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Asynchronous gain-scheduled control of deepwater drilling riser system with hybrid event-triggered sampling and unreliable communication

Key words: Riser system; Recoil control; Asynchronous gain-scheduled control; Data loss; Event-triggered scheme

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Motivation

1. Given the current linearization modeling and linear control methods, as the tension force is essentially nonlinear, it is necessary to present some specialized nonlinear modeling and recoil control methods for the riser-tensioner system.
2. So far, the existing recoil control strategies have been designed in a traditional control system structure. Currently, some dedicated wireless networks are used to deploy the network environment of deep-sea drilling devices, which can cause the issues of limited network resources, communication delay, and data loss. To handle these issues, it is necessary to develop some networked nonlinear modeling and recoil control methods.

Main idea

1. Inspired by the nonlinear modeling advantage of linear parameter-varying (LPV) systems, a triangle-based polytope LPV system is developed to equivalently describe the riser-tensioner system.
2. Considering the schedulable displacement information and the transmitted information affected by the limited network resources, communication delay, and data loss, an asynchronous gain-scheduled control strategy with hybrid event-triggered scheme is presented to implement the networked recoil control of the riser-tensioner system.

Method

1. For the closed-loop system model of the nonlinear networked riser-tensioner system, an asynchronous LPV system that blends input delay and impulsive update equation is presented, where the asynchronous deviation bounds of scheduling parameters are calculated.
2. To achieve the acceptable recoil response and suppress the adverse impact of friction force on the relative displacements, some sufficient conditions of disturbance attenuation analysis and recoil control design are derived by using a discontinuous Lyapunov–Krasovskii functional approach. These conditions are provided by linear matrix inequalities, which can ensure that the asynchronous LPV system is exponentially mean-square stable with prescribed H_∞ performance.

Major results

The comparison of recoil control effect between the proposed nonlinear networked control and the existing linear control

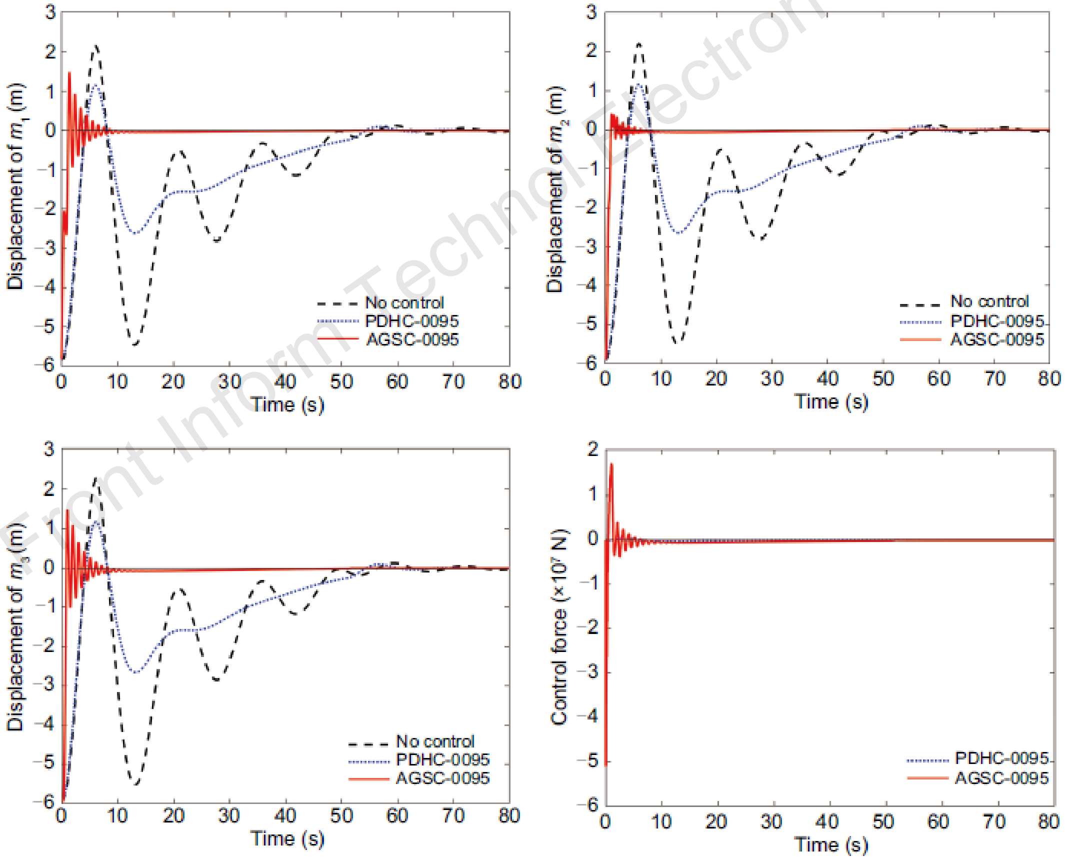

Fig. 1 Displacements and control force of the riser system without control, with AGSC-0095, and with PDHC-0095

Major results (Cont’d)

The recoil response achieved by the proposed nonlinear networked control

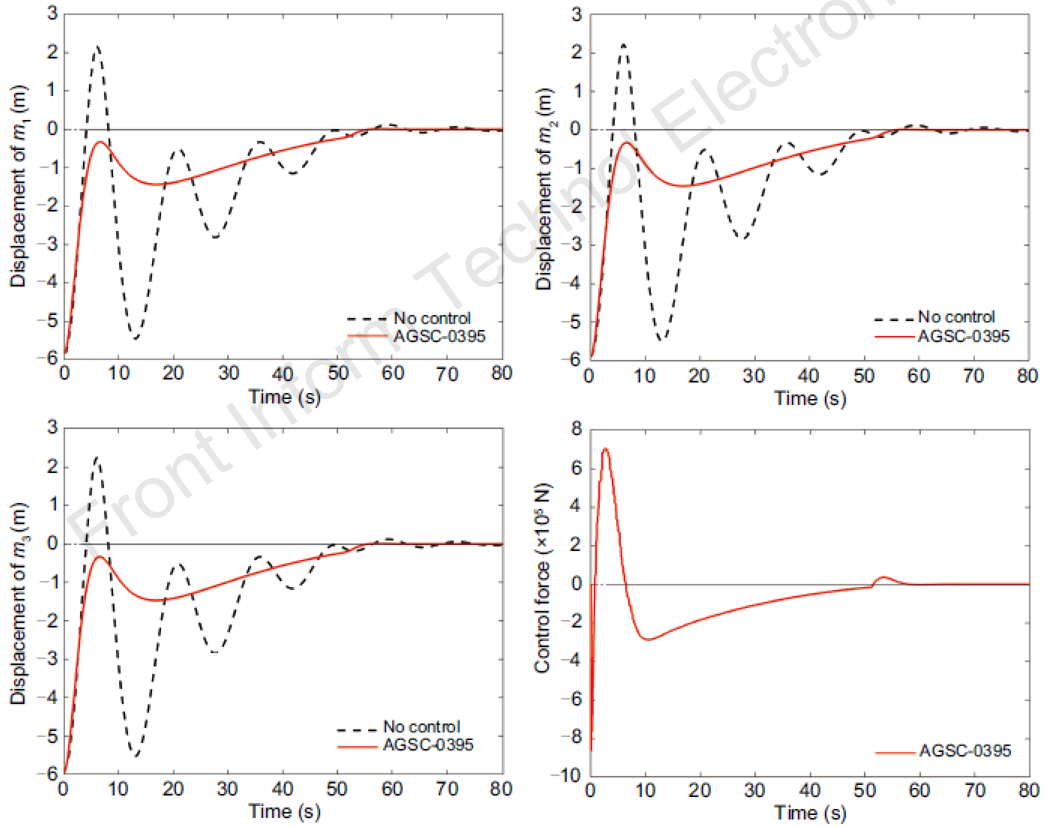

Fig. 2 Displacements and control force of the riser system without control and with AGSC-0395

Major results (Cont'd)

The validity of the hybrid event-triggered scheme in Fig. 1

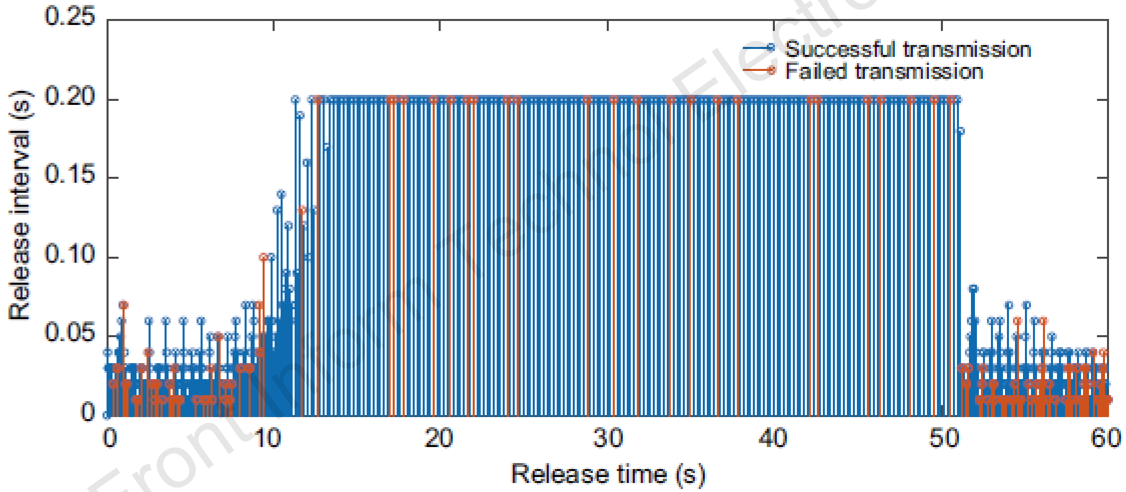

Fig. 3 Release time and release interval when $\varkappa = 0.2$ s, $\beta = 0.9$, and $\eta_M = 0.095$ s (References to color refer to the online version of this figure)

Major results (Cont'd)

The validity of the hybrid event-triggered scheme in Fig. 2

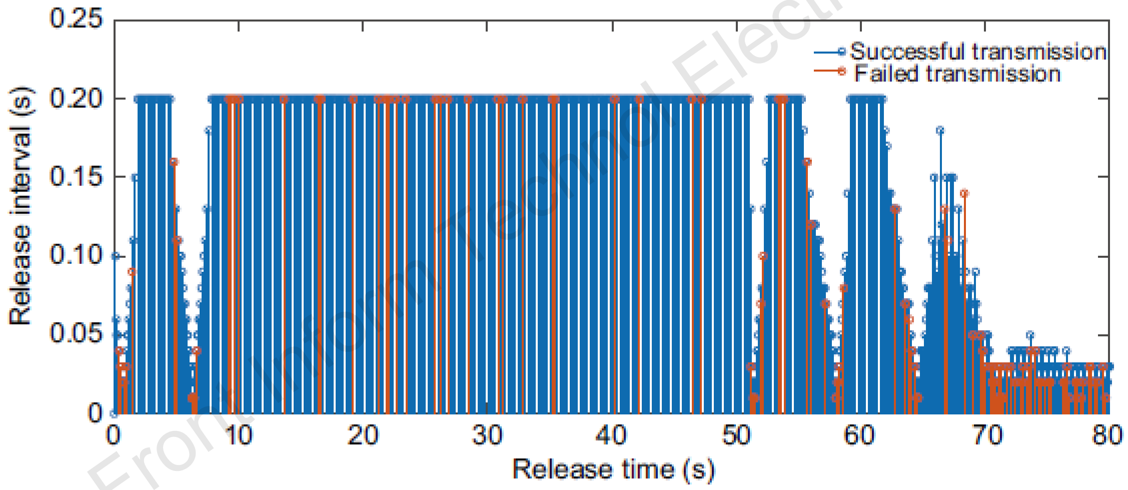

Fig. 4 Release time and release interval when $\varkappa = 0.2$ s, $\beta = 0.9$, and $\eta_M = 0.395$ s (References to color refer to the online version of this figure)

Conclusions

1. The nonlinear networked system modeling and an asynchronous gain-scheduled control method of the riser-tensioner system have been proposed.
2. The proposed nonlinear asynchronous gain-scheduled control method can suppress the recoil response of the riser-tensioner system subject to friction force, event-triggered sampling, communication delay, and data loss.
3. The proposed nonlinear asynchronous gain-scheduled control method can provide a better recoil control effect compared with the existing linear control.

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