Control of Nonlinear MIMO System using Novel Soft Computing Technique-Review

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Abstract— *Recent development in non-linear system theory combined with advances in control system hardware and software make the practical application of nonlinear process control strategy. These review article survey control of nonlinear system techniques of process. Specific strategies to control approaches based on nonlinear programing. The capabilities of all techniques to handle the common problem associated with nonlinear system such as model uncertainty, cross coupling effect, time delay, nonlinearity constraints are detail discussed. Although the recent progress in control of nonlinear system is encouraging a significant number of goals for future research in nonlinear control of twin rotor MIMO system.*

Keywords— Twin rotor MIMO system, PID controller, GA, PSO, RGA, LQR, Fuzzy logic controller, Neural network

I. INTRODUCTION

The behavior of Twin rotor MIMO system is same as helicopter in some manner. Hence it is interesting for control of nonlinear problem. Twin rotor MIMO system is highly complex and nonlinear problem with two or three degree of freedom. The control objective of any researcher is to make the beam of TRMS move quickly and accurately to the desired position and attitudes in terms of yaw angle and pitch angle under the decoupling effect of two axes for 2 degree of freedom. In this system, pivot point allows the TRMS to move in vertical and horizontal planes.

TRMS comprises of main rotor and tail rotor. Here, Main rotor is for lift up the load in vertical plane and Tail rotor can handle the system in horizontal plane. The angle of movement in horizontal and vertical plane can be measured by optical encoders and error from desired position can be measured. It will become the input of our controller. If we are controlling the TRMS for two DOF, we need two Controllers that will generate two outputs for each rotor. Each rotor has one propeller which generates a force directly proportional to the output of DC motor. The aim of this literature review is to make the system stable and obtain the better performance. The design of TRMS control system is difficult due to the system uncertainty. For designing the controller, we must know about mathematical model of a controlled system. In general the TRMS could be controlled by different control approach based on soft computing.

II. DIFFERENT METHODOLOGIES

Badar Ul Islam, Nisar Ahmed, Daud Latif Bhatli and Shahid Khan had discussed about fuzzy logic controller for TRMS. They designed a controller for 2 DOF in such a way that change in one degree should have minimum effect on other and system remains stable. They designed a two controller using Sugeno inference. The simulation result indicates that system performance using fuzzy logic is give better performance rather than conventional PID or LQR controller. [1]

Jih-Gau luang, Wen-Kai Liu, Cheng-Yu Tsai discussed about hybrid intelligent controller to stabilize the position of TRMS. The main objective of this intelligent control scheme is to obtain desired attitudes and pitch angle and azimuth angle under cross coupled condition. Here fuzzy compensator is applied to PID controller, then applied to real type Genetic Algorithm (RGA) with system performance index to optimize the parameter of the controller, reduce error, and control energy. The system performance index uses an integral time square error (ITSE) to build a proper fitness function. The simulation result shows that this new approach can improve the positioning, tracking performances, and reduce the energy [2].

Jih-Gau luang, Wen-Kai Liu, Ren-Wei Lin are says same as [2]. But they represent a new control schemes with the hybrid fuzzy PID controller. For real time control, they have been used a Xilinx Spartan II SP200 FPGA (Field programmable gate array) to construct a hardware in the loop system through writing VHDL (Verilog hardware description language) on this FPGA. Here position signal and command signal are converted into analog voltage to change propeller speed. But inharmonious frequency in FPGA will cause oscillations. They are investigating about the same [3].

A.Rahideh, M.H.Shaheed are also said that hybrid fuzzy PID can give satisfactory performance in terms of tracking in both planes horizontal and vertical. They also show the comparison with single PID controller by using square and sine as reference input. It is found that hybrid PID controller is better especially in steady state compared to PID controller. PID has reasonable performance in response to sine input but in response to square input is not satisfactory [4].

Akbar Rahideh, M. Hasan Shaheed, and Abdulrahman H. Bajodah was presented TRMS control by using neural network and genetic algorithm. They are considering one DOF mathematical model of TRMS in their study and they also developed a nonlinear inverse model for pitch control. If inversion errors are not present then GA tuned PD controller is used for tracking characteristics. If inversion errors are present then adaptive neural network element is used in feedback of the system to compensate the errors. Here sine and square reference input is used to test the performance of system. Simulation result shows that he model based controller performance can give satisfactory response in terms of tracking trajectory of pitch angle [5], [6].

Jih-Gau Juang, Ming-Te Huang and Wen-Kai Liu discussed about the PID control using real value type Genetic algorithm(RGA) and nonlinear control design(NCD) for TRMS provides less error in set point and trajectory tracking for sine and square wave inputs. The main control objective is to stabilize the TRMS under cross-coupling effect. In these method four controllers with individual input is used and all parameters of controller are obtained by real value type genetic algorithm (RGA) with performance index as fitness function to reduce the total error and control energy. The initial search range of RGA was obtained by a nonlinear control design (NCD) technique. The NCD provided a narrow initial search range for RGA. This control scheme can protect the system from nonlinearities and cross coupling [7].

Thair Sh. Mahmoud, Mohammed H. Marhaban, Tang S. Hong are investigate by using Adaptive Neuro Fuzzy Inference System (ANFIS) and Fuzzy Subtractive Clustering (FSC) methods to solve the problem of nonlinearities, cross coupling and trajectory of TRMS. They used a four FLCs with high consumers of memory and processing time. FSC method is used to extract new controller models based on input-output training data of FLC. This extraction is based on range of influence (ROI). The results shows that this method gives better response than FLC in terms of transient response characteristics [8].

Bidyadhar Subudhi, Senior and Debashisha Jena had investigated about identification of twin rotor MIMO system using neural network for modelling. Training for neural network is provided by genetic algorithm and applied to nonlinear system identification. In this identification scheme, they exploited three global search methods namely genetic algorithm (GA), particle swarm optimization (PSO) and differential evolution (DE) which had been hybridized with gradient descent method to overcome the slow convergence of evolving neural network. Result show that differential evolution back propagation (DEBP) genetic algorithm applied to neural network learning exhibits better result in terms of convergence and lowest mean square error (MSE) rather than GA, GABP, PSO, PSOBP, DE, DEBP [9].

C.W. Taoa, J.S. Taurb, Y.C. Chen was simplifies a fuzzy Takagi-Sugeno model of TRMS with complex nonlinear functions into propositional combination of linear functions. Based on that they applied a parallel distributed fuzzy LQR (PFLQR) controller to control the position of pitch and yaw angle in TRMS. The simulation result shows that effectiveness and robustness of the PFLQR [10].

Ferdose Ahammad Shaik, Shubhi Purwar , Bhanu Pratap said that observer design for TRMS is difficult but highly desirable to solve the problem of unknown nonlinearities and it can be estimated by Chebyshev neural network (CNN) whose weight are adaptively adjusted. Lyapunov theory is used to guarantee stability for state estimation and neural network errors. They shows the comparison of local state observer and adaptive observer by experiment results. Adaptive observer can substantially improve the performance for nonlinear system [11].

Mohamed T.L.T, K.M. Asraf K.Ishak, Hanif Ramli, M.S. Meon had represented active force control (AFC) based scheme combined with neural network and fuzzy logic. Only PID controller cannot eliminate the external and internal disturbances. So they investigated this new approach. The simulation result shows that the proposed approach can give reasonably good performance and it is capable to compensate the external-internal disturbances. AFC strategy has shown great reliability in manipulating the uncertainty characteristics of pitch and yaw responses and maintain it [12].

AP.S. Ramalakshmil, P.S. Manoharan had given a modelling of TRMS for two DOF and control of TRMS. They implement a simple PID control and cross coupled PID control in terms of error in plant output and control output for different reference inputs [13].

Mohd Suhairil Meon, Tengku Luqman Tengku Mohamed, Mohd Hanif Mohd Ramli, Muhammad Zulkifli Mohamed and Nor Fazli Adull Manan given a PID Active force controller (PIDAFC) for controlling the nonlinear system. The main objective is to control the TRMS in order to obey the desired position and reject the effect of external disturbances. Since the cross coupling effect between its two rotors of MIMO system it is a system with nonlinear behavior. So that they investigate a PID-AFC combined with neural network and fuzzy logic to compensate the disturbances. AFC will estimate the disturbances while neural and fuzzy logic will optimize the error. Only AFC cannot respond individually that's why they use a fuzzy and neural network [14].

Deepak Kumar Saroj and Indrani Kar present a Takagi-Sugeno (T-S) fuzzy model had used to approximate the nonlinear dynamics of the system. This dynamics is applied to the fuzzy logic controller and that guarantees not only stability but also satisfied performance criteria of the close loop system.

The controller gain is obtained by solving the set of inequalities. A fuzzy observer is also designed to estimate the state of the system. An integral sliding mode control is applied for vertical position control and sliding mode control is used for the horizontal position control. Simulation result shows that this approach can give better set point tracking performance [15].

Chi-Ming Chang and Jih-Gau Juang present a controller for FPGA to solve the mismatch frequency problem. They uses Altera FPGA Cyclone II research and development circuit board as a system on programmable chip (SOPC) for a TRMS. Although the frequency can be matched by division process but mismatch occurs frequently. The decoder and Verilog HDL are applied to implement a controller on FPGA and solve the mismatch frequency problem. The PID is used in controller design and GA is used to optimize the parameters of PID controller. Fuzzy controller is used as compensator to improve output performance and reduce the total error. This whole study is concentrate on how to generate a signal, encoding, decoding, sending a signal to the control terminal and then fed to the TRMS system [16].

III. CONCLUSIONS

In this paper, the nonlinear system like twin rotor MIMO system is highly nonlinear complex system. It has high nonlinearities which effects on system performance because of its cross coupling effect of two motor. This effect can be remove or reduce by different techniques to get desired performance but system have some limitations. This literature survey conclude that fuzzy, neural, genetic algorithm all Soft computing techniques can give better output performance rather than conventional controller like PID or LQR controller. But all of them ANFIS control techniques can give better control for TRMS but ANFIS have some limitation for controlling of TRMS after that survey of control of nonlinear

TRMS using hybrid fuzzy PI controller with novel switching functions may be reduce the coupling effect from twin rotor MIMO system better than other methodology and techniques and also future perspective.

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