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A Review Study on Fuzzy PID Controller and its Various Applications

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***Abstract*— The main objective of this paper is to describe fuzzy PID (FPID) controller, which is called the fuzzy proportional integral derivative controller or fuzzy logic proportional integral derivative controller. In this paper also briefly discus about the proposed application of fuzzy PID controller in various fields of control. Fuzzy PID controller has two section Fuzzy logic controller and PID controller. Fuzzy logic controller section tuned the parameters of Proportional Integral Derivative controller that gives much better performance in control system. Fuzzy PID controller gives minimum rise time, settling time, overshoot and steady state error in linear and nonlinear control system that's way they can be applied to more complicated problems. The main advantages of fuzzy PID controller are that linguistic variable are used in place of numerical ones, nonlinearity of the system can be handle easily and high degree of precision is accomplished. Fuzzy PID controller are used in aircraft pitch control ,real time speed control of D.C motor, CNC feed servo system, BLDC motor control system etc.**

Keywords*— *Fuzzy PID, fuzzy logic controller, PID controller, speed control of D.C motor, BLDC motor, aircraft pitch controller, nonlinear quarter car model.

I. INTRODUCTION

PID controllers have been used for several decades in industries for process control applications. The reason for their wide range of popularity is that simple to design and their efficiency for linear system but satisfactory control of performance may be difficult to achieve in higher nonlinear controlled system and some complex system. However expert can qualitative describe a controller, that's fuzzy logic controller which is provides a convenient method for constructing nonlinear controllers. Fuzzy logic controller makes the formulation of a tuning mechanism an extremely complex problem. Fuzzy logic control mechanism is used to reduce the complexity the linear combination of input variables with scaling of a PID controller. Therefore fuzzy logic controller blend with PID controller.[8] This intelligent controller has been an effective tool for control of many nonlinear and complex system. Fuzzy PID controller has the ability to produce better response performance against conventional controller.

A. PID CONTROLLER:-

PID controller stands as Proportional integral derivative controller. As the name PID controller indicate three terms first is Proportional, second is integral and third is derivative. These three terms are combined together in such a way with feedback that is gives desired control output. Fig.1 shows block diagram of PID controller used with feedback system. [9]

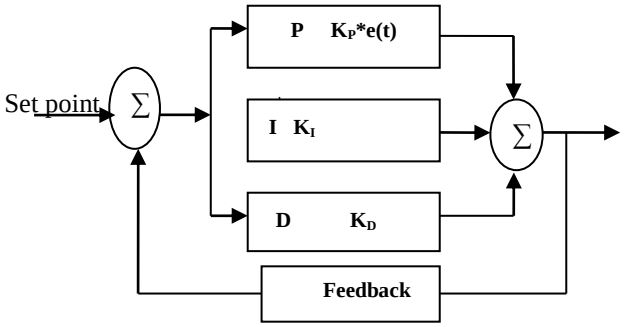

Fig-1 block diagram of PID controller

The generalized equation of the transfer function of PID controller is given by [9]

$$C(S) = G(S) / H(S) \quad (1)$$

$$C(S) = K_P + K_I/S + K_D*S \quad (2)$$

$$C(S) = K_P [1 + 1/T_{I*S} + T_D*S] \quad (3)$$

Where:

C(S)=Controller signal
G(S)= Control signal
H(S)=Error signal
K_P=Proportional gain
K_I=Integral gain

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K_D =Derivative gain
T_I= Integral time constant
T_D=Derivative time constant

B. FUZZY LOGIC CONTROLLER

Fuzzy logic controller are more robust than Proportional Integral Derivative controller because they can cover a much wider range of operating condition compare than PID controller and can also operate with noise and disturbances of different nature. Fuzzy logic controller is easier to understand and modify their rules, which not only use a human operator's strategy but also are expressed in natural linguistic terms. Fig.2 shows block diagram of fuzzy logic controller and their function.

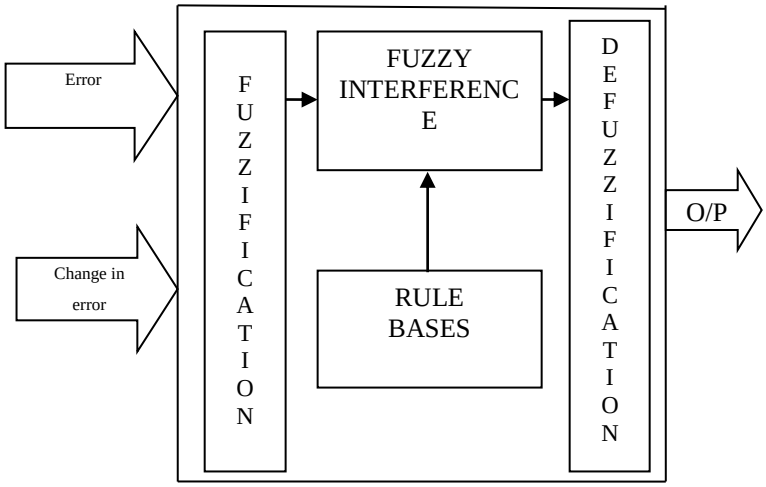

Fig.2 block diagram of Fuzzy logic controller

FUZZYFICATION:

- Membership function of input fuzzy set.
- Actual inputs are fuzzified and fuzzy inputs are produced. Because fuzzy logic controller work only on fuzzy input

FUZZY INTERFERENCE:

- Contain simple fuzzy Rules bases set. Rules bases set are simple if, than rules.
- Processing fuzzy inputs according to the defined fuzzy rules bases set and fuzzy outputs are obtained.

DEFUZZFICATION:

- Membership function of output fuzzy set.
- Bring out a crisp or real value for a fuzzy output. This is easily understandable by human.

C. FUZZY PID CONTROLLER

As I discussed previously a Fuzzy PID controller is a combination of the PID controller and the Fuzzy logic controller in a healthy way and thus a new intelligent controller has been accomplished. Fuzzy logic controller section tune the parameter of PID controller i.e. Fuzzy logic controller has supervisory role to readjust the gain of the PID controller during the control operation and also a fuzzy PID switching method gives smooth control during switching between Fuzzy logic controller and Proportional Integral Derivative controller. Fig.3 shows block diagram of fuzzy PID controller used with feedback system.

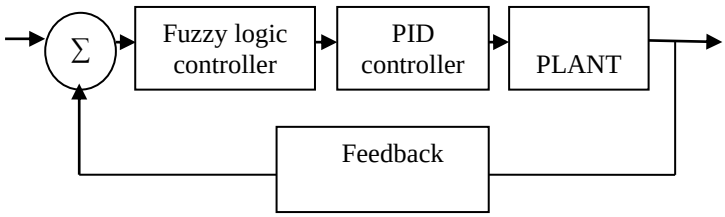

Fig-3 block diagram of fuzzy PID controller

The generalized equation of the transfer function of fuzzy PID controller is given by

$$G(S) = Y(S)/X(S) \quad (4)$$

$$G(S) = K_P(\text{readjusted}) + K_I(\text{readjusted})/S + K_D(\text{readjusted})*S \quad (5)$$

Where,

G(S) = controller output
Y(S) = control signal
X(S) = Output signal of fuzzy logic controller
K_P(readjusted) =Readjusted proportional gain by fuzzy logic controller
K_I(readjusted) = Readjusted integral gain by fuzzy logic controller
K_D(readjusted) = Readjusted derivative gain by fuzzy logic controller

II. APPLICATIONS OF FUZZY PID CONTROLLER

Many of the field like in aircraft pitch control, speed control of D.C motor, nonlinear quarter car model, BLDC motor etc are using fuzzy logic controller.

A. AIRCRAFT PITCH CONTRLER

In this paper self tuning controller introduced to control the pitch or longitudinal dynamic of aircraft for improved the fight stability [4]

B. Real time Speed control of D.C motor:

Fuzzy PID controller has been used to control the speed of DC motor with FPGA (Field Programmable Gate Array) to reduce the variation in speed when load varies. Fuzzy PID controller gives a constant speed when the load varies and better dynamic response when compared with PID controller and fuzzy controller. Fuzzy PID controller was implemented to run the motor as real time application under speed and load variation condition. [5]

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C. CNC feed servo system:

Fuzzy PID controller with genetic algorithm has been used to control the feed servo system. The Feed servo system of CNC machine is the complex electromechanical coupling control system because feed servo system is the main link between the CNC devices and driving part. The control system performance achieved accurately It's difficult due to the characteristics of time varying parameters, load disturbances and motor nonlinear. Fuzzy PID controller with genetic algorithm, optimization method has been used to remove the complex electromechanical coupling effect and it can also minimize the settling time and decrease overshoot.[6]

D. BLDC motor control system

This paper proposed fuzzy PID controller to control the speed of BLDC motor. Fuzzy PID controller has higher stability, control precision and faster dynamic response speed with PSO control strategy. It's give better dynamic, static performance and robustness of the BLDC motor control system and achieves a acceptable control result.[7]

CONCLUSION

This paper gives a brief description of fuzzy PID controller and its different application in various field of engineering .fuzzy logic controller and PID controller together gives the much better performance as compare to other controller. Fuzzy PID controller is used in both linear and nonlinear complex system with different tuning techniques like Genetic, PSO, etc

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