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弹道导弹中段突防弹道设计与验证

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Design and validation of ballistic missile midcourse penetration trajectory

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摘要 针对中段多脉冲弹道规划及评价问题,提出了一种新的弹道设计及评价方法。借鉴轨迹规划中节点搜索及扩展的思想,将多脉冲弹道的脉冲点火点视为节点,建立了多脉冲机动变轨模型。基于该模型,对突防弹道进行了设计及优化。运用"博弈论"的思想,在考虑敌方防御系统的探测机理、性能及部署基础上将敌方预测弹道与实际弹道的差值作为评价函数,以尽量降低敌方预测弹道的精度。最后,设计了导弹突防效能地面验证平台以验证所设计弹道的突防效率与弹道评价方法的有效性。选取了一个例子进行分析及验证,结果表明:相比最省能量弹道,设计的导弹防御系统对突防弹道的预测误差提高了5到15倍,达到了100~300 km,飞行时间缩短了8.53%,而且规划时间不到140 s。实验显示本文提出的弹道设计方法,能够在很短时间内规划出一条突防概率很高的弹道。

关键词 : 弹道导弹, 多脉冲弹道, 路径规划, 遗传算法, 卡尔曼滤波

Abstract : For the ballistic missile midcourse penetration trajectory, this paper presents a new trajectory design optimization and evaluation method. Based on search and extended node in trajectory planning, the pulse ignition point in a multi-pulse trajectory was taken as a node and a multi-pulse maneuvering orbital transfer model was established. According to the model, the penetration trajectory was designed and optimized.Then, by taken the detection mechanism, performance, deployment of the enemy defense system into account, the prediction error between enemy prediction trajectory and real trajectory was as the evaluation index of penetration trajectory to reduce the prediction accuracy of enemy missile based on "game theory". Finally, a ground verification platform for missile penetration effectiveness was designed to verify the validity of the penetration efficiency and trajectory evaluation method for the designed trajectory. As compared with the minimum energy trajectory, the experimental results show that the prediction error of ballistic missile defense system has increased by 5 to 15 times, reached 100—300 km, flight time is shortened by 8.53%, and the planning time is less than 140 s. These results show that the trajectory design method proposed in this paper can plan a ballistic with very high penetration probability in a short time.

Key words : ballistic missile multi-pulse ballistic trajectory trajectory planning genetic algorithm Kalman filter

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