MECHATRONICS BOOK SERIES

CONTROL AND INTELLIGENT SYSTEMS

Momoh Jimoh E. Salami
Abiodun Musa Aibinu
Yasir Mohd Mustafah

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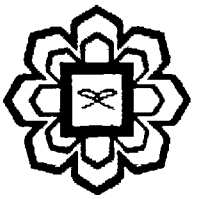

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Chapter 12
Adaptive Sliding Mode Control for 3dof Helicopter

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12.1 Introduction

Unmanned Arial vehicle (UAV) has a big role in human being life. It provides an intelligence, surveillance and reconnaissance. Due to its nonlinearity and underactuated properties, it demands for a sophisticated controller in order to stabilize such system. The three degrees of a freedom helicopter (3DOF) has the same characteristics to the UAV with fewer degrees of freedoms. Hence, the 3DOF helicopter is often considered as a valid benchmark in designing the controller for the UAV. Sliding mode control (SMC) is one of the robust control approaches that is used to control linear and nonlinear systems. SMC is a control algorithm that can deal with matched uncertainty when the disturbances and the uncertainties penetrate the system through the input signal channel. Since this approach was introduced, it became an attractive method for many researchers.

In model-following, the plant behaves like an ideal model; reference [4] uses a model-following Variable Structure Control System (VSCS) whereby the controller signal would be insensitive for changing parameters, with a good attenuation disturbance. That is by defining the sliding surface as an error between the model state and plant state. In reference [5], a variable structure control is combined with fuzzy logic control. The rules of fuzzy sets are designed by the sliding mode control, thereby increasing the robustness in fuzzy control due to the robustness feature, which is inherent in the sliding mode control. The simulation and experimental results show the effectiveness of the method compared to PID and neural network based fuzzy logic control. Reference [6] proposed the terminal sliding mode control for multi-input, multi-output linear system. The terminal sliding surface is the nonlinear term of the system state, because of the special feature of the terminal sliding surface which enforces the states to converge to equilibrium states in finite time, the dynamics of the sliding mode control system is substantially improved.

Variable structure control with non-sliding surface was proposed in [3] to overcome the problem of the chattering phenomena, which accompany the high frequency of the sliding surface. The high frequency excitation is prevented by utilizing smoothing functions at the discontinuities. The perturbation estimation procedure is used to compensate for the destabilizing effects of the perturbations. The upper bound of the estimation errors are taken as the robustizing parameters. The routine is presented therefore, called robust Lyapunov control with perturbation estimation (RLCPE).

In this chapter, an adaptive sliding mode control is proposed for the 3DOF helicopter. The underactuated property for the 3DOF is dealt with by introducing a slack variable, and the control input signal is augmented in order to match the dimensions of the output. The Lyapunov function is used to generate the update law to estimate the slack variable. The