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Stubborn and Dead-Zone Redesign for State Observers and Dynamic Output Feedback

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Abstract: Linear observers and regulators are usually applied to plants described by linear models. In this lecture, the possibility to employ estimators and controllers after a nonlinear redesign to increase noise reduction is discussed. For example, the transient response of the closed loop to measurement outliers can be improved by inserting a saturation. Similarly, with a dead-zone redesign one gets a reduction in the sensitivity of the closed loop to persistent disturbances, such as measurement bias or Gaussian noise affecting the output.

State observers have been recently proposed to include a saturation or a dead-zone nonlinearity with adaptive thresholds on the output injection term. Such estimators exhibit an increased sensitivity to measurement noises, while preserving the global asymptotic stability of the observer in nominal, noise-free conditions. In more details, the input-to-state stability of the estimation error of the observer with its early structure is preserved when using a saturated (stubborn) or ''dead-zonated'' output error according to an adaptive law with easily tunable parameters. This can be regarded as an effective redesign, which may be successfully applied to a wide range of state estimators such as linear observers, observers for Lipschitz systems, high-gain observers, and extended Kalman filters. An application of this paradigm to the redesign of dynamic output feedback controllers for linear systems may be addressed as well by showing that input-to-state stability holds in closed loop upon the satisfaction of linear matrix inequalities.

Observers and dynamic output feedback are well-suited to being redesigned by embedding adaptive stubborn and dead-zone nonlinearities in the estimator/controller structure. Future work includes the extension of such redesign methods to discrete-time systems and investigation of analytical proofs of the resulting improvements.

Biosketch: Angelo Alessandri received Ph.D. in Electronics and Computer Engineering from University of Genoa in 1996. From 1996 to 2005, he was a research scientist in the National Research Council of Italy. In 2005 he joined the University of Genoa, where he is currently Full Professor in the Dept of Mechanical, Energetics, Management, and Transportation Engineering. His research interests include estimation, fault diagnosis and optimal control. He was assoc. editor of IFAC Journal of Engineering Applications of Artificial Intelligence, IEEE Trans. on Neural Networks, and IEEE Trans. on Control Systems Technology. He is now the editor of the International Journal of Adaptive Control and Signal Processing and assoc. editor of the EUCA European J. of Control and of the IFAC J. Automatica

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