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Distributed fault-tolerant strategy for electric swing system of hybrid excavators under communication errors

Key words: Fault tolerant; Delay compensation; Controller area network (CAN); Communication errors; Electric swing system of hybrid excavator

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Motivation

- The swing motion performance of the electric swing system (ESS) of hybrid excavator will be degraded and even result in system damages due to the delays and packet dropouts induced by the communication errors occurs in the Controller area network (CAN) of the ESS.
- The swing motion performance of the ESS under communication errors has not been addressed, and none of the current delay compensation methods can overcome the limitations of the ESS simultaneously.
- A novel delay compensation method that can adaptively alleviate the adverse impacts of delays and packet dropouts without requiring additional network bandwidth is needed.

Main idea

- Constructing the feedback of motor speed under communication errors
- Making the control action of the implemented target motor torque under communication errors as close as possible to that of the generated target motor torque
- Adaptively compensate the feedback motor speed and the target motor torque in the central controller and the swing motor driver according to the real-time delay and packet dropouts, respectively.

Method

1. The feedback signal is compensated based on the estimation of the current motor speed and a reverse correction law
2. The control command is compensated based on the previously received target motor torque and the control law.
3. The real-time delay and packet dropout are detected based on the online delay estimation method (Gao et al., 2015).
4. The real-time plant model parameters are identified online based on the recursive least-squares algorithm with forgetting factor (FFRLS) (Beza and Bongiorno, 2014).

Major results

- The wobbles of the swing platform caused by the communication errors can be effectively suppressed by the proposed strategy.

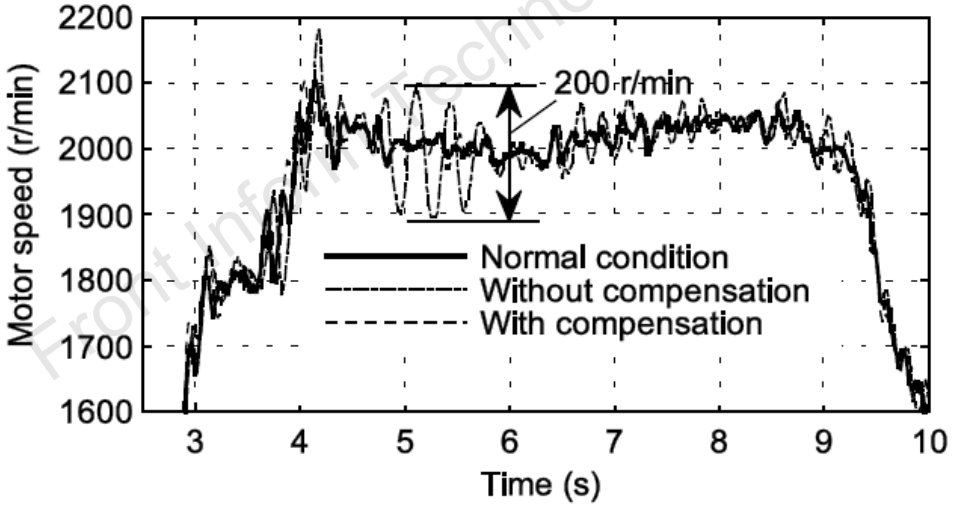

Fig. 11 Speed response of the electric swing system during an arbitrary operation

Conclusions

- A distributed fault-tolerant strategy based on a novel delay compensation scheme, where the feedback signal and the control command of the ESS are independently compensated in the central controller and the swing motor driver, respectively, was proposed to alleviate the adverse impacts of the delays and packet dropouts induced by communication errors for the ESS.
- Simulations and Experiments demonstrated the efficiency of the proposed strategy.