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Fuzzy Logic Based Control of a Dual Rotor MIMO

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Abstract:
The objective of this paper is to introduce to the simulation community. This tool is also called fuzzy set theory. This paper is containing brief discussion of the current trends in simulation Introduction to the fuzzy set is limited to the finite number of the element. In this paper attention will be devoted to the fuzzy logic. Fuzzy logic which lends itself to growth in the simulation of situation that arises in real life either because of variation of environment or because of the variation of the available data. Fuzzy controller is used to solve non-linearity of pitch AND yaw angles of Twin Rotor MIMO system (DRMS). FIS and Rule base were used to easier the controller and refine the response. Simulation results under MATLAB proved the improvement of response using fuzzy logic controller.

Keywords: fuzzy logic, Rule base, Fuzzy interference system (FIS) Control system, MATLAB

1. Introduction

PID is regarded as the standard control structures of the classical control theory, and fuzzy controllers have positioned as a counterpart of classical PID controllers on the same dominant role at the knowledge-rich spectrum. PID controllers are designed for linear
systems and they provide a preferable cost/benefit ratio. Fuzzy control provides a formal methodology for representing, manipulating, and implementing a human's heuristic knowledge about how to control a system. Here design a fuzzy PID controller so that response. Fuzzy PID controller has self-tuning ability and online adaption to nonlinear system, time varying, and an uncertain system. In simulation-based analysis to develop a simulation model of the physical system. The simulation model can often be made quite accurate, and you can include the effect of implementation. Simulations are performed on MATLAB/Simulink toolbox to illustrate the performance of the system [1,5]. In contrast with traditional linear and nonlinear control theory, a FLC is not based on a mathematical model and is widely used to solve problems under uncertain and vague environments, with high nonlinearities Since their advent, FLCs have been implemented successfully in a variety of applications such as insurance and robotics Fuzzy logic provides certain level of artificial intelligence to the nonlinearities and offend define dynamics. Consequently, Conventional Control mythologies based on the linear system theory have to simply / lineralize then on linear system before they can be used, but uncertain systems Fuzzy PID controllers provide a promising option for industrial applications with many desirable features.

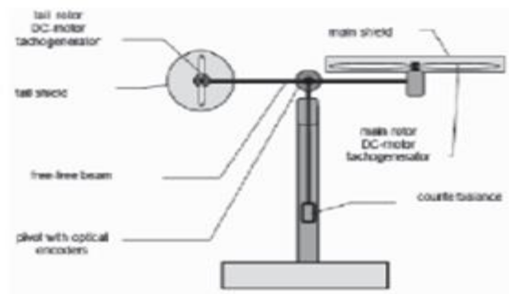

Fig.1. Diagram of Twin Rotor MIMO System

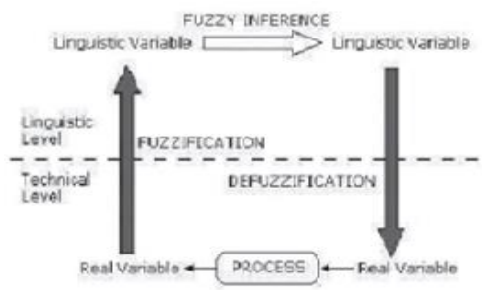

Fig. 2. Diagram of Fuzzy logic Controller

DRMS is a laboratory set-up designed for control experiments. It exemplifies a high-order non-linear system with significant cross-couplings from control point of view. A laboratory set-up of TRMS is depicted in Fig.1. A detailed approach to control problems connected with TRMS involves some theoretical

Knowledge of law of physics. The main parts of DRMS are the pedestal, the jib connected to pedestal, and two propellers at each end of the jib. These two propellers are driven by two Direct Current (DC) motors. The system jib can freely rotate around vertical axes by about 330 degree and horizontal axis and by about 100 degree. The system inputs are the voltages used to drive the DC motors of the propellers, and the outputs are the angular rotations with respect to horizontal and vertical axes. A counterbalance arm with a weight at its end is to the beam at the pivot [6, 12].

2. History

The concept of Fuzzy Logic (FL) was obtained at the starting of the 70s by Lotfi, a professor at the University of California, and presented as a type of processing the data accepting the data as a partial set membership instead of non-membership. This proposal of set theory was not implemented on different type of control systems because of the lack of small computer ability. He had given a justification that one does not want exact numerical data input because they are having the ability of highly adaptive control. If feedback controllers could bead dress for identification and the maximum amount of elements is limited for the communication channel and for the programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement. Prescribed; please do not alter them. It may be noted peculiarities. For example, the head margin in this template measures proportionately more than is customary.

The simplicity of designing these fuzzy logic systems has been the main advantage of their successful implementation over traditional approaches such as optimal and adaptive control techniques Even though rules can be developed for many control applications, they need to be set up through expert observation of the process. The complexity in developing these rules increases with the complexity of the process. FL of a number of parameters that are needed to be selected and configured in prior, such as selection of scaling factors, configuration of the center and width of the membership functions, and selection of the appropriate fuzzy control rule.

FL is a problem-solving control system methodology that lend itself to implementation in systems varying from easy, precise, embedded microcontrollers to big, networked, multi- channel computers or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a merger of hardware and software. FL provides a very easy way to arrive at a definite result based on uncertain, open to more than one interpretation, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much fast. Fuzzy logic is a logical system, which is a fixed extension of multi valued logic. In a wider sense fuzzy logic (FL), is almost synonymous with the theory of fuzzy sets.

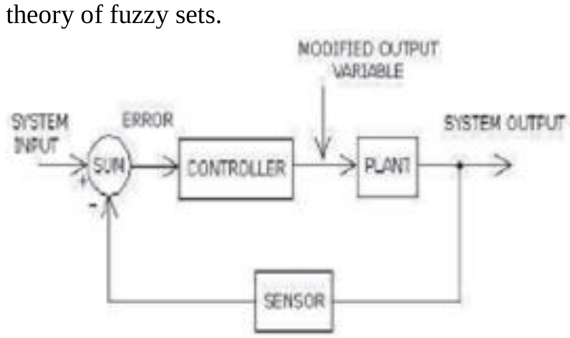

Fig. 3. Feedback System

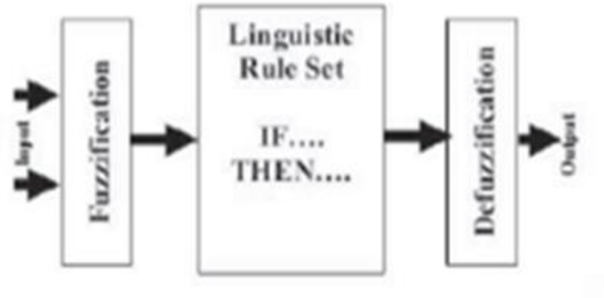

Fig. 4. Fuzzy Logic Controller

Here is a list of general observations about fuzzy logic. Fuzzy logic is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. Fuzzy logic is a more intuitive approach without the far-reaching complexity. Fuzzy logic is flexible. With any given system, it is easy to layer on more functionality without starting again from scratch. Fuzzy logic is tolerant of imprecise data. Everything is imprecise if you look closely enough, but more than that, most things are imprecise even on careful inspection.

Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end. Fuzzy logic can model nonlinear functions of arbitrary complexity. You can create a fuzzy system to match any set of input output data. This process is made particularly easy by adaptive techniques like adaptive. Neuro –Fuzzy Inference Systems (ANFIS), which are available in Fuzzy Logic toolbox. Fuzzy logic can be built on top of the experience of experts. In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system. fuzzy interference system Fuzzy logic can be blended with conventional control techniques. Fuzzy systems don't necessarily replace conventional control methods. Fuzzy systems augment them and simplify their implementation. Fuzzy logic is based on natural language. The basis for fuzzy logic is the basis for human communication.

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all of the pieces Membership Functions, Logical Operations, and If-Then Rules. There are two types of fuzzy inference systems that can be implemented in Fuzzy logic Toolbox: Mamdani-type and Sugeno-type. Fuzzy interference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, experts systems, and computer vision. Because of its multi-disciplinary nature, fuzzy inference systems are associated with a number of names, such as fuzzyrule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and simply fuzzy systems [2, 5, 7, 17].

3. Fuzzification Ruleset, Fuzzyset And Crispset

The inputs are most often hard to measure from some measuring equipment, rather than linguistic Examples of preprocessing are: Quantization in connection with sampling or rounding to integers; normalization or scaling onto a particular, standard range; filtering in order to remove noise; averaging to obtain long term or short term tendencies; combination of several measurements to obtain key indicators and differentiation and integrationor their discrete equivalences. The rules may use several variables both in the condition and the conclusion of the rules. The controllers can therefore be applied to both multi-input-multi-output (MIMO) problems and singleinput- single-output (SISO) problems. The typical SISO problem is to regulate control signal based on an error signal. The control objective is to regulate some process output around a prescribed set point or reference. The presentation is thus limited to single-loop control [3, 8, 9, 13].

4. Test and Result

In order to understand any elevator algorithm implementation. Fuzzy Interference System for horizontal part is shown in figure 5. [4,10,11,14].

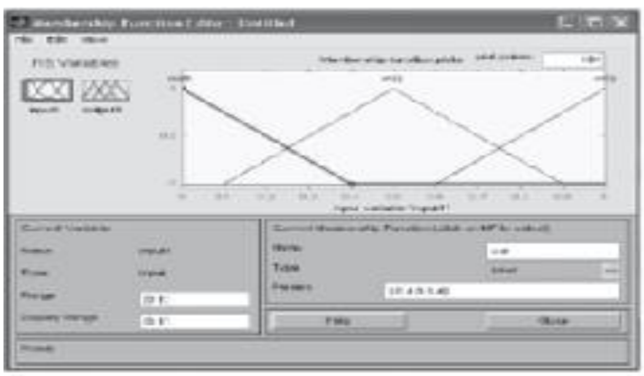

Fig. 5. Membership Function

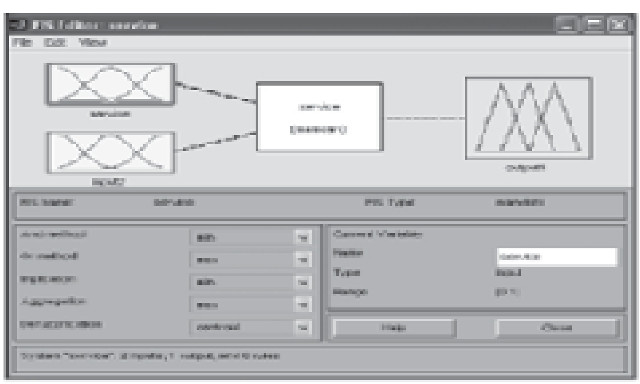

Fig. 6. Fuzzy Interference system

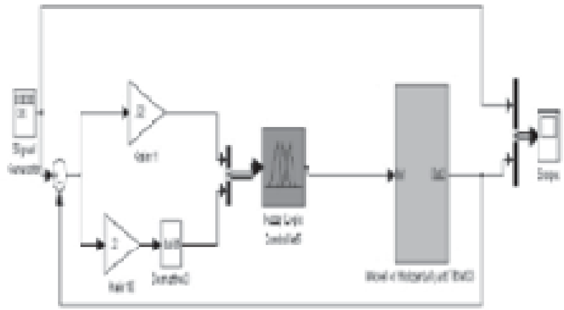

Fig. 7. Diagram of Horizontal part

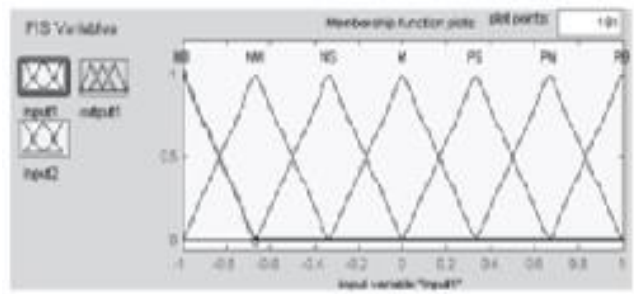

Fig. 8. Input Variable 'input1'

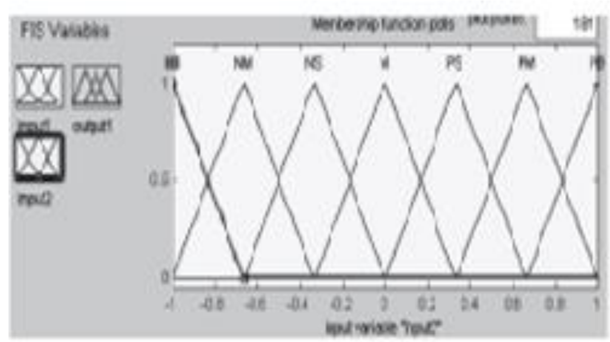

Fig. 9. Input Variable 'input2

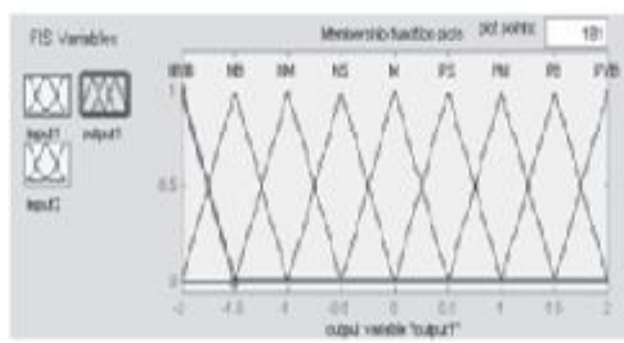

Fig. 10 Output Variable 'output

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Rule base is as shown in figure 11.

Fig. 11. Rule base

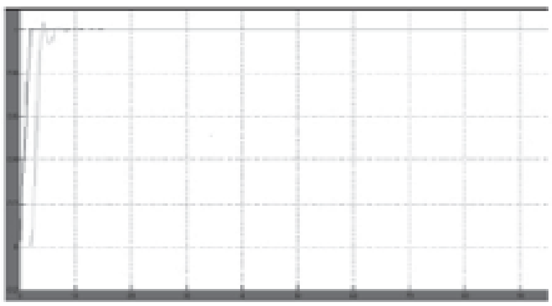

Fig. 12. TRMS Control system response for step input

When Step input is applied to the input of the Horizontal part of the TRMS system [15, 16].

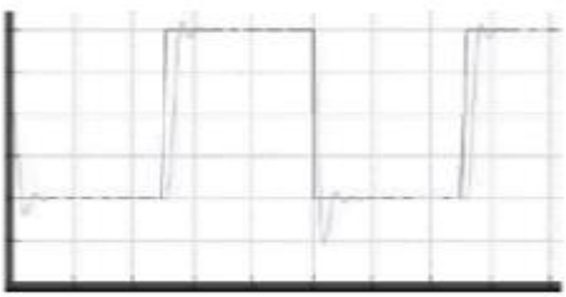

Fig. 13. TRMS Control system response for square input

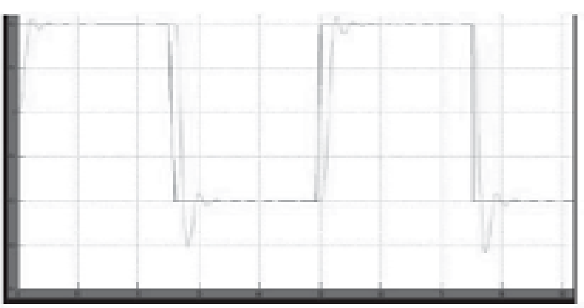

Fig. 14. TRMS Control system response for square input

Figure 14 shows the response of a TRMS control system when square input is applied on it. It denotes the peek overshoot and then settled down. When Sine input is applied to the input of the Horizontal part of the TRMS system.

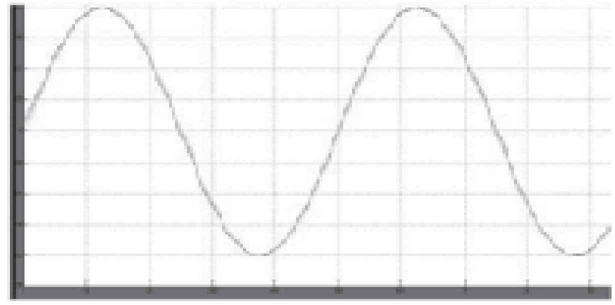

Fig. 15. TRMS Control system response for sine input Rule Viewer

Fig. 16. Rule Viewer

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