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A Composite Impact-Time-Control Guidance Law and Simultaneous Arrival

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Abstract

A new composite impact time control guidance law is proposed for simultaneous attack against a ground target. The guidance strategy is composed of two phases. Specifically, the first phase is to guide the missile to proper switching relative range for the second phase. After which, the second phase will lead the missile to the target with a desired impact time by using the proposed Lyapunov based guidance scheme. The impact time is given in a simple analytical form of initial states and switching relative range, the value of which is determined to control the impact time. The proper range of the switching state is analyzed considering the line of sight angle constraint. And the permissible range for impact time can be calculated corresponding to the proper switching state. Two classes of simultaneous attack are considered to demonstrate the effectiveness of the impact time control. One is the sequential launch, and the other is a salvo launch of multiple missiles from different positions. Numerical simulations are carried out to verify the performance of the proposed methodology.

Keywords: Composite; Lyapunov based; Switching relative range; Impact time control; Simultaneous attack

1. Introduction

The primary objective for a guidance law is to reduce relative distance to an acceptable order of magnitude. As the ground targets are equipped with defensive system, the task for the missile becomes more complex in practical engagement. In order to improve the missile's performance, many advance control technologies have been proposed to cope with uncertainties and external disturbances [1-3]. And recently developed guidance laws are imposed to other objectives, like a desired impact angle [4-7], or a desired impact time for simultaneous attack [8-10]. Obviously, simultaneous attack is the most effective way to cope with the defense mechanisms. It's difficult for the target to defend multiple missiles at a time. Even if some missiles may be intercepted, the remaining ones can still destroy the target. Thereafter, simultaneous attack of multiple missiles against a single target has attracted much attention.

Works in simultaneous attack can be achieved in two ways. The first approach is individual homing, in which a suitable impact time intersection between different missiles is determined beforehand, and common impact time within the intersection is commanded to all members. Then each missile tries to impact the target without any information from the other missiles. One of the earliest attempt in this direction was in [11]. Based on linearized framework, the guidance law in [11] was presented as a combination of two terms. The first term was the proportion navigation term, and the second term was the error between the desired time-to-go and the estimated time-to-go. Based on the same linearized framework as that in [11], a guidance law to control both the impact time and angle was proposed in [12], a feedback loop to achieve desired impact angle and an additional loop to control the impact time. The design framework in [11] was further enhanced in [13] , a rule of the cosine of weighted leading angle in the biased term was used to guarantee that the heading error limit was not violated. There are also guidance laws with impact time constraint considering nonlinear framework. In [14], nonlinear guidance law considering the impact time constraint was proposed, the