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Special Track

ACAS: Adaptive Control and Autonomous Systems

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Adaptive Control and Autonomous Systems

- Autonomous systems must function with little or no human supervision or intervention. The active controllers for such systems must be able to adapt to changing scenarios and situations. The foundation of such adaptation is the use of nonlinear direct adaptive control, i.e. controllers that nonlinearly modify their feedback gains to maintain stability in the presence of a changing environment or track idealized models of acceptable behavior and suppress persistent disturbances from the environment.
- When adaptive control is used in the development of autonomous systems both aerospace and earth-based, it is very effective at maintaining stability and performance even when used as an augmentation of a well-designed fixed gain system. The dynamic interaction of adaptive controllers with multiple vehicle systems and general networked systems can be better understood via nonlinear theoretical methods as the include papers show. Even quantum systems which have an inherently infinite-dimensional nature can be included.

Presenters

- Vinod Gehlot, Projection-Based Inter-Agent Collision Avoidance in Dual Agent Systems.

- Vahid Rezaei and Margareta Stefanovic, Distributed Stabilization of Interconnected Linear Multiagent Systems without Persistency of Excitation.

- Mark Balas, Reduction of Decoherence in Quantum Information Systems Using Direct Adaptive Control of Infinite Dimensional Systems

Projection-Based Inter-Agent Collision Avoidance in Dual Agent Systems

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ABSTRACT: Inter-agent collisions can occur in otherwise dynamically-stable (i.e., Lyapunov stable) dual-agent leader-follower systems. These inter-agent collisions between the leader and the follower happen during the transient phase of the system's evolution, although the steady-state behavior of the system is asymptotically/exponentially stable. Therefore, to avoid such inter-agent collisions, it is essential to control the relative error trajectory between the leader and the follower during the transient phase of the system's evolution.

In this paper, we introduce a novel projection operator-based model reference control architecture that can mitigate impending inter-agent collisions by modifying the transient dynamics of relative trajectories. This controller augments the follower's baseline controller and consists of two essential components: a collision-free reference model based on the projection operator and a model reference tracking controller to guide the follower to follow the reference-model. This paper defines the concept of transient-instability in leader-follower systems, introduces ollision mitigation controller architecture, and presents an illustrative example demonstrating its effectiveness.

Data-Assisted Distributed Stabilization of Interconnected Linear Multiagent Systems without Persistency of Excitation

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ABSTRACT: Stability of large-scale systems has been commonly achieved using centralized and decentralized control configurations. Several graph theoretic protocols have recently been developed for the distributed stabilization of partially unknown interconnected multiagent systems, when an upper bound on the unknown interconnection allocation matrices is provided to the control designer.

The need for such an upper bound can be relaxed using adaptive control ideas. However, due to the inaccurate parameter estimation in the absence of the persistency of excitation for all agents' regressors, the use of traditional adaptive control ideas will only ensure the boundedness of all trajectories. We develop a data-assisted distributed protocol which operates under a new condition, collective finite excitation, in order to overcome this challenge. Despite the completely unknown interconnection allocation matrices, we prove the exponential estimation

Reduction of Decoherence in Quantum Information Systems Using Direct Adaptive Control of Infinite Dimensional Systems

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ABSTRACT: Quantum systems are inherently infinite dimensional. In particular, quantum computers will use quantum systems as gates to store and manipulate information. But such systems suffer from decoherence which is caused by the quantum gate becoming entangled with its environment and losing information into that quantum environment. Feedback control has the promise of reducing this decoherence, but the feedback must be adaptive in the sense that it can perform its control tasks with very little information about the details of the quantum system itself. This paper is concerned with providing a framework for adaptive control of infinite dimensional quantum systems.

The quantum system is described as a linear continuous-time infinite-dimensional plant on a complex Hilbert space with persistent disturbances of known waveform, but unknown amplitude and phase caused by fluctuations in the external quantum environment. We show here that there is a stabilizing direct model reference adaptive control law with disturbance rejection and robustness properties. The plant is described by a closed, densely defined linear operator, which is the Hamiltonian of the quantum system that generates a continuous semigroup of bounded operators on the complex Hilbert space of states. There is no state or disturbance estimation used in this adaptive approach.

We show that adaptive control can produce convergence of a quantum system t a Decoherence-Free Subspace. Our research direction continues on using our developing research in adaptive control of infinite dimensional systems to explore how these feedback control ideas in conjunction with quantum gates and quantum error correction can reduce decoherence in quantum information and computing

Adaptive Control and Autonomy: Quo Vadis

Autonomy is the current watchword in vehicle systems and engineering systems in general, but adaptive control is the foundational element without which there is potential chaos. The technical future will be dominated by Human-Machine Interaction, and the stability of these interactions during complex encounters cannot currently be guaranteed or even understood.

Machines are capable of carrying out rapid dynamic simulations of a tremendous multiplicity of scenarios, but humans must use their superior recognition of patterns and make judgements of sensible outcomes justified by efficiency, expediency, and moral regard. Human emotion is a fundamental element of human cognition and decision-making. At present the understanding of human cognition and semiautonomous machine interactions as a feedback system is wide-open for exploration.