Research and Development of Rehabilitation System for Bilateral Upper Limbs Training to Stroke Patients Using Force Presentation by Brakes "PLEMO-BAT"

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Abstract: There are a lot of patients with movement impairment who are paralyzed by brain stroke. Sufficient rehabilitative training is necessary for these patients. Rehabilitation support systems using force display devices are also expected to quantify the effects of rehabilitative training and enhance the motivation of patients and rehabilitation effects. Development of Upper Limb Rehabilitation System PLEMO-BAT for Stroke Patients Using Bilateral Limb Motion is presented in this paper.

Keywords: Rehabilitation, Robotics, Virtual Reality, Mechatronics

1. Introduction

Furusho Lab at the Osaka University, in collaboration with Asahi Kasei Group, developed an upper extremities rehabilitation support system EMUL (Fig. 1) by using ER fluid actuators in the 5-year NEDO project “Physical Function Rehabilitation System (FY1999-FY2003)”[1-3][7][8][20]. In the last year of the project, clinical evaluation for stroke patients was conducted at Hospital of Hyogo College of Medicine, and positive good results were obtained[4][5]. Then, in 2-year NEDO project “Practical realization project of next generation robots (FY2004-FY2005)” a rehabilitation support system for upper extremities “Serafy (Robotherapist)” (Fig.2) (Good Design Award) was developed and presented at Aichi Expo[2][3][6]-8.

![Fig.1 EMUL](image1.png) ![Fig.2 Serafy (Robotherapist)](image2.png)

2. Passive-Type Rehabilitation Systems for Upper Limbs

EMUL and Serafy (Robotherapist) both cost about 10 million yen and were suitable for use at rehabilitation hospitals. Furusho Lab at the Osaka University then developed the PLEMO series with force display and using brake only which are less than 1 million yen. The system with a brake is a Class I medical device as it has essential safety. PLEMO-P-Prototype[11] is shown in Fig.2 and PLEMO-P3[12][13][20] in Fig.4. PLEMO-P3 was developed based on the technology of PLEMO-P-Prototype (Best Paper Award, The Virtual Reality Society of Japan). The basic rehabilitation training software of PLEMO-P3 developed by Furusho Lab is shown in Reference[12][13][20]. In the clinical evaluation for stroke patients, PLEMO-P3 was shown to have a significant rehabilitation training effect[2][12][13][20].

![Fig.3 PLEMO-P Prototype](image3.png) ![Fig.4 PLEMO-P3](image4.png)

3. Bilateral Upper Limbs Training to Stroke Patients

By using a wearable two-hand rehabilitation robot, Simkains et al. showed that the rehabilitation effect of two-hand motions was higher than that of single-hand motions[17]. Figure 6 shows a primary prototype of two-hand rehabilitation training system PLEMO-BAT developed by Furusho Lab [16][18][19] A brake was used for giving a sense of force and to restrict the motion range of the user’s arm to prevent subluxation. The system shown in Fig.6 is of the same-side type where a user’s right and left hands move in the same direction. A mirror-symmetric type PLEMO-BAT is now being developed.

![Fig.5 PLEMO-Y](image5.png)
4. Future Research

Since April 2015, Furusho improved PLEMO-Y at Basic Research Institute of Mechatronics, Osaka Electro-Communications University, with the support of Yoshida Lab at Department of Mechanical Engineering, Osaka Electro-Communications University, and Hayakawa Lab at Osaka Prefecture University College of Technology. PLEMO-Z (Fig.7), which is a low-cost, more-compact practical model of PLEMO-P3, attempts for the practical realization of an upper extremities rehabilitation training system.


Reference


