Prescribed-Time Human-in-the-Loop Optimal Consensus Control for Multi-Agent Systems with Input Dead-Zone

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***Abstract*—In recent years, with the rapid development of multiple unmanned aerial vehicles (UAVs), multiple unmanned ground vehicles (UGVs) and other fields, multi-agent systems (MASs) have been paid more and more attention by scholars. With the development of automation, incidents with Boeing 737 jetliners and Tesla's autonomous driving systems have raised serious concerns and highlighted the challenges that fully autonomous MASs face in making judgments during in uncertain and complex environments. Therefore, it is urgent to develop monitoring schemes to complete tasks when MASs encounter unexpected situations. For this special case, the human-in-the-loop (HiTL) control method is considered in the controller design. Besides, in view of the requirement of practical engineering, the optimal performance and prescribed-time convergence need to be satisfied simultaneously. For this case, the prescribed-time performance method can be integrated in the design process of the optimal controller, so that the controller design is based on the prescribed-time performance error transformation. Since the physical properties of electronic components of these practical systems, it can easily lead to input dead-zone causing serious incidents. Therefore, it is necessary to design a universal HiTL optimal control framework under performance constraints and input dead-zone. In this work, the reinforcement learning (RL)-based HiTL optimal consensus control problem for nonlinear MASs with input dead-zone based on a novel prescribed-time performance function is solved. First, to respond to any emergencies and guarantee the safety of MASs, the MASs are monitored by human operator sending command signals to the non-autonomous leader. Then, under the joint design architecture of prescribe-time performance function and error transformation, a novel performance index function involving transformed error and control input is developed to achieve optimal consensus with prescribed-time. Subsequently, the RL method is utilized to learn the solution to Hamilton-Jacobian-Bellman (HJB) equation, in which the fuzzy logic systems (FLSs) are employed to implement the method. The stability analysis illustrates that the proposed control approach can ensure that all signals in the closed-loop system are bounded. In simulation, a numerical example and a practical mass-spring-damping MAS example are used to verify the effectiveness and superiority of the control scheme. Future work will concentrate on employing the designed controller for practical unmanned marine vehicle (UMV) systems to verify the validity.**

***Index Terms*—Human-in-the-loop control, prescribed-time control, reinforcement learning, input dead-zone, nonlinear multi-agent systems.**

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