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Fixed-time robust attitude tracking control for high-speed aircraft: a precise funnel-guided approach

Key words: Funnel control; Fixed-time theory; Attitude control; RBFNN; High-speed aircraft

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Main contents

The paper focuses on developing fixed-time robust attitude control scheme with severe funnel driving constraints for high-speed aircraft developed concerning uncertain signals. The main contents include following steps:

Step 1**:** An adaptive fixed-time radial basis function neural network (AFTR) observer is designed as a compensation control based on a converted attitude error system.

Step 2**:** Propose a performance-prescribed transformation strategy that can effectively enhance the accuracy of error tracking and state convergence by constructing second-order performance error functions.

Step 3**:** Present a double-integral fixed-time sliding mode controller combined with an auxiliary oscillation-suppression function designed to achieve fixed-time convergence of attitude angles and angular rates, ensuring the rapidity of error tracking and state convergence. And the fixed-time stability of entire closed-loop system is proved.

Method

A funnel-guided performance-prescribed fixed-time robust attitude control framework with an AFTR observer for high-speed aircraft is proposed, and the control system feedback loop is shown in the figure below.

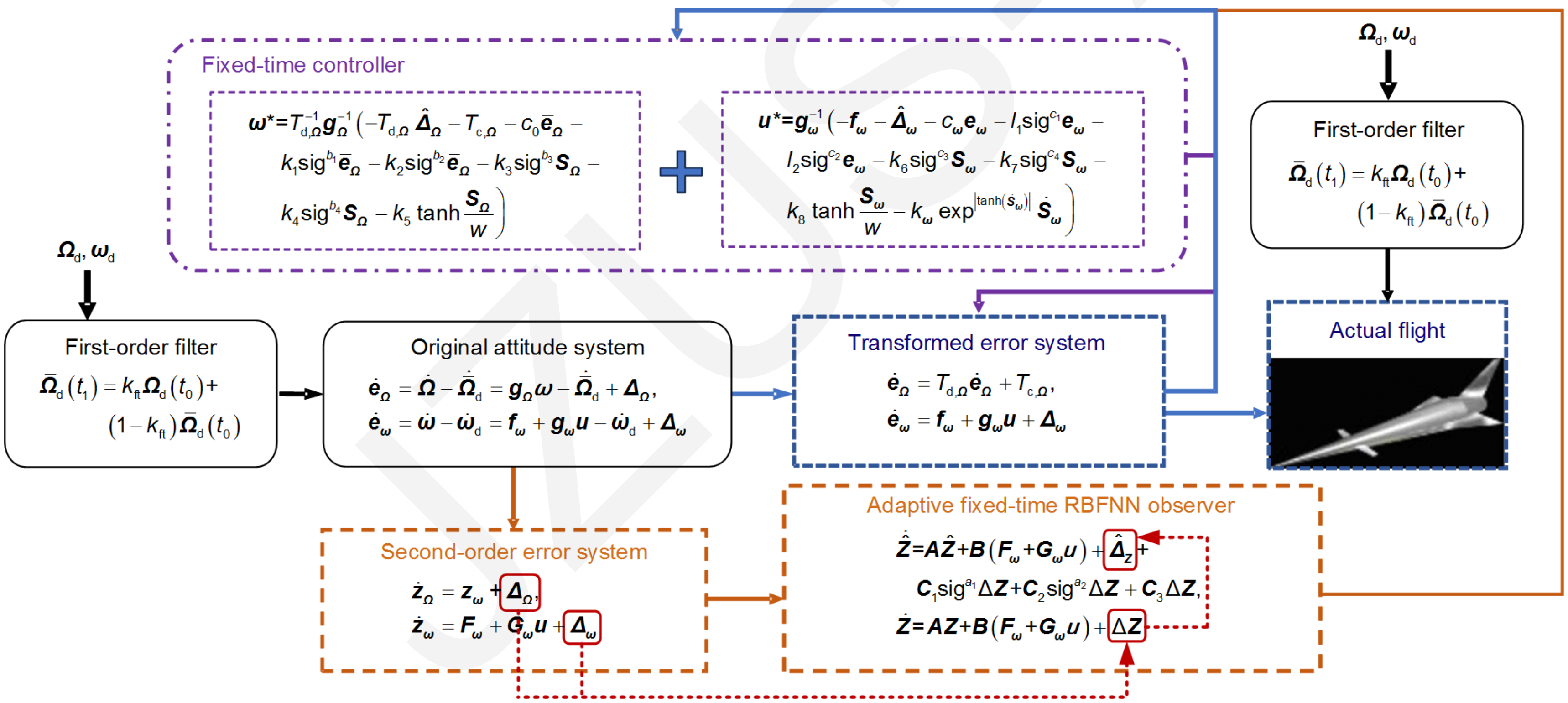


Fig. 2 Integrated fixed-time control framework.

Conclusion

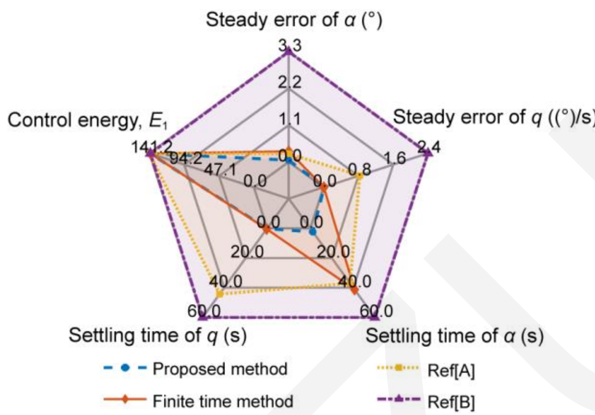
1. The resulting simulation findings suggest that the fixed-time control performance desired for high-speed aircraft can be achieved in the presence of unknown uncertainties.

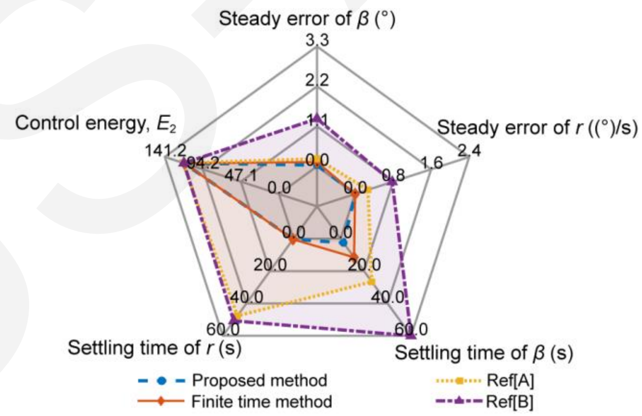
2. The proposed composite control scheme can accomplish attitude control tasks for high-speed aircraft under strong nonlinearity and complex coupling with remarkable steady-state error and a robust convergence process.

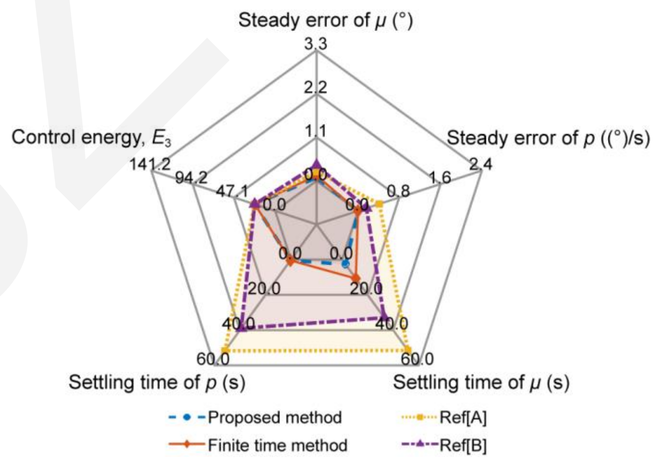
3. The empirical guidelines for parameter fine-tuning can enable the composite controller to be effectively applied to tracking control tasks in other nonlinear systems.

Conclusion

The radar charts demonstrate that the proposed method exhibits significant advantages in settling time, steady-state accuracy, and average control energy consumption.







Innovation points

1. Faced with the weakness of wide boundaries of steady-state error and uncontrollable error trajectories of existing PPC approaches, a funnel-guided PPC scheme combined with improved funnel boundaries is proposed to guarantee the control performance.

2. An effective double-integral fixed-time sliding mode manifold is proposed to achieve stable and rapid convergence of the attitude angles and angular rates with an auxiliary oscillation-suppression function.

3. To address the significant effects of uncertain signals, a fixed-time RBFNN enhancement observer with a developed adaptive weight updating law named AFTR is designed.