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电子与自动控制

通信和测量受限条件下异构多UAV分布式协同目标跟踪方法

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Distributed Cooperation Target Tracking for Heterogeneous Multi- UAV Under Communication and Measurement Constraints

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摘要 研究了通信和测量受限的异构多无人机(UAV)网络化分布式协同目标观测与跟踪问题。该分布式UAV系统采用长机-僚机异构型网络结构,以实现在电子静默和战术隐身条件下扩大探测和打击纵深。提出改进的一致性信息滤波(ICF)算法,实现通信和测量范围内各UAV节点的分布式信息融合。由于一致性算法的收敛性与网络拓扑结构的连通性密切相关,引入通信连接鲁棒性作为最优控制的指标函数之一,以解决通信和测量受限条件下的UAV分布式滤波与控制问题。将长机作为控制中心,使用滚动时域优化(RHO)方法求最优解,导引各架UAV按最优轨迹飞行,以获取最好的跟踪效果。仿真表明,在网络连接性比较强时,改进的ICF算法可以达到与集中式信息滤波(CIF)相当的效果。与没有考虑通信连接鲁棒性的控制对比表明,该算法可以加强通信拓扑连通性,提高一致性算法的收敛性和跟踪精度,改善系统的可靠性和鲁棒性。

关键词： 目标跟踪 长机-僚机 通信和测量受限 一致性信息滤波 通信连接鲁棒性 滚动时域优化

Abstract： This article presents a study of the network distributed cooperation observation and tracking of heterogeneous multi-unmanned aerial vehicle (UAV) based on local communication and limited detection range. The distributed UAV system adopts a heterogeneous Leader-Follower type network structure for the purpose of enlarging detection and attack depth under electronic silence and tactic invisibility. An improved information consensus filter (ICF) is proposed to achieve distributed data fusion for the UAVs within their communication and measurement range. Because the convergence of the consensus algorithm is relevant to the connectivity of the topology graph, communication connectivity robustness is introduced as an optimal index to solve the distributed filter and control problem of the UAVs under communication and measurement constraints. The Leader acts as the control center, while receding horizon optimization (RHO) is used to obtain the optimal solution, thus controlling the trajectory of each UAV to acquire the best tracking performance. Simulations reveal that the performance of the proposed ICF is equal to that of the centralized information filter (CIF) when communication is strong. Compared with the optimization when ignoring the communication connectivity robustness, this algorithm can dramatically enhance the connectivity of the topology graph, improve the tracking performance and convergence of the consensus algorithm, and enhance the reliability and robustness of the system.

Keywords： target tracking Leader-Follower communication and measurement constraints information consensus filter communication connectivity robustness receding horizon optimization

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