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Position Control Of A Dual Parallel Mechanism For A Nursing Robot

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ABSTRACT: *In this paper, the micro-position change of double parallel mechanism caused by the change of load quality and density of nursing robot is studied, and thecharacteristics of stable, stable and safe operation of nursing bed need to be guaranteed. A current feedforward channel is proposed to predict the overshoot of position change of double parallel mechanism. By adjusting the control factor of the fuzzy controller, the stable operation of the main loop of the position control of the double parallel mechanism is ensured. The experimental results show that the current curve, load curve and position curve of parallel mechanism are improved obviously.*
KEYWORDS: *Nursing Robot dual parallel mechanism fuzzy control position change*

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I. INTRODUCTION

With the intensification of population aging in China, the number of elderly people and disabled people is increasing. The demand for nursing robots in hospitals, nursing homes, communities and families is also increasing. How to ensure the safety, efficient and stable operation of nursing robots has become a key issue in this research field. Parallel mechanism of nursing robot is its key component. Only by real-time detection and control of the load change of parallel mechanism can the torque change of the mechanism be controlled, so that the position of parallel mechanism will not change greatly, so as to ensure the stable operation of Nursing Robot [7].

II. CHARACTERISTICS AND STATUS QUO

2.1 mechanism configuration and characteristics

The parallel mechanism described in this paper is an arc-shaped mechanism composed of two parallelograms, which is controlled by a servo motor. Nursing robots serve a variety of elderly people and disabled and semi-disabled people. Because of the different body mass and body shape, the load and load distribution of the dual parallel mechanism of nursing robots are different, which results in the change of the torque of the parallel mechanism of nursing robots, and thus micro-occurs. Small displacement changes. This tiny change and uncertainty can hardly be detected by [6].

2.2 control status

At present, the double parallel mechanism of nursing robot is mainly controlled by servo motor. In order to ensure the smooth operation of the double parallel mechanism, the servo motor controls the speed, position and moment. The servo motor gives the corresponding number of pulses to the parallel mechanism to ensure the stable operation of the mechanism. At present, encoder detection or image recognition detection are widely used in position change detection. The principle of encoder detecting position change is to calculate the fixed number of pulses emitted by the encoder reading of the starting and stopping position of the equipment when the encoder rotates. Generally, the high-speed counter is used to calculate the number of pulses when the encoder rotates. When the encoder is measured, the position difference between the two devices with double parallel mechanism can be obtained by adding the encoder to read the difference of the pulse value of the encoder in one rotation cycle. But this monitoring method can only get the position change after rotation, and can not detect the double parallel mechanism in real time. The loosening of the encoder will cause the instability of the feed motion and affect the control of the servo motor. In order to detect the change of position in image recognition, it is necessary to recognize the captured image. By extracting the eigenvalues, we can judge whether there is a change of position by comparing the small changes of the eigenvalues. But it takes time for image processing to judge, so the detection of the change of position is too late. For the above problems, the photoelectric switch is used to detect the real-time change of position, which makes the real-time control of position possible [9,10].

2.3 current questions

Due to the uncertainty of the load of the nursing robot, overweight or lightweight, or too high or too low height will exert different degrees of pressure on the parallel mechanism, thus making a slight change in its position. In the process of operation, some or all of the parallel mechanisms will temporarily stagnate due to the slippage or clamping of the lead screw, which will also lead to too large or too small changes in their position. In the course of operation, the photoelectric switch restricts the limit of parallel mechanism, and plays its role when the parallel mechanism reaches the maximum angle of the mechanism. It ensures that the two parts stop at the same position. However, the uncertainty of the position of the photoelectric switch after all the pulses of the servo motor will also affect the parallelism. The location of the institution. This greatly reduces the stability and stability of dual parallel mechanisms. The main reasons for the problems are: (3 points)

A. Because of the different nursing objects and the different load density and stress points of each part of the nursing robot, its dynamic model and motion trajectory are difficult to describe statically, and it is difficult to establish a definite control model and servo loop.

B. Because the servo control is realized by the number of pulses, and the relative position of the parallel mechanism is adjusted proportionally, the current stability is an important factor to ensure the position and change rate of the two mechanisms.

C. In order to ensure the stability of the system, three kinds of limit modes, i.e. pulse number, power-off switch and mechanical limit, are adopted. However, there are mutual restrictions among the three modes, such as inconsistency or even conflict between the limit of photoelectric switch and the end of pulse operation.

III. DESIGN OF FUZZY CONTROLLER FOR POSITION CONTROL OF DOUBLE PARALLEL MECHANISM

In recent years, with the rapid development of artificial intelligence technology, the problems that are difficult to solve in practice are handed over to the computer, which imitates the human brain for thinking and reasoning, thus realizing the fuzzy control of complex problems.

3.1 fuzzy controller

Fuzzy controller can be used in pulse number and photoelectric limit regulating circuit. Because the position control process of double parallel mechanism is complex and real-time changes, the number of pulses and photoelectric control should be adjusted with the position change of parallel mechanism. If the photoelectric switch is not set, the initial position of the servo motor may be dislocated after a round trip, which will change the position of the parallel mechanism. Therefore, the position that parallel mechanism should reach is decided by photoelectric switch. When the number of pulses set by servo motor has gone away and the limit of photoelectric switch has not arrived, the photoelectric of the system has not triggered, so the upper computer system generates photoelectric alarm, and the fuzzy controller controls the proportional coefficient of the number of pulses through internal adjusting parameters to make the pulse. Increase to reach the photoelectric position. If the photoelectric switch has reached the limited position before the set pulse is finished, it proves that the parallel mechanism has reached the limited position. If the pulse is further taken, there may be potential safety hazards, which will affect the stability of the nursing bed. Therefore, in order to ensure that the parallel mechanism can run stably and return to the initial position without position offset, a pulse optoelectronic fuzzy controller is designed.

In the process of parallel mechanism operation, the sampling period should be longer in order to obtain an accurate position control law. In a running cycle, the number of times to control is more, so the sampling time is considered to be about 1/5. Sampling for three minutes, the sampling deviation is $d(k)$, the sampling deviation is $d_c(k)$, the change of its speed is $v(k)$, the following is used d , d_c, and k expressed, its fuzzy subset is used, D, D_C and K expressed [3].

The fuzzy sets M are {NB, NM, NS, NO, PO, PS, PM, PB},the fuzzy sets N and P are all N, and are all of them.

If the basic domain of deviation D is {-x_d ,x_d }, the basic domain of deviation change d_c is {-x_u ,x_u }, and the basic domain of controlled quantity K is{-x_u ,x_u }. The position control value and setting deviation of the parallel mechanism D of the fuzzy controller X are {-p,-p+1,…1,0,…,p-1,p}; the range of variation D_C is Y ={-q,-q+1,…0,…,q-1,q}; the control area Z is {-l,-l+1,…,0…,l-1,l}。

The above parameters are determined according to the running status of parallel mechanisms. Firstly, the continuity of the position control process is considered. In order to make the fuzzy subset of the fuzzy variables cover the universe better, the number of quantized levels needs to be sufficiently large. Thirdly, considering the complex process and the limitation of some programs in the control process, and referring to the similar theory of successful control (when the fuzzy subset of the fuzzy variables covers the universe better, the number of quantized levels needs to be sufficiently large When the total number of elements in the universe is 2-3 times of the total number of fuzzy subsets, the distribution of each fuzzy subset in the universe is more reasonable.

The number of subsets of the fuzzy D, D_C, K set is 8,7,7 respectively. The number of elements in the domain of the fuzzy subset of the deviation and its variation is 13 (p=q=6), and the control quantity is 15 (l=7) according to the characteristics of the control object.

To deal with the deviation and variation of input variables, it is to use fuzzy factors to multiply input variables. The position control of the dual parallel mechanism of nursing robot is improved step by step based on field experience. For example, "If the change of position is large and there is a tendency to continue to increase, the number of pulses will be reduced". How to adjust the control according to the quantitative factors?

The principle of determining the change of position control is that when the deviation of position change is large or too large, the control quantity should mainly eliminate the deviation, while when the deviation of position change is small, the control quantity should avoid overshoot and take the stability of the system as the starting point.

The non-fuzzification of position change control variables and the decision-making method adopt Mamdani reasoning method [1,2], and the fuzzy subset of the control variables (the fuzzy quantity of position control variables) is determined. The control rules of the two-dimensional fuzzy controller with two inputs and one output can be written as the following conditional statements:

if $E = M_i$ $E_C = N_i$ then $K = P_{ij}$ (i=1,2,….,8;j=1,2,…,7)

Formula: M_i, N_i, P_{ij} represent error, error change and position change control domains respectively. On the fuzzy set, then:

$$R = \bigcup_{i=j} M_i \times N_j \times P_{ij}$$

Membership function:

$$u_R(x,y,z) = \bigvee_{i=1,j=1}^{i=8,j=7} u_{Mi}(x) \wedge u_{Ni}(y) \wedge u_{Pij}(z)$$

$$(x \in X, y \in Y, z \in Z)$$

If it is taken as time, according to the synthesis rule of fuzzy reasoning, the change of control quantity of position change is as follows:

$$K = (A \times B)R$$

Membership function:

$$u_{ij}(Z) = \bigvee_{x \in X, y \in Y} u_R(x,y,z) \wedge u_A(x) \wedge u_B(y)$$

In order to calculate the position control quantity, we adopt the maximum membership method in the process of de-fuzzification. Then the control table is obtained by changing the corresponding control variables in the combination of all elements in the set. The change of control volume is calculated in advance by computer. After fuzzing the error and error value, the position is controlled in real time. The change of the control quantity can be obtained by looking up the table, then multiplied by the scale factor, so as to modify the control parameters of the parallel mechanism as a controller, so as to realize the stable operation of the parallel mechanism.

3.2 position vector controller

Parallel mechanism is controlled by servo motor. Solving the problem of AC motor torque control by vector control theory of servo motor is the core of vector controller. By controlling the stator current vector of the motor, the position vector controller controls the torque current according to the principle of field orientation, and then controls the torque of the servo motor, so that the parallel mechanism can run smoothly. During the operation of parallel mechanism, because of the individual difference of the nursing robot's carrying capacity, the difference of its weight and height, the difference of the nursing bed's load weight and density is great. Therefore, the torque of parallel mechanism changes slightly during the operation. The torque current is controlled by the magnetic field orientation principle of servo motor, and then the torque current is controlled. The torque of parallel mechanism is controlled to control its position. The change of the torque will affect the parameters of the membership function of the fuzzy controller, so the process is as follows: position vector controller.

As shown in the diagram, the torque current of the servo motor does not change and the pulse is constant at no load. The vector controller has no effect, the torque current coefficient a is 1, the servo motor speed is constant, and it runs smoothly. When the load is added, the torque coefficient K increases, which results in a slight change in the torque and position of the parallel mechanism. By adjusting the current coefficient a, the vector controller can increase or decrease the speed of the servo motor, i.e. change the number of pulses, so as to reduce the position gap of the parallel mechanism and ensure that the parallel mechanism can resume stable operation in a short time [8]. In this process, the control model process can be expressed as:
LoadM↑, ΔX↑, torque coefficientK↑, controller control torque current coefficient a↑, ΔX↓

3.3 mechanism cross limiting controller

The parallel mechanism in this paper is two parallelograms which are cross connected. The nursing bed can turn over in two directions. In parallel institutions, they turn left or right. When turning left, the parallelogram on the left turns up at a larger angle, while the parallelogram on the right falls down at a certain angle. The overturn action is controlled by a motor, which drives the slider, which drives the screw to run a certain distance to the left. When the position of the photoelectric switch arrives, the parallelogram stops rotating. When the left turns down, it returns to the position of the plane, and the motor drives the slider back to the initial position. When turning right, it is similar to turning left, the parallelogram on the right turns up at a larger angle, and the parallelogram on the left falls down. The motor drives the slider to slide right to the middle position, and returns to the initial position when falling. During the operation of the mechanism, the limit of the mechanism is certain. After determining, the maximum angle of the mechanism is fixed. Its operation parameters are determined by the position of the photoelectric switch and the pulse sent by the servo motor

IV. DEBUGGING OF THE SYSTEM

The control system in this paper adopts multi-loop adaptive control mode. The parameters in the loop affect each other. In order to ensure the stable operation of parallel mechanism, the following adjustments can be made.

4.1 main adjustment loop

In the position of pulse and photoelectric switch, the final position of the mechanism is determined by photoelectric switch. $u_A(x) = e^{-(\frac{x-a}{b})^2}$ The number of pulses is given at first. When the position offset occurs, the number of pulses is adjusted by the fuzzy controller. The final position is determined by the position of the photoelectric switch.

4.2 modulation fuzzy control factor

The fuzzy control function of the fuzzy controller is Gauss membership function, and the position change curve obeys the standard normal distribution. Usually, the position change simulation curve of parallel mechanism before and after the fuzzy control is taken as b=1, a=0. Figure 4 is as follows [4,5].

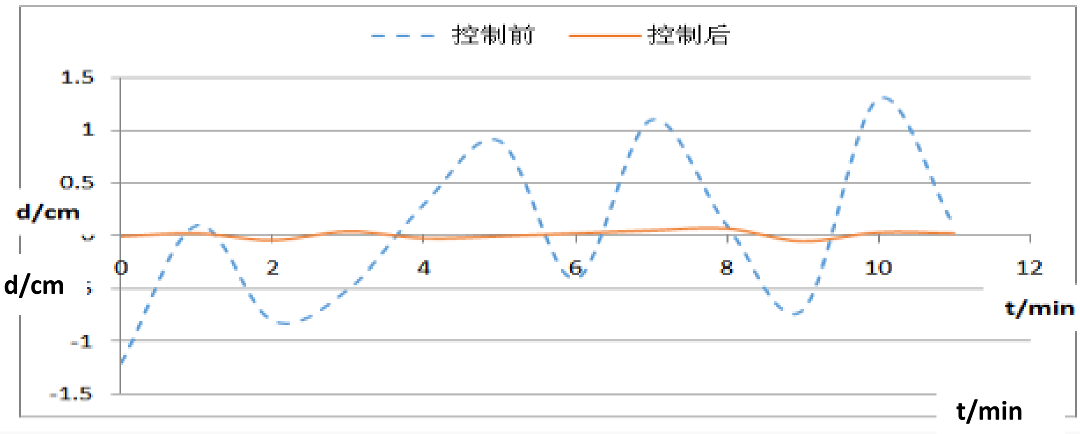

Fig. 4 position change simulation of parallel mechanism before and after fuzzy control3.3 adjusting proportionality coefficient

In position vector control, the position of parallel mechanism changes because of the load of the system, which results in the change of the torque and the increase of the torque coefficient. Through the position vector controller, the torque current coefficient a is adjusted to increase, thus speeding up the operation of the mechanism and reducing the position gap, thus ensuring the stability of the parallel mechanism. The purpose of adjusting the proportional coefficient and adjusting the position difference of the main loop is realized.

4 concluding remarks

One year after the design and operation of the parallel mechanism, the system is controlled by the photoelectric switch, and the proportion coefficient of the pulse is adjusted, so that the number of the pulses of the system changes and the difference of the position changes becomes smaller. The position vector controller reduces the change of the torque by adjusting the current of the torque, and restores the small change of the torque in a very short time, thus ensuring the stable operation of the system. On the premise of guaranteeing the stable operation of the system, the maximum angle of the system operation does not exceed the mechanical limit value of the mechanism. At the same time, it realizes the control of the left and right turn by a motor. The three kinds of controllers ensure the stable operation of the system, which can be well reflected from the position change curve.

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