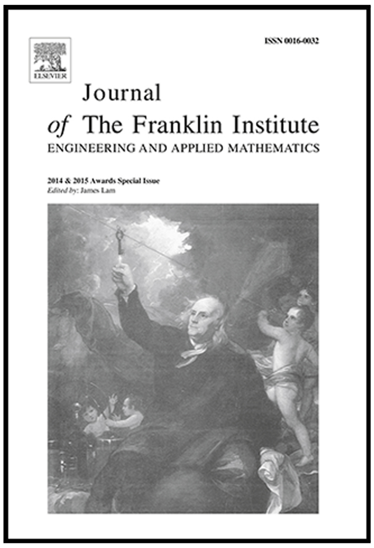
Accepted Manuscript



Network-Based PI Control for Output Tracking of Continuous-Time Systems With Time-Varying Sampling and Network-Induced Delays

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PII: S0016-0032(18)30295-3
DOI: 10.1016/j.jfranklin.2018.04.041
Reference: FI 3431

To appear in: *Journal of the Franklin Institute*

Received date: 8 January 2018
Revised date: 4 March 2018
Accepted date: 22 April 2018

Please cite this article as: Dawei Zhang, Zhiyong Zhou, Xinchun Jia, Network-Based PI Control for Output Tracking of Continuous-Time Systems With Time-Varying Sampling and Network-Induced Delays, *Journal of the Franklin Institute* (2018), doi: 10.1016/j.jfranklin.2018.04.041

Network-Based PI Control for Output Tracking of Continuous-Time Systems With Time-Varying Sampling and Network-Induced Delays

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Abstract

For a continuous-time linear system with constant reference input, the network-based proportional-integral (PI) control is developed to solve the output tracking control problem by taking time-varying sampling and network-induced delays into account. A traditional PI control system is introduced to obtain the equilibriums of state and control input. Using the equilibriums, a discrete-time PI tracking controller in a network environment is constructed. The resulting network-based PI control system is described by an augmented system with two input delays and the output tracking objective is transformed into ensuring asymptotic stability of the augmented system. A delay-dependent stability condition is established by a discontinuous augmented Lyapunov-Krasovskii functional approach. The PI controller design result of in-wheel motor as a case study is provided in terms of linear matrix inequalities. Matlab simulation and experimental results resorting to a test-bed for ZigBee-based control of in-wheel motor are given to validate the proposed method.

Keywords: Network-based PI control, time-varying sampling, output tracking control, in-wheel motor, discontinuous Lyapunov-Krasovskii functional

1. Introduction

Proportional-integral (PI) control is a classical and popular control strategy that is often applied in practical systems due to its particular advantages in eliminating steady-state tracking errors through an integral control action [1–3]. For traditional systems, PI control gains appear as adjustable parameters in the controller to achieve system stability and various performance specifications, and a great number of PI tuning rules are reported to meet the control requirements [4–8]. In these systems, the controlled plants and the PI controller are shared with analog or digital signals through hardwired connections. In the last decade, along with the networking tendency of modern industrial systems, the presence of communication networks in a control system leads to a networked control system (NCS) structure [9–13], endowed with attractive advantages such as wiring reduction and remote control as well as some challenging issues like unavoidable network-induced delays [14–17]. For the NCS, the traditional PI control theory may no longer fit perfectly, which demands some deep insights and reevaluation of network-based PI control to adapt to the new control system structure.

In recent years, network-based PI or proportional-integral-derivative (PID) control for discrete-time systems has been primarily investigated [18–20]. In [18], a discrete-time linear time-varying system that depends on random network delays is established by using a delay-dependent dual-rate PID controller form and its mean square stability is analyzed. In [19], stabilization of discrete-time NCSs subject to network-induced delays and random packet dropouts is considered by a digital PID controller and the controller design is converted into a static output feedback control design by an augmentation system method. Under the assumption that the upper bound of network-induced delay is less than a fixed sampling period, the stability of a discretization system model with a discrete-time PID controller is

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