International Journal of Future Generation Communication and Networking
Vol. 13, No. 1s, (2020), pp. 39- 45

Analysis of Flexible Robotic Manipulator using Fuzzy and SNC Controller

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Abstract

This work presents a study of two different control strategies for a flexible single-link manipulator. We are going to present two type of controller: 1) Sliding Mode Controller and 2) Neuro Fuzzy Controller. The trajectory tracking control using Sliding Mode Control (SMC) strategies for a flexible link robot manipulator have been presented SMC controller mostly used for flexible-link manipulator control. Tackling uncertain nonlinear systems is powerful method. Also, another strategy used to eliminate connection vibrations and get good trajectory tracking output is the Neuro Fuzzy logic control system. In this system we are going to implement a Hybrid Neural Network (HNN) based optimization to optimize the controllers. Here we will optimize two controllers first, Sliding Mode Controller (SMC) and Fuzzy logic Controller by which problem of energy consumption, error, vibration suppression and trajectory tracking will be eliminated. The contribution of our proposed system is to improving the performance of SMC by implementing the Fast Terminal Sliding Mode Controller. This simulation can be done by using Matlab Simulink.

Keywords: *SNC, HNN, SMC, Matlab etc.*

1. Introduction

Manipulators of computers today often have large systems. In addition to expensive material needs and power consumption, running speed also becomes relatively slow. Researchers Attention was paid to versatile, lightweight manipulators [1,2] in an effort to eliminate these disadvantages. Flexible manipulators are now commonly used for advantages in the light, fast and high load weight ratio in the automotive and aerospace industries. Stability of the systems, technical issues, External fluctuations, and internal nonlinear dynamics make it difficult to handle manipulators.

A figure of control planning [3-5] have been established successfully to move the modular manipulator to adopt the required trajectories, adding proportional derivative (PD) regulation. Neural network control, Adaptive control, sliding mode control performance redefinition etc. A number of control strategies were advanced to successfully pushing modular manipulator to follow the desired trajectories [3-5] Command, adaptive command, neural network-based regulation, output redefinition, sliding mode management, including proportional derivative (PD), etc. A new stable controller layout based on Neuro fuzzy logic and sliding mode control is proposed in [7], taking into account simulation errors, stress, external interference, variance of parameters and other problems in the adaptive joint robot control system.

Sliding mode control is an efficient control approach for unpredictable nonlinear systems, due to its high vigor for software errors and external interference, such as the Hugh precision multi-joint interference manipulator tracking problem. A new type of control method on sliding mode in recent years is non-single terminal sliding mode regulate, which solves unique dispute designing functionality directly from sliding mode design. Deliberately performs regional, non-single device power. At the same time, it inherited terminal sliding mode's finite time convergence property. Which control system can compact in a finite time. Yet conventional nonsingular sliding terminal regulation has a more sluggish convergence [5]. Hence a novel technique Quick Nonsingular. Terminal sliding mode control (FNTSMC) is used to clarify the handheld manipulator's trajectory capture dispute. The dynamic model was evaluated by Euler Lagrange equation, and we moved to a state-space form. So a novel technique Fast Nonsingular Terminal Sliding Mode Regulation (FNTSMC) is implemented to solve the trajectory tracking issue of the mobile schemer. By Euler Lagrange

ISSN: 2233-7857 IJFGCN

equation, we analyzed the dynamic model and switched to a state-space form. Finally the modular manipulator system's trajectory tracking controller is built on that basis. Our main purpose here is to optimize the controllers via the Hybrid Neural Network (HNN). The control objectives are to control angular displacement of the core in a compact single-link schemer and to eliminate vibration at the end point.

2. Literature Review

We have studied various existing system, we have described the existing work below. Ravi Kant Gupta, et al [7] addressed the operation of robot manipulators. It uses the Adaptive Neuro Fuzzy control method to track the direction of robotic arm and the trajectory with three degrees of freedom. This approach also addresses the problems associated with the PID controller, such as tuning and machine uncertainty. It has the capability to learn the different development involved with each of the interactions, which creates accuracy and incentive management.

Ge Xinsheng, et al [8] addressed the problems of trajectory detection of rigid fluid manipulators in space. A rigid flexible manipulator with two-links is known for its non-linear dynamic equation. By applying the model-based nonlinear feedback control method, the joint angle variables and the elastic deformation are partially decoupled. By using the reverse functional manipulator process, Problems with space rigid adjustable manipulator trajectory detection was studied. Methods their proposed are shown to be effective by numerical simulation.

Xiaoguang Li, et al [9] presented PB-ANN feed forward control for the pre differential PID controller. The versatile manipulator de-couples the elastic two-link manipulator movements. A PID controller with ANN feed forward control is designed for flexible two-way vertical planar manipulators. It regulates mutual trajectory detection asymptotically reliable. The simulation results indicate that when the manipulator tip trajectory is mapped with this method, the elastic vibrations of two links manipulator are limited.

Kamal Rsetam, et al [10] proposes a hierarchical sliding mode management (HSMC) framework for a lightweight rotating joint manipulator (RFJM). Secondly, two subsystems are based on the rotary flexible joint manipulator. Secondly, all subsystems are designed to cover the surfaces that pass. Finally, the Lyapunov function is used to design the control system. Computer simulation experiments show the feasibility of the proposed test.

The testing method is eventually based on the Lyapunov rule. Computer simulation experiments indicate the feasibility of the proposed Regulation. To build an effective sliding manifold, the first-order sliding mode regulation (SMC) is connected with the Linear-Quadratic-Regulator (LQR). The regulation of first order sliding mode (SMC) is combined with the Linear- Quadratic-Regulator (LQR) to create a suitable sliding manifold. Simulation testing for 2-link robot manipulators shows our method's applicability and effectiveness in demonstrating its efficiency.

W.Benaziza, et al [12] suggested a method of monitoring angular velocity to integrate angle error with asymptotic stability into zero in a short time. Second, on linear velocity, a global sliding mode regulation is proposed to reduce the location error to zero and to guarantee asymptotic stability using the Lyapunov principle. The proposed regulation finally shows the algorithm's efficiency, and the results of the simulation show strong convergence for circular, sinusoidal and special trajectories.

Huang Yiqing, et al [13] used the AFSM technique to create a three-dimensional (3d) handheld robot tracking device on board. The controller feedback (position error, curvature, and orientation error) is transformed into a series of fuzzy sets in a bubbling logic system. The number and exact form of these fuzzy sets essentially determines the controller output. The blurred sliding mode monitoring system is then fitted with a blurred index touching scale for the wheeled handheld robot computer. In the end, the numerical simulation output shows that the suggested method has better control accuracy and increased convergence speed with respect to the PID control method and reduces chatter in conventional sliding mode operation.

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1. Fuzzy entry sets

In a fluffy logic controller the controller input (position error, curvature error, and orientation error) is transformed into a sequence of fluffy sets. Such fuzzy sets define contextual conditions in which the controller's output is qualitatively unique.

In another altercation, whenever the controller changes the desired action in an input situation (e.g. from straight to left oscillating or going from high to medium speed), a fuzzy range is created to reflect the event. Curvature consists of three Fuzzy sets: Curvature Right, Curvature Straight, and Left. PositionaL fuzzification consists of five sets: NegLowDist (NLD), (Neg: Negative, Dist: Distance), NegHighDist (NHD) , ZeroDist (ZD), PosLowDist (PLD) (Pos: Positive) and PosHighDist (PHDIt is advantageous to have the robot (ZeroDi) on site. Assume the robot is off the line, then either turn right / left towards the track, drive straight towards the track, and then turn left / right to straighten out. So on either side of the Path we need 2 additional sets.

Related reasoning contributes to classification of Fuzzy sets orientation errors.To define various cases, a total of five 3NB sets were used: NegHighAngle (NHA),ZeroAngle (ZA) NegLowAngle (NLA), , PosLowAngle (PLA) and PosHighAngle (PHA)

2. Fuzzy output sets

From the Fuzzy interface to the robot there are two outputs: (a) speed and (b) steering angle. To define the heuristic pace vector, there are four membership functions: Slow, Zero, Fast and Medium. The steering angle is determined using five membership functions;, LowLeft (LL), Straight (ST), LowRight (LR) and SharpRight (SR), SharpLeft (SL). From this fuzzy set a crisp output value is then calculated. That step is known as defuzzification. In this research, we used the well-known centroid defuzzification method which uses the center area as the crisp value of productivity.

3. Fuzzy base rule

Because of these bogus input sets, a bogus controller uses a set of bogus rules to define the control actions it needs. The architecture of the fuzzy input and output sets is simple considering the construction of the fuzzy rules. In addition there are 5 URL5 = 75 different data configurations. For each of these input parameters a rule has been specified to denote the desired velocity and directional settings. Definitions of whimsical laws found in Table 1.

Table 1. Specifications and Hub Input Tracking for DLRF Pragram

		Parameters			**Rise Time**	**Sett. Time**	**Overshoot**	**SSE**
		KP	KI	KD				
FLC	L1	7.45	22.5	51.40	0.086	1.19	2.84	0.006

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	L2	5.48	29.3	15.02	0.089	4.62	3.13	0.002
FTSMC	L1	3.65	56.9	4.40	0.068	1.30	0.99	0.004
	L2	2.19	87.2	0.68	0.053	0.69	2.64	0.003
ZN	L1	2.09	0.54	2.01	2.97	7.15	4.69	0.681
	L2	4.15	1.3	3.32	1.46	5.45	5.45	0.284

The suggested control system is implemented using novel evolutionary Hopfield Neural Network (HNN) algorithms to modify the PD controller parameters. The aim optimization functions are developed using the device angle error Mean Squared Error (MSE) and the endpoint vibration control functions.

4. Result and Discussion

In terms of time transition, constant depletion of state and excess relative to Ziegler-Nichols, the FTSMC and the FLC controller accomplished a very significant improvement I reveal that the FTSMC controller's steady state error, rise time and over-shoot value for connection 1 is recorded at a lower value than the FLC-based power. Although FLC-based control has a adjusting lower settling time, the FTSMC-based control is almost twice the overshoot duration. A trade-off between decreased over-shooting and settling time will arise in comparison to [10]. For contact 2, the FTSMC controller has shorter rising time, lower settling time, lower over-shooting value and a steady state error compared to each other overall, the results indicated that in all application reaction regions, the FTSMC-based controller superseded the FLC controller. The two suggested controllers that were used in this work generally achieved satisfying response to the hub angle. Nonetheless, this gives better performance on FTSMC and FLC averages.

Flexible motion control

The FLC and FTSMC controls were added to the DLFR system to effectively eliminate the end of contact 1 and 2 vibration. These controller are then optimized by HNN. The results of the vibration reduction simulation are shown in Fig.7
Using FLC and FTSMC as opposed to HNN can eliminate the vibration furtherIt can be seen in Fig.

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7 That the response of the FLC and FTSMC tuning methods has nearly the same vibration amplitude. Numerical findings shown in Table II show that the MSE value of the FTSMC controller is lower than that of the FLC controller. This could be further discussed from the product of the frequency domain, as shown in Fig.8. FTSMC control delivers the highest Mode 1 attenuation value meanwhile FLC gives highest attenuation value of mode 2 and 3. The first mode, however, is dominant and contributes considerable effect to the system. In general, FTSMC displays dominance over FLC

Table 2.Parameters and Vibration Suppression performance for DLRF Program

Controller's		**Parameters**			**Rise Time**	**Attenuation of amplitude at natural frequency (Db)**		
		KP	KI	KD				
						1st	2nd	3rd
FLC	L1	28.10	55.07	89.05	6.879e-07	36.18	66.9	66.6
	L2	48.09	44.88	21.98	7.432e-08	38.5	83.7	84.6
FTSMC	L1	3.15	456.1	2.78	4.978e-08	44.9	28.5	12.3
	L2	8.16	834.9	1.99	5.110e-08	44.24	44.43	33.6
ZN	L1	7.2	21.176	0.612	2.82e-06	8.9	41	40.9
	L2	16	55.08	1.281	7.564e-07	11.8	53.3	54.4

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			2					

3. Conclusion

This paper describes the Fuzzy Controller and FTSMC Neuronal Configuration. Fuzzy controller and FTSMC are used for manipulator controlling of trajectories with a rigid and fluid joint.Standard FC has three simple set of fuzzification inputs, set of rules and output collection. This paper finds the two- link manipulator to be robust when dealing with external disturbances. A fast nonsingular terminal sliding mode control (FNTSMC) is proposed to solve the directing monitoring problem which may increase convergence time compared to conventional terminal sliding mode control (NTSMC).Lyapunov's theorem provides evidence of system reliability. MATLAB's simulation findings show that the compact manipulator performs good trajectory control and has a strong robustness to minimize disruption. The suggested controller for the sliding mode is continuous and thus chatter-free.Furthermore, a HNN- optimization strategy for design of PD controllers in the FLC and FTSMC controller incorporated with end-point acceleration feedback paths of the control structure has been investigated and the performance of the developed control approach has been assessed in comparison to previously reported PID-ZN control, and it has been demonstrated that good performance is achieved with the proposed approach. The control scheme has been shown to perform well in reducing endpoint modulation noise, angle error and vibration reduction at endpoint.

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ISSN: 2233-7857 IJFGCN