Quantifying the Information Value of Sensors in Highly Non-Linear Dynamic Automotive Systems

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ABSTRACT

In modern powertrains systems, sensors are critical elements for advanced control. The identification of sensing requirements for such highly nonlinear systems is technically challenging. To support the sensor selection process, this paper proposes a methodology to quantify the information gained from sensors used to control nonlinear dynamic systems using a dynamic probabilistic framework. This builds on previous work to design a Bayesian observer to deal with nonlinear systems. This was applied to a bimodal model of the SCR aftertreatment system. Despite correctly observing the bimodal distribution of the internal Ammonia-NOx Ratio (ANR) state, it could not distinguish which state is the true state. This causes issues for a control engineer who is less interested in how precise a measurement is and more interested in the location within control parameter space. Information regarding the dynamics of the systems is required to resolve the bimodality. Therefore, a hierarchical dynamic Bayesian observer is proposed to observe the heteroscedastic nature of the uncertainty in ANR. This utilises the sampling-based Markov Chain Monte Carlo methods. The dynamic Bayesian observer successfully resolved the bimodality caused by the ambiguity in the NOx sensor by using transient information. The quality of the observation depends on the operating point, as it requires the transition point to be in the window to solve the bimodality. The knowledge of the history collapses the bimodal ANR distribution into a more certain unimodal distribution. This result can then be used for appropriate closed loop ANR control.

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