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# NOVEL ATTITUDE CONTROL DESIGN OF SPACE LAUNCH VEHICLE

**Abstract**

In this paper, the model predictive control (MPC) is applied to the launch vehicle attitude control in order to deal with two major issues of the research field: the uncertain and time-varying character of the dynamics. Until quite recently, a combination of the H-infinity control and the gain scheduling approach have been applied to the real launch vehicles. The H-infinity control can make the system robust against uncertainties of the system parameters. On the other hand, the gain scheduling approach requires a controller designed for each time block into which the entire flight time is divided. To increase launch frequencies of rockets, this old-fashioned design procedure must be improved. The goal of the study is to design a robust control algorithm that can directly deal with the time-varying character of the launch vehicle control. The study is conducted for the first stage of a launch vehicle as it provides the highest level of challenge: uncertainty of the dynamics under rapidly changing wind disturbance, which means not only robustness but response time characteristics is important for safe flight. The rigid body attitude motion and the elastic vibration are taken into account as the fundamental dynamics of the control model. Both are highly coupled and the elastic vibration greatly affects the stability of the attitude motion. The control can be executed by the nozzle deflection angle based on the measurements of the attitude angle and its rate of the vehicle. The study is conducted by a step-by-step approach. As the first step, a robust controller is designed at a fixed time as the dynamic model is taken to be uncertain but time invariant. The controller's form is shaped by H-infinity control design approach. The second step is aimed at tackling with the time-variant character of the system by applying the MPC method. The MPC is expected to have better control performance to track time-varying dynamic characteristics of the controlled plant because it predicts real-time the dynamic state of the system as optimizing a specified cost function. The effectiveness of the MPC is evaluated by comparing the tracking response of the MPC applied to a time-variant dynamic model with one of the H-infinity robust control. It is shown that the MPC can better deal with time-varying system and that it will be the next and the final step of the study to make the MPC robust against the system uncertainties.