CERTAINTY EQUIVALENCE IMPLIES DETECTABILITY

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Abstract

"Certainty equivalence" is a well known heuristic idea which advocates that in an adaptive context, the feedback control to an imprecisely modeled process should, at each instant of time, be designed on the basis of a current estimate of what the process model is, with the understanding that each such estimate is to be viewed as correct even though it may not be. On the surface justification for certainty equivalence seems self-evident: if process model estimates converge to the "true" process model, then a certainty equivalence based controller ought to converge to the nonadaptive controller which would have been implemented had there been no plant uncertainty. The problem with this justification is that because of noise and unmodeled dynamics, process model estimates don't typically converge to the true process model – even in those instances where certainty equivalence controls can be shown to perform in a satisfactory manner. A more plausible justification stems from the fact that any {stabilizing} certainty equivalence control causes the familiar interconnection of a controlled process and associated output estimator to be *detectable* through the estimator's output error e_p, for every frozen value of the index or parameter vector p upon which both the estimator and controller dynamics depend. Detectability is key because adaptive controller tuning/switching algorithms are invariably designed to make e_p small – and so with detectability, smallness of e_p ensures smallness of the state of the controlled process and estimator interconnection. The fact that certainty equivalence implies detectability has been known for some time – this has been shown to be so whenever the process model is linear and the controller and estimator models are also linear for every frozen value of p. In this talk we will make use of recently introduced concepts of input-to-state stability and detectability for nonlinear systems, to prove that the same implication is valid in a more general, nonlinear setting.