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Wearable Lower Limb Rehabilitation Training Robot

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Abstract

For the elderly, aging and organ function degradation is a common phenomenon, which is manifested in the elderly's limb stiffness, decreased flexibility, mobility, and nervous system function degradation. When the nervous system problems, will lead to human walking disorders, which makes their daily life affected. Stroke is a high incidence in China, mostly in the elderly. At the same time, with the rapid development of modern transportation system and the popularity of transportation, traffic accidents are increasing year by year at an amazing speed. The typical injuries of the injured include nerve injury and limb injury. In order to recover and improve the limb motor function of the injured, scientific rehabilitation training is indispensable. Because of the damage of motor function, these patients generally have some movement disorders, they can not carry out rehabilitation training alone, and need the assistance of medical staff or other professionals. However, due to the lack of professional nursing staff and high medical costs, most Chinese patients prefer to train at home, which brings a serious problem. Due to the wrong training method and the lack of training, patients will miss the best time for rehabilitation. Many cases have shown that due to improper or insufficient intensity of rehabilitation training, patients' physical activity ability is gradually lost. However, according to the survey, most of the lower limb rehabilitation training devices on the market are used by hospitals and self-employed people. Although this meets the needs of patients, the equipment is huge and expensive, and some bedridden patients can't afford it at home, which affects the entry of lower limb rehabilitation training device into the family. The research and development of rehabilitation robot in China started late, with low level and few achievements. Therefore, our intelligent lower limb rehabilitation training system is dedicated to this vacant part of the market. It is not only for the needs of individual users for "convenience", but also has complete functions, low price, small size, wearable, and can be matched with VR training system. After wearing VR glasses, patients can enter different scenes, such as walking in the garden, jogging, and swimming In different scenarios, our lower limb rehabilitation training device intelligently moves the lower limbs of patients to do related movements. The industry prospect is optimistic, and there is a large space for development. This paper presents the design of a lower limb rehabilitation robot. In this paper, the overall framework of a wearable lower limb rehabilitation training robot is built, and its working principle and basic composition are briefly introduced.

Keywords

Lower Limb Rehabilitation Robot; Wearable; VR Glasses.

1. Background analysis

The research of walking aid rehabilitation robot has been widely concerned by academic circles at home and abroad, but at present, the research and application level of rehabilitation robot in China is

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still relatively low and started late. Supported by the national "863" program, Tsinghua University began to study rehabilitation robots in 2000, and has developed horizontal lower limb rehabilitation robots, weight-loss walking rehabilitation training robots, etc. Harbin Engineering University has developed a kind of lower limb rehabilitation walking aid, which is improved on the basis of wheelchair, so users can achieve the conversion of sitting and standing posture without the help of others. In addition, Harbin Institute of technology has been committed to the research of rehabilitation robot. The multifunctional walking aid robot developed by Harbin Institute of technology can not only help patients with rehabilitation training, but also be used as a walking tool in daily life. The intelligent wheelchair aided navigation system jointly developed by Shanghai Jiaotong University and Shanghai Electric Group is a breakthrough in the field of intelligent wheelchair research in China. The intelligent wheelchair system uses a variety of sensor systems, including vision sensor, ultrasonic sensor, infrared sensor and collision sensor. It can achieve simple obstacle avoidance, fall prevention and other functions. It can also achieve a variety of autonomous functions, such as walking along the wall, following the owner, passing through the door and so on [1].

It can be seen from the above that there is still some research on the rehabilitation training of motor function in China, and some trainers have been developed. But in the research of rehabilitation walking aid robot, at present, most of the domestic research is still based on multi-functional wheelchair. Although some universities and enterprises have also developed some intelligent wheelchairs with certain auxiliary functions, and are trying to commercialize them, the research of walking aid robot in a strict sense, especially the research of its motion control, including the most important people The deep research of mechanical interaction control is rare.

2. Medical theoretical basis of robot assisted rehabilitation of lower limbs

The movement of human lower limbs is completed by the coordination of bones, joints, skeletal muscles and neural control system. Its basic mechanism is: skeletal muscle produces contraction according to the brain's command, which makes people produce a specific movement state or static posture under the joint action of external force and contraction force, so as to realize the movement with certain characteristics in time and space. Therefore, the recovery training of lower limb motor function is mainly to reestablish this connection. In recent years, researchers at home and abroad have done a lot of research in the field of brain nerve rehabilitation medicine, especially a large number of experimental studies on the possibility and possible mechanism of functional recovery after central nervous system injury. Finally, one of the most important research results is that the central nervous system has a high degree of plasticity, and some experiments also show that specific auxiliary functional rehabilitation training is essential in the process of functional recovery after central nervous system injury, which has become an important theoretical medical basis for functional recovery after central nervous system injury and robot assisted rehabilitation technology. It also means that patients with nervous system diseases can train and improve their daily activities through enough repetitive activities and specific rehabilitation training [2].

Rehabilitation robot is the product of the combination of robot technology and rehabilitation medicine. Therefore, its emergence and development depends on the development of rehabilitation theory, and different rehabilitation theories can give birth to rehabilitation training robots with different principles. This paper is the whole rehabilitation robot system based on the principle of neural plasticity. Under the guidance of the rehabilitation robot control system, the robot body worn on the patient can drive the patient to do repetitive rehabilitation training, and finally make the reconstituted cerebral cortex learn and store the correct movement mode through deep experience, and finally restore the control ability of the nervous system to the walking function, so as to achieve the purpose of restoring the walking function.

3. Research objectives

After the occurrence of diseases or accidents, the leg dysfunction of users is often caused. Because the patients with Lower Limb Dyskinesia lose the ability to move, their lower limb rehabilitation

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mainly depends on passive movement. It will take a long time to recover the full or partial motor function of these users, and it will take a lot of time for family members and medical staff to take care of them. During hospitalization, the rehabilitation training of patients' legs and limbs is generally carried out under the guidance of medical staff. However, due to the unreasonable proportion of doctors and patients, the number of patients far exceeds that of medical staff, resulting in the high work intensity of nursing staff, which makes it difficult to guarantee the duration, intensity and rehabilitation effect of patients' forced rehabilitation training. For those users who are sick and lying at home, it is more difficult to guarantee regular and quantitative forced exercise due to the influence of economic conditions and the lack of caregivers. On the one hand, for doctors, accurate leg movement data are needed for disease analysis; on the other hand, for patients, full recovery of leg function still needs long-term postoperative guided leg rehabilitation training. In view of the above problems, the intelligent lower limb rehabilitation training robot for leg rehabilitation has great potential [3].

4. Research meaning

At present, Most of the research on the market of lower limb rehabilitation robot is still in the initial stage, and the price of the robot is relatively high Most families can not enjoy these medical devices. Rehabilitation training is of great significance to the recovery of human body function. Rehabilitation training device has been used as an important role in medical equipment [4]. According to statistics, the scale of China's medical device market in 2017 was about 445 billion yuan, an increase of 75 billion yuan compared with 370 billion yuan in 2016, with a growth rate of about 20.27%. It is predicted that the average annual compound growth rate will be about 14.41% from 2019 to 2023, and the scale of China's medical device market will exceed one trillion yuan in 2023, reaching 1076.7 billion yuan. The transaction price of medical rehabilitation robots ranges from 1 million to 5 million per set, and the market capacity of medical rehabilitation robots in China is expected to be about 10 billion. However, the number of users with lower limb dyskinesia in China is huge. 55% of the elderly over 60 years old suffer from physical disability, which is mainly caused by osteoarthritis, spinal cord injury and cerebrovascular disease. Pain and dysfunction of osteoarthritis can lead to the loss of walking ability, labor force and even disability. According to the average charge level of the hospital, patients need to pay 100 yuan for every 40 minutes of using the rehabilitation robot in the hospital. Huge market demand can not be met, this situation is widespread [5]. Therefore, the lower limb rehabilitation training robot has a broad prospect.

In addition, the proportion of China's elderly population continues to rise, and the elderly over 60 years old has reached 167 million, accounting for 12.5% of the total population of the country. The aging of the population is developing in depth and showing a trend of obvious acceleration. Under the background of building a lifelong learning society, the development of elderly education is an important measure to cope with the severe challenges of the aging of the population and build a harmonious society As an important part of national education, more and more attention has been paid by the state and society. In the national medium and long term education reform and development plan (2010-2020), it is also clearly proposed that we should "pay attention to the education for the elderly". However, the development of China's elderly education is uneven in different regions. The number of the elderly educated is very small, accounting for only 3% of the total number of the elderly, while the proportion of the rural elderly educated is less, which leads to many elderly people can not use smart phones correctly and effectively, and human-computer interaction based on speech recognition will play an important role in this situation.

5. General design requirements

The wearable lower limb assisted rehabilitation robot system designed in this paper mainly replaces the nurses to carry out repetitive exercise training for patients, so as to recover the range and ability of joint movement of patients. As an integrated human-computer system, first of all, it is necessary to ensure the safety and reliability of the system, and avoid the secondary injury of patients' lower

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limbs caused by system control and other problems; secondly, this paper designs a "wearable" rehabilitation system, so its structural design should conform to the principles of ergonomics [6], Finally, in order to enable patients to achieve certain rehabilitation requirements and effects, the control system design should be able to achieve the control objectives. Based on the above factors, the design of lower limb rehabilitation robot in this paper must meet the following technical specifications:

(1) The maximum weight of 100 kg can be driven to complete the rehabilitation training;

(2) The flexion and extension frequency of the lower limb joints can be adjusted according to the patients, and the maximum walking speed is 0.8m/s;

(3) The leg can achieve the necessary number of degrees of freedom for walking. The mechanism designed in this paper can achieve 6 degrees of freedom (3 for hip joint, 1 for knee joint and 2 for ankle joint).

6. Primary coverage

It can be seen from the above design requirements that the lower limb rehabilitation robot designed in this paper is an automatic mechanical device for active rehabilitation training of patients with lower limb dyskinesia. It can help elderly patients with lower limb dysfunction or stroke caused by moderate diseases to carry out motor function recovery training, help to restore limb function and prevent muscle "disuse" atrophy. Through the computer control system to control the machine body to simulate the movement state of normal people walking, the movement function of the sick leg can be trained. Therefore, in order to enable the robot to complete the whole rehabilitation task independently, including automatically obtaining gait data, autonomously conducting rehabilitation evaluation and planning, and finally generating control execution instructions to drive the robot body structure to drive patients to complete the specified rehabilitation training task, this paper builds the wearable lower limb rehabilitation training robot.

The wearable lower limb rehabilitation training robot can be divided into active and passive rehabilitation training modes, mainly passive training.

(1) Active: the patients with lower limb dyskinesia are active, it is driven by the patients with Lower Limb Dyskinesia to train, and relative to the patients with lower limbs, the rehabilitation training device is driven.

(2) Passive: the rehabilitation training device drives the lower limbs of the patients with dyskinesia to move repeatedly in order to achieve the training purpose. Compared with the training device, the lower limbs of the patients are passive. The points for attention of passive movement are: the patient should not be forced to move in a painless physiological range; the frequent change of body position should be avoided; the activities that can be carried out in the same body position should be concentrated as much as possible; the type of movement should be selected according to the degree of injury. The advantages of this method: the training mode can be adjusted freely. Many of the patients with Lower Limb Dyskinesia have weak limb movement ability and weak active movement ability, which is suitable for passive training method. The patients sit in a higher position, which can make the legs droop naturally. The rehabilitation training device drives the lower limbs of the patients with dyskinesia to move repeatedly, so as to achieve the training purpose [7]. You can choose different training methods, such as using the rehabilitation machine to drive your legs to do the same movements, stretching, walking, jogging and so on.

The wearable lower limb rehabilitation training robot adopts wearable equipment, and the patients with lower extremity dyskinesia wear the mechanical legs of rehabilitation training. Patients can adjust different rehabilitation training methods by operating mobile app. We preset almost all actions that the patient may need, such as legs can do the same action, walking action, stretching action, stair climbing action, jumping action, etc. The legs are driven by the machine to carry out rehabilitation training by clicking different buttons on app. The patient can adjust the strength and speed of the

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exercise freely, and the operation is very convenient. At the same time, the lower limb rehabilitation training device can collect the relevant data of the patients' legs, and display them in app in real time. Each training will save the data. Doctors can guide the patients according to these data.

The wearable lower limb rehabilitation training robot can be used with VR glasses. After wearing VR glasses, the robot intelligently moves its legs to do corresponding actions. Mobile app can interact with VR glasses, patients can freely choose to enter different scenes, such as walking in the garden, morning running in the park, shopping and so on. There are default training methods in different scenes, which are suitable for most patients. However, in order to provide personalized service, patients can input relevant data of their legs in the app, and the app will intelligently recommend training methods. At the same time, patients can freely set the strength and speed of the machine driving their legs. With VR glasses, patients can train in such a pleasant and realistic environment that they like, which can greatly enhance the rehabilitation effect.

The wearable lower limb rehabilitation training robot also provides support function and can bear body weight. For severe patients with lower limb dyskinesia, after a period of rehabilitation training, after the doctor's analysis of the relevant data of the patients' rehabilitation training, the patients can try to walk with the help of their families with the permission of the doctor. The passive training method is mainly used, and the lower limb rehabilitation training device drives the patients to walk on the real ground Walking; if active walking mode is adopted, the machine will provide certain auxiliary force [8].

The wearable lower limb rehabilitation training robot is small in size and can be used at home or in the workplace. Let patients in a pleasant environment for rehabilitation training, so that more patients with Lower Limb Dyskinesia get stronger independent living ability, so that their quality of life has been greatly improved is our goal.

7. Project characteristics and advantages

This product has four features, one is that it can carry out active training, but also can carry out passive training, mainly passive training, patients can freely adjust the movement, speed, strength and so on. The second is to apply VR technology to rehabilitation medicine in order to achieve better rehabilitation effect. The third is the customized production mode based on the characteristics of products for all kinds of consumers. Fourthly, the intelligent lower limb rehabilitation machine can collect the relevant data of patients' legs in real time and send it to the mobile app, so that patients can freely adjust the way of rehabilitation training according to the data. The application of advanced machine technology to rehabilitation training device reflects the perfect combination of mechanical technology and rehabilitation medicine.

Mark the forefront of the times and follow the general secretary Xi Jinping's call for policy superiority. With complete functions, low price and small size, it can help patients to carry out rehabilitation training without hospitalization treatment and achieve a certain rehabilitation effect, so as to avoid some unnecessary high hospitalization treatment. At the same time, it can help patients with lower limb disabilities carry out daily walking. Personalized support for high-end users, easy to get personalized target. It can be combined with VR glasses to achieve better rehabilitation effect. The above points are the advantages of the project.

8. Market prospect

At present, In China, the research of lower limb rehabilitation training device is still in its infancy. Only some simple rehabilitation devices are available on the market, which is far from meeting the needs of the market and patients in terms of intelligence, ergonomics and other aspects of rehabilitation training device. Moreover, the price of most lower limb rehabilitation training devices is relatively high, and most families can not enjoy these medical devices But the number of patients is huge. The huge market demand can not be met, this situation is widespread. Therefore, the

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rehabilitation training device has a broad market prospect, which will promote the theory and technology in this field to get faster development and promotion in the future.

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