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Parity Space-based Fault Diagnosability Analysis for Unmanned Aerial Vehicles

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In this paper, we present a parity space-based fault diagnosability analysis scheme for unmanned aerial vehicles (UAVs) with linear discrete time-varying (LDTV) dynamics. Robust residual generators are first designed through H_-/H_∞ optimization problems to ensure sensitivity to faults while maintaining robustness against disturbances and noise. Next, an algebraic scheme is employed for effective fault isolation. Furthermore, a comprehensive set of quantitative indices is proposed to evaluate the fault diagnosability of LDTV systems, providing effective references for assessing the performance of parity space-based diagnosis in UAVs. The proposed approach is validated through simulations of a UAV flight dynamics model. The results indicate high detectability indices, with the elevator fault at 99.52, the throttle lever fault at 72.14, the angle of attack sensor fault at 26.49, and the roll gyroscope fault at 3.06. These indices correspond to fault detection rates of 100.00, 100.00, 100.00, and 99.40%, respectively. Furthermore, the scheme achieves strong isolability for the first three faults, with indices exceeding 8.0 and fault isolation rates (FIRs) beyond 99.80%. However, in the case of a roll gyroscope fault, the isolability index of 0.76 results in a lower FIR of 8.38% than the FIRs in the other three faulty cases. These results demonstrate the accuracy and reliability of the proposed indices in evaluating fault diagnosability in UAV systems.

References

1 Y. Bu, Y. Yan, and Y. Yang: Drones **8** (2024) 1. https://doi.org/10.3390/drones8070320
2 Y. R. Shiau and W. C. Chang: Sens. Mater. **36** (2024) 2655. https://doi.org/10.18494/SAM5005
3 L. Yang S. Li, Y. Zhang, C. Zhu, and Z. Liao: IEEE Sensors J. **24** (2024) 31681. https://doi.org/10.1109/JSEN.2024.3451648
4 X. Chu, X. Zhou, Q. Bu, and Q. Miao: IEEE Trans. Instrum. Meas. **73** (2024) 1. https://doi.org/10.1109/TIM.2024.3450064
5 Y. Zhang, S. Li, L. Yang, Y. Zhu, Z. Liao, Y. Wang, C. Li, and H. Wang: IEEE Trans. Instrum. Meas. **73** (2024) 1. https://doi.org/10.1109/TIM.2024.3449957
6 M. H. Wang, F. C. Chan, and S. D. Lu: Sens. Mater. **36** (2024) 2597. https://doi.org/10.18494/SAM4834
7 D. Wu, Y. Chen, and Y. Chen: Sens. Mater. **36** (2024) 4607. https://doi.org/10.18494/SAM5063
8 S. Zhou, M. Wang, J. Jia, K. Guo, X. Yu, Y. Zhang, and L. Guo: IEEE Trans. Aerosp. Electron. Syst. **60** (2024) 4010. https://doi.org/10.1109/TAES.2024.3371967

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9 Y. Zhang, S. Li, A. Zhang, and X An: Mech. Syst. Signal Process. **215** (2024) 1. https://doi.org/10.1016/j.ymssp.2024.111418
10 X. P. Gu and X. Shi: Meas. Control **1** (2024) 1. https://doi.org/10.1177/00202940241307629
11 X. P. Gu and X. Shi: Measurement **238** (2024) 1. https://doi.org/10.1016/j.measurement.2024.115334
12 J. Lv, X. Shi: Appl. Sci. **13** (2023) 1. https://doi.org/10.3390/app131810080
13 S. X. Ding: Model-Based Fault Diagnosis Techniques: Design schemes, Algorithms, and Tools. (Springer, Berlin, Germany 2013) 2nd ed., Chap. 7.
14 D. Zhao, Y. Shi, S. X. Ding, Y. Li, and F. Fu. IEEE Trans. Autom. Control **70** (2025) 2390. https://doi.org/10.1109/TAC.2024.3476309
15 A. Zhirabok, A. Zuev, and V Filaretov: Int. J. Adapt. Control Signal Process. **38** (2024) 2520. https://doi.org/10.1002/acs.3816
16 D. Eriksson, E. Frisk, and M. Krysander: Automatica **49** (2013) 1591. https://doi.org/10.1016/j.automatica.2013.02.045
17 J. Aslund, E. Frisk, and D. Jung: Automatica **106** (2019) 143. https://doi.org/10.1016/j.automatica.2019.04.041
18 F. Fu, D. Wang, D. Zhao, and Z Wu: IEEE Trans. Syst. Man Cybern. Syst. **52** (2022) 5962. https://doi.org/10.1109/TSMC.2021.3130245
19 F. Fu, T. Xue, Z. Wu, and D. Wang: IEEE Trans. Cybern. **56** (2022) 5113. https://doi.org/10.1109/TCYB.2020.3027549
20 D. Zhao, F. Fu, D. Wang, and Y. Shi: Automatica **173** (2025) 1. https://doi.org/10.1016/j.automatica.2024.112090
21 V. Klein, and E. A. Morelli: Aircraft System Identification: Theory and Practice (AIAA, Reston, 2006) 1st ed., Chap. 3.
22 D. Guo, M. Zhong, H. Ji, Y. Liu, and R. Yang: Neurocomputing **319** (2018) 155. https://doi.org/10.1016/j.neucom.2018.08.046