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Active fault-tolerant tracking control of a quadrotor with model uncertainties and actuator faults

Key words: Model reference adaptive control; Neural network; Quadrotor; Fault-tolerant control; Fault detection and diagnosis

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Motivation

1. Quadrotor has experienced unprecedented growth in the civilian and military applications. To complete various missions, an effective control system is indispensable.

2. Existing control methods are designed without consideration of actuator faults. However, actuator faults may significantly deteriorate system performance or even cause a crash.

3. Passive fault-tolerant tracking control systems (PFTTCS) have limited fault-tolerant capabilities.

4. Compared with PFTTCS, active fault-tolerant tracking control systems (AFTTCS) have better fault-tolerant performance.

Main idea

1. A reliable AFTTCS is designed to address the trajectory tracking problem for a quadrotor with model uncertainties and actuator faults.

2. Model reference adaptive control (MRAC), radial basis function neural network (RBFNN), and fault detection and diagnosis (FDD) scheme are integrated in a stable and natural manner.

3. Actuator dynamics need to be considered in the controller design.

Method

1. The MRAC method is adopted to guarantee the global asymptotic stability of a quadrotor system.

2. A RBFNN algorithm is used to adaptively identify the model uncertainties online and modify the reference model.

3. A FDD scheme is constructed to diagnose actuator faults, and a fault compensation term is added to the control law to compensate for the adverse effects of actuator faults.

Major results

1. The tracking performance of the proposed AFTTCS is superior to that of the normal controller in the presence of model uncertainties.

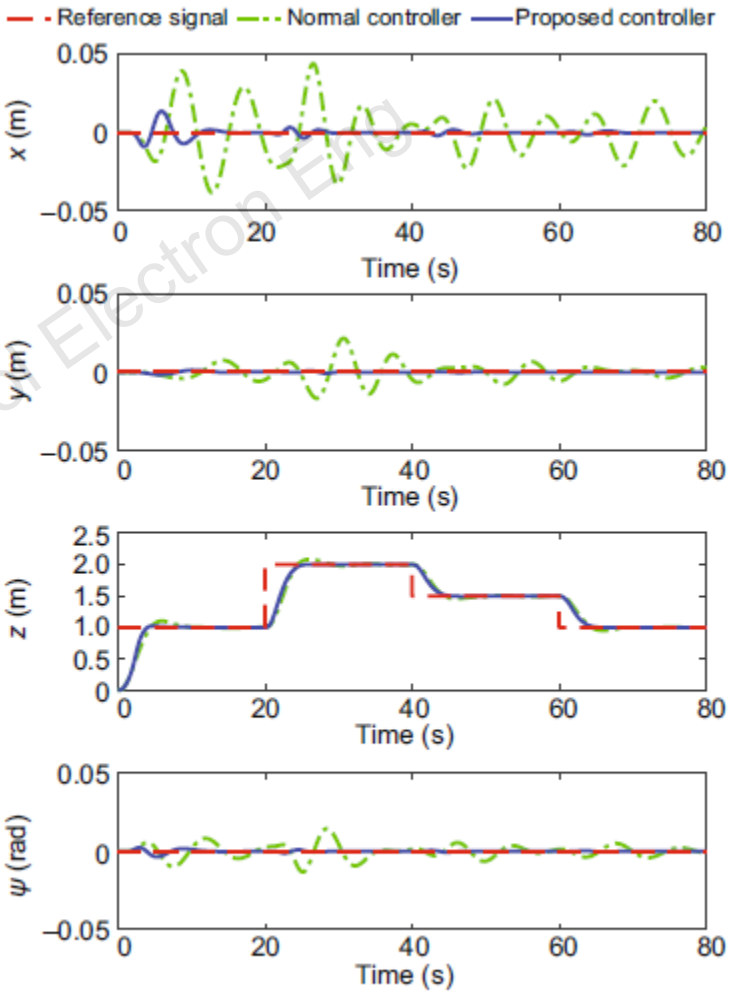

Fig. 2 Tracking performance of the different controllers in scenario 1

Major results

2. The proposed controller provides a more satisfactory tracking performance than the normal controller after the occurrence of actuator faults.

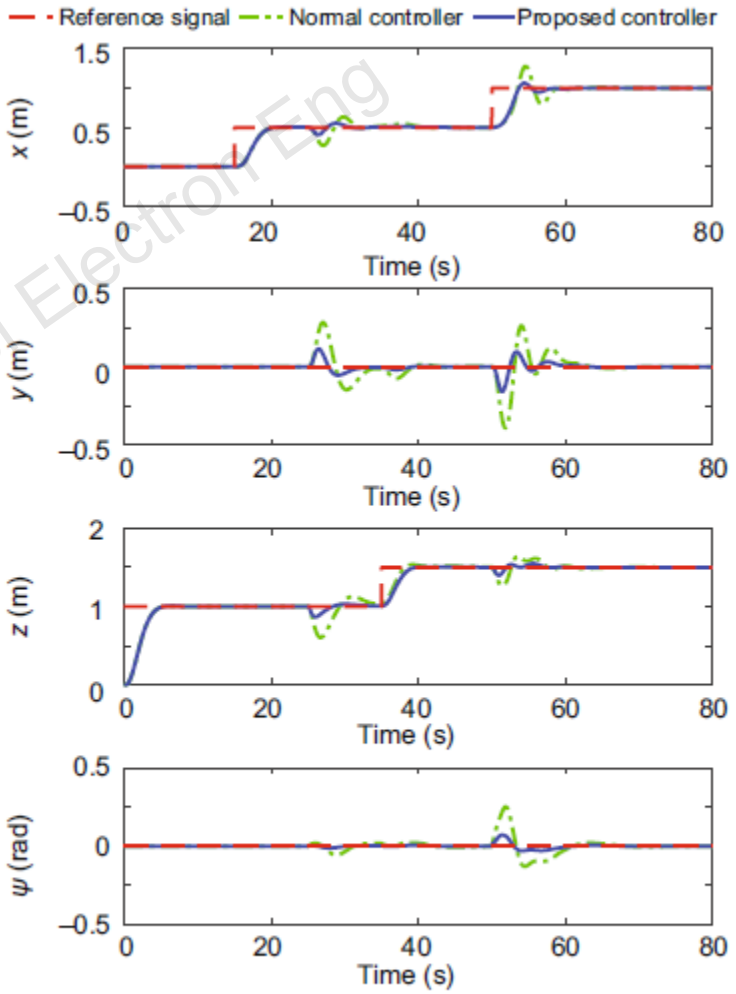

Fig. 4 Tracking performance of the different controllers in scenario 2

Major results

3. The tracking performance of the proposed AFTTCS under the simultaneous influence of model uncertainties and actuator faults is still satisfactory.

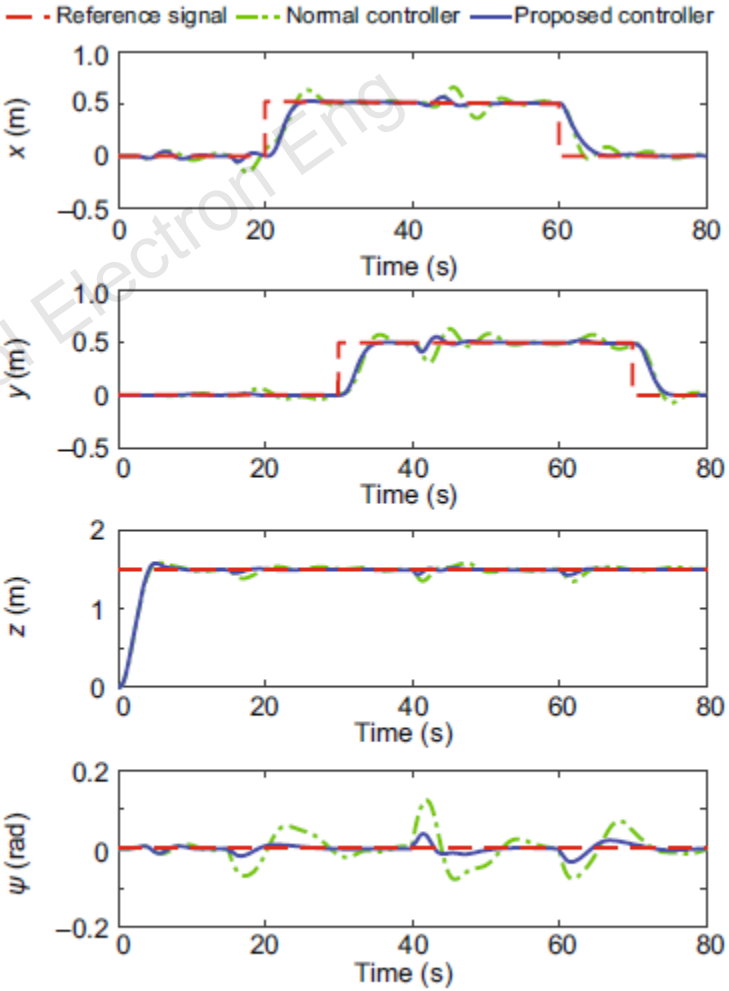

Fig. 7 Tracking performance of the different controllers in scenario 3

Conclusions

1. A high-performance AFTTCS was designed for a quadrotor with model uncertainties and actuator faults.

2. Fundamentally, AFTTCS used the MRAC scheme.

3. A RBFNN method was employed to approximate the unknown model uncertainties to modify the mismatched reference model.

4. A fault-compensating mechanism was incorporated into AFTTCS and effectively counteracted the adverse effects of the actuator faults.