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STATE PREDICTOR BASED COMPENSATION FOR TIME-DELAYS IN DISTRIBUTED REAL-TIME SYSTEMS

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Inherent time-delays in distributed real-time control systems can degrade the performance or unstable the system unless treated properly. Standard delay compensation schemes usually include time stamped measurements, which require clock synchronization at different nodes. This needs periodic re-synchronization to minimize the impact of clock drift, consuming additional bandwidth. Further, the controller to actuator delay is unknown prior to the controller calculation, where probability distribution based complicated methods are required, to know it in advance.

In this paper, a plant model based predictor is cascaded to the state observer to predict the states corresponding to the next sampling instant. These states are then used in the controller to derive the next control signal, which is released just after reading the next sample. Note that both sensor and actuator are at the same location and are synchronized in sampling. This completely eliminates clock synchronization and complications in delay compensation. The main characteristic of the operation is that the control signal at the time instant 'k' is based on the predicted states at time instant 'k'. These predictions are based on the output measurements at time instant 'k-1'.

The proposed method is implemented in simulation in True-Time 1.13, a MATLAB^{TM}/Simulink based real-time environment. Sequential programming in a non real-time simulating environment does not simulate dispatching tasks according to schedule, pre-emption or starvation based on priority and context switching. However periodic sampling and actuating tasks in the Sensor / Actuator module must pre-empt event-triggered sending or receiving tasks incase if they get delayed more than the period. To accommodate this scenario in the simulation a real-time simulating environment is necessary.

The first test system is a position control DC servo-motor where the electrical time constant is much lower than its mechanical time constant. The second system comprises of a double integrator. The third example is the standard inverted pendulum system, which is an unstable system. All the systems have been operated in the distributed mode, i.e., sensor, actuator and the plant are at one location while the controller is at another location and the two parties bridged with Switched Ethernet non-deterministic network.

Simulation results in terms of the step response show that for all three cases the proposed state predictor based delay compensation outperforms even the most recently developed delay compensation methods. This is expected because the actuation is periodic with no control delay from sensing to actuation despite stochastic delays in the networked distributed system.