Robustness Bounds of the Vertical Take-Off and Landing Aircraft System with Structured Uncertainties

Jang Hyen Jo*

* Department of Mechanical Engineering, Halla University, Heungup-Ri San 66, Wonju, 220-712 Korea
(Tel : 82-33-760-1216; Fax : 82-33-760-1211; E-mail: jhjo@hit.halla.ac.kr)

Abstract

The purpose of this paper is the application of the techniques for the new estimation of robustness for the aircraft systems having structured uncertainties. The basic ideas to analyze the system which is the originally nonlinear is Lyapunov direct theorems.
The nonlinear systems have various forms of terms inside the system equations and this investigation is confined in the form of · bounded uncertainties. The number of uncertainties will be the degree of freedoms in the calculation of the robust stability regions called the robustness bounds. This proposition adopts the theoretical analysis of the Lyapunov direct methods, that is, the sign properties of the Lyapunov function derivative integrated along finite intervals of time, in place of the original method of the sign properties of the time derivative of the Lyapunov function itself. This is the new sufficient criteria to relax the stability condition and is used to generate techniques for the robust design of control systems with structured perturbations. Using this relaxing stability conditions, in this paper, the quadratic form of Lyapunov function is utilized. In this paper, the practical system of vertical take-off and landing (VTOL) aircraft is analyzed with the proposed stability criteria based upon the Lyapunov direct method. The application of numerical procedures can prove the improvements in estimations of robustness with structured uncertainties. The applicable aircraft system is assumed to be linear with time-varying with nonlinear bounded perturbations.

1. Introduction

The Lyapunov direct method has been widely used in the various fields of applications for control system analysis and design, especially for the determination of the stability region and robust control of design problems. This is the most general method for the estimation of the stability of nonlinear and time-varying systems. The control of dynamic systems which contain uncertain elements and are subject to uncertain inputs is often treated by the application of stochastic control theory. The construction of measured(or estimated) state feedback controls that provide guarantee that system responses enter and remain within a particular neighborhood of the zero state after a finite interval of time was considered by Leitemann[23], as well as controller design for uncertain systems [25]. According to Patel and Toda [10], the bounds of perturbation can be computed numerically, providing a useful quantitative measure of robustness for asymptotically stable systems. The Lyapunov method to testing for the stability of state-space models was studied by Yeadavalli and Liang [15] and the principal topic was the reduction of the conservatism of the stability robustness bounds. The principal theme of their approach was the reduction of the conservatism of the stability robustness bounds. Recently, the widespread interest in the robust design of control system subject to structured perturbations has served to shift research activity toward parameter space methods, and enlargement of the scope of the approach to include the Lyapunov method as well as frequency domain concepts [17,8,50]. In many applications such as the control of VTOL aircraft, it is desired to maneuver it to nonzero set points in spite of the changes in the dynamics of the aircraft over varying flight conditions. The adaptive controller of [2,3], requires on-board computers which are not presently available in many VTOL aircraft. Sensitivity reduction methods for parameter perturbations have been used to obtain controllers in [11,12]. And S. N. Singh and Antonio A. R. Coelho [13] derived the nonlinear control which guarantees that every system response is ultimately bounded within a certain neighborhood of the desired nonzero set point and these results are applied to control of a VTOL aircraft system whose time-varying parameters are uncertain. In this paper, a new approach to the determination of robustness bounds which is already introduced in [1] accompanied by consideration of improved stability criteria for relaxing Lyapunov stability concepts is applied for the flight control system design of a VTOL(Vertical Take-Off And Landing) aircraft.

2. Theoretical Backgrounds

The objective of the current investigation is to improve the robustness estimates of dynamic systems with structured uncertainties, using Lyapunov stability conditions to weaken the stability conditions formulated in conventional Lyapunov theorems. The main concept