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Event-triggered adaptive finite-time control for nonlinear systems under asymmetric time-varying state constraints

Key words: Event-triggered control; Nonlinear mapping; Adaptive fuzzy control; Finite-time; State constraints

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Motivation

1. Note that output/state constraints often occur in practical systems. The transgression of output/state constraints may decrease system performance or even cause danger.

2. When using log-type barrier Lyapunov functions (BLFs) or tan-type BLFs, the output/state constraints should be transformed on error constraints, which leads to the initial state selection tending to be conservative.

3. Different from infinite-time control approaches, finite-time control approaches have better robustness and tracking performance. Unfortunately, when tracking errors converge to zero, time derivative of the virtual control laws will grow infinitely.

Main idea

1. Another effective way to handle output/state constraints is nonlinear mapping (NM). When using NM, the considered system can be transformed into a new system that is free of constraints. Then, the controller is designed based on the transformed system, so that the state constraints of the system will not be violated.

2. To solve this problem, smooth switch functions are applied to the virtual laws. Then, the singularity in traditional finite-time dynamic surface control (DSC) can be avoided.

3. To save communication resources, event-triggered control (ETC) approaches have received much attention.

Method

1. A novel NM function is introduced to transform an asymmetric time-varying state-constrained system into a new one that is free of constraints.

2. A new ETC-based smooth finite-time DSC approach is introduced for state-constrained systems. Smooth switch functions are applied to the virtual laws. Moreover, an ETC rule is introduced to reduce the burden of communication while maintaining the stability of the state-constrained system.

Method

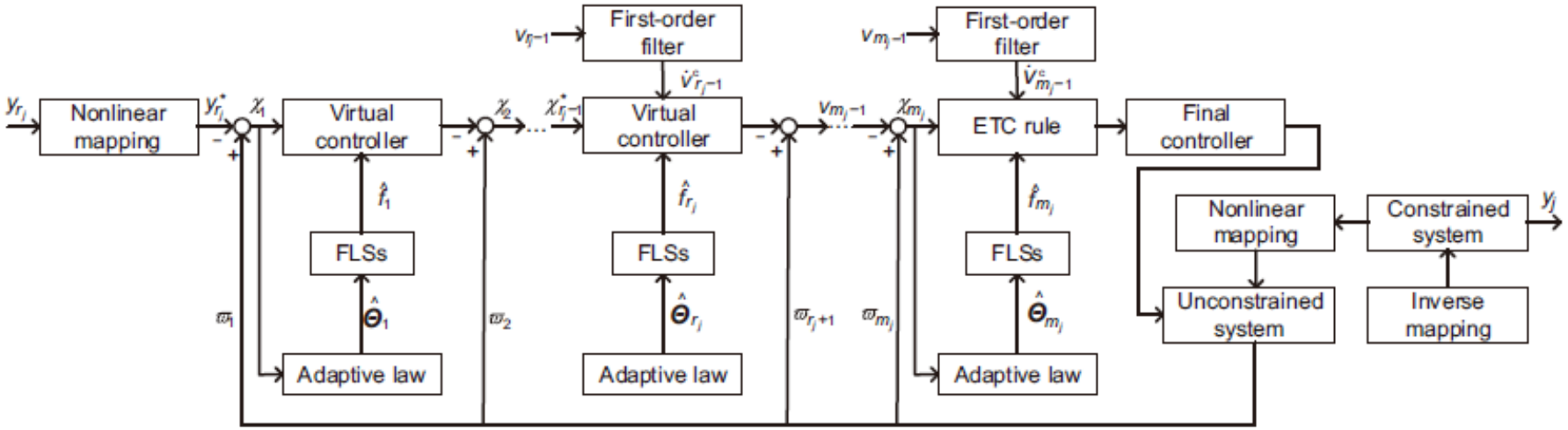


Fig. 1 Block diagram of the proposed control approach

Major results

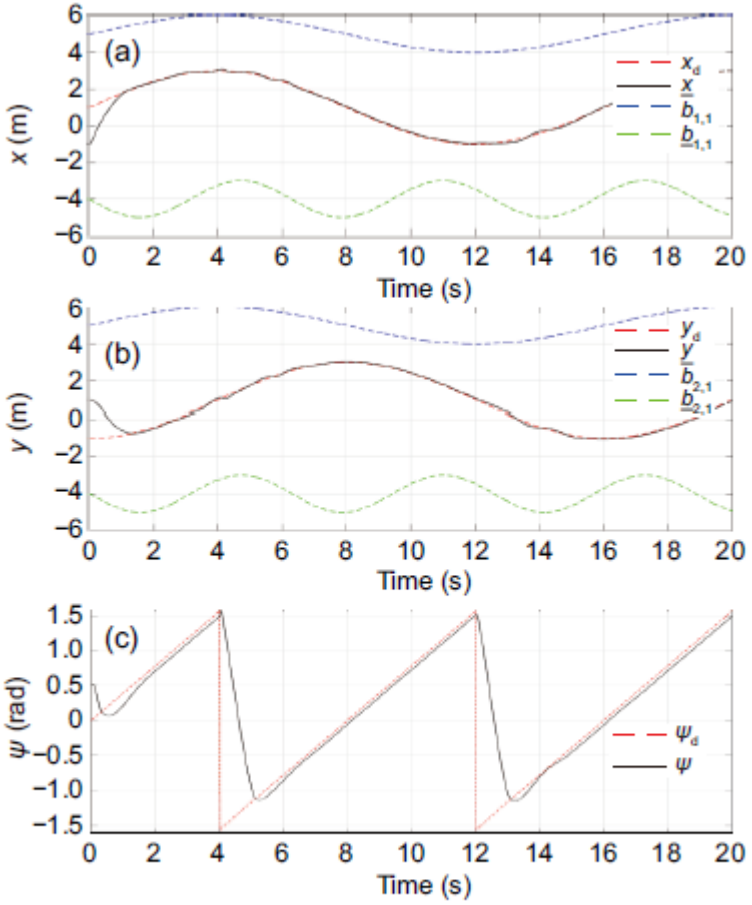


Fig. 2 Output-tracking performance under constraints x (a), y (b), and ψ (c) in Example 1

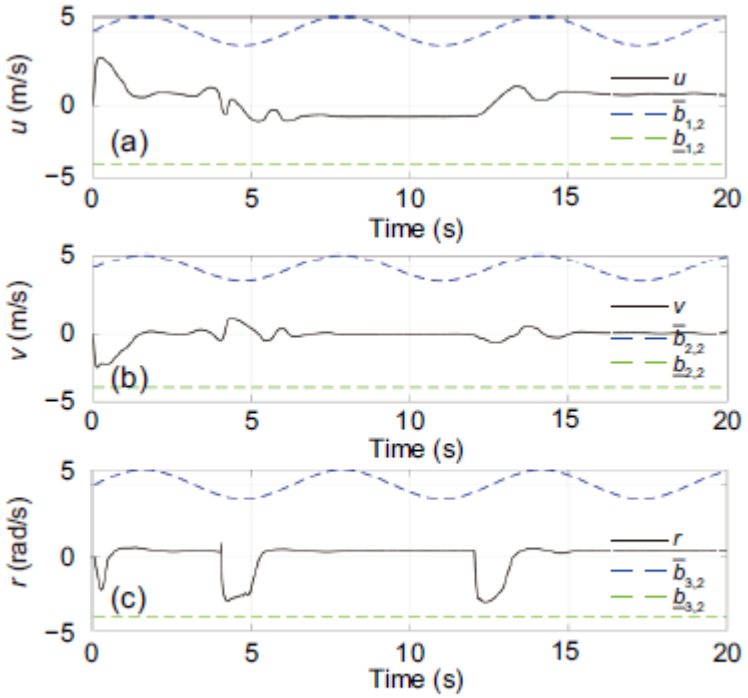


Fig. 3 Trajectories of the system states under constraints u (a), v (b), and r (c) in Example 1

Major results

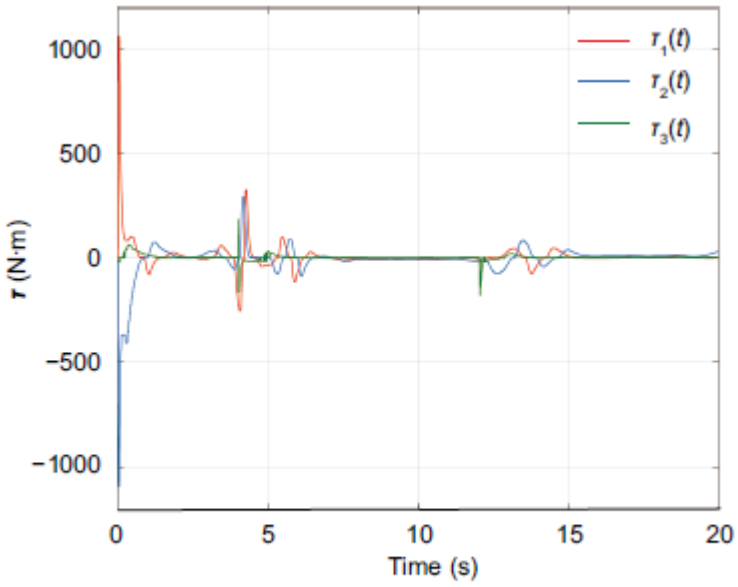


Fig. 5 Trajectories of control inputs in Example 1

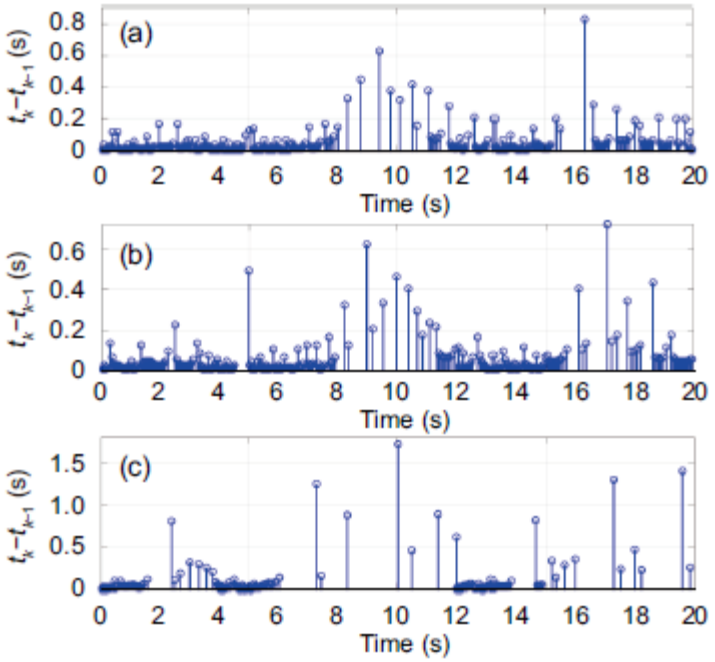


Fig. 6 Time intervals of triggering events $\tau_1(t)$ (a), $\tau_2(t)$ (b), and $\tau_3(t)$ (c) in Example 1

Conclusions

1. With the help of tan-type NM, the considered system can be transformed into an equivalent “non-constrained” one, and the feasibility conditions can be removed.

2. Under the limitation of an unbalanced small-sample dataset, the scheme of fusing texture features and deep features, combined with the training approach of transfer learning, showed an excellent classification accuracy.

3. Furthermore, the energy consumption was reduced using the designed ETC.



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