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Persistence Filters for State Observation and Feedback Control in Shared-Sensing Based Reversible Transducer Systems

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Summary

We investigate state observer design for systems endowed with shared-sensing and control through reversible transducers. In this framework, reversible transducers are continually switched between the actuation and sensing modes at some specified schedule. Design and analysis of stable state-observers and feedback controllers for these classes of switched/hybrid systems are significantly complicated by the fact that at any given instant of time, the overall system loses either controllability (during the sensing phase) or observability (during the actuation phase). In this work, we consider linear systems with a single shared-sensing (reversible) transducer and provide a novel observer that guarantees exponential reconstruction of state estimates to their true values. These developments hinge on a rather mild technical assumption that the transducer dwell time for both the sense and actuation modes satisfies a persistence of excitation condition. An important feature here is that the convergence rate is arbitrary. We go a step further to derive an exponentially stabilizing controller design that uses the state estimates resulting from our observer. This amounts to the establishment of a rather remarkable separation property of the control design for this class of switched dynamical system. Our theoretical results are validated through numerical simulations of challenging test-cases that include open-loop unstable dynamics. Some preliminary statements on potential nonlinear extensions are also discussed in this paper.