

Adaptive sliding mode control for high-order system with mismatched disturbances

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Appendix A Parameters setting

Table A1 Control parameters setting

| Items | Parameters |
|-------|-----------------------------------------------------------------------------------------|
| ASMC | $c_1 = 0.8, c_2 = 8, \gamma_1 = 10, \gamma_2 = 100, k_l = 5, k_\varepsilon = 3$ |
| MSMC | $c_1 = 1, c_2 = 1, c_3 = 1, k_l = 40, k_s = 20$ |
| DO | $l_{11} = 100, l_{12} = 3000, l_{13} = 50000, l_{21} = 500, l_{22} = 800, l_{31} = 600$ |
| sat | $\varepsilon = 0.001$ |

Where ASMC denotes adaptive sliding mode control proposed in this letter and MSMC denotes modified sliding mode control proposed in Ref. [1]. DO means disturbance observer and Sat means $\text{sat}(\bar{\sigma}_{n-1})$.

Appendix B Simulation results

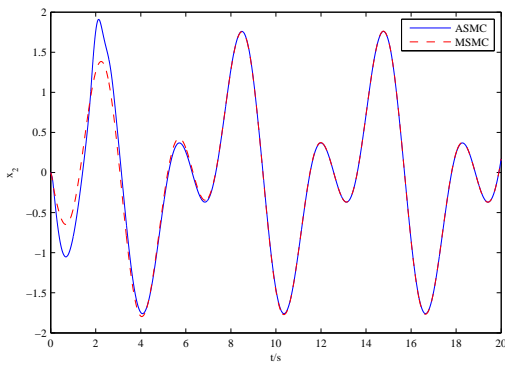


Figure B1 State x_2 .

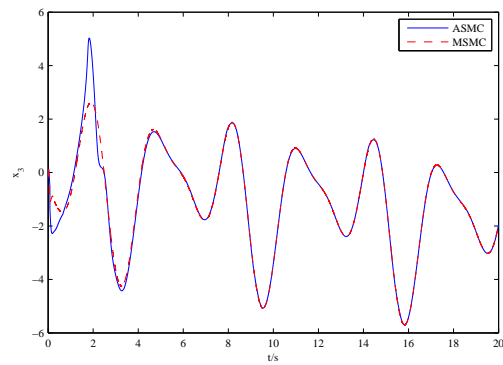


Figure B2 State x_3 .

Figure B1 and Figure B2 show the state x_2 and x_3 under the control law. Figure B3 shows the estimation errors of the disturbance observer. Legend e_1, e_2 and e_3 denote the estimation errors of d_1, d_2 and d_3 respectively. From the Figure B3, it can be obtained that the disturbance observer can estimate the disturbances accurately. Figure B4 show the sliding

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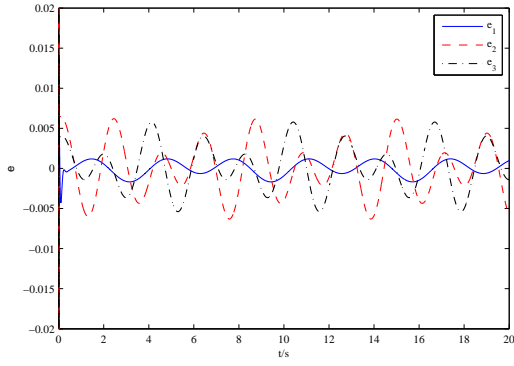


Figure B3 Estimation error of disturbance observer.

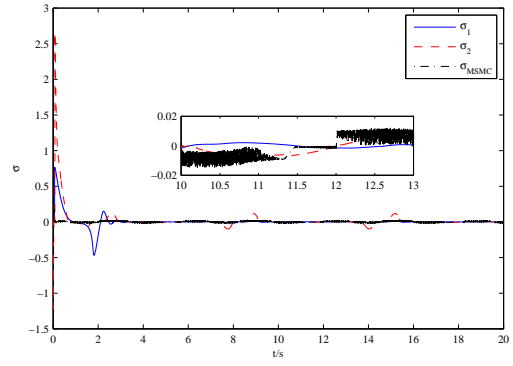


Figure B4 Sliding surface.

surface. From the results, it can be obtained that the chattering problem exists in the MSMC method, and the ASMC method can avoid the chattering problem under the same *sat* function. Where

$$sat(\bar{\sigma}_{n-1}) = \begin{cases} sgn(\bar{\sigma}_{n-1}) & \text{if } |\bar{\sigma}_{n-1}| > \varepsilon \\ \frac{\bar{\sigma}_{n-1}}{\varepsilon} & \text{if } |\bar{\sigma}_{n-1}| \leq \varepsilon \end{cases}$$

References

- 1 Ginoya D, Shendge P D, Phadke S B. Sliding mode control for mismatched uncertain systems using an extended disturbance observer. *IEEE Trans Ind Electron*, 2014, 61(4): 1983-1992