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多导弹时间协同制导:一种领弹-被领弹策略

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Time-cooperative Guidance for Multi-missiles: A Leader-Follower Strategy

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摘要

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摘要 首先,假设各枚导弹的速度为相同常值,领弹采用经典比例导引(PNG),被领弹采用经典比例导引和机动控制相结合的方式,推导出采用领弹-被领弹策略的多导弹时间协同控制设计模型,该模型实际上描述的是一个非线性的弹目相对运动状态跟踪控制系统。在此系统中,领弹的弹目距离与导弹前置角作为两个参考状态量,被领弹的弹目距离与导弹前置角作为两个待控制的状态量。针对这一弹目相对运动状态跟踪控制系统,采用时标分离的方法设计了期望的慢子系统和快子系统。对这两个子系统分别进行动态逆控制设计,得到了被领弹的机动控制指令。该机动控制指令用于调整被领弹相对目标的运动状态,来逼近领弹相对目标的运动状态,这就保证了所有的导弹能够同时攻击目标。然后,通过为每枚被领弹引入一个与其速度相同的虚拟领弹,将上述方法推广到各枚导弹速度可为不同常值的情况。仿真结果验证了本文方法的有效性。

关键词: 制导 非线性控制系统 协同控制 比例导引 领弹-被领弹 虚拟领弹 攻击时间

Abstract: First, if it is assumed that each missile has the same constant velocity, then the leader-missile (“the leader” for short) is guided by the conventional proportional navigation guidance (PNG), and the led-missile (“the follower” for short) is guided by a combination of the conventional PNG and a maneuver control. The model for the design of time-cooperative control of multi-missiles using the leader-follower strategy is derived. This model represents in essence a nonlinear state tracking control system of the motion of the missile relative to the target, in which the range-to-go and the heading error angle of the leader relative to the line of sight are selected as two reference state variables, and those of the follower as two controlled state variables. For this system, the time-scale separation method is used to design both the desired slow and fast sub-systems. Nonlinear dynamic inversion controllers are designed for the two sub-systems respectively and the maneuver command for the follower is derived. This maneuver command is used to adjust the state variables of the motion of the follower relative to the target to approach that of the leader, which guarantees that all the missiles can attack the target simultaneously. Then, for each follower, a virtual leader with the same velocity is introduced. Thus, the above strategy is extended to the case where each missile can have a different constant velocity. Simulation results show the validity of the proposed approach.

Keywords: guidance nonlinear control systems cooperative control proportional navigation guidance leader-follower virtual leader impact time

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