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Sampled data based containment control of second-order multi-agent systems under intermittent communications

Key words: Containment control; Second-order multi-agent system; Sampled position data; Intermittent communication; Communication width

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Motivation

1. The containment control problem has attracted considerable attention due to its broad applications in areas such as hazardous material handling, search and rescue, and cooperative transport.
2. Due to sensor/actuator failures, network-injected packet losses, and the limitation of sensing ranges, the whole communication link among agents will be intermittent, and the control inputs will be zero during disconnected communication time intervals.
3. The velocity information among agents may be difficult to achieve in practical applications. Moreover, to save space, cost, and reduce weight, agents might not be equipped with velocity sensors in many real systems.

Main idea

1. Intermittent control and sampled control are critical control methods, and are often used for the time-varying or discontinuous control tasks.
2. A new kind of intermittent containment control protocol for second-order multi-agent systems is designed via the current and sampled position data.
3. Modern control theory, algebraic graph theory, and matrix theory are used for stability analysis of multi-agent systems.

Method

1. Under intermittent communications, an intermittent sampled data based control method for solving the second-order containment control problem without velocity measurements has been put forward.
2. To use less information and save more energy, a novel intermittent sampled containment controller is first put forward via intermittent sampled position data communications.

Major results

Suppose that the communication network is undirected and connected. The sampled data based containment control of second-order multi-agent systems under intermittent communication can be achieved via the proposed control protocol, if and only if

$$\begin{cases} 0 < \beta < \alpha, \\ 0 < \theta < \dfrac{\pi}{|\sqrt{\alpha\bar{\mu}}|}, \\ T < \varrho + \theta, \end{cases} \tag{6}$$

where $\bar{\mu} = \max_i\{\mu_i\}$, $\varrho = \min_i\left\{\frac{2(1+\cos(\sqrt{\alpha\mu_i}\theta))}{(1-\beta/\alpha)\sqrt{\alpha\mu_i}\sin(\sqrt{\alpha\mu_i}\theta)}\right\}$, and μ_i are the eigenvalues of $\boldsymbol{L}_1$, $i = 1, 2, \ldots, N$.

Major results (Cont'd)

1. State trajectories of all agents

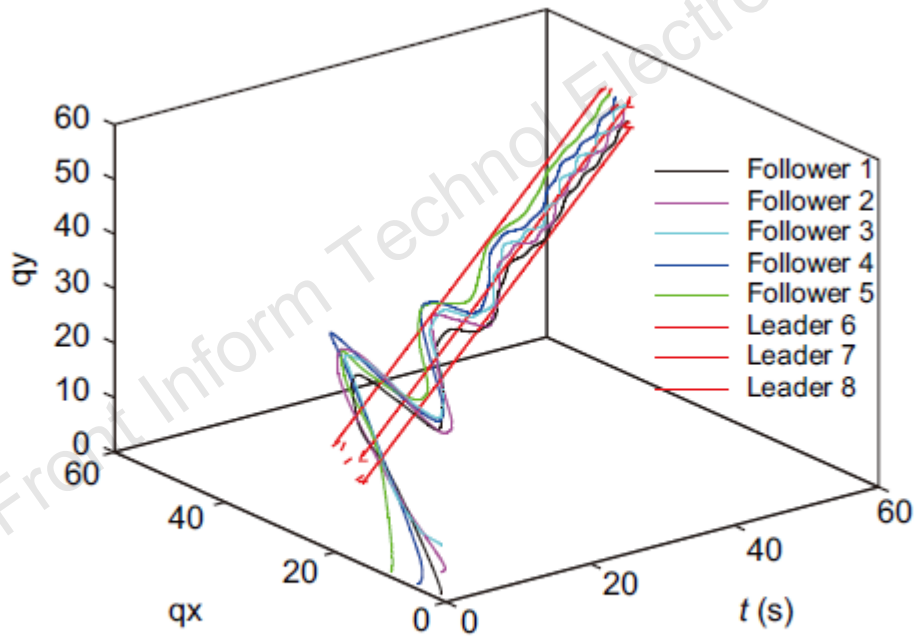

Fig. 3 State trajectories of agents under the fixed communication topology when $\theta = 1.5$ and $T = 2$

Major results (Cont'd)

2. State trajectories of all agents

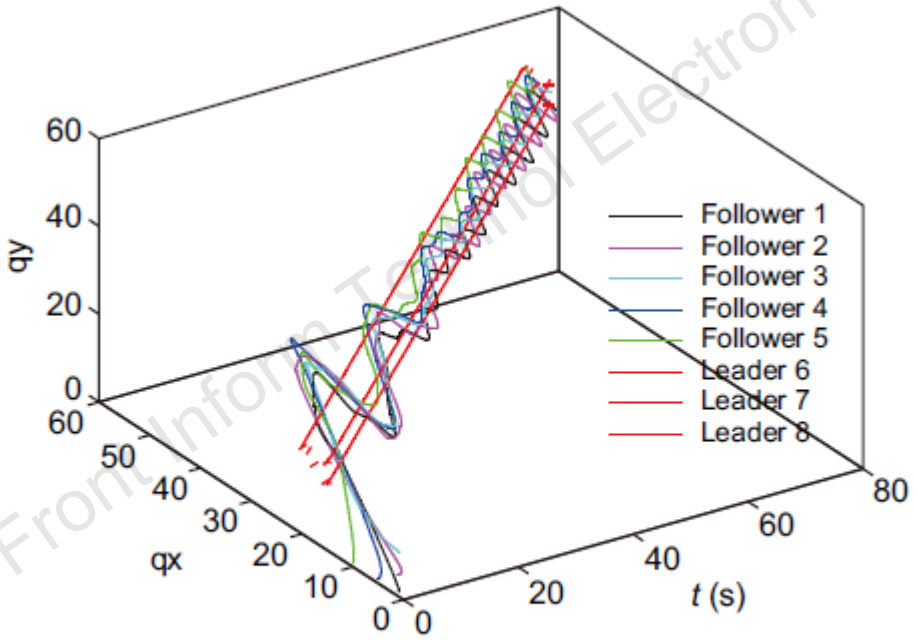

Fig. 4 State trajectories of agents under the fixed communication topology when $\theta = 1.5$ and $T = 2.3$

Conclusions

1. A novel distributed intermittent control protocol has been proposed, which uses only intermittent sampled position data to solve the second-order containment control problem without velocity measurements.
2. Necessary and sufficient conditions hinging on the feedback gains, eigenvalues of the Laplacian matrix, the sampling period, and the communication width are derived under undirected and connected communication networks.

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