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OPTIMAL CONTROL FOR SHAPE AND VIBRATION OF SPACE INTELLIGENT TRUSS STRUCTURE WITH PIEZOELECTRIC ACTUATORS

Abstract

The large space structure during in-orbit assembly could result in structure deformation due to some space environment factors, such as inhomogeneous thermal radiation, and the vibration will come out along with the shape correction. The deformed shape and vibration may affect the in-orbit assembly process of the structure, and even lead to assembly failure. Therefore, it is imperative to study the active shape and vibration control of space structure.

In this paper, the modeling and shape control problem of space intelligent truss structure with piezoelectric actuators is studied. First of all, the basic unit of intelligent truss structure is divided into piezoelectric bar element and normal bar element, and their dynamic model is developed respectively. The dynamic function of the piezoelectric bar element is derived according to piezoelectric constitutive equations and Hamilton's principle. The dynamic model of the whole structure can be then established by the finite element modeling technique. Furthermore, the dynamic model of the structure is reduced using the modal truncation method, and the reduced order model is transformed into the state space form. The target values for the piezoelectric actuators to correct the deformation of the structure are estimated according to the dynamic model. However, the space intelligent truss structure is inherently flexible, and the vibration exists in the process of structure shape correction obviously. According to the minimum principle, the optimal controller on the voltage input profile of piezoelectric actuators is designed by minimizing vibration amplitude during the process of the structure shape control. Then the optimal control problem is solved utilizing the nonlinear programming method. Simulation results are finally provided to illustrate the performance of the proposed model and controller. The results will demonstrate that the structure vibration is better suppressed using optimal voltage profile rather than other voltage profiles such as sine profile, exponential profile, and etc. Using optimal control techniques appears to provide a promising solution to correct the deformed shape of the structure, as well as minimum residual vibration for space intelligent truss structure.