A Review on Model Based Methods to Degrade Nonlinearity Effects for Control Prosthetic ARM

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Abstract— As required controlling speed of motors to do control prosthetic arm movement, conventional control method is not reliably control multiple functions together, So, new control strategy is requiring tackling with this difficult problem. In this review paper we survey some recent developments of various methodologies for improvement in settling time and overshoot.

Key words: ANFIS-PID (Artificial Neural Fuzzy Inference System- Position Integral Derivative) Controller Method, DC Motor, Fuzzy Controlling Method, PID Controller, Pole Placement Method

I. Introduction

In order to control movement of prosthetic arm, fuzzy PID controller based system is developing for reducing steady state error and getting smooth step response. Movement of arm is such a smooth & parallel like human persuasive. A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) commonly used in control systems. Fuzzy logic is recently finding wide popularity in various applications that include management, economist, and medicine and process control systems[3]. An appropriate mathematical model of the dynamical system is not available and information access from human expert knowledge about plan operation.[1]

All real time control systems are nonlinear. This covers a wider class of systems that do not obey the superposition principle. Nonlinear systems are often analyzed using numerical methods on computers, for example by simulating their operation using a simulation language. If only solutions near a stable point are of interest, nonlinear systems can often be linearized by approximating them by a linear system using perturbation theory. Nonlinear systems control Processes in industries like robotics and the aerospace industry typically have strong nonlinear dynamics. Differential geometry has been widely used as a tool for generalizing well-known linear control concepts to the non-linear case, as well as showing the subtleties that make it a more challenging problem.

Intelligent control uses various AI computing approaches like neural networks, Bayesian probability, fuzzy logic, machine learning, evolutionary computation and genetic algorithms to control a dynamic system. Optimal control is a particular control technique in which the control signal optimizes a certain "cost index". Two optimal control design methods have been widely used in industrial applications, as it has been shown they can guarantee closed-loop stability. These are Model Predictive Control (MPC) and linear-quadratic-Gaussian control (LQG). However, the "optimal control" structure in MPC is only a means to achieve such a result, as it does not optimize a true performance index of the closed-loop control system. Together with PID controllers, MPC systems are the most widely used control technique in process control. Robust control deals explicitly with uncertainty in its approach to controller design. The early methods of Bode and others were fairly robust; the state-space methods invented in the 1960s and 1970s were sometimes found to lack robustness. Examples of modern robust control techniques include H-infinity loop-shaping and sliding mode control (SMC). In typical stochastic control problems, it is assumed that there exist random noise and disturbances in the model and the controller, and the control design must take into account these random deviations. Energy-shaping controls view the plant and the controller as energy-transformation devices. The control strategy is formulated in terms of interconnection (in a power-preserving manner) in order to achieve a desired behavior.

Motor functionality should be such a smooth that not look like jerky artificial hand. For such a purpose Fuzzy logic offers a simpler, quicker and more reliable solution. The fuzzy logic controller has been designed and tuned for an expected average mass of the object to meet prescribed overshoot imposition and settling time in transient response.[2] the fuzzy rules identify & reduce unusual & erratic movements. The simulation study clearly indicates the superior performance of fuzzy control, because it is inherently adaptive in nature.[3] According to review movement of fingers operate at time and angle define in below table.

Sr. No.	Finger movement	Angle	Apply voltage	Operating time of movement
1	Four fingers close	45°	5 to 12 volt individual fingers	2 to 3 seconds
2	Four Fingers open	0°	-	-
3	Thumb close	135°	5 to 12 volt	2 seconds
4	Thumb open	45°	-	-

Table 1: Functionality

In this paper next section described the review of various methods for controlling motors.

II. Methodology

A. DC Servomotor System

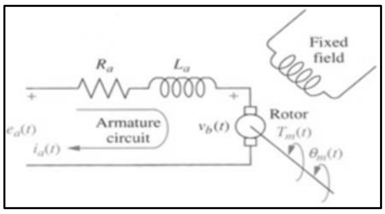

Fig. 1: DC Motor System

Where
J= Total moment of inertia of the rotor together with that of reflected load on the rotor side,
B= Total viscous friction of the rotor together with that of reflected load on the rotor side,
K_T= Motor torque constant,
K_b= back-emf constant,
R_a= Armature resistance,
L_a= Armature inductance.

The electrical equation for DC servomotor system is given by

$$e_a(t)-e_b(t) = R_a i_a(t)+L_a (di/dt)$$

Taking Laplace transform of the above

$$E_a(s)-E_b(s) =(R_a+L_a\ s)\ I_a(s)$$

The back-emf, induced by the angular speed of the motor shaft, such that

$$E_b(s) =k_b\omega_m(s)= k_b s\theta(s)$$

Mechanical equation

$$\Gamma_m(t)=J\frac{d^2\theta m}{dt^2}+B\frac{d\theta m}{dt}$$

Taking laplace transform of above

$$\Gamma_m(s)=(s_2J+sB)\theta_m(s)$$

Electromechanical equation of the DC servomotor

$$\Gamma_m = K_T i_a$$

Taking laplace transform of above

$$\Gamma_{m(}(s) = K_T\ I_a(s)$$

The transfer function for a third order armature controlled DC servomotor system is given as follows:

$$\frac{\theta m(s)}{Ea(s)} = G(s) = \frac{K_T}{(JL_a)s^3) + \left((R_a)J + (L_a)B\right)\ (s^2)) + ((R_s)B + (K_b)K_T)s)}$$

B. *PID Controller Method*

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems. A PID controller continuously calculates an "error value" as the difference between a measured process variable and a desired set point. The controller minimizes the error by adjusting of a control variable. Stability can often be ensured using only the proportional term. The integral term permits the rejection of a step disturbance. The derivative term is used to provide shaping of the response. P accounts for present values of the error, I accounts for past values of the error, and D accounts for predicted future values of the error, based on its current rate of change.

C. *Pole Placement Method*

Pole placement controller provides excellent control as designer can adjust the time to reach on the reference point by adjusting poles. In this controller equation is 2nd order. Poles are placed in closed loop transfer function in reasonable position. By adjusting poles one can adjust time to reach on reference point .Model of system is formulated by discrete transfer characteristics. System response is slow during poles places far from origin and response is faster during poles places near to origin.

D. *Fuzzy Controlling Method*

The typical FIS inputs are the signals of error (e(k)) and change of error (e(k)-e(k-1)). The FIS output is the control action inferred from the fuzzy rules. Fuzzy logic is widely used in controlling machine. A mathematical system that analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1. By this way it is easy to mechanize tasks that are already performed by humans.

Robustness test for both the controllers-FLC and general PD controller has shown that Fuzzy Logic Controller is more robust as compared to general PD controller[1]. The implementation of fuzzy logic control shows its robustness as the results in case of both simulation and experiment remain identical with respect to the load mass change[2]. As the servomotor is used for position control system like in robotic arm, it is used to pick some objects of varying masses[1]. Design & build a fuzzy logic controller which reduces muscle tremors by smoothening signal[3]. As change in input occurred set membership Function such that smooth output gets. The fuzzy rules identify & reduce unusual & erratic movements. So there is much application where we need smooth output. We can give smooth muscle output to wheelchair joystick which use for people have multiple sclerosis.

E. *ANFIS–PID Controller Method*

ANFIS–PID controller reduced more tracking error compared to PID controller and demonstrates better results when disturbance is applied to the control system[14]. In this method ANFIS system is made by fuzzy rules and membership function with together of inverse input and output and PID controller parallel with it. By such system errors reduces.

III. Result & Discussion

This paper is described various methodology for degrade nonlinearity effect. For the desired output controlled signal requires working as step by step implementation.

The paper represent methodology for the reduce steady state error and settling time and overshoot, from the above review we can say that there are various methodology available for remove nonlinearity effect in prosthetic arm movement. The state space representation (also known as the "time-domain approach") provides a convenient and compact way to model and analyze systems with multiple inputs and outputs. With inputs and outputs, we would otherwise have to write down Laplace transforms to encode all the information about a system. Conventional PID system has poor performance in terms of oscillation in transient period. Pole placement controller gives excellent control to control system and output of system is smooth but for nonlinear system zeros and poles are unknown so need to convert nonlinear system into linear system. Fuzzy logic methods can be used effectively to complement conventional control methods. As it improves performance in term of load mass varies. As Design such a system hybrid fuzzy PID controller for improving system performance in both steady states and transient can been achieved. So by using advanced technology Fuzzy logic is gives better performance in terms of reduce overshoot and settling time. As only use ANFIS or PID is not as best as ANFIS-PID performance.

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