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論　文　要　旨(博士)

論文題目	**Study on Robotics with Haptic Feedback, Teleoperation, Vibration Control and their Applications to Rehabilitation and Industrial Processes**

(要旨 1,200字程度)

Robotics has been playing a very important role in industry and daily life to replace and assist people to do various tasks. In this research, in the first part, robot with teleoperation and haptic feedback is considered in rehabilitation field. Moreover, in the second part, the problem of vibration suppression caused by fast movement of robot is considered to improve robot's performance and increase productivity in industrial processes.

Currently, the number of elderly people is increasing, especially in the developed countries, and with this increase comes an increase in the number of people who need some type of medical care. At the same time, people of all ages continue to require assistance recovering from accidents, congenital problems, or chronic illness. However, the number of doctors and nurses is not increasing in step with the increasing number of patients. In order to fill this need, it is necessary to replace humans with intelligent machines. One alternative that is attracting a lot of interest is the use of welfare- or life-supporting robots.

Teleoperation systems combined with audio-visual communication support are applied in a wide range of areas including telemanufacturing, telemaintenance, telesurgery and rescue applications. Teleoperation with haptic feedback, in which contact force information is provided directly to the human operator, can improve task performance. In the case of rehabilitation, telerehabilitation is an effective solution problems caused by geographical distance between the patient and physician, a lack of expertise, the high cost of delivery in rural areas, and so on. Moreover, because haptic feedback is provided to the physician, the physician can improve the rehabilitation process by adjusting the rehabilitation exercise according to the patient's status.

In the first part of this paper, a rehabilitation robot with teleoperation and human sensing for upper limb function is proposed that can do two common rehabilitation techniques: the passive assisted movement technique and active assisted movement technique. At the first step of establishing a new rehabilitation system, a rehabilitation system with a passive movement mode for the passive assisted movement technique was developed. The master-slave system for using in the passive movement mode includes a 2-DOF master robot arm and a 2-DOF slave robot arm for rehabilitation of the shoulder and elbow. The master arm has brakes for the implementation of feedback force. It is shown that by using the brake to present the haptic feedback in the master site, the stability of the system over communication time delay is guaranteed.

In the above system, brakes prevent the system from being used in the active movement mode with active assisted movement technique. Thus, at the next step, we develop a rehabilitation robot system with both a passive movement mode and an active movement mode. The brakes in the master robot are replaced by motors and the force sensor is installed in the master robot. A new teleoperation mechanism is proposed to maintain the stability of the system in both the passive movement mode and the active movement mode. The feedback force is represented by means of impedance adjustment. The active site where the movement is generated is decided by physician, thus the bilateral teleoperation can be done and the stability of the system is guaranteed.

With two above teleoperation mechanisms, the stability of the system with communication time delay is guaranteed. However, the system's performance may be affected by network traffic that depends on the packet transfer rate in packet switched network such as Internet. In order to reduce network traffic, the sending rate is reduced by proposing a deadband control mechanism. Moreover, a first-order interpolation for data reconstruction algorithm is proposed in the receiving site to keep acceptable system's performance. The stability of the system with the proposed deadband control and data reconstruction algorithm is guaranteed.

In tele-rehabilitation system, the biological information of patient is very important to improve the efficient of the rehabilitation exercise. In order to evaluate the arm's muscle and create the bio-feedback function for the rehabilitation system, electromyography (EMG) is used and relation between EMG signals of some specified muscles and the moment generated by these muscles at shoulder and elbow is established. An optimization process is used to identify the proposed EMG-moment model's parameter and the model is validated with different objects.

In the second part of this paper, a vibration suppression tool is developed based on preshaping approach to generate the preshaped input that eliminate the vibration when the machines move in high speed. An algorithm to generate the preshaped input from the commanded input is clarified more clearly from preshaped approach. Moreover, an identification process for vibration model is built by combining frequency characteristics and time domain identification. Finally, a graphical user interface (GUI) is developed to help user to use the tool more easily. This tool was used for some industrial robot system such as semiconductor wafer transfer robot and gantry loader and the good results were obtained.

In conclusion, this research has established fundamental results of building a tele-rehabilitation robot system with haptic feedback via a communication network such as Internet. Moreover, biological information such as EMG has been considered to establish more efficient rehabilitation exercises. In addition, an efficient tool for suppress the vibration in fast speed robot system was developed to improve the system performance and increase productivity.