Accepted Manuscript

Lateral entry guidance with no-fly zone constraint

Zixuan Liang, Siyuan Liu, Qingdong Li, Zhang Ren

PII: S1270-9638(16)30946-4
DOI: http://dx.doi.org/10.1016/j.ast.2016.10.025
Reference: AESCTE 3811

To appear in: *Aerospace Science and Technology*

Received date: 28 February 2016
Revised date: 13 September 2016
Accepted date: 26 October 2016

Please cite this article in press as: Z. Liang et al., Lateral entry guidance with no-fly zone constraint, *Aerosp. Sci. Technol.* (2016), http://dx.doi.org/10.1016/j.ast.2016.10.025

Lateral Entry Guidance with No-Fly Zone Constraint

Zixuan Liang, Siyuan Liu, Qingdong Li*, Zhang Ren

Science and Technology on Aircraft Control Laboratory, Beihang University, Beijing 100191, China

Abstract:

No-fly zones are geographic constraints for the atmospheric entry flight. Two lateral guidance methods are presented for the entry flight constrained by multiple no-fly zones. The first method employs a dynamic heading corridor to control the vehicle's velocity heading angle. The corridor is generated based on a chain mode strategy that takes heading limits for all the no-fly zones and the target into account. The dynamic corridor is adaptively updated during the flight according to the vehicle's state and the actual constraints. The second method is designed based on a waypoint vector which is located between each pair of no-fly zones. This waypoint vector contains both the location and the direction constraints for the flight trajectory. The vehicle is capable of flying the avoidance trajectory by passing through one or more expected waypoints in specified directions. The two guidance methods are finally tested in four entry missions constrained by various no-fly zones. Results indicate that these methods are effective for no-fly zone avoidance missions in both the nominal and dispersed cases.

Keywords: Entry guidance; geographic constraint; no-fly zone; dynamic heading corridor; waypoint

1. Introduction

The guidance for aerospace vehicles with no-fly zone constraint is an interesting and challenging problem. The no-fly zone is defined as the area where vehicles are not allowed to fly into [1]. This zone originates from obstacles and threats for Unmanned Aerial Vehicles (UAVs), missiles, or other aerospace vehicles [2-4]. In order to generate a trajectory for a UAV to avoid enemy radars, a planning method was developed by Bortoff [5] based on the Voronoi Graph and the virtual force. Kumar and Ghose [6] proposed a sliding circle guidance algorithm for the obstacle avoidance in a planar flight, and extended it to a three-dimensional flight mission. Yang and Zhao [4] developed four geometric shape models for obstacles, including ellipsoid, cuboid, cylinder, and pyramid. For the mission of multiple UAVs, Richards et al. [7] investigated the trajectory planning problem of the fleet coordination under the no-fly zone constraint.

The no-fly zone constraint for entry vehicles was first paid attention to by Jorris [8]. Typical entry vehicles are the crew exploration vehicle (CEV), the Space Shuttle, the X-33 vehicle, and the

*Corresponding author. Tel.: +86-10-82314573-13.
E-mail address: buaa.gnc@gmail.com (Q. Li).