Research on Hand Function Rehabilitation Training Device Based on Human Multimodal Sensation

Kai GUO¹, Sha-sha ZHAO¹,*, Yong-feng LIU¹, Bin LIU¹, Hong-bo YANG¹, and Zhen-lan Li²

¹Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences, Suzhou 215163, China

²The first hospital of Jilin University, Changchun, China

*Corresponding author

Keywords: Hand function, Rehabilitation, Training device.

Abstract. Hand rehabilitation training plays a vital role in the rehabilitation of other diseases such as hand diseases and strokes. Among them, the rehabilitation and training of the fingers is an important means of hand function loss or hand disability treatment. In many sequela of stroke, hand dysfunction is one of the most common obstacles in patients with hemiplegia after stroke, seriously affecting patients. The activities of daily life bring a heavy burden to the patients' families and society. Developed a multi-modal sensory functional rehabilitation device based on the sense of vibration, vision, and auditory multi-channel fusion mode. The physical sensory signal mobilizes the active participation of the brain in rehabilitation training, thereby effectively improving the function of finger movement after stroke. Rehabilitation effect.

Introduction

Hand rehabilitation training plays a vital role in the rehabilitation of other diseases such as hand diseases and strokes[1,2]. With the aging of the population, the number of patients with hemiplegia increases year by year, but the rehabilitation doctors and rehabilitation resources are very scarce. Therefore, most patients tend to choose to train at home, resulting in insufficient training intensity, lack of scientific training methods and fuzzy training steps[3-5]. Wait. As a result, more patients have lost the best time to recover and gradually lost the mechanism of the hand. With the development of computer science and technology, robotics technology has begun to be applied in the field of rehabilitation medicine[6], the development of rehabilitation medical robots, the use of rehabilitation medical robots to alleviate the shortage of physicians and the self-training of patients, will be the future development trend of home care. This paper developed a hand rehabilitation training device as shown in Figure 1.

Figure 1. Hand rehabilitation training device.

The training based on the hand rehabilitation of patients is not effectively implemented due to many restrictions. These factors are mainly, Firstly, China has a large population, lack of medical resources, patients have difficulty in medical treatment, and later rehabilitation is unsupervised. Secondly, Departmental rehabilitation training is basically a qualitative measurement, lack of quantitative and
accurate guidance. Then, patients generally have longer recovery time, the negligence of patients and their families, the hospital's powerless supervision may lead to poor rehabilitation, and even due to unreasonable patient training Secondary injuries. Finally, due to the lack of rehabilitation knowledge, people do not know the importance of rehabilitation. In order to effectively improve the above situation, patients can get a timely and effective rehabilitation system for scientific rehabilitation. The normal functions of the human hand include the motor function and the sensory function, and the sensory function includes a shallow feeling such as tactile pain, a deep feeling such as a vibratory sensation, and a complex feeling such as a weight sense.

![Figure 2. Hand rehabilitation training device.](image)

**Main Hardware Components of the Hand Function Training Device**

The electronic control system uses the ARM chip as the core processor. The peripheral circuits can be divided into power module, input button module, real-time clock module, voltage monitoring module, motor drive module and alarm module according to functions. The function modules are shown in the figure 3.

![Figure 3. Main hardware function module.](image)

**Enhanced Vibrational Stimulation**

The micro-motor is arranged on the patient's finger to generate a somatosensory signal, the motor was shown in Figure 4. The active participation of the brain in the rehabilitation training is mobilized, thereby improving the exercise function, and the medical massage rubber particle is used to enhance the vibration stimulation and improve the rehabilitation effect. The intensity of the vibrational stimulus is adjusted by adjusting the vibration frequency.

![Figure 4. Hand rehabilitation training device.](image)
Treatment modes include: finger-by-finger vibration mode, all knuckles with fixed frequency vibration mode, all joint variable frequency vibration modes, single different knuckle random vibrations, and a specified tempo vibration mode. The vibration intensity and frequency are adjustable, and the LED corresponding to the knuckle is illuminated.

Parallel to the structural design and circuit design, first of all, according to the circuit design, the first draft of the structural design is completed, and then the simulation software is drawn according to the first draft, so as to adjust the parameters, and then communicate with the manufacturer to determine the software simulation drawing of the production mold, and finally try a batch of products, for principle and functional verification.

The wearable device generally has two methods of fabric and silicone. The project intends to design a fixed structure of the related hand function rehabilitation device by using an integrated silicone molding scheme, as shown in the figure.

Figure 5. Multi-mode sensory hand function rehabilitation device body.

Body Structure Design of Lightweight Hand Function Rehabilitation Device

The structure of the multi-mode sensor-driven hand function rehabilitation device mainly comprises a fixing device, a control module, a micro motor, a motor, etc., the hand function rehabilitation device has a fixing device fixed on the hand, and the control module controls the micro motor and the electrode according to the need and the feedback information. Jobs. Controls include batteries, chips, boards, batteries, electrodes, and the like. Body structure design of lightweight hand function rehabilitation device was shown in Figure 6.

Figure 6. New body structure design.

Summary

The multi-mode sensor-driven hand-function rehabilitation device developed has many meanings. First, reduce the cost of rehabilitation and allow patients to perform effective hand rehabilitation training at home. Then, the patient's hand exercise guidance is changed from qualitative to quantitative, and the scientific effect is used to measure the rehabilitation effect, so that the patient can get more effective and accurate treatment. Finally, the patient training activities are visualized to achieve the coordination of hand training. Hand rehabilitation training for strokes and other diseases is a long process, multi-modal feeling of hand-function rehabilitation devices visualizing vibration training fingers to solve these problems.
Acknowledgement

This work was financially supported by “Changchun Science and Technology Innovation Major Project” (No.CC003247), “Jiangsu Province Science and Technology Plan Key Project” (No. BE2017007-2), “Jiangsu Science and Technology Plan Project” (SBE2017740113), “Science and Technology Service Network Initiative of Chinese Academy of Sciences” (KFJ-STS-QYZX-028), and “Suzhou City Science and Technology Plan Key Industry Technology Innovation Prospective Application Research Project” (SYG201824).

References


