Optimal network resource allocation for monitoring continuous and hybrid systems

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Abstract

The goal of the proposed project is to apply topological entropy concepts and techniques for nonlinear continuous and hybrid systems to the problems of state estimation and model detection over finite-data-rate communication links. We consider a scenario where an output function with finitely many values, such as a quantizer, provides measurements of the state of a continuous-time process. First, we introduce a fundamental quantity called estimation entropy that corresponds to the minimal bit rate needed for estimating dynamical systems. We will develop upper and lower bounds on this quantity in terms of some contraction metrics in the general nonlinear case, or matrix eigenvalues in the linear case. Next, we address the problem of estimating the state of the continuous dynamical systems with desired eventual accuracy using coarse output measurements. When sufficient data rate is available, a concrete algorithm for state estimation of continuous systems will be constructed. We will study the efficiency gaps between the algorithms and the lower bounds. We will then develop algorithms for state estimation of switched and hybrid systems which will require us to tackle the intermediate problem of determining which one among a set of modes (or continuous models) is operational. Finally, we will explore applications of these algorithms in the context of the automotive and aerial vehicle control and monitoring.

Keywords monitoring, dynamical systems, hybrid systems, topological entropy, estimation, control networks, quantization, detection