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A Design and Analysis on Dual Thumb Pneumatic Flexible Robot Hand Base on Active Flexible Bending Joints

Jian CAO[1], Xiao-peng GONG[2], Sen ZHAO[2] and Ang QIU[1,*]

[1]Air Force Engineering University, Xi'an, Shaanxi Province 710051, P.R. China

[2]Jiangnan Design and Research Institute of Electrics and Machinery, Gui Yang, Guizhou Province 550009, P.R. China

*Corresponding author

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Abstract. Conventional Proportional Integral Derivative (PID) control is often used in present industrial field. Fuzzy rules and its inference mechanism are the assurance of achieving feature fusion. The flexible joint is composed of four elongation artificial muscles with parallel arrangement. The robot hand has five multi-actuated fingers each with three flexible joints. Because the control parameters are fixed, the tuning results are difficult to meet the demands and the system is unstable or even out of control. This paper has a design and analysis on the dual thumb pneumatic flexible robot hand base on the active flexible bending joints we have developed. In this paper, Matlab is used to confirm that the fuzzy control system has good adaptability and anti-jamming capability.

Introduction

Flexibility and universality are two characteristics of robot hand we developed. All joints of robot hand are pneumatic and flexible which improve the flexibility of robot hand; the universality is implemented by the amount and arrangement of fingers [1,2].

The flexible joint we developed is mainly composed of four elongation artificial muscles and flanges, with two ends fixed on the flanges. It can axial elongate and bend two-dimensional two-way control in space simultaneously, and it has three degrees of freedom. Through controlling the air pressure of the four artificial muscles, the joint can bend anti-stretch, abduct and adduct. For example, ensuring the air pressure of muscle is equal to muscle and more than muscle and muscle simultaneously, the joint can bend about Y-axis. The degree of bending is determined by the pressure differential controlled by the proportion valve. The bending of joint behaves like the nonlinear beam with large deformation which is characterized by the elongation of axis and the bending angle of the end [3, 4].

Genetic algorithm (GA) is an effective probability searching algorithm based on the natural selection and the genetics principle, and it carries on the search and the optimization through the simulation organic evolution, and it automatically gains and accumulates the related knowledge of searching space in the searching process, and it controls the searching process to obtain the optimal solution of the question [5].

The simulation and experiments verifies the model and the grasp capability of robot hand. The robot hand we developed has good flexibility and compliance, and easy to soft control, which provide a new way to solve the entire flexibility of robot hand. This algorithm has many characteristics such as automatic identification of antigen, feature extraction, the diversity of immune body, distributional examination, learn and memory, self-plan etc, and it is also parallel distributional self-adaptive system which has the great potential in the application of intelligent computation. In recent years the immunity genetic algorithm has obtained the widespread application in many domains because it can effectively maintain the diversity of population and eliminate not mature astringency and the oscillatory occurrences. The reference presented an immunity genetic algorithm which extracts vaccine from the system knowledge and vaccinates to the evolution process, thus, it can fully use the system message, but the algorithm has not considered the diversity of population which influences the evolution process.

Structural Design on Finger of Robot Hand

In Figure 1, the flexible finger is made of three pneumatic flexible joints connected in series, with the two ends of joint fixed on the wedge plate. One finger has one degree of freedom and two degrees of maneuvering. Thanks to the wedge angle of wedge plate, the bending angle about the orthogonal directions will increase to 3 ±120° at the maximum working pressure, which greatly improve the flexibility and grasp range of robot hand.

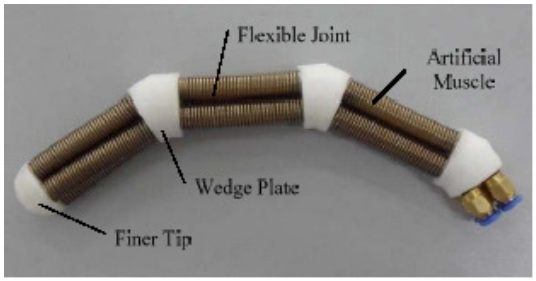

Figure 1. Structure of finger.

Design and Simulation of Fuzzy Control System

Operators need three procedure parameters to control drum water level deviation between actual drum water level, variation of confluent and steam flow. According to above parameters, operators observe water level, evaluate the equilibrium relation between water injection and steam flow, and then operate the master control injection valve to increase/decrease water volume. Above empirical process of ideation of human being should be reflected by designing of fuzzy controller. The experience form previous experiments showed that regulating drum water and changing steam flow should be at the same time. When designing fuzzy control system, it just considers the relationship between steam flow and variation of water level in system adjusting structure, i.e. just reflects double impulse control system, and the estimation and adjustment of feed water flow was not considered in drum level major loop system. According to this analysis, fuzzy control system as shown in Figure 2 was built. In this system, because limited change of water level under field situation could not change in the whole range of water level, a limiting structure joined in step of water level deviation. Suppose the change of amplitude in the range of [-0.3 0.3]. Inputs of Mux1 are water level deviation and variation of water level deviation, Ke is the quantification factor of water level deviation, Kc is the quantification factor of variation of water level deviation, Ku is the quantification factor of output of fuzzy controller. Inputs of Mux2 are the system given signal and system output signal, the track response ability is easy to observe through the results of numerical simulations by using oscilloscope.

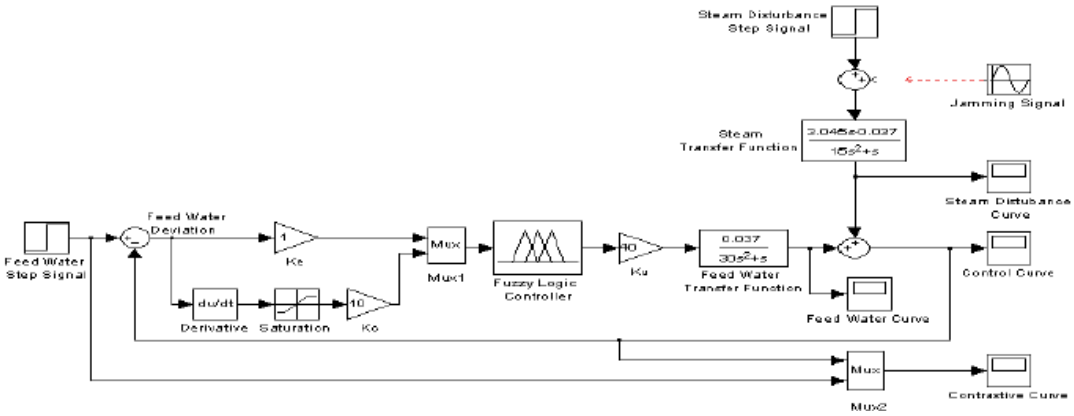

Figure 2. Structure of fuzzy control system.

Because the value of Ku, which is the output scaling factor of fuzzy controller, influences greatly the system performance, it is able to meet system fast response requirement with larger Ku. System response curve is received and shown in Fig.3 at the time of keeping the value of K_u =1, K_c=10, K_h=40. At this moment, there is no overshoot, have small setting time and response time, but remains about 2.5% static error in system. It can be observed that the properties of fuzzy control system are improved obviously. Moreover, it just needs to adjust two parameters to achieve better performance after establishing fuzzy rule.

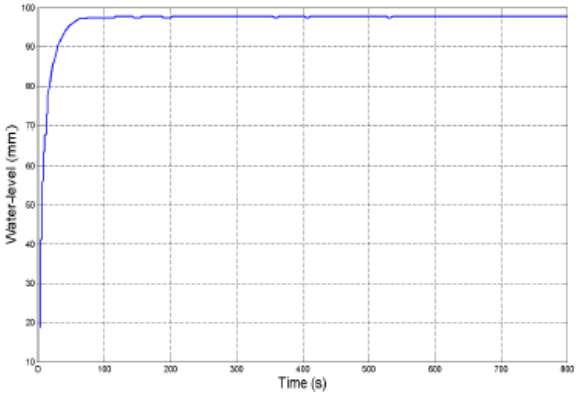

Figure 3. Fuzzy control system response graph.

Anti-jamming Capability of Fuzzy Control System

Add small amplitude sinusoidal interference signal as shown in Figure 4 response curve of conventional fuzzy control system is represented in Figure 5.

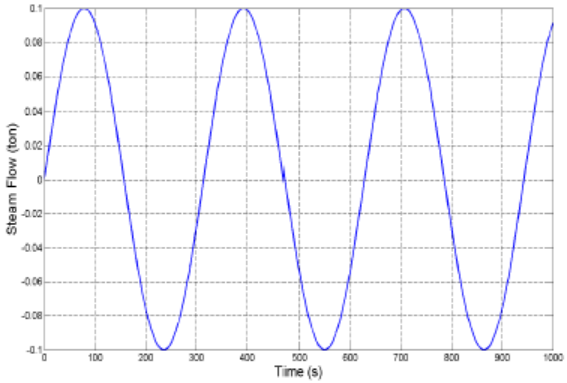

Figure 4. Interference signal with small amplitude.

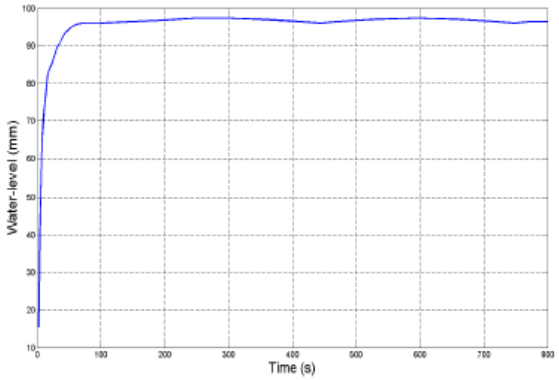

Figure 5. Conventional system response graph with interference.

Compare Figure 3 with Figure 5, it is shown that conventional fuzzy system has minor fluctuation around desired value and the overshoot of fluctuation is in the range of permitted errors. However, there is little change in rise time and accommodation time. All these facts suggested that fuzzy control system posses better dynamic performance and good robustness.

Summary

This paper proposed a dual-thumb pneumatic flexible robot hand. The algorithm can improve the search speed because chaos is introduced in the initial population and diversity adjustment. The algorithm can carry on the local optimization and increase precision nearby the optimal solution. The result of experiment shows the algorithm validity. We can draw a conclusion from experiment comparison, the paper's algorithm makes average movement algebra small, and the algorithm overcomes the shortcoming of slow convergent speed which generic algorithm has, and the algorithm is superior to convergent speed of immune genetic algorithm. The simulation results and the experiments prove the validity of the theoretical model. Through simulation curves, it could be indicated the effectiveness of fuzzy control strategy. It has short transient time, small overshoot and high anti-jamming capability. Meanwhile, it would overcome the effect of steam flow disturbance which fully reflects the characteristics of fuzzy control. During running process, even though there have be some problems such as steady-state error and small fluctuation, they could be settled down completely through further increasing number of input/output fuzzy subset, modifying fuzzy control query table and working point. Obviously, fuzzy control method has a good application prospect.

References

[1] Olfa Nasaroui, Fabio Gonzdez, Dipankar Dasgupta .The Fuzzy Artificial Immune System: Motivations, Basic Concepts and Application to Clustering and Web Profiling [J].Fuzzy System 2012, 1(2):711-716.

[2] Leandro N, Castro De Timmis J. Artificial Immune System: A Novel Computational Intelligence Approach [M]. Springe–Verlag 2010.

[3] S. Wang, D. Yang, Z. Liu and D. Luo, "Simulation Study on High Dynamic GPS Software Receiver," The International Journal for Computation and Mathematics in Electrical and Electronic Engineering, vol. 28, iss. 6, pp. 1386- 1401, 2009.

[4] J. Li, X. Ba, S. Anjum and J. Chen, "Adaptive PLL Based Carrier Tracking Algorithm for GPS Signals in High Dynamic Environment," Chinese Journal of Electron Devices, vol. 30, no. 4, pp. 1440-1443, August 2007.

[5] Luo Zhi-yong, "Application of Fuzzy-pid Control in Water Level Control", Computer Applications and Software vol. 4 No. 1, pp. 200-202, 2009.