EDITORIAL

Adaptive Control, with Confidence

As far as the propositions of mathematics refer to reality they are not certain; and as far as they are certain they do not refer to reality."

Albert Einstein, 1921

This special issue is devoted to data-driven methods for adaptive control. The basic theme is to present ideas for resolving the problem of transforming measured data into a control design by "tagging" each candidate control design with a quantitative level of confidence. These experimentally derived confidence measures then drive the controller adaptation process.

Although a robust controller can be designed to accommodate a range of uncertainty, in the face of sudden or large performance degradation, this design strategy is often too conservative. In this situation adaptive control becomes a necessity in order to achieve the best performance possible.

Classical adaptive control methods can work well in some of these instances, e.g., when the plant variations are slow and the input excitation is concentrated at those frequencies which are critical. But even in this almost ideal case, initial plant-model mismatch can induce unacceptably large transients. In highly unpredictable circumstances (e.g., sensor/actuator faults, equipment failure, or damage) the adaptive system can exhibit instabilities, limit cycles, and chaotic behavior, even when initialized at a desired controller parameter setting. Many illustrative examples can be found in the literature as well as theoretical studies that expose some of the underlying mechanisms for stability and instability of these classical adaptive control approaches.

These problems are generic to the classical approach to adaptive control and certainly explain why no methodology or paradigm has been embraced wholly by the research and engineering community. And for the same reason, there do not exist any widely accepted software tools, such as those that are available for robust control and system identification.

Adding a quantifiable confidence level to adaptive control would be a first step in resolving many of these long-standing problems. But can confidence really be mathematically quantified?

The collection of papers in this issue present various attempts to at quantifying the "confidence level" of a proposed controller or proposed change to a controller. Though not certain, the confidence bounds presented are at least unfalsified by experimental evidence when said evidence is consistent with specified assumptions. The range of assumptions varies among the papers, with each striving in its own way to relax assumptions so as to ensure that observed data is allowed to have a firm and quantifiable impact.

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