Development of Rehabilitation Training Gloves Based on Flexible Robot Technology

Kai Guo¹, Shasha Zhao¹, Bin Liu¹, Yongfeng Liu¹, Hongbo Yang¹ and Zhenlan Li²

¹ Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences, Suzhou 215163, China
² Jilin University First Hospital, Changchun 130000, China
Email: guok@sibet.ac.cn

Abstract. This paper develops an intelligent sports rehabilitation glove based on flexible robot technology. Designed for sports rehabilitation gloves through the rational design of flexible pressure sensing systems, micro-precision drives, intelligent control systems, and ergonomic gloves. Through the use of flexible lasso transmission, rehabilitation training is performed on the patient’s hand, and the endurance and endurance of the wearer’s daily life are enhanced. This paper combines the latest flexible sensing technology, intelligent control technology, and micro-precision driving technology with the advanced concepts and methods of sports medicine. Through the combination of medical and industrial research, it has developed low cost, comfortable wearing, convenient and practical, and can meet families, hospitals, and Wearable smart rehabilitation gloves for use in industries such as industry.

1. Introduction
This paper is based on flexible robot technology in the form of lasso transmission for hand function rehabilitation and assist [1, 2]. The hand function robot we developed is shown in figure 1. Reciprocating exercise rehabilitation training for the patient’s fingers and wrist joints by using a flexible lasso transmission development device [3-7]. When used in patients with movement disorders, the device can enhance the endurance and endurance of the wearer’s daily life [8, 9].

Figure 1. Rehabilitation training gloves based on flexible robot technology.
Since the wearer grabs the object, the finger first needs to perform a slight flexion and extension motion to generate a pressure signal. Therefore, smart assist gloves are not suitable for patients whose opponents are completely paralyzed.

At the same time, for patients with severe hand sputum or rigid joints and fingers, it will also affect the normal use of gloves. For patients with weak hand strength and lack of endurance, hand-functioning robots can play a real role.

2. Design of Structure and Hardware for Hand Function Rehabilitation Robot System
The overall structure of the hand function rehabilitation machine glove is shown in figure 2. The equipment mainly includes: drive and control system components, glove connector, glove assembly. When the glove is worn or faulty, the glove assembly can be replaced directly.

![Figure 2. The overall structure of the hand function rehabilitation machine glove.](image)

2.1. Hand Function Rehabilitation Robot Drive and Control System Component Design
The control hardware system of the hand function rehabilitation robot device is shown in figure 3. The hardware of the hand function rehabilitation robot mainly includes a battery, the main control circuit, a display screen, a linear actuator, an output wire lasso and the like.

![Figure 3. The control hardware system for hand function rehabilitation robot.](image)

As a power output unit, the miniature precision driver is worn together with the control system at the waist of the wearer. It is small in size, light in weight, low in noise, high in precision, large in a range of movement of the nut, real-time detection of nut position, safety limit, etc.

The intelligent control system accepts pressure signals from the flexible pressure sensor system in real-time and determines the amount of boost that needs to be generated. In order to improve the performance of the power assist gloves, the control strategy is adjusted. Three assist modes can be
implemented: weak, medium, and strong. At the same time, the maximum assist output of each finger in the glove can be set separately, and the pressure required to activate the booster glove can be adjusted.

2.2. Glove Assembly Design
The gloves are made of durable anti-fouling material to ensure the life of the product. The shape of the glove is designed to maintain the wearer’s fine movements as much as possible. At the same time, the glove needs to be tightly fitted to the wearer’s hand, and the length of the glove finger can be appropriately adjusted. We have developed a detachable wearable glove device, as shown in figure 4.

![Glove Assembly Design](image)

Figure 4. Removable wearable glove device.

Combined with the structural characteristics of the smart power-assisted gloves and the physiological structure of the fingertips of the hands and the pressure distribution of the fingertips, a flexible pressure sensor is designed in the glove to monitor the pressure generated by the wearer’s fingers in real-time and as an input signal for activating the power-assisted gloves.

The flexible artificial tendon is installed in the glove, one end is connected with the hard piece in the fingertip of the glove, and one end is connected with the titanium wire in the driving and control system component through the buckle 1 and the buckle 2, and finally the linear motion of the nut is converted into the finger Flexion and extension exercise. When providing power, there is relative movement between the flexible artificial tendon and the glove. In order to improve the assisting efficiency, the flexible artificial tendon guiding device should minimize the flexible artificial tendon and the glove while ensuring the finger bending and the hand grasping direction are the same friction between.

2.3. Hand Function Rehabilitation Robot Drive and Control System Component Design
The gloves are made of durable anti-fouling material to ensure the life of the product. The main part of the glove is made of synthetic leather, and rubber particles are added to the fingertips and palms to improve the friction when gripping the object. According to the principle of force applied when the hand is grasped, and in order to maintain the fine movement ability of the wearer’s hand as much as possible, the assisting glove only designs three fingers: the thumb, the middle finger and the ring finger. The reason for this is that the wearer does not interfere with other fingers when using the index finger, which allows the wearer to pick up small objects, such as coins, which in most cases do not require much muscle power.

There are five sizes of gloves, and the total length is four sizes, as shown in figure 5. To fully utilize the performance of the power-assisted glove, the glove needs to be compact with the wearer’s hand. The gloves are divided into left and right hands, male and female. There are five models in size: XS, S, M, L, XL. At the same time, to make the wearer feel no pulling when using the gloves, the waist has four sizes: 60, 70, 80, 90 cm.
2.4. Design of Motion Decoupling Module
There is a decoupling structure between the body drive and the glove, as shown in figure 6. At the same time, for different users, the finger length of the glove can be finely adjusted by a mechanical mechanism.

3. Design of Control System for Hand Function Rehabilitation Robot
The ultimate goal of the intelligent power-assisted glove control system is to enable human-machine coupling to be successfully implemented and to implement it technically using the follow-up control technology. We use the PID control system as shown in figure 7.

In the entire control system, the information flow follows the process of generating, acquiring, analyzing, calculating, and finally outputting to the control end. According to the flow, the control system can be divided into information-aware acquisition, wearer’s hand motion intention identification, and control. Strategic research and implementation are four levels.
According to the judgment information of the motion intention or the motion state, the corresponding motion controller is designed for different motion modes, and the corresponding control command is output to the micro precision transmission mechanism to achieve the purpose of the follow-up control. Firstly, according to the flexible pressure sensor, the acquisition of the pressure signal generated by the wearer’s hand is completed, and as the input signal of the control system, the assisting force required to be generated is determined, and the flexible artificial muscle tendon is driven by the micro-precision driver to generate the required assist force. The wearer can change the control strategy through the control panel, and select different training modes according to different occasions, including weak, medium and strong modes. At the same time, the assisting power of the finger can be independently adjusted to adapt to different occasions.

4. Conclusion
The flexible lasso-driven robot has the advantages of simple structure, lightweight, strong flexibility, comfortable wearing, and convenient use, and is the development direction of the future hand-functioning robot. The intelligent glove based on flexible robot technology can not only realize the daily hand function rehabilitation training of the patient, but also assist the patient to achieve normal work and life and enhance the patient’s confidence.

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