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Controlling the Arm of Flexible Robot by using New Hybrid Approach

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Abstract

Background/Objectives: The combination of fuzzy logic and neural networks enables the system to have the capability of learning and adapting to the environment, as well as tolerating the imprecise circumstances which is an advantage of fuzzy logic methods. The objective is to control robot's claw with two movable arms. **Methods/Statistical Analysis**: A new hybrid approach is proposed to control the arm of flexible robots by using neural networks, fuzzy algorithms and particle swarm optimization algorithm. **Findings:** As a result of the recommended network, the values of 91.353e-5 and 0.030255 have been recorded for MSE and RMSE, respectively. **Applications/Improvements:** It was simulated to control the movement of a robot with two arms in a completely flexible manner in which the network can be momentarily trained by moving the rotation ring.

Keywords: Controlling the Flexible Arm, Fuzzy Neural Networks, Particle Swarm Optimization Algorithm, Soft Computing

1. Introduction

Soft computing is the combination of fields including fuzzy logic, neuro-computing, evolutionary procedures, genetic computing and statistical computing[1–4]. This combination of methods to model complex systems, which otherwise impossible or very hard by applying computational regulations of pure mathematics and hard logic, while the applicable simulation and practical implementation can be conducted by using soft computing methods[5,6].

The advantage of soft computing is the behavior it shows toward uncertain, approximate and relative systems. It leads to human-like behaviors which are highly generalizable. The development procedure of the boundaries of soft computing field is shown in Table 1.

Unlike hard computing, soft computing is well-flexible against imprecision, approximation and partial truth. The importance of using soft computing methods is clarified when non-linear systems and complex physical structures can be modeled more precisely and flexibly at a lower cost and in a shorter period of time, so they match with elite human decisions in a high correctness percentage[7,8].

The only noteworthy matter is that soft computing is not precisely a concoction, mixture or combination, while it is considered to be a type of cooperation in which each member moves toward the desirable objective in its unique way. The main principle in soft computing is complementation, not competition. Therefore, soft computing is considered to be a foundation emerging in perceptual intelligence[9].

2. The Recommended Control System

Integral and derivation operands are frequently used in controlling the smart robot. These operands, which are known as common methods in control systems known as PID, are simulation and maintained in non-classic methods in terms of general structure.

Unlike fuzzy logic controllers which are described in[10,11], a great deal of input and output variables are used. It is because each section is fed by more than one input in systems with high connectivity. Therefore, a multi-variable

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Table 1. Development of soft computing boundaries[5–8]

Method	Presenter	Year
Neural Network	McCulloch	1943
	+	
Evolutionary Computing	Rechenberg	1960
	+	
Fuzzy Logic	Zadeh	1965
	=	
Soft Computing	Zadeh	1981

fuzzy controller is designed[12,13] to control such situation in this system (MIMO). The usual procedure of designing these systems is in a way that the general system is divided into some sub-systems which are Multiple Input Single Output (MISO)[14,15]. Each of these sub-systems goes through the path from input to output in a parallel and coordinated manner[16]. In the proposed method, the minimal values of membership functions are selected in accordance with three reference values and then the maximizing value is applied. MIMO structures of fuzzy logic controller are shown in Figure 1 for the flexible control of multi-connectional hard connections[17,18].

Two consecutive links (i *and* $i+1$) are assumed in Figure 1. FLC of input i include angle error connection ($e_i = \theta_{di}$-θ_i) and acceleration signal at the tip (toe) of a_{ti}. The scale factor is related to the tracking error, acceleration at tip and input torque for FLC of input i. It is respectively equal to k_{pi}, k_{ai} and k_{ti}. FLC of input $i+1$ also follows the procedure of input i and controls its relevant output. It is recommended that scale factors be normalized in period [−1, 1], so the computing process becomes easier[19].

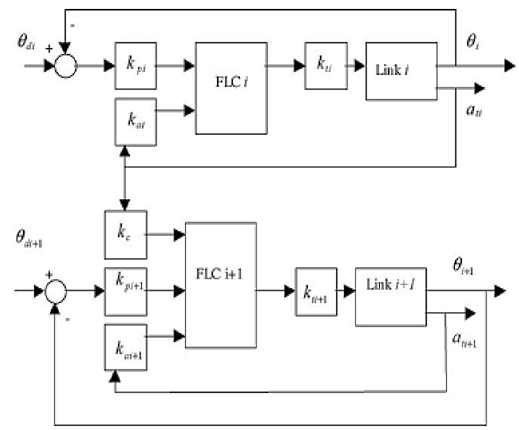

Figure 1. MIMO structure of coupled fuzzy controller.

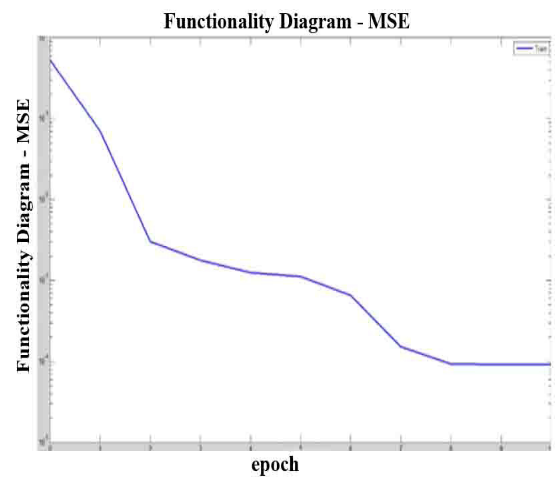

Figure 2. Changes in parameter MSE.

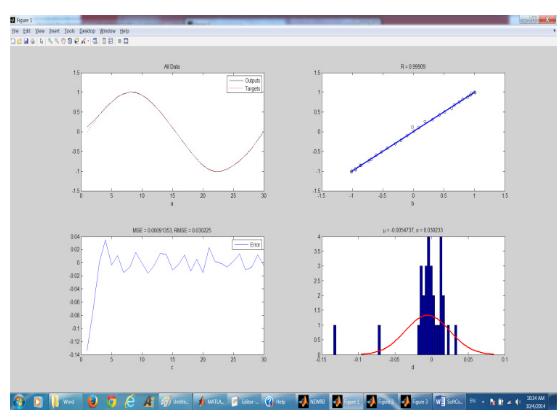

Figure 3. Neural fuzzy network outputs for all data: (a) Difference between real and target output of all data; (b) Regression; (c) MSE; and (d) Changes in values of μ and σ as Gaussian Functions of RBF Network in Training.

3. Simulations

After training RBF neural network with PSO method, the real output error is shown in Figure 2 with target output after 10 epoch repitition.

Given the type of problem, extracting the parameters MSE, RMSE and regression can indicate the behavior of robot's claw along the assumed path, so Figure 3 is considered.

The final values of MSE, RMSE and regression are indicated in Table 2.

The considerable improvement of proposed network can be observed in Table 3 by taking a look at previous activities.

In a two-dimensional input space with two connection arms having specific coordinates, the main problem is to find two involved angles. The first angle is the one between the first arm and the horizon, while the second angle is the one between the first arm and the second arm. The assumed arm is indicated in the general schema (Figure 4).

Given the structure of a flexible arm with two connections, a neural network learns to map the coordinate (x, y) on θ_1 and θ_2. The trained Anfis network is one part of a control system which is responsible for controlling the robot's arm. Knowing the desirable position of arm tip, the network is responsible for generating the optimal values of angles and applying the necessary force in the correct direction in order to reach those angles so that it can guide the arm tip to the desirable position. We assume that θ_1 is the angle between the first arm and the ground, while θ_2 is the angle between the second arm and the first arm. For instance, we assume that the minimal length of the first arm is 11 cm and the length of the second arm is 12 cm. We also assume that the first arm is able to rotate from 0 to 90 degrees and the second angle varies between 0 to 180 degrees. Therefore, Figure 5 explains this[20].

Table 2. The values of parameters in the recommended neural fuzzy network

Test Data	Training Data	All Data	
0.99687	0.99999	0.99999	Regression
281.25e-5	9.9841e-5	91.353e-5	MSE
0.053029	0.009992	0.030255	RMSE

Table 3. The considerable improvement of proposed network

RMSE	MSE	
0.053029	281.25e–5	Current Project
–	2.003e–2	Mote, T. P. *et al.*[17]
44.67e–1	6.6667e–2	MOHAMED, M. J. *et al.*[18]
–	0.0637	Bazargan, A. *et al.*[19]

Now we should be able to define the coordinates of x and y for the system. Therefore, we have:

$$X = L1 * \cos(\theta_1) + L2 * \cos(\theta_1 + \theta_2) \quad (1)$$

$$Y = L1 * \sin(\theta_1) + L2 * \sin(\theta_1 + \theta_2) \quad (2)$$

Now we can generate the sum of data through Equation 3:

$$\text{Data } 1 = [X, Y, \theta_1] \quad (3)$$

$$\text{Data } 2 = [X, Y, \theta_2] \quad (4)$$

Figure 6 indicates the position of arm tips in connection points:

Now we should observe the real performance of claw in the positions specified in the previous figure (Figure 7).

Given these figures, it is now clarified that robot claw is able to go through the path specified by training points.

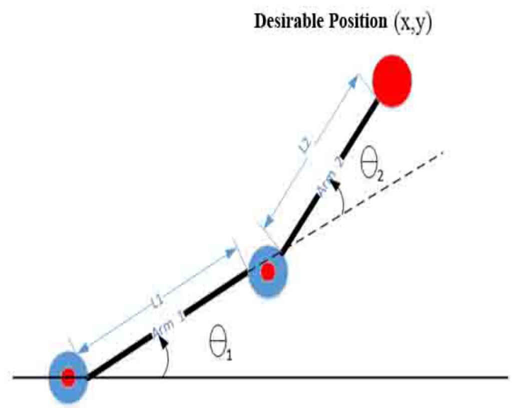

Figure 4. The flexible arm with two connection arms.

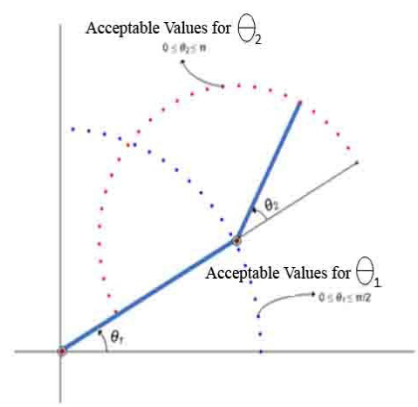

Figure 5. Conditions considered for the rotation of robot arms.

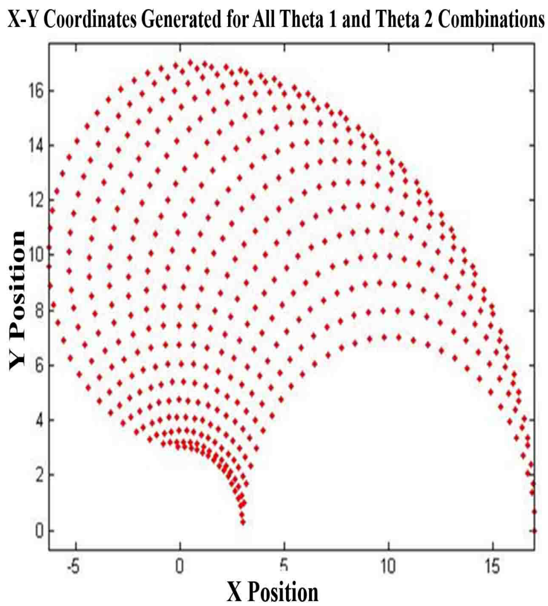

Figure 6. Position of X's and Y's of the claw for the values of the first and second angles.

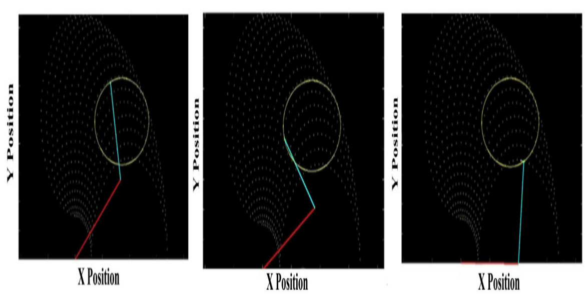

Figure 7. Claw movement on a ring assumed by using the proposed network.

4. Conclusion

A hybridized method of neural fuzzy network has been used to design a controller in this system. In this method, PSO algorithm was used to decrease error and time in order to generate neural network factors. It was simulated to control the movement of a robot with two arms in a completely flexible manner in which the network can be momentarily trained by moving the rotation ring. This network was designed in five layers. It was simulated to control the movement of a robot with two arms in a completely flexible manner in which the network can be momentarily trained by moving the rotation ring.

5. Reference

1. de Pedro T. Fuzziness in CAR: Fuzzy procedures for robots and cars, in Enric Trillas: A Passion for Fuzzy Sets. Switerzerlad: Springer International Publishing; 2015. p. 301–13.
2. Lochan K, Roy B. Control of two-link 2-DOF robot manipulator using fuzzy logic techniques: A review. Proceedings of Fourth International Conference on Soft Computing for Problem Solving. Springer, India. 2015; 335:499–511.
3. Oniz Y, Kaynak O. Control of a direct drive robot using fuzzy spiking neural networks with variable structure systems-based learning algorithm. Neurocomputing. 2015 Feb; 149(Part B):690–9.
4. Di Mario E, Navarro Oiza I, Martinoli A. Distributed particle swarm optimization using optimal computing budget allocation for multi-robot learning. IEEE Congress on Evolutionary Computation; Sendai. 2015 May 25-28. p. 566–72.
5. Vahdani B, Tavakkoli-Moghadam R, Meysam Mousavi S, Ghodratnama A. Soft computing based on new interval-valued fuzzy modified multi-criteria decision-making method. Applied Soft Computing. 2013 Jan; 13(1):165–72.
6. Datta S, Chattopadhyay P. Soft computing techniques in advancement of structural metals. International Materials Reviews. 2013 Nov; 58(8):475–504.
7. Wilk T, Wozniak M. Soft computing methods applied to combination of one-class classifiers. Neurocomputing. 2012 Jan; 75(1):185–93.
8. Ahmad I, Abdullah A, Alghamdi A, Hussain M. et al. Optimized intrusion detection mechanism using soft computing techniques. Telecommunication Systems. 2013 Apr; 52(4):2187–95.
9. Giacomin PAS, Hemerly EM, Pedrycz W. A probabilistic approach for designing nonlinear optimal robust tracking controllers for unmanned aerial vehicles. Applied Soft Computing. 2015 Sep; 34:26–38.
10. Lin J, Lewis F. Fuzzy controller for flexible-link robot arm by reduced-order techniques. IEE Proceedings-Control Theory and Applications. 2002 May; 149(3):177–87.
11. Renno JM. Inverse dynamics based tuning of a fuzzy logic controller for a single-link flexible manipulator. Journal of Vibration and Control. 2007 Dec; 13(12):1741–59.
12. Ren YQ, Duan XG, Li HX, Philip Chen CL. Multi-variable fuzzy logic control for a class of distributed parameter systems. Journal of Process Control. 2013 Mar; 23(3):351–8.
13. Xinping L, Xiaodong Z. Multi-variable fuzzy controller for water tank temperature control system. JDCTA. 2012 Jul; 6(13):82–8.
14. Sangfeel K, Eunji S, Kyung Sik K, Byung Seop S. Design of fuzzy logic controller for inverted pendulum-type mobile

robot using smart in-wheel motor. Indian Journal of Science and Technology. 2015 Apr; 8(S5):1495–503.

15. Wong DHT, Chee CM. Usable, flexible and adaptive network data visualization design for multiple levels of computer users. Indian Journal of Science and Technology. 2015 Jul; 8(15):1-7.
16. Kaur A, Kaur A. Comparison of fuzzy logic and neuro-fuzzy algorithms for air conditioning system. International Journal of Soft Computing and Engineering. 2012 Mar; 2(1):417–20.
17. Kordrostami S, Noveiri MJS. Evaluating the efficiency of decision making units in the presence of flexible and negative data. Indian Journal of Science and Technology. 2012 Dec; 5(12):3776–82.
18. Bazargan A. Design, development and human analogous control of a climbing robot. Canada: University of Regina; 2012.
19. Kasaeipoor A, Ghasemi B, Aminossadati SM. Convection of Cu-water nanofluid in a vented T-shaped cavity in the presence of magnetic field. International Journal of Thermal Sciences. 2015 Aug; 94:50–60.