SAC Workshop: **Simple Adaptive Control and New Results in Stability Analysis**
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Description: Simple adaptive control (SAC) techniques have been conceived for large-scale systems. Before appropriate mathematical tools of analysis had been developed, SAC was considered to be just a modest version of the standard model reference adaptive control (MRAC). Further developments showed that SAC techniques can readily be applied to such applications as robots, airplanes, missiles, satellites, fine motion control, etc. Various drawbacks related to classical MRAC have been addressed and eliminated and conditions needed for robust stability have been significantly mitigated. Recent developments in nonlinear systems stability analysis tools lead to clear proofs of SAC stability in realistic environments. Realistic examples from various domains of flight control, guidance and aerospace are used to show that indeed SAC is the stable direct MRAC methodology. A non-minimum-phase and unstable UAV will be used as a detailed case-study to show the simplicity of SAC as an add-on to classical control design which improves performance. Application to real hardware will be demonstrated.
Although Lyapunov stability theory is the customary basis of any modern stability analysis, its direct application requires fitting a positive definite function to the system whose derivative ”along all trajectories of the system” is negative definite, whereas in most non-trivial problems the derivative is at most negative semi-definite. Because early extensions of Lyapunov stability theory were only covering autonomous systems, various alternatives were sought for non-autonomous systems. An alternative provided by the Barbalat Lemma imposes conditions of uniform continuity of functions and even continuity of derivatives that again could limit its applicability. Besides, even when applicable, it only ends with partial results. Although extensions of LaSalle's Invariance Principle to non-autonomous systems have been available since at least 1976, they have remained surprisingly unknown for large circles of the nonlinear control community. Moreover, even if assumed known, misinterpretations of its larger mathematical scope (that covers much more than mere asymptotic stability) may have misled users with respect to its usefulness. The review of LaSalle’s Invariance Principle along with a new extended Invariance Principle, together with a presentation of various alternatives to stability analysis, will help show the extreme efficiency of the new theorems of stability for nonlinear systems stability analysis.

Program:

- The need for adaptation
- Review of other adaptive control approaches.
- Simple adaptive control for engineers
- Optimal-control-based architectures
- The role of passivity in adaptive (or any nonlinear) control
- New stability results and their implications for SAC
- Application of the SAC algorithm