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Abstract

A novel leader-following strategy based on fuzzy logic is introduced to design a formation flight controller for unmanned quadrotors. The proposed strategy uses particle swarm optimization (PSO) to optimize the fuzzy membership function in the guidance law, and a nonlinear dynamic inversion (NDI) controller is designed to control the nonlinear dynamics of the quadrotor. The simulation results show the proposed method has significant advantages in comparison with conventional leading-following strategies in terms of robustness against wind gusts, uncertainties, and unknown dynamics.

References

1. A. Abbaspour, K. K. Yen, S. Noei, and A. Sargolzaei, "Detection of Fault Data Injection Attack on UAV Using Adaptive Neural Network," Procedia Computer Science, vol. 95, pp. 193-200, 2016.
2. A. Abbaspour, P. Aboutalebi, K. K. Yen, and A. Sargolzaei, "Neural adaptive

observer-based sensor and actuator fault detection in nonlinear systems: Application in UAV," ISA transactions, vol. 67, pp. 317-329, 2017.

3. P. Forouzannezhad, A. Jafargholi, and A. Jahanbakhshi, "Multiband compact antenna for near-field and far-field RFID and wireless portable applications," IET Microwaves, Antennas & Propagation vol. 11, pp. 535 – 541, 2017.

4. S. Waharte and N. Trigoni, "Supporting search and rescue operations with UAVs," in Emerging Security Technologies (EST), 2010 International Conference on, 2010, pp. 142-147.

5. R. D'Angelo and R. Levin, "Design of an Autonomous Quad-rotor UAV for Urban Search and Rescue," A Major Qualifying Project Report. Worcester Polytechnic Institute, 2011.

6. M. D. Schmidt, "Simulation and control of a quadrotor unmanned aerial vehicle," 2011.

7. L. G. Carrillo, E. Rondon, A. Sanchez, A. Dzul, and R. Lozano, "Stabilization and trajectory tracking of a quad-rotor using vision," Journal of Intelligent & Robotic Systems, vol. 61, pp. 103-118, 2011.

8. C. C. Murray and A. G. Chu, "The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery," Transportation Research Part C: Emerging Technologies, vol. 54, pp. 86-109, 2015.

9. M. O. Milhouse, "Framework for Autonomous Delivery Drones," in Proceedings of the 4th Annual ACM Conference on Research in Information Technology, 2015, pp. 1-4.

10. P. Bouffard, "On-board Model Predictive Control of a Quadrotor Helicopter: Design, Implementation, and Experiments," DTIC Document2012.

11. D.-Y. Jeong, T. Kang, H. R. Dharmayanda, and A. Budiyono, "H-infinity attitude control system design for a small-scale autonomous helicopter with nonlinear dynamics and uncertainties," Journal of aerospace engineering, vol. 25, pp. 501-518, 2011.

12. S. Bouabdallah and R. Siegwart, "Full control of a quadrotor," in Intelligent robots and systems, 2007. IROS 2007. IEEE/RSJ international conference on, 2007, pp. 153-158.

13. P. Castillo, A. Dzul, and R. Lozano, "Real-time stabilization and tracking of a four-rotor mini rotorcraft," Control Systems Technology, IEEE Transactions on, vol. 12, pp. 510-516, 2004.

14. P. C. Garcia, R. Lozano, and A. E. Dzul, Modelling and control of mini-flying machines: Springer Science & Business Media, 2006.

15. H. Moradisizkoohi, J. Milimonfared, M. Taheri, and S. Sina, "A high step-up half-bridge DC/DC converter with a special coupled inductor for input current ripple cancelation and extended voltage doubler circuit for power conditioning of fuel cell systems," International Journal of Circuit Theory and Applications vol. 44, pp. 1290-1307, 2016.

16. M. H. Khansari, M. Yaghoobi, and A. Abaspour, "Independent Model Generalized Predictive Controller Design for Antilock Braking System," International Journal of Computer Applications vol. 114, 2015.

17. J.-J. E. Slotine and W. Li, Applied nonlinear control vol. 199: Prentice-Hall Englewood Cliffs, NJ, 1991.

18. A. Abaspour, N. Tadrisi Parsa, and M. Sadeghi, "A new feedback Linearization-NSGA-II based control design for PEM fuel cell," International Journal of Computer Applications, vol. 97, 2014.

19. A. Abbaspour, A. Khalilnejad, and Z. Chen, "Robust adaptive neural network control for PEM fuel cell," International Journal of Hydrogen Energy, vol. 41, pp. 20385-20395, 2016.

20. M. Ghanavati and A. Chakravarthy, "Demand-Side Energy Management by Use of a Design-Then-Approximate Controller for Aggregated Thermostatic Loads," IEEE

TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY, 2017.

21. M. Ghanavati, A. Chakravarthy, and P. Menon, "PDE-based analysis of automotive cyber-attacks on highways," presented at the American Control Conference (ACC), 2017.

22. I. Voos, "Nonlinear control of a quadrotor micro-UAV using feedback-linearization," in Mechatronics, 2009. ICM 2009. IEEE International Conference on, 2009, pp. 1-6.

23. A. Das, K. Subbarao, and F. Lewis, "Dynamic inversion with zero-dynamics stabilisation for quadrotor control," Control Theory & Applications, IET, vol. 3, pp. 303-314, 2009.

24. M. Bouchoucha, S. Seghour, and M. Tadjine, "Classical and second order sliding mode control solution to an attitude stabilization of a four rotors helicopter: from theory to experiment," in Mechatronics (ICM), 2011 IEEE International Conference on, 2011, pp. 162-169.

25. A. Abaspour, S. H. Sadati, and M. Sadeghi, "Nonlinear optimized adaptive trajectory control of helicopter," Control Theory and Technology, vol. 13, pp. 297-310, 2015.

26. K. Z. Meguenni, M. Tahar, M. Benhadria, and Y. Bestaoui, "Fuzzy integral sliding mode based on backstepping control synthesis for an autonomous helicopter," Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering, p. 0954410012442119, 2012.

27. C. Coza, C. Nicol, C. Macnab, and A. Ramirez-Serrano, "Adaptive fuzzy control for a quadrotor helicopter robust to wind buffeting," Journal of Intelligent & Fuzzy Systems, vol. 22, pp. 267-283, 2011.

28. A. Sargolzaei, C. D. Crane, A. Abbaspour, and S. Noei, "A Machine Learning Approach for Fault Detection in Vehicular Cyber-Physical Systems," in Machine Learning and Applications (ICMLA), 2016 15th IEEE International Conference on, 2016.

29. T. Dierks and S. Jagannathan, "Neural network control of quadrotor UAV formations," in American Control Conference, 2009. ACC'09., 2009, pp. 2990-2996.

30. A. Abdessameud and A. Tayebi, "Formation control of VTOL unmanned aerial vehicles with communication delays," Automatica, vol. 47, pp. 2383-2394, 2011.

31. B. Yu, X. Dong, Z. Shi, and Y. Zhong, "Formation control for quadrotor swarm systems: Algorithms and experiments," in Control Conference (CCC), 2013 32nd Chinese, 2013, pp. 7099-7104.

32. Y.-C. Choi and H.-S. Ahn, "Formation control of quad-rotors in three dimension based on euclidean distance dynamics matrix," in Control, Automation and Systems (ICCAS), 2011 11th International Conference on, 2011, pp. 1168-1173.

33. V. Roldao, R. Cunha, D. Cabecinhas, C. Silvestre, and P. Oliveira, "A leader-following trajectory generator with application to quadrotor formation flight," Robotics and Autonomous Systems, vol. 62, pp. 1597-1609, 2014.

34. S. Noei, A. Sargolzaei, A. Abbaspour, and K. Yen, "A Decision Support System for Improving Resiliency of Cooperative Adaptive Cruise Control Systems," Procedia Computer Science, vol. 95, pp. 489-496, 2016.

35. M. Sadeghi, A. Abaspour, and S. H. Sadati, "A Novel Integrated Guidance and Control System Design in Formation Flight," Journal of Aerospace Technology and Management, vol. 7, pp. 432-442, 2015.

36. W. Ren and R. W. Beard, "Virtual structure based spacecraft formation control with formation feedback," AIAA Paper, vol. 4963, 2002.

37. J. Kennedy, "Particle swarm optimization," in Encyclopedia of machine learning, ed: Springer, 2011, pp. 760-766.

38. L. Wang, Y. He, Z. Zhang, and C. He, "Trajectory tracking of quadrotor aerial robot using

improved dynamic inversion method," Intelligent Control and Automation, vol. 4, p. 343, 2013.

39. T. I. Fossen, "Mathematical models for control of aircraft and satellites," Department of Engineering Cybernetics Norwegian University of Science and Technology, 2011.

40. A. Abaspour, M. Sadeghi, and H. Sadati, "Using fuzzy logic in dynamic inversion flight controller with considering uncertainties," in 13th Iranian Conference on Fuzzy Systems (IFSC), 2013.

41. A. Abbaspour, M. Sanchez, A. Sargolzaei, K. Yen, and N. Sornkhampan, "Adaptive Neural Network based Fault Detection Design for Unmanned Quadrotor under Faults and Cyber Attacks," presented at the 25th International Conference on Systems Engineering, Las Vegas, USA, 2017.

42. H. Ghadiri, M. Sadeghi, A. Abbaspour, and R. Esmaelzadeh, "Optimized Fuzzy-Quaternion Attitude control of Satellite in Large maneuver," presented at the 14th International Conference on Space Operations, 2016.

43. M. R. Khalghani and M. H. Khooban, "A novel self-tuning control method based on regulated bi-objective emotional learning controller's structure with TLBO algorithm to control DVR compensator," Applied Soft Computing vol. 24, pp. 912-922, 2014.

44. A. Khalilnejad, A. Abbaspour, and A. Sarwat, "Multi-level optimization approach for directly coupled photovoltaic-electrolyser system," International Journal of Hydrogen Energy, vol. 41, pp. 11884-11894, 2016.

45. A. Khalilnejad, A. Sundararajan, A. Abbaspour, and A. Sarwat, "Optimal Operation of Combined Photovoltaic Electrolyzer Systems," Energies, vol. 9, 2016.

46. M. R. Khalghani, M. H. Khooban, E. Mahboubi-Moghaddam, N. Vafamand, and M. Goodarzi, "A self-tuning load frequency control strategy for microgrids: Human brain emotional learning," International Journal of Electrical Power & Energy Systems, vol. 75, pp. 311-319, 2016.

47. A. Abaspour, M. Sadeghi, and S. H. Sadati, "Optimal Nonlinear Trajectory Control of an Unmanned Helicopter," presented at the The 2nd ICRoM International Conference on Robotics and Mechatronics (ICRoM 2014), Tehran, Iran, 2014.

48. R. Asadi, S. H. Sadati, and A. Abaspour, "Optimized Adaptive Feedback Linearization Control of Wing Rock by Using Neural Network and NSGA_II," Journal of Aerospace Engineering & Technology, vol. 5, pp. 1-10, 2015.

49. A. Sargolzaei, K. Faez, and S. Sargolzaei, "A new method for Foetal Electrocardiogram extraction using Adaptive Nero-Fuzzy Interference System trained with PSO algorithm," presented at the Electro/Information Technology (EIT), 2011 IEEE International Conference on., 2011.

50. A. Sargolzaei, M. Jamei, K. Yen, A. I. Sarwat, and M. N. Abdelghani, "Active/reactive power control of three phase grid connected current source boost inverter using particle swarm optimization," In Progress in Systems Engineering, pp. 141-146., 2015.

51. A. Sargolzaei, K. K. Yen, and M. N. Abdelghani, "Preventing time-delay switch attack on load frequency control in distributed power systems," IEEE Transactions on Smart Grid, vol. 7, pp. 1176-1185, 2016.

52. H. Moradisizkoohi, J. Milimonfared, M. Taheri, and S. Sina, "Duty-cycle-controlled resonant dual-half-bridge converter with multifunctional capacitors for distributed generation applications," IET Power Electronics, vol. 9, pp. 1873-1884, 2016.

Index Terms

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Keywords

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