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Title: Trading off feedforward and feedback, remote and local in the control of complex interconnected plants

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Abstract: The past decade has witnessed a dramatic growth in interest for complex distributed interconnected systems and their control. The pervasive penetration of control, computation and communication capabilities in human artifacts of any scale is inducing a deep architectural change: from closed, isolated devices performing individual tasks, we are migrating toward highly interconnected systems comprised of a large number of heterogeneous devices cooperating for achieving common goals.

Networked control structures are ubiquitous even in biological systems. Despite the wide heterogeneity of theories that have been proposed to explain how control is computed and communicated through a relatively slow network (the nervous system), two common elements usually recur: a combination of feedback and feedforward control actions; a set of direct and inverse models for the motor system and the environment.

We consider a control architecture for networked system which is inspired by those two factors, spreading computational power locally, in sensors and actuators, and remotely, in shared computational units. A remote computer exploits the available information gathered by sensors and the availability of a possibly imprecise model of the plant in order to produce a feedforward sequence of commands suitable for the plant. Such sequence is built on a model prediction basis by virtually controlling the model of the plant with a stabilizing feedback controller. The locally (onboard the plant) available computational power is exploited for storing the control sequence and for choosing the right command value to apply according to the plant internal clock (control/plant synchronization).

Apparently, the complexity of implementable control laws and the stringency of their temporal requirements depend on the amount of locally available or remotely accessible computation resources. The design challenge thus becomes to find a good trade-off between local and remote resources, to understand what is the exact amount of decentralized intelligence to embed in the system to guarantee fulfillment of the specified requirements.