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UNCERTAINTY ESTIMATION BASED GAME CONTROL FOR ATTITUDE REGULATION DURING ON-ORBIT ASSEMBLY

Abstract

On-orbit assembly is one of the key technologies for large space missions such as space solar power system and large space telescopes. Because of the dangerous environments, it is expected that this work will be done by teams of space robots. In this paper, the problem that designs a control scheme for multiple assembly robots to stabilize attitude of main structure during on-orbit assembly is addressed. One of the major challenges in the assembly process would be the external disturbance and uncertainty caused by the moving assembly robots or the new adding substructures. An uncertainty estimation based game control method is designed to stabilize the attitude of the combination which consists of assembly robots and the main structure, which includes an identification and an observer-based differential game controller. Once there is new substructure constructed to the main structure, the identification of nominal inertia matrix and transfer matrix is triggered to avoid control failure which results from large model deviation. By dividing the whole mission into multiple procedures, the influence of the abrupt change of system parameter can be avoided by identifying the parameters, and the dynamics uncertainty is up-bounded in each procedure. Then, based on the identified nominal model, the observer-based differential game controller is designed including equivalent control part and compensation control part. In order to realize the cooperation between robots, a differential game control is developed to get the equivalent control for each robot by optimizing individual performance index functions of each robot. By introducing the state-dependent coefficient matrix in the nonlinear model, the pseudo-linear differential game can easily get the Nash equilibrium strategies. Moreover, a nonlinear disturbance observer is used to reconstruct the uncertain dynamics, based on which the compensation control is designed to improve the robustness of the controller. Stability and optimality of the controller are proved. Furthermore, numerical simulations verify the effectiveness of the uncertainty estimation based game control method for attitude regulation of the space structure during assembly.