Yan WEI, Jun LUO, Huaicheng YAN, Yueying WANG, 2021. Event-triggered adaptive finite-time control for nonlinear systems under asymmetric time-varying state constraints. *Frontiers of Information Technology & Electronic Engineering*, 22(12):1610-1624. https://doi.org/10.1631/FITEE.2000692

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

Corresponding author: Yueying WANG
E-mail: wyy676@126.com
ORCID: https://orcid.org/0000-0001-9737-6765

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

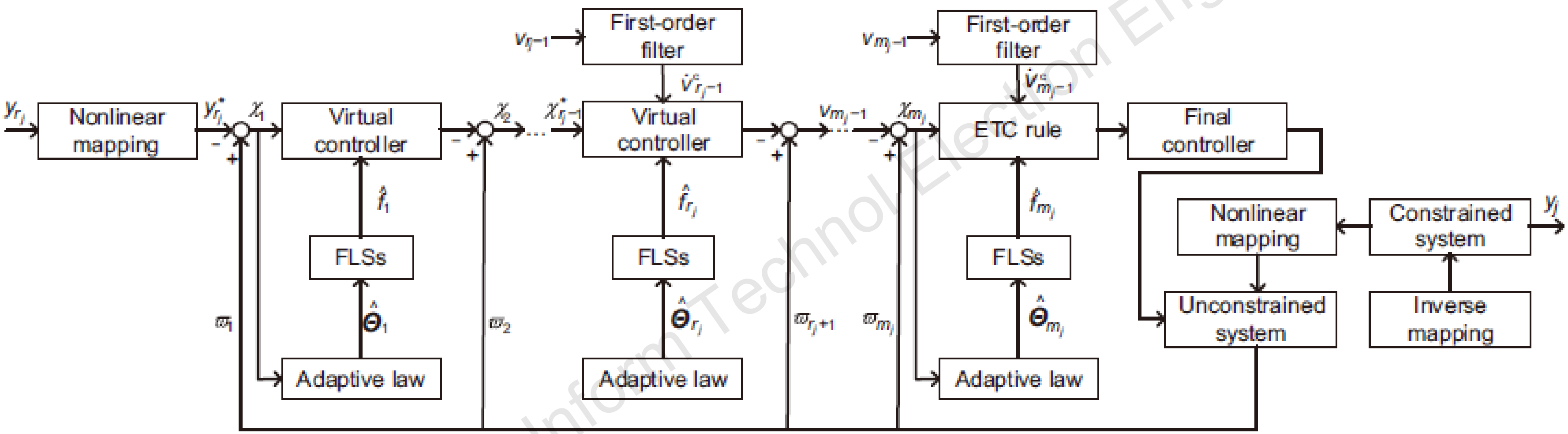

Fig. 1 Block diagram of the proposed control approach

Major results

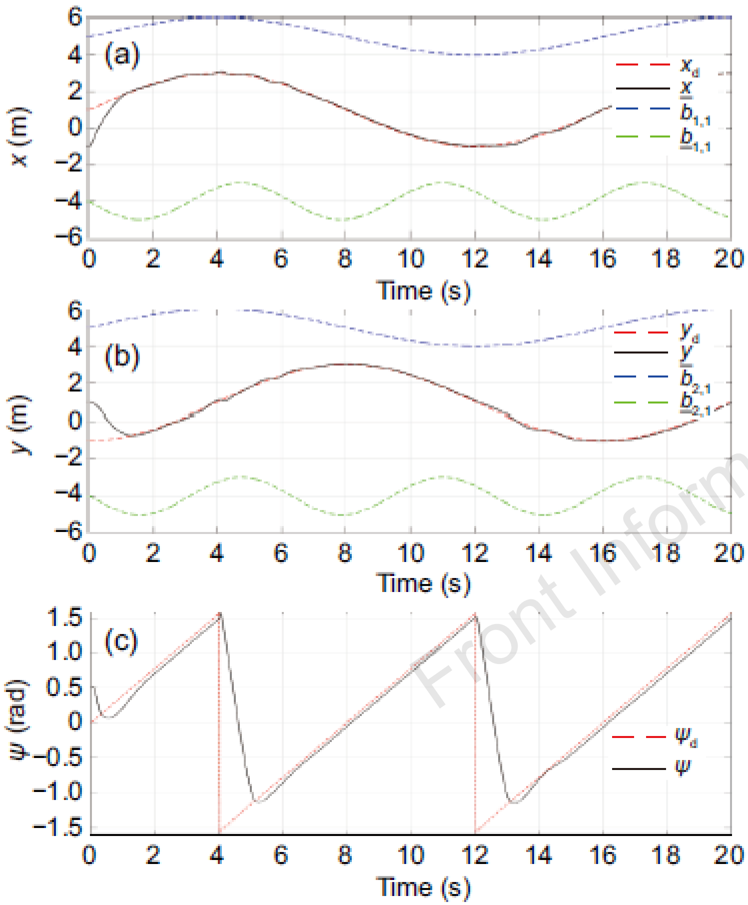

Fig. 2 Output-tracking performance under constraints x (a), y (b), and ψ (c) in Example 1

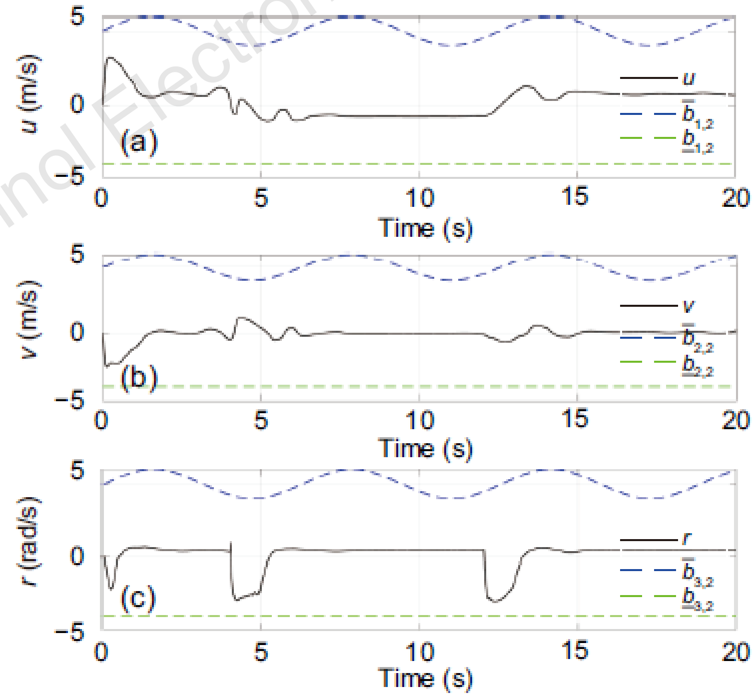

Fig. 3 Trajectories of the system states under constraints u (a), v (b), and r (c) in Example 1

Major results

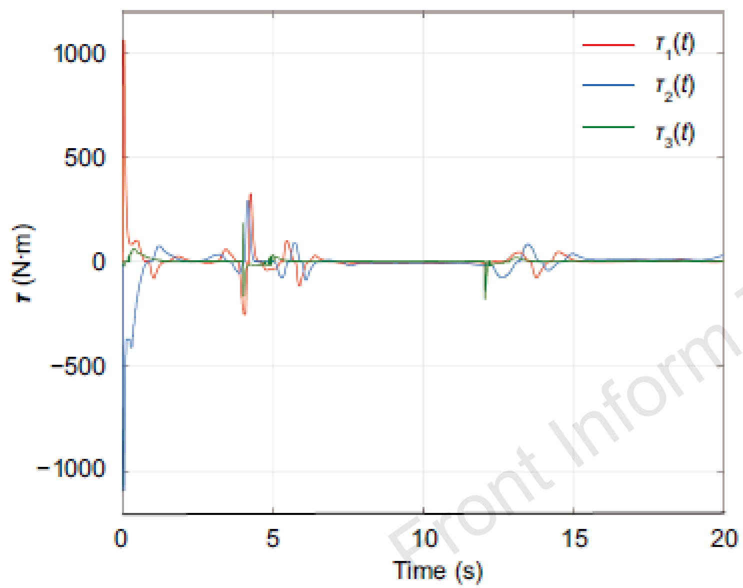

Fig. 5 Trajectories of control inputs in Example 1

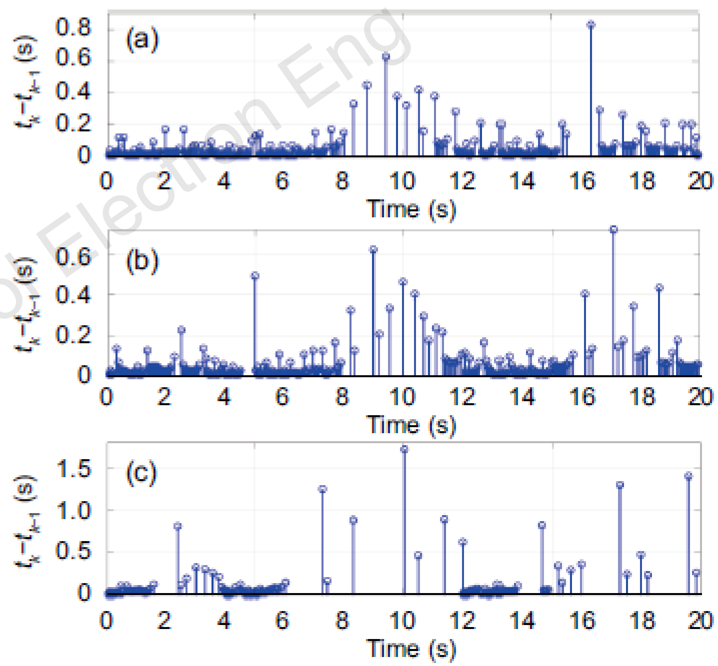

Fig. 6 Time intervals of triggering events $\tau_1(t)$ (a), $\tau_2(t)$ (b), and $\tau_3(t)$ (c) in Example 1

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.

Yan WEI is currently an assistant professor with the School of Information Engineering, Zhejiang University of Technology, Hangzhou, China. His current research interests include state-constrained control systems, adaptive control, and control of multi-agent systems.

Jun LUO is currently a professor with the School of Mechatronic Engineering and Automation, Shanghai University, Shanghai, China. His current research interests include robot sensing, sensory feedback, mechatronics, human–machine interfaces, and special robotics.

Huaicheng YAN is currently a professor with the School of Information Science and Engineering, East China University of Science and Technology, Shanghai, China. His research interests include networked control systems, multiagent systems, fuzzy systems, and smart grids.

Yueying WANG is an associate professor with the School of Mechatronic Engineering and Automation, Shanghai University, Shanghai. His current research interests include intelligent and hybrid control systems, and control of unmanned aerial/surface vehicles.