Towards Neural Adaptive Hovering Control of Helicopters---**V3** ****

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Abstract: This paper presents the results of a preliminary study on the use of neural adaptive control techniques which have the potential for implementation in hover control in a helicopter.

For this hover study a 'laboratory-scale helicopter simulator' was employed. This constrained the system to one degree of freedom. The neural adaptive controller is designed by combining the dynamic response from a desirable reference model with a radial basis function (RBF) neural network. The performance of the control system is compared with classical approaches of PI controllers. The proposed neural controller system is shown to be an improvement over classical PI controllers.

1. Introduction

For helicopters it is well known that hovering poses some of the most difficult problems for flight control due to the inherent nonlinearity, dynamical instability and the unsteady operating conditions. Recently, a great deal of research on helicopter dynamic stability and control issues have been reported (including Su and Cao 2001, Guo and Xu, 2000, Mclean and Matsuda 1998, KrishnaKumar and Heidhoefer 1997, and Faller and Schreck 1996). In Particular, neural networks have been applied in helicopter dynamic identification and control (Mclean and Matsuda 1998, Faller and Schreck 1996, Elshafei, Akhtar and Ahmed 2000, Park and Lee 1999, and KrishnaKumar and Sawhney and Wai 1994). As a body of currently emerging techniques, neural networks have been widely used to deal with nonlinearity and uncertainties in control engineering area both in theory and applications. The comprehensive surveys on general neural control may be found from the publications of Hunt, Sbarbaro, Zbikowski and Gawthrop (1992), Narendra (1996).

In the research work of McLean and Matsuda (1998), a neural network was trained off-line in advance and used as a controller for the helicopter hovering control. KrishnaKumar and Heidhoefer (1997) presented simulation results of the immunised neural control for helicopters by combining neural network with a genetic algorithm. A simple neural network based PID controller was proposed in Park and Lee (1999), whose effectiveness, however, is only illustrated by theoretical computer simulation rather than a real plant control. The long term aim in this work is to develop a simple, stable, yet effective neural adaptive control strategy to be applied to the problem of hover control in real helicopters. To this end, at this preliminary research stage, a laboratory-scale helicopter simulator, referred to as the 'hover-beam', has been employed. This simple 1 DOF system is used as the plant to be controlled by the neural adaptive controller in the hover tests.The hover beam is one meter long with an electric motor driving a propeller at one end and a counter balance at the other. The beam angle can be established by reading a potentiometer fixed to the pivot shaft.

The design of a controller for a real helicopter is clearly very difficult. We argue therefore that it is realistic to start our programme of study with a restricted DOF system with the intention of releasing constraints as the study progresses. We believe that such an approach, starting with a simple hover-beam, can provide valuable insight into the control of a real-world helicopter operating under various flight conditions. One of the main difficulties in designing a controller for such a nonlinear dynamic system is the lack of a general structure for it. Fortunately, if we regard this control system design problem as an approximate model matching problem, then Hammer (2000) provided necessary and sufficient conditions for the existence of a controller. The model matching problem states that for a controlled plant Σ, a desirable model M and an input signal v, find a controller C so that the closed-loop control system is closed to the response of the model for all input sequences v. Furthermore, it has been shown in Hammer (2000) that whenever the approximate model matching problem for a plant Σ and a desirable model M is solvable, it can be solved by using a controller with the following form