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Title:
Towards Intelligent System Control

Abstract:
We present a general framework for understanding system intelligence, i.e., the level of system smartness perceived by users, and propose a novel metric for measuring intelligence levels of dynamical systems, defined to be the maximum average reward obtained by proactively serving user demands, subject to a resource constraint. We provide an explicit characterization of the system intelligence, and show that it is jointly determined by user demand volume (opportunity to impress), demand correlation (user predictability), and system resource and action costs (flexibility to pre-serve).

We then propose an online learning-aided control algorithm called Learning-aided Budget-limited Intelligent System Control (LBISC). We show that LBISC achieves an intelligence that is within O(N(T)^1/2 + ε) of the highest level, where N(T) represents the number of data samples collected within a learning period T and is proportional to the user population size in the system. Moreover, we show that LBISC possesses a much faster convergence time compared to non-learning based algorithms. The analysis of LBISC rigorously quantifies the impacts of data and user population, learning, and control on achievable system intelligence, and provides novel insight and guideline into designing future smart systems.