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Title: Fast Prescribed-Time Convergent Observer Using Modulating Functions: Application to the Coupled Tanks System

Abstract: This work presents a fast prescribed-time convergent observer based on the modulating function approach for estimating water levels in a coupled tanks system. Unlike traditional asymptotic observers [1] , which provide slow convergence, the proposed modulating function-based observer ensures finite-time error convergence [2], making it suitable for time-critical applications. The method builds on the transformation T_n introduced by Djennoune et al. [3], which cancels the influence of initial conditions through a time-output-dependent coordinate transformation. Originally developed for parameter identification [4], the modulating function technique has since been applied to parameter and source estimation and fault detection [5,6]. A revised formulation is proposed, including adjustments to the convergence constant κ, the activation condition, and the analytical expressions to improve implementation efficiency. Numerical simulations confirm the robustness and accuracy of the proposed design, achieving rapid and precise state estimation for the nonlinear coupled tanks system. (This is a joint work with Ania Adil and Fazia Bedouhene.)

References

[1] D. Luenberger, "An introduction to observers," *IEEE Transactions on Automatic Control*, vol. 16, no. 6, pp. 596–602, 1971.

[2] D. Efimov, A. Polyakov, et al., "Finite-time stability tools for control and estimation," *Foundations and Trends® in Systems and Control*, vol. 9, no. 2–3, pp. 171–364, 2021.

[3] S. Djennoune, M. Bettayeb, and U. M. Al-Saggaf, "Modulating function-based fast convergent observer and output feedback control for a class of non-linear systems," *IET Control Theory & Applications*, vol. 13, no. 16, pp. 2681–2693, 2019.

[4] H. Preisig and D. Rippin, "Theory and application of the modulating function method—i. review and theory of the method and theory of the spline-type modulating functions," *Computers & Chemical Engineering*, vol. 17, no. 1, pp. 1–16, 1993.

[5] L. Ghaffour, M. Noack, J. Reger, and T.-M. Laleg-Kirati, "Non-asymptotic state estimation of linear reaction diffusion equation using modulating functions," *IFAC-PapersOnLine*, vol. 53, no. 2, pp. 4196–4201, 2020.

[6] S. Asiri, D.-Y. Liu, and T.-M. Laleg-Kirati, "Selection of modulating functions' design parameters for estimation problems," *IEEE Control Systems Letters*, vol. 5, no. 1, pp. 277–282, 2020.