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Author: Dr. Sung-Woo Kim
Hanwha Thales, Korea, Republic of, sungwooquim@gmail.com

SPACECRAFT ATTITUDE CONTROL USING PD CONTROLLER WITH GAIN TUNNING BY NEURO-FUZZY SYSTEM.

Abstract

In this paper, an adaptive PD controller is developed for spacecraft attitude control. The controller uses a neuro-fuzzy system to generate optimal PD gain. The neuro-fuzzy system is designed as a neural network based on Takagi-Sugeno fuzzy model. Each set of training data for the neuro-fuzzy system consists of two inputs and one output. Inputs are change of state error(angle and angular velocity), and output is corresponding PD gain. To generate training data, a number of attitude control simulations are performed extensively using PD controller with gains randomly generated in a specific range. For each simulation, a set of training data which minimizes predefined cost function is selected. Two types of cost functions are suggested. One is the same with the one used in Linear Quadratic Regulator(LQR) except there is no integration. The other is designed uniquely in this paper to optimize the state error profile with respect to state overshoot, converging speed, and steady-state stability. The adaptive PD controller developed in this paper has been tested using simulations. The spacecraft model used in the simulation is COSMOS satellite which is being developed by Hanwha Systems and planned to be launched in 2023. The simulation results are compared with the results using different controllers such as state-dependent Riccati equation(SDRE) controller and LQR controller. The adaptive controller based on LQR-like cost function shows comparable performance with SDRE controller in the presence of sudden disturbance torque for which the LQR diverged. More importantly, the adaptive controller based on the cost function uniquely presented in this paper outperforms the SDRE controller in terms of minimizing control torque and stabilization time. The approach presented in this paper is in principle an adaptive optimal gain tunning using supervised learning technique. This can be done using reinforcement learning instead of supervised learning without generating vast training data sets, because reinforcement learning agents learn by itself interacting with environments. Applying reinforcement learning to attitude control is planned as a future work.