International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Comparison of Results of PID and Fuzzy Control of Two Linked Rigid Manipulator

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Abstract: ***In this dissertation Euler-Lagrange's method is used to model the dynamics of two linked rigid manipulator. The multi input and the multi output model is found to be nonlinear. To observe and control the output response of manipulator, SIMULINK model is designed using S-Function block without any controller and the response found is unbounded. In order to control the position of the manipulator PID and Fuzzy Controllers are used. PID Controller and Fuzzy controllers are designed using RH criteria and linearizing the model about a point respectively. Comparison of controller is made and observed that Fuzzy control is better than PID control.***

Keywords: PID Controller, Fuzzy Controller, Membership functions, Simulink, Two Linked Rigid Manipulator

1. Introduction

Manipulator is a machine that has functions similar to human upper limbs, and moves the objects spatially. The Robotics Industries Association (RIA) of USA defines the robot as "A reprogrammable, multifunctional manipulator designed to move material through variable programmed motions for the performance of a variety of tasks."

The robot anatomy is therefore, the study of skeleton of a robot, i.e. the physical construction of a rigid manipulator. The structure of a rigid manipulator that consists of links Connected by means of joints is segmented into an arm that ensures mobility and reaches ability, wrist that confers orientation, and an end factor that performs the required task. Most manipulators are mounted on a base fastened to the floor or on the mobile platform of an Autonomous guided vehicle (AGV).

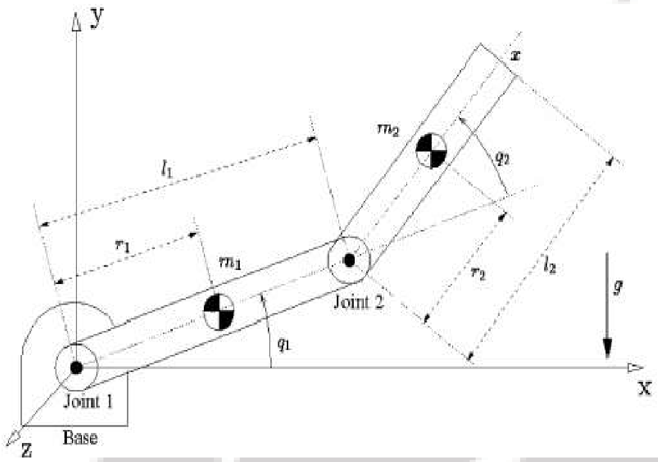

Figure 1: Two Link rigid manipulator

2. Dynamic Modeling of Two Linked Rigid Manipulator

For the Two linked rigid manipulator the state space model is obtained and then the using the same the M file for the simulink obtained. Fig 2 shows the simulink model of two linked rigid manipulator without any controller.

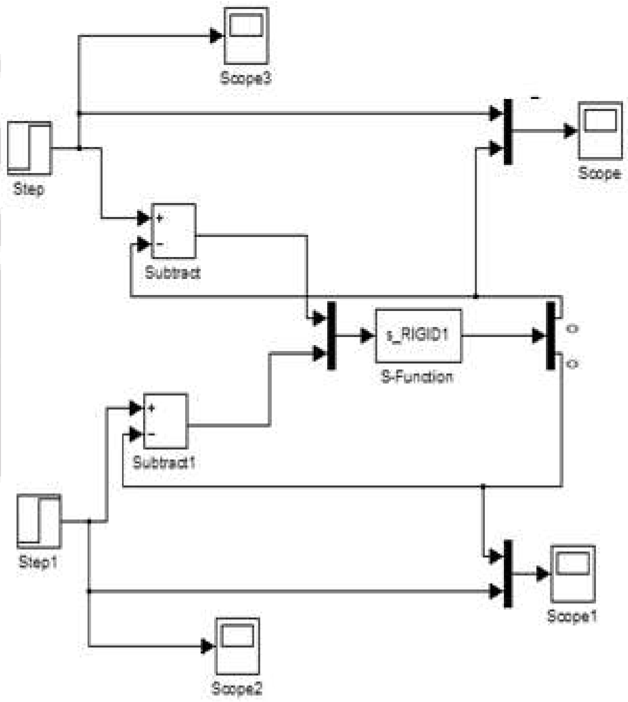

Figure 2: Closed Loop Model Of Two Link Rigid manipulator

3. PID Controller

A proportional integral derivative controller (PID controller) is a generic control loop feedback mechanism widely used in industrial control systems. The PID controller attempts to eliminate the error between a measured process variable and a set point by calculating and outputting a corrective action that can adjust the process accordingly. The PID controller algorithm have three unique parameters; proportional, Integral and derivative values. The Proportional part determines the reaction to the error, the Integral part determines the reaction based on the sum of recent errors and the Derivative part determines the reaction to the rate at which the error has been changing. The averaged sum of these actions is used to adjust the process via a control element like the position of a control valve or the power supply of a heating element. By "tuning" the three constants in the PID controller algorithm the PID can control the process as per requirements. The response of the controller can be stated in terms of the responsiveness of the controller to an error, the degree to which the controller deviates from the set point and the degree of system oscillations. The use of the PID algorithm for control does not guarantee required control of the system or system stability. Some applications may require using only one or two modes to provide the required system control. This can be achieved by manipulating the gain of undesired control outputs to zero. A PID controller will be called a P,PI,PD or I controller in the absence of the respective control actions. PI controllers are common and derivative action is very sensitive to noise measurements, and the absence of integral value may obsolete the system from reaching its target value due to the control action.

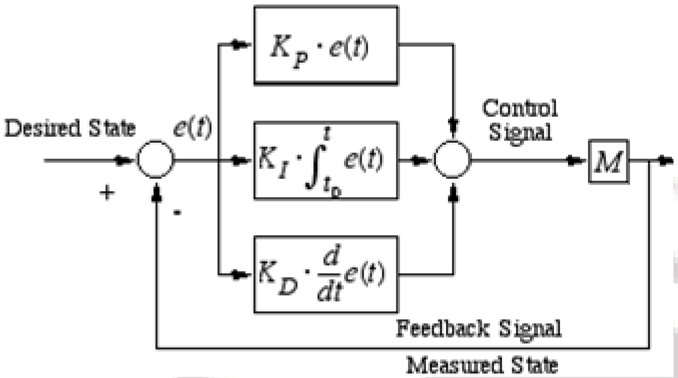

Figure 3: Block Diagram of PID controller

4. Generalized Form of Conventional PID Controller

A PID controller is designated by:
G(s) = P+I+D
= K_p + K_i/s + K_d s--------------- (1)
= K_p (1+ 1/ T_i/s +T_d s) ---------- (2)
Where K_p = proportional gain, K_i= integration coefficient, K_d = derivative coefficient.
T_i = integral action, T_d = derivative action.

For the best results from the system, there is requirement of adjusting these parameters which is more difficult & time consuming.

5. Designing Of Conventional PID Controller

A PID controller is a design to control the Two-Link Rigid Manipulator parameters. (ϴ1 and ϴ2). For this we calculate the parameters used in this controller.
Parameters of manipulator are

m= mass= 0.585 Kg,
l=length=0.5mm,
b=breadth=25mm

Closed loop transfer function using PID controller is given as

$$TF = \frac{\frac{1}{Js^2+Bs} * \frac{1}{s}(K_p s + K_d s^2 + K_i)}{1 + \frac{(K_p s + K_d s^2 + K_i)}{s(Js^2+Bs)}}$$

Where J=$\frac{ml^2}{3}$
B=mean friction coefficient= 0.05
PID control parameters are obtained using the RH criteria for rigid manipulator are given below

K_p = 10
K_d= 1.3
K_i = 10
T_i = 1s
T_d = 0.13s

Simulation of two link rigid manipulator using PID Controller was done. All the functions and blocks used in model designing are predefined in Simulink library browser. Results for the same controller are obtained on the Simulink for the both links of the manipulator.

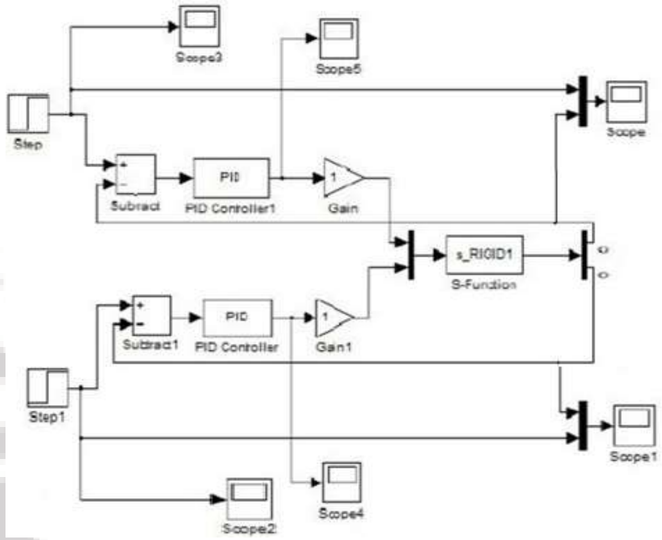

Figure 4: PID Controller Model of Two Linked Rigid Manipulator

6. Designing of Fuzzy Logic Controller

For the same system the fuzzy logic controller is shown in fig 6. Here in this paper for two input Fuzzy Logic Controller the seven membership functions are used. To design the fuzzy PID controller first rule base has been created in FIS Editor and the controller has been used as feedback controller. The controller has been tuned by Hit and Trial Method. Fuzzy logic controller produces the output with two inputs. First input is Error and second is change in error.

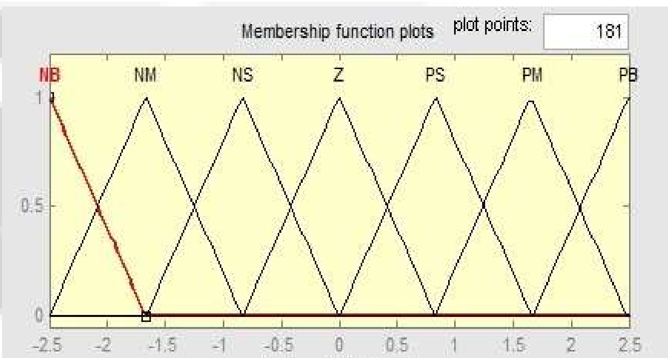

Figure 5: Membership Functions for Output Parameters

Membership functions for the output parameter are shown in Fig 5, here NB means Negative Big, NM means Negative Medium, NS means Negative Small, ZE means Zero and PB means Positive Big, PM means Positive Medium & PS means Positive Small.

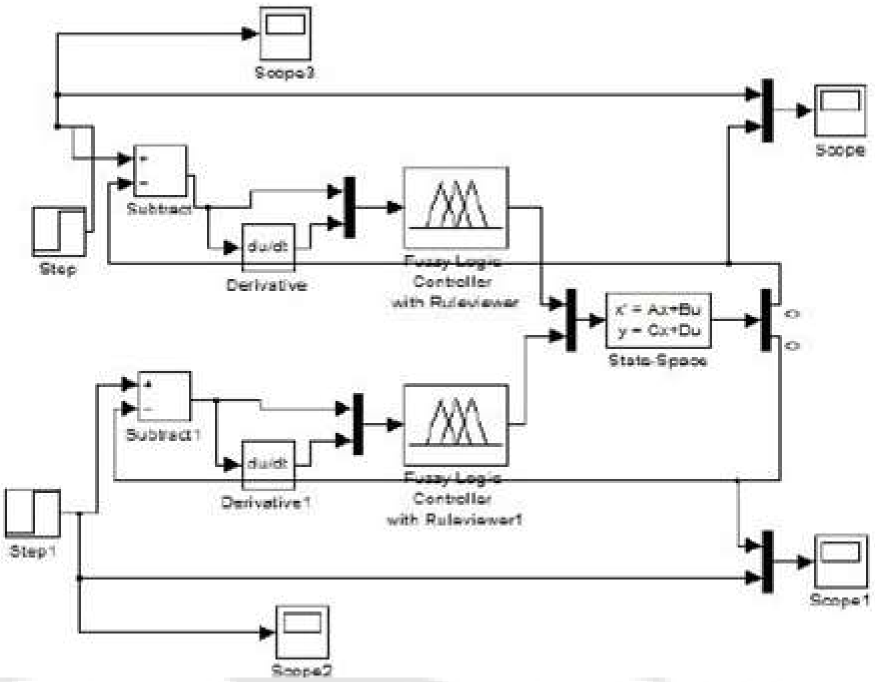

Figure 6: Simulink Model Using Fuzzy Controller

7. Results

The settling time and the peak overshoot was measured from both controllers and compared. Response of the two linked rigid manipulator parameters (ϴ1 and ϴ2) using PID controller are shown below.

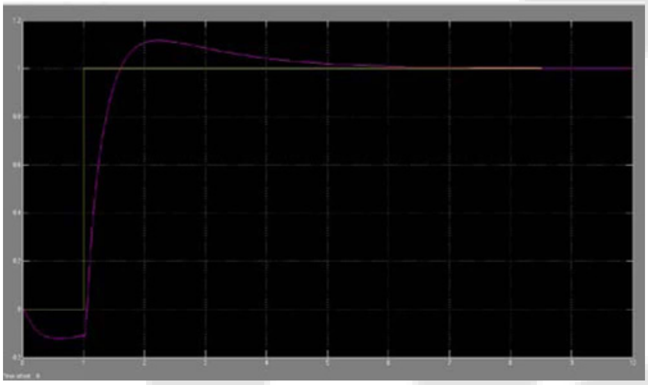

Figure 7.1: Response of ϴ1 using PID controller

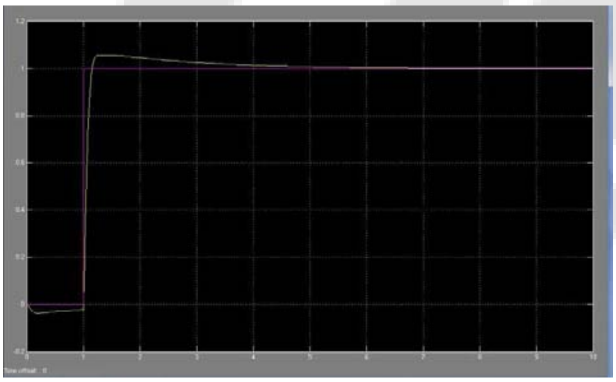

Figure 7.2: Response of ϴ2 using PID controller

Here the response of the two linked rigid manipulator parameters (ϴ1 and ϴ2) using Fuzzy controller are shown below.

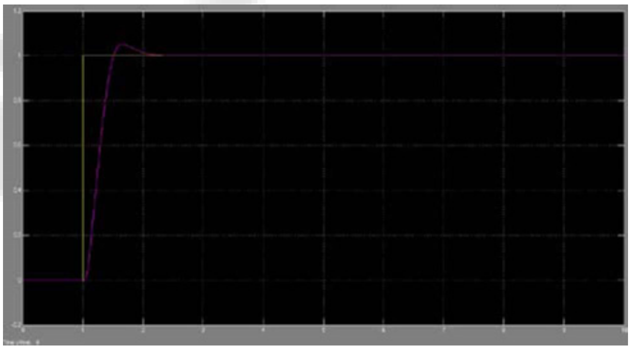

Figure 7.3: Response of ϴ1 using Fuzzy controller

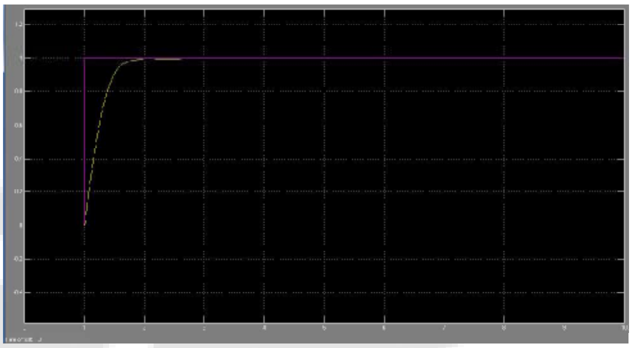

Figure 7.4: Response of ϴ2 using Fuzzy controller

8. Comparison and Conclusion

Fig 8.1 and 8.2 shows the comparison responses of ϴ1 and ϴ2 for both the controllers.

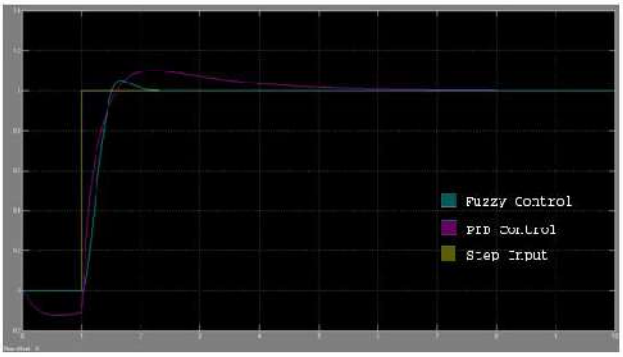

Figure 8.1: Response of ϴ1

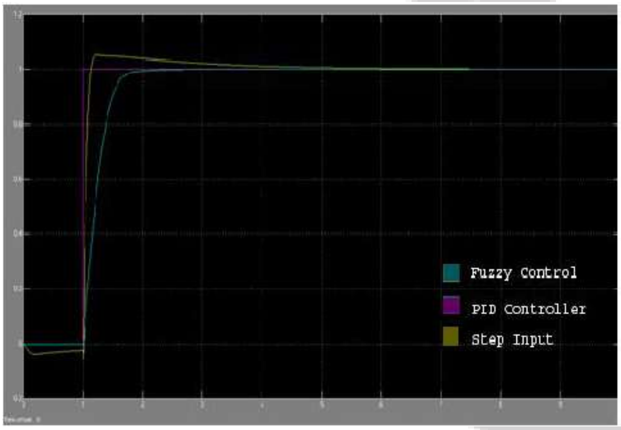

Figure 8.2: Response of ϴ2

Table 1: shown below gives the comparison values of settling time and Peak overshoot.

	Parameters	*Settling Time (Seconds)*	*Peak Overshoot*
ϴ1	PID Control	6.05	0.12
	Fuzzy Control	2.11	0.05
ϴ2	PID Control	5.05	0.06
	Fuzzy Control	1.67	0.00

This comparison shows that the Fuzzy Control of Two linked Rigid Manipulator is better than PID control.

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