Leonark present a stable control strategy for groups of vehicles to move and reconfigure cooperatively in response to a sensed, distributed environment based on artificial potentials [12]. Later artificial potential field based formation control is used in formation maintaining [13-14] and formation reconfiguration [15]. In sum, artificial potential achieve the trend of formation by definition of individual potentials, and the equilibrium points correspond to equilibrium structure [16]. But the defect of artificial potential field based formation control is the possible local stability [17]. Thus Cortes proposes a simple, distributed algorithm that achieves global stabilization of formations for relative sensing networks in arbitrary dimensions with fixed topology by introducing potential field function in the form of stress function [18]. But the error dynamics need to be analyzed individually. Reference [19-20] analyzed the error