Distributed Fault Detection of Multiple Unmanned Marine Vehicles Based on Fuzzy Model

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***Abstract*—Unmanned marine vehicles (UMVs), as agent capable of independently executing tasks, offer advantages such as high autonomy, low cost,low risk, long endurance, adaptability to harsh environments, and reduced manpower requirements. They can operate in hazardous or inaccessible areas for manned vehicles, thereby expanding the scope and efficiency of maritime operations. With advancements in UMV technology and the expansion of application areas, multiple UMVs are often used in collaboration to tackle complex tasks. However, facing diverse environmental conditions and prolonged operation periods, UMV systems may encounter various faults.Without timely detection and resolution, these faults can propagate through communication networks to other UMVs, potentially leading to system-wide failures and significant economic losses. Therefore, research on distributed fault detection schemes for UMVs systems is crucial. Existing fault detection approaches mostly focus on single-agent systems, often struggling to effectively handle nonlinear systems or being limited to linear systems. Addressing these challenges, this paper proposes a distributed fault detection scheme for UMVs systems based on fuzzy control.Firstly, we derive the dynamic equations of UMVs and consider the communication topology among them, along with potential propulsion system faults, establishing a fuzzy T-S model for each UMV that incorporates fault information. Subsequently, observers are constructed for each UMV to generate residual signals. These observers not only receive measurement data from their own UMV but also information from neighboring UMVs and their respective observers. Additionally, a fault reference model is employed to enhance the fault detection performance of the system. We develop methods based on fuzzy Lyapunov functions and inverse convex techniques, introducing a free-weight matrix approach to ensure that the obtained sufficient conditions guarantee asymptotic stability and $H\infty$ performance of the fuzzy fault detection system. Furthermore, corresponding solvability conditions are constructed to address coupling issues in matrix inequalities.Finally, we validate the proposed approach through simulation involving a multi-agent system composed of four USVs. During simulation, we use Matlab's LMI toolbox to solve the constructed matrix inequalities and obtain observer gains. By comparing instances where residual evaluation functions exceed threshold values at different time points, we verify the effectiveness and applicability of the distributed fault detection scheme.**

***Index Terms*—Multiple unmanned marine vehicle systems, T–S fuzzy system, distributed fault detection.**

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