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Modified dynamic event-triggered scaled formation control for multi-agent systems via a sparrow search algorithm based co-design algorithm

Key words: Scaled consensus; Formation control; Dynamic event-triggered scheme; Switching topology

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Motivation

- In multi-agent systems (MASs), the states and control information of agents are exchanged through network transmission with high requirements in terms of network bandwidth and hardware equipment. It is of significance to explore a better event-triggered scheme to ensure that the states and control signals of the agents are updated only when specific conditions are ensured, thereby reducing unnecessary communication.
- A more practical collaborative control framework of MASs needs to be investigated to achieve more complicated cooperative control through combining scaled consensus and formation control.
- An effective algorithm needs to be developed to compute the triggering parameters, weighting matrix, and control gain jointly in the context of MASs possessing numerous nodes and complex topological connections.

Main idea

- By introducing a random variable and two different threshold parameters into the traditional dynamic event-triggered (DET) mechanism, the event-triggering conditions can be adjusted by choosing different threshold parameters according to different statuses of the network.
- The absolute value of the combination error term and an auxiliary dynamic variable (ADV) are introduced. Thus, the number of event-triggered moments can be effectively reduced and more efficient convergence can be achieved.
- By introducing the sparrow search algorithm (SSA) into the stability criteria for the formation error system in terms of nonlinear matrix inequalities, the control gain can be obtained more reasonably and accurately, thereby reducing the conservatism for control gain design.

Framework

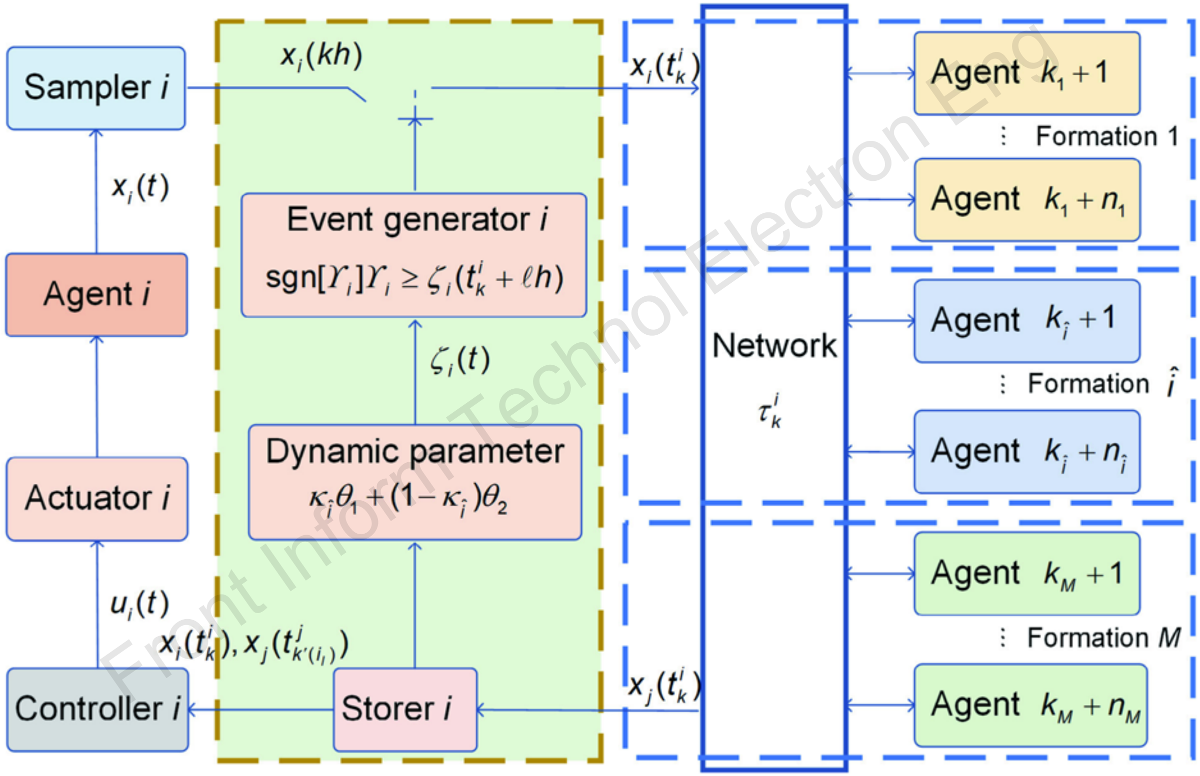

Fig. 1 Scaled formation control framework for the i^{th} agent

Major results

- Fig. 4 depicts the position trajectories of UAVs 1–12 under a fixed topology. The positions of UAVs 1–3 achieve a triangular formation, those of UAVs 4–7 a square, and those of UAVs 8–12 a pentagon.
- Fig. 8 depicts the position trajectories of UAVs 1–12 under a switching topology. During 0–10 s, the positions of UAVs 1–3 achieve a triangular formation, those of UAVs 4–7 a square, and those of UAVs 8–12 a pentagon. During 10–20 s, the positions of UAVs 1, 2, 4–6, and 8–10 transform into the formation of a circle, and those of UAVs 3, 7, 11, and 12 into that of a rhombus.

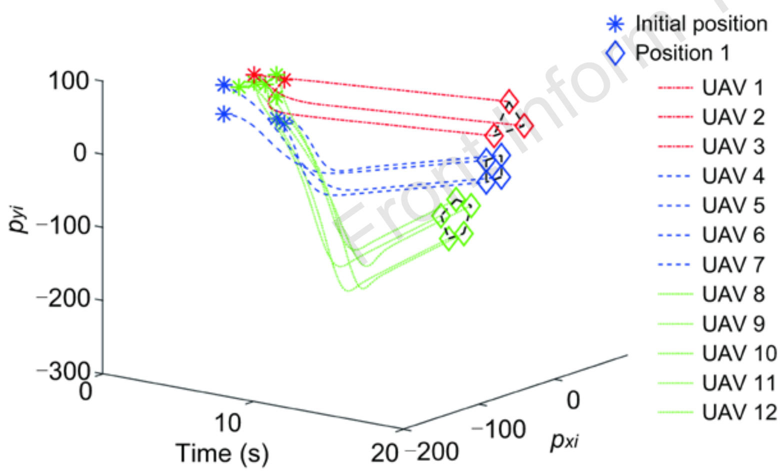

Fig. 4 Position states of UAVs 1–12 under G_1 ($i = 1, 2, \cdots, 12$)

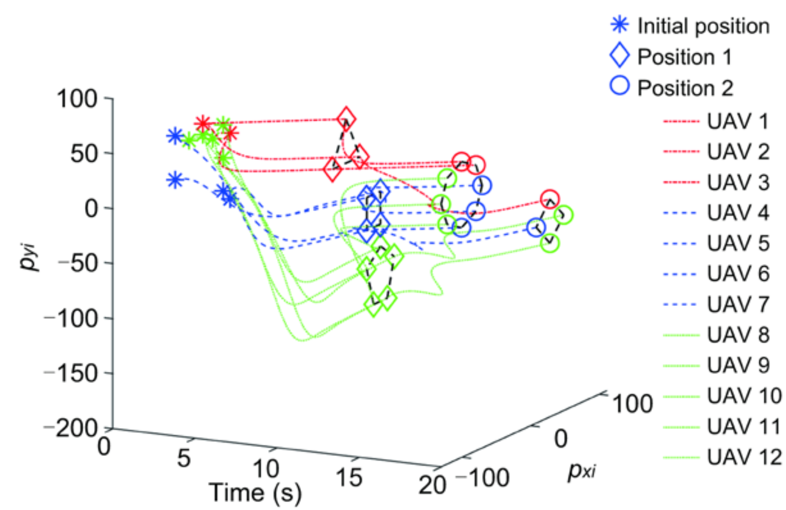

Fig. 8 Position states of UAVs 1–12 under G_1 and G_2 ($i = 1, 2, \cdots, 12$)

Major results

- Tables 4 and 5 show that, due to the use of the proposed modified resilient DET mechanism with an absolute value, the required formation control can be reached under a fixed topology with a smaller error, as well as a greater number of instances characterized by a small triggering number.

Table 4 Number of event-triggered instants under different mechanisms with a fixed topology for UAVs 1–12

Mechanism	Number of event-triggered instants												Total	Error ($\times 10^4$)
	1	2	3	4	5	6	7	8	9	10	11	12		
$\lvert\Upsilon_i\rvert$ with θ_1, θ_2	80	316	334	372	487	431	397	499	430	420	439	536	4741	1.1806
$\lvert\Upsilon_i\rvert$ with θ_1	80	315	333	402	506	448	418	530	474	468	492	597	5063	1.2545
Υ_i with θ_1, θ_2	80	315	333	405	511	451	419	537	475	468	491	601	5086	1.2358
Υ_i with θ_1	80	315	333	402	506	448	418	530	474	468	492	597	5063	1.2545

Table 5 Number of event-triggered instants under different mechanisms with a switching topology for UAVs 1–12

Mechanism	Number of event-triggered instants												Total	Error ($\times 10^4$)
	1	2	3	4	5	6	7	8	9	10	11	12		
$\lvert\Upsilon_i\rvert$ with θ_1, θ_2	275	316	602	503	574	555	659	576	525	617	534	540	6276	1.0311
$\lvert\Upsilon_i\rvert$ with θ_1	275	315	593	496	562	548	662	569	522	609	533	537	6221	1.0688
Υ_i with θ_1, θ_2	275	315	595	499	564	549	663	570	522	610	533	537	6232	1.0609
Υ_i with θ_1	275	315	593	496	562	548	662	569	522	609	533	537	6221	1.0670

Conclusions

- The scaled formation control for MASs subject to fixed and switching topologies is investigated.
- Different from traditional DET mechanisms, a modified resilient DET mechanism based on sampled data with two different threshold values and the absolute value of the combined error is proposed.
- A scaled formation control protocol is designed by introducing certain formation information, through which agents in an MAS can realize its formation in groups.
- Adoption of SSA has made it possible to deploy a co-design algorithm through dealing with the derived criteria in terms of matrix equalities, which is essential for the design of the control gain matrix and triggering parameters.