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- [6] Z. Zhu and Y. Guo, "Adaptive coordinated attitude control for spacecraft formation with saturating actuators and unknown inertia," *Journal of the Franklin Institute*, vol. 356, no. 2, pp. 1021-1037, 2019.
- [7] Q. Li, J. Yuan, and C. Sun, "Robust fault-tolerant saturated control for spacecraft proximity operations with actuator saturation and faults," *Advances in Space Research*, vol. 63, no. 5, pp. 1541-1553, 2019.
- [8] Y. Bai, et al., "Attitude tracking with an adaptive sliding mode response to reaction wheel failure," *European Journal of Control*, vol. 42, pp. 67-76, 2018.
- [9] Q. Hu, and B. Xiao, "Fault-tolerant sliding mode attitude control for flexible spacecraft under loss of actuator effectiveness," *Nonlinear Dynamics*, vol. 64, pp. 13-23, 2011.
- [10] Q. Hu and B. Xiao, "Adaptive fault tolerant control using integral sliding mode strategy with application to flexible spacecraft," *International Journal of Systems Science*, vol. 44, no. 12, pp. 2273-2286, 2013.
- [11] S. M Sadigh, A. Kashaninia, and S.M.M. Dehghan, "Fault tolerant nano-satellite attitude control by adaptive modified nonsingular fast terminal sliding mode control," *Journal of Control*, 2021.

فهرست علائم اختصاری	
$\omega$	بردار سرعت زاویه‌ای ماهواره [rad/sec]
$q_0$	بخش اسکالر چهارگان‌های وضعیت
$q$	بخش برداری چهارگان‌های وضعیت
$J_s$	ماتریس اینرسی ماهواره [ $\text{kg.m}^2$ ]
$\Omega_w$	بردار سرعت زاویه‌ای چرخ‌های عکس‌العملی [rad/sec]
$J_w$	ماتریس اینرسی چرخ‌های عکس‌العملی [ $\text{kg.m}^2$ ]
$D_w$	ماتریس توزیع عملگرهای چرخ‌عکس‌العملی
$E_w$	ماتریس عیب کاهش اثربخشی عملگرها
$u$	بردار گشتاور تولیدی توسط عملگرها [N.m.]
$d$	بردار اغتشاشات خارجی [N.m.]
$S$	بردار متغیر سطح لغزش
$V_1, V_2$	توابع لیاپانوف
$T_s$	زمان همگرایی متغیرهای وضعیت [sec]
$\theta$	بردار زوایای اویلر [rad]
$q_d$	بخش برداری چهارگان‌های وضعیت مطلوب
$\theta_d$	بردار زوایای اویلر مطلوب [rad]
$\omega_d$	بردار سرعت زاویه‌ای مطلوب ماهواره [rad/sec]

## مراجع

- [12] د. بوستان، س. ک. حسینی ثانی، ن. پریز، "کنترل تحمل‌پذیر برای ماهواره به روش معکوس دینامیک غیرخطی،" *علوم و فناوری فضایی*، دوره ۸، شماره ۲، ص ص ۱۱-۱۷، ۲۰۱۵.
- [13] م. نوایی و پ. زارعی، "کنترل وضعیت ماهواره ی کوچک دارای کمبود عملگر با استفاده از کنترل پیش‌بین مدل،" *کنفرانس انجمن هوافضای ایران*، ۱۳۹۸.
- [14] م. نوایی و پ. زارعی، "کنترل پیش‌بین غیرخطی وضعیت فضاپیما با وجود نقص دو چرخ عکس‌العملی دارای زاویه‌ی نصب،" *علوم و فناوری فضایی*، ۲۰۲۱.
- [15] H. Bolandi, M. Haghparast, and M. Abedi, "A reliable fault tolerant attitude control system based on an adaptive fault detection and diagnosis algorithm together with a backstepping fault recovery controller," *scientiairanica*, vol. 20, no. 6, pp. 1999-2014, 2013.
- [16] م. نوایی و م. حسینی، "مدل‌سازی و کنترل وضعیت یک ماهواره به کمک چرخ عکس‌العملی با روش خطی‌سازی پس‌خورد و بررسی عملکرد آن با معیارهای توان و اولرینت،" *مهندسی مکانیک مدرس*، دوره ۱۸، شماره ۱، ص ص ۵۱-۶۱، ۲۰۱۸.
- [1] Y. Miao, et al., "Adaptive fast nonsingular terminal sliding mode control for attitude tracking of flexible spacecraft with rotating appendage," *Aerospace Science and Technology*, vol. 93, pp. 105312, 2019.
- [2] S.M. Sadigh, A. Kashaninia, and S.M.M. Dehghan, "Adaptive Fault Tolerant Attitude Control of a Nano-Satellite with Three Magnetorquers and One Reaction Wheel," *Journal of Aerospace Engineering*, vol. 35, no. 1, pp. 04021113, 2022.
- [3] S. Eshghi, and R. Varatharajoo, "Nonsingular terminal sliding mode control technique for attitude tracking problem of a small satellite with combined energy and attitude control system (CEACS)," *Aerospace science and technology*, vol. 76, pp. 14-26, 2018.
- [4] S. Boulouma, S. Labiod, and H. Boubertakh, "Direct adaptive control of a flexible spacecraft with disturbances and uncertain actuator failures," *Mechanical Systems and Signal Processing*, vol. 110, pp. 73-89, 2018.
- [5] S. M. Sadigh, A. Kashaninia, and S.M.M. Dehghan, "Fault-tolerant Satellite Attitude Tracking by Modified Non-Singular Fast Terminal Sliding Mode," *2020 28th*

- [17] M.J. Sidi, *Spacecraft dynamics and control: a practical engineering approach*, Vol. 7, Cambridge university press, 1997.
- [18] Q. Hu, "Robust adaptive sliding-mode fault-tolerant control with L2-gain performance for flexible spacecraft using redundant reaction wheels," *IET control theory & applications*, vol. 4, no. 6, pp. 1055-1070, 2010.
- [19] Y. Jiang, Q. Hu, and G. Ma, "Adaptive backstepping fault-tolerant control for flexible spacecraft with unknown bounded disturbances and actuator failures," *ISA transactions*, vol. 49, no. 1, pp. 57-69, 2010.
- [20] S. Gao, et al., "Finite-time adaptive fault-tolerant control for rigid spacecraft attitude tracking," *Asian Journal of Control*, vol. 23, no. 2, pp. 103-1024, 2020.
- [21] Z. Zhu, Y. Xia, and M. Fu, "Attitude stabilization of rigid spacecraft with finite-time convergence," *International Journal of Robust and Nonlinear Control*, vol. 21, no. 6, pp. 686-702, 2011.
- [22] H. Lee and Y. Kim, "Fault-tolerant control scheme for satellite attitude control system," *IET control theory & applications*, vol. 4, no. 8, pp. 1436-1450, 2010.
- [23] X. Shao, et al., "Fault-Tolerant Prescribed Performance Attitude Tracking Control for Spacecraft Under Input Saturation," *IEEE Transactions on Control Systems Technology*, vol. 28, no. 2, 2018.
- [24] Z. Han, et al., "Spacecraft fault-tolerant control using adaptive non-singular fast terminal sliding mode," *IET Control Theory & Applications*, vol. 10, no. 16, pp. 1991-1999, 2016.
- [25] Q. Hu, X. Shao, and L. Guo, "Adaptive fault-tolerant attitude tracking control of spacecraft with prescribed performance," *IEEE/ASME Transactions on Mechatronics*, vol. 23, no. 1, pp. 331-341, 2017.
- [26] X. Wang and C.P. Tan, "Fault-tolerant spacecraft attitude control under actuator saturation and without angular velocity," *International Journal of Robust and Nonlinear Control*, vol. 29, no. 18, pp. 6483-6506, 2019.



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