# Event-Triggered Consensus of Uncertain Euler-Lagrange Multi-Agent Systems on Jointly Connected Digraphs

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***Abstract*—This paper presents a fully distributed event-triggered protocol aimed at solving the consensus problem in uncertain Euler-Lagrange (EL) multi-agent systems (MASs) under jointly connected digraphs. Firstly, distributed event-driven reference generators are introduced to generate continuously differentiable reference signals via event-based communication within the jointly connected digraphs. Unlike some existing work, this approach only necessitates the transmission of agent states, without the need for virtual internal reference variables, among agents. Secondly, adaptive controllers are implemented, allowing each agent to track the reference signals. The uncertain parameters are shown to converge to their actual values under the initially exciting (IE) condition. It is established that the uncertain EL MAS achieves asymptotic state consensus using the proposed event-triggered protocol, which includes the reference generators and adaptive controllers. A distinguishing feature of the proposed protocol is its fully distributed characteristic, as it does not require global information about the jointly connected digraphs. Moreover, a minimum inter-event time (MIET) is guaranteed. Lastly, two simulations are carried out to confirm the effectiveness of the proposed protocol.**

***Index Terms*—Adaptive; consensus; Euler-Lagrange; event-triggered protocol; fully distributed; jointly connected digraphs; multiagent systems.**

## I. Introduction

Over the last two decades, the distributed cooperative control problem of multi-agent systems (MASs) has emerged as a central research area in the control community, driven by its broad range of applications [1], [2]. Key topics include consensus, flocking, and formation [3], [4], [5], with consensus being the most fundamental among them. Consequently, many researchers have focused on investigating the consensus problem in MASs with various dynamics [3], [6], [7], [8]. More recently, cluster consensus (or multiconsensus), where distinct partitions of MASs are directed to achieve different consensus states, has also gained significant attention [9], [10].

Communication among agents is generally necessary for reaching consensus in the cooperative control of MASs, as is well known [11]. Nevertheless, continuous communication can be inefficient or even impractical due to the limited communication bandwidth and energy available to each agent. To address this, distributed event-triggered protocols have been developed, which facilitate communication between neighboring agents only when a specific event-triggering condition is met [12]. A key challenge in event-triggered protocols is avoiding Zeno behavior, where an infinite number of events occur within a finite time period. Two commonly adopted strategies to prevent Zeno behavior involve the use of a contradiction argument [13], [14], [15], [16] and ensuring a positive minimum inter-event time (MIET) [17], [18], [19].

The design of event-triggered protocols is significantly influenced by the network topologies of MASs. In connected undirected topologies, the symmetry property of the Laplacian matrix is often utilized as a critical design element [14], [16], [17], [18], [19], [20], [21]. Directed topologies, however, usually feature asymmetric Laplacian matrices, prompting the introduction of the graph symmetrization technique [22], [23]. In practical applications, time-varying topologies may arise due to factors such as power constraints, multipath fading, or external attacks [24]. Consequently, researchers have examined event-triggered protocols for MASs under time-varying topologies. For instance, jointly connected undirected topologies are studied in [25] and [26], while an event-triggered protocol for jointly connected directed topologies, inspired by [27], is developed in [28].

The literature discussed earlier [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26] primarily examines linear MASs. However, the cooperative control of nonlinear MASs has more extensive applications, such as the on-orbit autonomous assembly of flexible spacecraft teams [29]. Some studies have addressed the consensus problem in MASs with nonlinear dynamics, as seen in [7], [30], [31], [32], and [33]. Specifically, the consensus problem for Euler-Lagrange (EL) MASs under fixed topologies is solved through distributed control protocols using continuous communication in [7] and [31], and this work has been extended to jointly connected topologies in [30] and [32]. More recently, event-triggered communication mechanisms have been employed for the cooperative control of EL MASs [34], [35]. In [33], a quantized sampled-data control method is developed to achieve robust consensus for a class of nonlinear MASs, but the topologies are constrained to be fixed in [33] and [34]. The event-triggered protocols proposed in [34] and [35] require global information about the communication topologies, and no positive MIET is provided.