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Research on Active and Passive Mode Design of Rehabilitation Robot

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Abstract: In order to meet the needs of limb rehabilitation, the active and passive training mode of the limb rehabilitation training robot was designed. The structure of the prototype and the hardware components of the system are briefly introduced. The design ideas and implementation methods of the core motion mode are expounded. Through the prototype experiment, the current and speed data of the motor are collected to verify the feasibility of the active mode and the passive mode.

1. Introduction

With the increase in the total number of people in Japan and the growing problem of aging, as well as other factors including environmental factors, the total number of disabled people in China is increasing year by year. Since persons with disabilities are a special group, they have defects in certain aspects of the body and are at a disadvantage in society. How to restore them to health is a problem to be solved, which has become the focus of attention. The incidence of physical disability in the disabled population is very high. Rehabilitation training is an important treatment for patients with physical disabilities, which can promote the plasticity of the brain function of patients, which is especially important for the recovery of patients' condition. As a new type of medical tool, rehabilitation robot is gradually approaching people's lives. It has the advantages that traditional therapists do not have. It has changed the traditional rehabilitation mode with its highly intelligent and objective evaluation criteria. The rehabilitation robot achieves the purpose of rehabilitation training by driving the limb movement of the patient, and scientifically and effectively trains the patient. At the same time, the rehabilitation robot is a man-machine cooperation robot. Due to the participation of people, the structure and control of the robot are put forward higher requirements. The current rehabilitation equipment is mainly from abroad, and the domestic is in its infancy. Traditional rehabilitation training robots have some problems to be solved. For example, the rehabilitation training robot has a single function. In different stages of the limb recovery of the patient, the rehabilitation robot cannot provide various training methods according to the patient's condition; the patient usually passively accepts the rehabilitation robot. Treatment, poor participation in treatment, is not conducive to the recovery of the body; rehabilitation robots can not display the various data in the treatment process in real time, which is not conducive to the therapist to provide a basis for the patient to develop an effective treatment plan.

Limb motor dysfunction imposes a burden on the patient, family, and society. There are many treatments available, but no matter which method, rehabilitation is indispensable for patients. Medical theory and clinical rehabilitation practice show that exercise rehabilitation training has important significance for skin care of the central nervous system and prevention of muscle atrophy. In the process of limb exercise rehabilitation training, for patients who have completely lost limb exercise ability, a training program for passive movement of the injured limb is implemented, and the limb exercise ability is slowly restored; for patients who have lost part of the limb exercise energy, A training program that combines active training with passive training on a damaged limb. Therefore, when designing intelligent rehabilitation training equipment, how to realize the passive training mode, active training mode and automatic switching of active and passive training modes in the patient training process has become the core content that designers of intelligent rehabilitation training equipment should consider.

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2. System design and function realization

Passive mode means that during the rehabilitation training, the patient's legs do not need to be consciously active, and the lower limbs are trained by the body. Active mode refers to the conscious force of the patient's leg during training, and the driver is trained. Different training modes are used in different patients during training, which is of great significance to patients. In response to this situation, the rehabilitation training equipment has designed different passive motion modes and active motion modes.

The system is mainly a man-machine interface (touch screen), the control system includes a PLC controller and a motor driver, and the control execution component is an electric motor.

Through the touch screen as the man-machine interface, connect to the PLC controller through the communication interface, and set the speed, power value, control time, and control time in various modes. PLC controller, as the main control unit, accepts the control signal provided by the touch screen and the motor status information provided by the driver (current speed value, torque value, torque direction value, motor rotation direction, etc.), and the patient is judged after processing. Under what state of motion, the input speed and input torque voltage value of the motor are controlled by analog quantity, and the state of starting, stopping, and suspending is controlled. The motor driver is the state acquisition unit and direct control unit of the motor. The state acquisition unit means that not only the speed of the motor can be collected by the encoder installed at the rear of the motor, but also the motor current can be collected by the Hall sensor, and the torque value and the direction of the motor output can be calculated according to the current state. The direct control unit refers to the closed loop control of the motor directly after calculation according to the control command provided by the PLC controller.

In order to achieve the purpose of patient rehabilitation training, different training methods are implemented for different recovery periods and different limb conditions of patients. 1) Passive mode: In the early stage of rehabilitation training, the patient loses muscle strength and cannot actively complete the exercise. He can only rely on the help of external forces to achieve passive training. Passive mode is to use the motor drag effect, the external can adjust the drag speed, when the drag speed is not changed, the training device pushes the lower limbs to move at a constant speed. The flow chart is shown in Figure 3. 2) Active mode: the patient's muscles have a certain strength, can carry out active movement of less torque on the rehabilitation training equipment, and automatically activate passive training when the active movement is lower than the design standard, which can quickly help restore muscle strength and enhance confidence. The active motion mode is implemented on the basis of the passive motion mode. The speed of active motion is based on the speed of passive motion. First, the speed and torque of passive motion are set. The device performs passive motion in a uniform manner. When the patient is actively engaged in motion, the speed of active motion must exceed the passive speed. The speed of the movement, the speed of the device is adjusted to the actual speed of the active movement. When the active motion cannot be detected, the speed of the device will drive the leg to run in a uniform deceleration until the speed is reduced to the target speed.

In the passive motion mode, the motor drives the limb movement, which plays the role of drag force. The speed of the motor is constant when the person does not actively change the speed. The size of the drag force and the drag speed can be set by the host computer. The PLC system is used to calculate the parameters set by the host computer, and the operation result is sent to the motor driver, and then the speed and torque of the motor output drag state are controlled by the control of the driver. Complete passive mode control. 2) In the active mode of the motor, how to detect the active force of the patient and the end of the active force is the key to the active mode design. According to the principle of motor control, the direction of the output torque of the motor is reversed during the process from the state of providing the drag force to the state of providing the resistance. Therefore, during the operation of the motor, the detection of the torque inversion is equivalent to detecting the signal of the patient's active force application. In general, the motor current can represent the direction of the motor output torque, and the motor current can be detected by the Hall sensor. In the active mode design process, the PLC detects the patient's active force signal through the Hall sensor, the system enters the active state, and the motor speed becomes the actual speed driven by the patient's main power. When the PLC detects the end of the force signal, the system starts the deceleration motion at the current speed. When the speed value reaches the system-set value (v0 + vmax /5) (v0 is the speed at the start of active motion, vmax is active). The maximum speed during exercise), the speed is passive mode motion (v0 + vmax /5).

3. Prototype experiment and conclusion analysis

The experimenter adopts a random test method to continuously change the strength and speed of training, and conduct active mode and passive mode experiments. 1) In passive mode: the drag torque of the motor does not change greatly, which means that the current of the motor does not change greatly, and the current direction of the motor does not change. The design experiment is as follows. When the motor is rotating forward, the speed of the motor is adjusted from low to high, and then from high to low, and the continuous change is observed to observe the actual current value and speed value of the motor feedback. The sampling waveform with a sampling time of 190 microseconds is shown in Figure 5. The black thick line at the sampling point is the velocity sampling waveform, and the black thin line is corrugated as the current sampling waveform. When the black thick line appears as a peak, the value is from 300 to 1148, and then decreases to about 300, while the current waveform remains at 4 to 25. There is no significant change in the left and right ranges, indicating that there is no large change in current when the speed changes in passive mode. This verifies that our speculation is correct. The same test was performed with the motor reversed, and the passive mode inversion waveform also verified that our guess was correct. 2) In the active mode: When the patient applies force, the motor changes from the drag state to the resistance state, and the direction of the force of the motor changes. At this time, the current of the motor should have a process of changing direction. The design experiment is as follows. When the motor is rotating forward, the ankle is slammed, and then the output is stopped, and the motor rotates. With a sampling time of 190 microseconds, the sampled waveform is as shown in Figure 7. In the case of a slamming, the current waveform changes direction, from greater than 0 to less than 0. The speed value waits until it has soared and then decrements in a uniform deceleration. This process validates the control of the speed active mode and also validates our inferences. The same effect is not listed in the case of reversal. 3) Analysis of problems and solutions: There is a phenomenon that when you rub your ankles too hard, you will feel a slippery phenomenon. When the motor is no longer actively applying force, the initial speed does not decelerate from the highest value of the current actual speed, but starts to decelerate from a smaller value. In this way, an instantaneous high-speed value occurs, so that slippery phenomenon occurs. (1) Analysis reason: This is because the system adjusts the system speed after receiving the information of the sudden change of the current, so the system has a reaction time problem. When the system reacts, the highest speed has passed with the actual The speed change has passed. (2) Solution: By adjusting the integration time, this phenomenon is alleviated, but it cannot be completely eliminated.

4. Conclusion

The active exercise mode and the passive exercise mode provide better device functions for the patient and provide a unified control method, which is the functional core of the intelligent rehabilitation training device design. The design method is simple and easy, and the cost is low. The prototype model verifies the feasibility of the designed intelligent rehabilitation equipment. The design method is simple and easy, and the cost is low. Although this prototype only provides rehabilitation training design methods for lower limbs, this method can be applied to the design of upper limb training equipment.

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