Multirate control for high accuracy and low cost: dual-stage experiments

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Motivation: balancing performance versus cost
Dual-stage systems are commonly used in industry to achieve a high position accuracy over a large range. The different performance requirements of the stages (e.g., µm vs nm: order 10³) result in different control bandwidths which naturally leads to a multirate design. Multirate designs balance performance versus cost through use of different sampling frequencies. This enables reduction of implementation cost in terms of hardware, e.g., sensors, actuators, AD/DA converters. This is a clear advantage over traditional single-rate designs in which the sampling frequency for all control loops is determined by the control loop with the most stringent performance requirements.

Contribution: experimental validation of multirate control design framework
Although multirate control has many potential, at present its deployment is hampered by a lack of control design techniques. The main reason is linear periodically time-varying (LPTV) behavior for which well-known control designs based on Bode plots and Nyquist diagrams are not directly applicable. In this work, the design framework for multirate feedforward control [1] is validated through experiments on a dual-stage system. Recent developments in feedback control for LPTV systems are presented in [2].

Experiments on a dual-stage system
The experimental setup of the dual-stage system is shown in Figure 1. Figure 2 shows the experimental results. The proposed approach multirate high, achieves high performance (similar to single-rate high) with limited cost since one of the feedback loops is evaluated at low rate.

Figure 1 Experimental multirate dual-stage system with the part in blue at high rate (---) and the part in red at low rate (--). The objective it to minimize error \( \varepsilon \) through design of feedforward.

Figure 2 Experimental results showing performance versus cost and the advantages of multirate control.

Conclusion
Multirate control may substantially contribute to improved performance and reduced implementation cost for systems with multiple control loops. The presented experimental results confirm this potential.

References