Research Perspective in Flexible Hand Exoskeleton

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Abstract. The purpose of writing this review paper is to make it more convenient for the public to use and adapt to hand exoskeletons, especially to enhance the promotion of flexible hand exoskeletons, and to put forward some of my own views. In recent years, a flexible exoskeleton human-machine intelligent system has become a new research hotspot in the fields of robotics, electromechanical engineering, automatic control, bioengineering and artificial intelligence, and has been widely used in scientific research, industrial production, space or deep-sea exploration, entertainment, etc. Sports rehabilitation and daily life have gradually been widely used. Flexible exoskeletons are most commonly used in the medical and biological fields. The human-machine intelligent technology of a flexible exoskeleton takes man-machine integration technology as the core, and the advantages of people and intelligent machines can be fully utilized. Through organic human-machine coupling, perception and decision-making at the execution level, the performance of the system is enhanced. Teleoperated exoskeletons and augmented exoskeletons are two important research directions for flexible exoskeleton human-machine intelligent systems.

Keywords: Flexible Exoskeleton; Spinal Cord Injury; Stroke; Human-Computer Interaction; Artificial Intelligence.

1. Introduction

In recent years, the development prospects of exoskeletons have become a very hot topic. In view of the inconvenience of post-stroke rehabilitation in Chinese people, a new exoskeleton manipulator was proposed based on the analysis of the biological characteristics of the human hand [1]. It is used for postoperative rehabilitation of traumatized fingers. In order to assist patients who, lose their or her hand motion function to complete the grasping of daily necessities, a flexible exoskeleton robot system based on line tension feedback has been developed, which can realize fingertip grasping [2]. Stable control of power take-off, the flexible hand exoskeleton uses materials that can be closer to the human body to improve portability and safety. The safety of the wearable flexible exoskeleton human-machine intelligent system mainly depends on the mechanical structure design of the system. Selection and placement, design of protective measures and security control strategies. Many paraplegics are still very dependent on caregivers in daily living. For those with paraplegia, even if the orthosis is used to enhance walking function, they still require a lot of baseline strength and a huge energy expenditure. This leads to the fact that options for movement for people with complete paraplegia have traditionally been confined to wheelchairs, and although wheelchairs offer improved independence, wheelchair users still face difficulties with access and mobility. At the same time, exoskeleton hand robots have been rapidly and extensively developed in the recovery of sensorimotor disorders after central nervous system (CNS) injury and central nervous system (CNS) injury. Many of these innovations are technology-driven, restricting their use and effect on clinical clinics. However, the concept of recovery exoskeleton hand robots demands neurophysiological vision into regular and jeoparded sensorimotor function, which demands multidisciplinary cooperation and backdrop information. The rehabilitation of sensorimotor effect after medium tight setup injury depends on the utilization of neuroplasticity and emphasizes the recovery of movement required for self-independence. This demands physiologic limb flesh activation, which can be implemented by practical hand/arm and ham motor exercise and activation of suitable surface sense organs. These things have led to the growth of innovative exoskeleton hand machines with high-ranking interactive command programs, as well as the application of imploded implodeds to always monitor and adjust sustain to the practical condition of the patient, but many challenges reserve. To have an active effect on functional outcomes, recovery methods should be based on neurophysiology and clinical vision, keeping in the brain that functional rehabilitation is restricted. Therefore, the device of exoskeleton hand machines demands an association of customized undertaking and neurophysiological knowledge. When used correctly, machine auxiliary therapy can offer more advantages than traditional ways, comprising a standardized cultivated condition, adaptive sustainability, and the capability to enhance the strength and potion of therapy while decreasing the burden on the therapist's body. Therefore, exoskeleton hand robots ideal to complement traditional clinical therapy and continuous therapy have great potential and aid in the use of simple equipment at home.

There are also many classifications of flexible hand exoskeletons, such as the pneumatic soft hand exoskeleton, a new pneumatic soft exoskeleton glove proposed by Harvard University that produces deft movements of finger joints with hardly any restriction on mind movement. Four pneumatic man-made muscles are placed on every finger to form two pairs of antagonistic muscles which are similar to human anatomy, enabling diverse postural control over a single joint [3-5]. The advantage is the use of soft materials, good portability and good wearing comfort. The disadvantage is that the driving force is less. The second is a tendon-driven hand exoskeleton designed by Shenyang Automation. This hand exoskeleton is a ductile wearable robot of hand, with gloves made entirely of polymer material, operated by a tendon-driven actuation device for spinal cord injury (SCI). EGP II can recover the capability of SCI patients to grasp and hold any item in their daily routine. The glove design makes it terse and expands the scope of hand measurement which can be fitted. A passive pollex construction was developed to counter the pollex for enhanced grip. The advantage is that it adopts a tension drive, a compact structure and good portability. The disadvantage is that tendons tend to entangle with objects and cause discomfort to the hand.

2. Clinical Trials

The Toronto Institute for Rehabilitation conducted an experiment in which researchers tested the hand function of nine participants with spinal cord damages to evaluate the functioning of an arm robot. Since spinal cord damage is a overpowering disease which greatly hinders the motor function of the arm, assistive devices, both active and passive, are becoming increasingly common to correct and improve loss hand intensity and flexibility. Mild skeletal robotics is an new branch of learning that combines the working principle of robotics with mild stuff into a fresh kind of active auxiliary equipments. Soft robotic aids enable human-robot interplay through compliance and lightweight construction. The goal of this research is to illustrate that based on fabric soft-skeletal robotic mitten can help participants influenced by spinal cord damage disease effectively manipulate and use objects they need in their daily lives. The test was performed twice for every participant; first time without assistance gloves to offer baseline data, and second times with assistance gloves. Object-operator subtests were assessed using linear mixed models, comprising influences of interactions and variables, for instance how long was injured. Lift measurements were independently assessed using the Wilcoxon Signature Rating Test [6]. Soft robotic gloves improve target operation in ADL missions. Distinct in average marks among baseline and auxiliary requirements were major across every participants and every manipulations. This suggests that gloves sufficiently enhance hand function during the ADL task. In addition, the lift force when applying the assistance flexible robotic mitten is also increased, Further more proof of the positivity and usefulness of the flexible hand exoskeleton in assistance hand function. The outcomes collected in this research project confirm that the fabric-based soft-skeletal extra-hand robot can be used as an useful rehabilitation device to restore hand function in injured patients with upper extremity paralysis following spinal cord injury, and the same is true for stroke patients. step.

While considering how to assist patients with loss of hand motor function to complete the grasping and use of daily objects, scientists have also developed a flexible exoskeleton robot system based on wire tension feedback, whose stable control is embodied in the fingers. The gripping force of the fingertips. In addition, the scientists introduced the structural design of the flexible exoskeleton glove and their control strategy. Then, by establishing a static mechanical model of the finger, the lateral line tension of the lasso entrance was calculated to obtain the contact force between the fingertip and the object. In order to solve the problem of friction loss in the process of cable transmission, the variation range of the cumulative bending angle of the lasso is limited within the range of 0° to 90° by physical methods, and the friction loss is compensated by the method of median compensation. In order to verify the practical effect of the flexible exoskeleton glove, the grasping experiment of the flexible exoskeleton glove was carried out on the patient who lost the function of hand movement [7]. The experimental results show that the flexible hand exoskeleton can assist the patient to complete grasping in daily life. Take the need.

3. Application Advantages of Flexible Hand Exoskeleton

A problem that frequently arises in this field is that both existing robotic hand exoskeletons and commercially available robotic hand exoskeletons can provide technical rehabilitation of the shoulder and elbow, which greatly reduces the clinician's ability to deal with personalization, possible ways of effectively rehabilitating the problem. Scientists have released and introduced fresh software that lets FES-assisted holding be integrated with ArmeoSpring (Hocoma AG). Man-In-The-Loop is the control method used by this system, where both surface EMG signals from the proximal muscle can be applied to spark and modulate a multi-channel FES used to the distal muscle, permitting the sufferer to adapt through induction and force movement trajectories and movement patterns of the hand. Integrating voluntary commanded FES with arm weight recompense permits early application of FES-assisted treatment, enhancing its function and extending ArmeoSpring's training capabilities. In daily life, wearable robots can help people with sensorimotor disorders in daily life, or sustain industrial labor to complete manual labor tasks. In this case, low quality and terse devices are crossover elements for equipment commitment. Remote Actuation Systems (RAS) have become a prevalent method for wearable machines to decrease perceived iteration and improve availability. Distinct RAS have been proposed in the literature to suit a broad scope of appliances and concerned devices. The shove for out-of-lab applications to use wearable robotics in clinics, home conditions or industries leads to a shift in RAS demand. In this situation, high endurance, ergonomics, and uncomplicated retention become increasingly important. However, although these factors are drivers of end-user abandonment of devices, they are considered uncommon and assessed in study announcements. In this paper, the existing RAS methods in wearable assistive technology are summarized in the literature commentary, and their merits and hurts are compared, focusing on the concrete assessment standard for outdoor application, so as to supply guidance for the choice of RAS. Based on the insights obtained, we current the growth, majorization, and access of cable-based RAS for off-lab applications of wearable assisted soft hand exoskeletons. The demonstrated RAS has complete wear resistance, high endurance, high efficiency and an attractive design while meeting ergonomic standards such as low quality and high wear consolation. This work aims to sustain the transmission of RAS for wearable robots from controlled laboratory circumstances to out-of-laboratory applications [8].

On the other hand, inspired by the flexible and curved properties of octopus tentacles and the external actuation of traditional exoskeletons, a novel adaptive underactuated digital mechanics is proposed, which scientists call OS finger. Similar to an octopus' tentacles, OS fingers consist of artificial muscles that pass through all joints and are driven by fluid, eight serially articulated joints, and changeable components. The force-variable component is mainly composed of a spring and an elastic rubber membrane, coordinated by a layer of rubber material on the surface of the finger to stabilize the grip. The OS fingers can perform different grasping modes according to the shape and size of the grasped object, and grasp the object in a gentle and snug way. OS fingers combine the rigid grip of traditional fingers with the good qualities of a form-fitting grip of flexible fingers. The kinematic analysis and experimental results show that the OS robot hand uses four OS fingers to perform precise pinch, self-adaptive, strong double-teaming, and grasping force, which can vary freely in a wide range [9, 10]. The OS exoskeleton arm has the advantages of strong adaptability, various grasping configurations, and a wide range of grasping forces.

Research on an exoskeleton arm rehabilitation training robot has been widely recognized in the field of rehabilitation. Compared with the traditional rehabilitation methods, the rehabilitation robot optimizes the rehabilitation training effect of hemiplegic patients. Combined with virtual reality technology, the rehabilitation training effect is remarkable, and the rehabilitation process is developing in the direction of programmatic, digital and convenient. At the same time, evaluation also plays an important role in the rehabilitation process of patients. Based on the first generation of exoskeleton upper limb rehabilitation robots, combined with the feedback of clinical experiments, the second generation of exoskeleton upper limb rehabilitation robots is designed, and the matching virtual reality software game program of rehabilitation training and virtual reality motion control evaluation program are compiled. In the aspect of rehabilitation evaluation, in addition to writing the virtual reality motion evaluation software, the effect of rehabilitation training was evaluated by combining the body surface EMG signal. First of all, the research progress of upper limb rehabilitation robot system at home and abroad was thoroughly studied, and the principles of hemiplegia movement disorder caused by stroke and its rehabilitation were deeply studied, including brain remodeling theory, motor relearning theory and other basic medical theories. At the same time, the evaluation of rehabilitation motor function and daily life function, functional electrical stimulation theory and surface EMG signal processing theory were fully studied. Second, the optimization of the exoskeleton structure of the upper limb rehabilitation robot should ensure that the mechanical structure is more safe, flexible and scientific. Not only the weight of the robot is reduced in structure, but also the overall structure of the support part and the brake part of the robot is improved through the mobile point cloud computing, and the collection structure of the hand grasping force is increased. In addition, a complete set of training devices can be formed, which can focus on the recovery of hand, finger, wrist and other parts of patients with neuromuscular injuries.

4. Point of View

Although there are always shortcomings in flexible and rigid exoskeleton robots, this can be compensated for, and the goal is to combine the mechanical power advantages of rigid exoskeleton robots with the portable and flexible characteristics of flexible exoskeleton robots to achieve breakthroughs results. From the experimental results of the soft material exoskeleton robot gloves in this paper, it can be seen that the soft robot has a very significant help in assisting people who need postoperative rehabilitation after suffering from devastating diseases. This robot has obvious advantages in material selection and assistance, but it is slightly insufficient in power due to material problems. Use hard material hand, on the other hand, the advantage of the exoskeleton robot is very obvious, because in material selection of the exoskeleton hand robot can have a powerful incentive to help patients restore hand movement, but the disadvantages are also obvious, is easy to cause the patients were injured in the treatment process, treatment for patients with late did not convenient at the same time, it can't be carried around like soft material robots.

5. Conclusion

Rehabilitation of human exoskeletons worn by potentially disabled people is becoming easier and easier to treat with exercise rehabilitation therapy while reducing costs and labor. Flexible exoskeleton human-machine intelligence technology is based on human-machine integration technology, which can maximize the advantages of intelligent machines and people, and enhance the performance of the system through organic human-machine coupling at the level of perception, decision-making and execution. Teleoperated exoskeletons and augmented exoskeletons are two important research directions for flexible exoskeleton human-machine intelligent systems. At present, although flexible hand exoskeletons have been used in many fields, there are still many shortcomings to be improved. In recent years, technical research and related product development in related fields at home and abroad have shown that flexible exoskeleton human-machine intelligent systems have great basic scientific research. Significance and application prospects.

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