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CONTROLLER DESIGN FOR LAUNCH VEHICLES BY INTEGRATING ADAPTIVE CONTROL WITH ROBUST CONTROL BASED ON MODEL PREDICTIVE CONTROL

Abstract

Model predictive control (MPC) is applied to launch vehicle attitude control in this research. Generally, one of the most important things for automatic control is the accuracy of modeling. The same is true for attitude control of launch vehicles. However, rocket parameters such as the mass and the stiffness have uncertainties. This is because these parameters cannot be measured directly with a flight vehicle, and they are estimated. Furthermore, regarding launch vehicles, parameters like the mass change because a launch vehicle flies while consuming fuels. Massive changes of rocket parameters with time also should be considered. Therefore, control systems have to respond to both the uncertainties and the time-varying characteristics. The current method is a combination of robust control and gain-scheduling control. The robust control, such as H∞ control and μ control, can respond to uncertainty. However, this method is not suitable for massive changes of systems because robust stability is in a trade-off relationship with response performance. In short, response performance would be bad if the massive change of the system was treated as uncertainty. Hence, the gain-scheduling control is applied. In this approach, the entire flight time is divided into multiple blocks, and controllers are designed under the assumption parameters are nearly constant in each block. In short, one robust controller has to be designed for every block in the current method. Therefore, the current approach requires significant time and labor, and this should be simplified. To simplify the procedure, the goal of this research is to design a robust controller which can directly respond to the time-varying characteristics. In the first step, two controllers are designed. One is the adaptive MPC controller designed for the time-varying characteristics. This controller can calculate the better-manipulated variable than a non-adaptive MPC controller using the nominal time-series data of the controlled system. Moreover, the other controller is the robust MPC (RMPC) controller designed for uncertainty. Manipulated variables are calculated under a robust algorithm. In the second step, the two controllers are combined to respond to both the time-varying characteristics and the uncertainty. In RMPC, robust stability is guaranteed by Lyapunov theory under the assumption a controlled system changes within one constrained range. For combining this robust control with adaptive control, an integrated robust algorithm is proposed. When this study is completed, the controller design procedure will be simplified greatly. This leads to improving the performance and the frequency of rocket launches.