PC-Based Rehabilitation System with Biofeedback

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Abstract. The purpose of this research is to emphasize on the concept of integrating computer and interactive technologies to the rehabilitation robotic with biofeedback. First, the robot is actuated with pneumatic muscle actuator which have interesting characteristics that can be exploited for upper limbed machines. The rehabilitation robotic system is using measurement which has two channels to detect and collect the rehabilitation robotic system from electromyography and the rotary encoder. Through PCI interface transferring the rehabilitation robotic system to personal computer, we can use our algorithms to attain real-time the force and/or contraction velocity of the muscle detection and other common information like the frequency of under muscle curve of user. Finally, the human-computer interface for rehabilitation system is designed. In this human computer interface consists of three main parts: detect the signal; a control scheme of robotic system combined with multimodal environment based biofeedback system; clinical database.

Keywords: rehabilitation robotic, biofeedback, human computer interface.

1 Introduction

The most of contemporary robots use DC or AC motors like the actuators. However, these implementations are often too heavy and rigid, particularly for work in contact with human. Using of these "traditional" actuators in the field of rehabilitation and force feedback devices is especially unsuitable, because rehabilitation are usually grounded on the user is can not bear while being comfortable. The DC or AC motor is relatively unfriendly in feeling. That is the reason why the researchers try to find an actuator similar to human muscles. The most promising actuator in this field of research [1] is undoubtedly McKibben pneumatic muscle actuator(PMA).

A PMA which has achieved increased popularity to provide the inherent safety and mobility assistance to humans performing tasks and another advantages such as high strength and power/weight ratio, low cost, compactness, ease of maintenance, cleanliness, readily available and cheap power source and so on [2-4]. In contrast to traditional pneumatic actuators, PMA have very high power/weight and power/volume ratios [1], [2]. This is an advantage for robotic and exoskeleton applications, in which heavy actuators can add significantly to the payload.

Some scholars have already set up system modelling and performance to assess to the atmospheric pressure muscle driver [5], model analysis of the dynamic characteristic 6]. As for other application, for instance: Is it good for robot to reply [7,8], recovery

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system [9], nucleon of waste material, use atmospheric pressure muscle biceps and triceps structure that driver form, simulation track, joint of angle control [10,11], applications for robotics [12,13]. Above-mentioned methods are all feedback methods. In the rehabilitation process, the user's feeling is taking most. Thus, biofeedback is considered in the rehabilitation. Originally we consider in the article the rehabilitation system include feedback and biofeedback. In addition, progress made in computer technologies has encouraged rehabilitation engineers to apply computer technologies in helping disabled people to enjoy greater degree of independence in their daily living. However, users may still rely upon special interface to communicate with a computer. Providing physically disabled persons with adequate human/computer interface may thus contribute greatly to improve their independence. The human-computer interface which operators of the rehabilitation engineer use is very important.

2 Structure in Rehabilitation System

2.1 Mechanical Structure

The PMA is a kind of principle of moving on the basis of studying the organism, change external energy but become the soft driver with similar human muscle characteristic.PMA consists of a cylindrical flexible rubber or plastic airtight tube that fits snugly inside a braided plastic sheath with helical winding. When the tube is inflated, it widens and due to the braided sheath, shortens. The axial force exerted when the PMA shortens is quite large in proportion to the PMs weight. Because of their

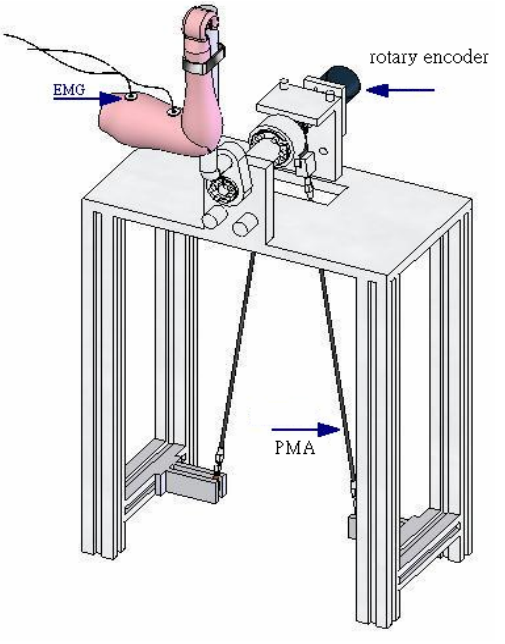

Fig. 1. The prototype of the rehabilitation robotic

construction, PMA are similar to human skeletal muscles in size and power output capability. However, PMA can only exert a single directional pulling force. In order to build a bi-directionally working revolute joint, two PMAs are coupled similarly to the antagonistic muscles of animals. Hence, the rotating torque is generated by the pressure difference between the antagonistic muscles and the external load is rotated. A joint angle is detected by rotary encoder. The prototype of the rehabilitation robotic are illustrated in Fig. 1. The operation principle of this robot, give two atmospheric pressures muscle in the regular initial pressure first, the arm is in the state of making for the first time at this moment, then mediate the pressure of both sides muscle. At this moment, the pressure expands greatly but the pressure is extended small, the arm joint will rotate the angle.

2.2 Electrical Structure

Many physiological processes can be monitored for biofeedback applications, and these processes are very useful for rehabilitation services. Biofeedback is a means for gaining control of our body processes to increase relaxation, relieve pain, and develop healthier, more comfortable life patterns. Electromyography is a seductive muse because it provides easy access to physiological processes that cause the muscle to generate force, produce movement and accomplish the countless functions which allow us to interact with the world around us [14].

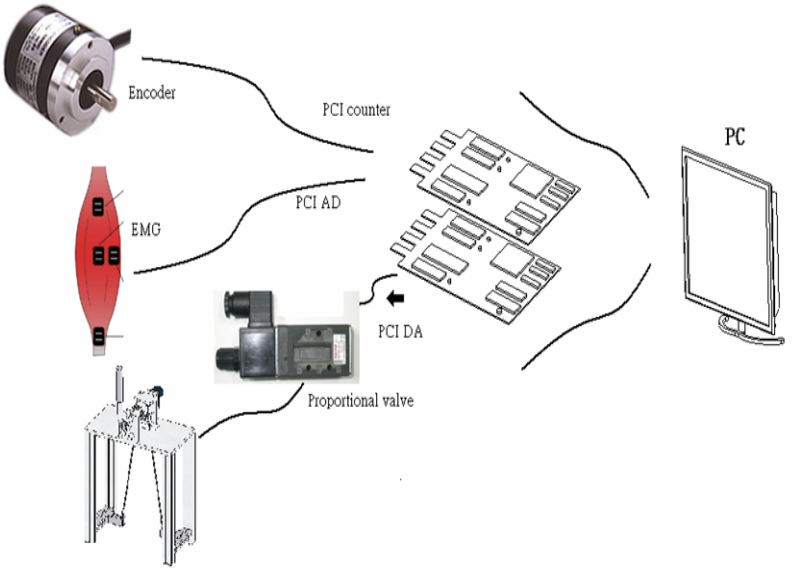

Fig. 2. Schematic diagram of the rehabilitation robotic

The experiment are carried out according to the closed-loop structure of t the rehabilitation robotic shown in Fig. 2. In the rehabilitation robotic, the joint angle, θ, is detected measured by rotary encoder and the processing of electromyography (EMG) signals from the user and feedback to PC through PCI counter board and AD board,

respectively. A primary function of the robot is controlling the gas pressure sent to PMA via the processing of electromyography (EMG) signals from the user. The rehabilitation robotic system is using measurement which has two channels to detect and collect the rehabilitation robotic system from EMG and the rotary encoder. Through PCI interface transferring the rehabilitation robotic system to personal computer, we can use our algorithms to attain real-time the force and/or contraction velocity of the muscle detection and other common information like the frequency of under muscle curve of user. Besides, the personal computer calculated the control input and controlled the proportional valve through D/A board.

3 PC-Based Rehabilitation System

3.1 Software Structure

Soft Structure unit interface shown in Fig. 3. was developed for physiological monitoring of a diver using embedded digital signal process. The software is built in Visual Basic environment and runs under Windows XP. The sequence of implemented procedures follows:

- Reading of encoder via PCI counter.
- Reading of EMG signal via PCI AD card.
- Connecting the database.
- Computing of forces to be applied to control valve via PCI DA card.
- Design the man-machine interface.

The software also displays to user important data, like angle, EMG signal, desired and real pressure in muscles. User can set time, angle and force.

3.2 Human-Computer Interface

The human-computer interface which operators of the rehabilitation engineer use is very important. If there is any operation error, the consequence will cause the muscle injuring. It is necessary to verify the design of interface which operators use in advance to prevent errors for the reason of inadequate design. Then we can get the advice for improvement, and low down the chance of error. In this human computer interface consists of three main parts: detect the signal; a control scheme of robotic system combined with multimodal environment based biofeedback system; clinical database. These interfaces are shown in Fig.4-6.

3.3 Clinical Database

Users can check their medical treatment records just by entering ID numbers. Because the processing of rehabilitation, these records are very useful for long-term tracing and analyzing users' condition. In this study, the rehabilitation database system consists of three main parts: user's operating time; user's functional ability dataset and related outcome information. From the experiences of establishing the database

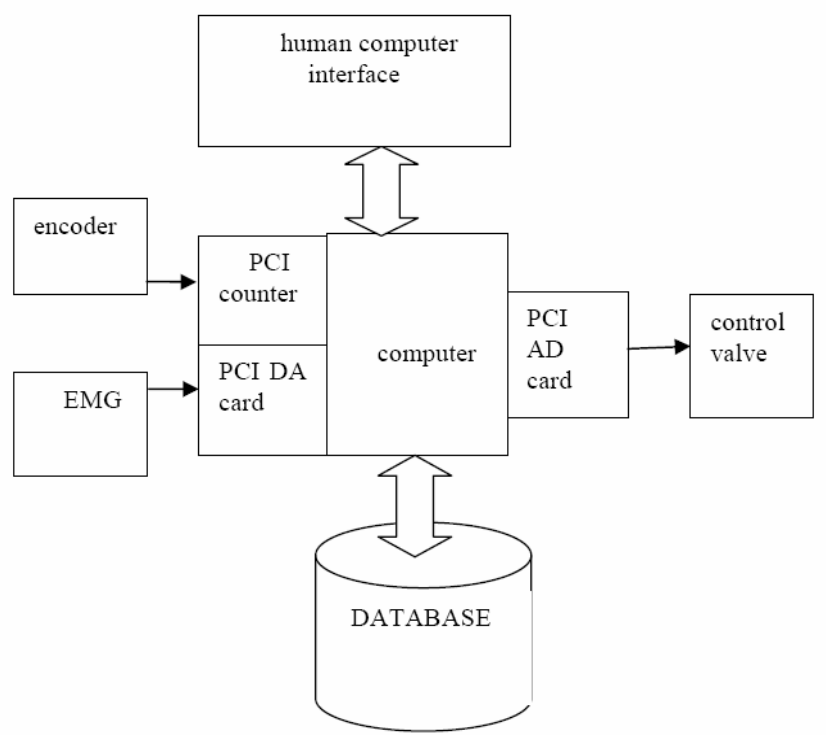

Fig. 3. Instructure of Robot Monitor

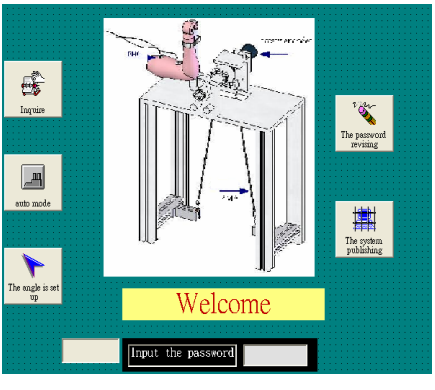

Fig. 4. Screen shot of "Multimodal environment"

as well as the clinical data collection, suggestions about the use of the database and limitations will be discussed. Moreover, the development of this project facilitates the disabled persons to use commercial pointing devices that are lowly priced and easily available. Also, with this newly developed robotic, the disabled persons can have a second choice over some specific devices that are highly priced or difficult to maintain.

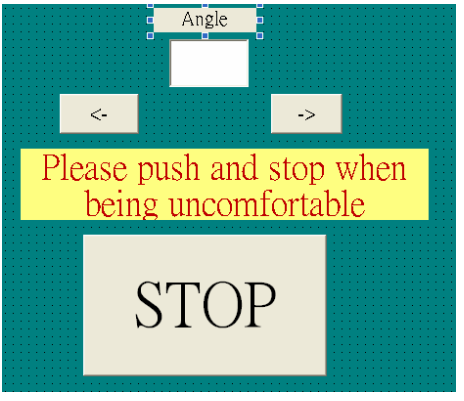

Fig. 5. Screen shot of "The joint angle testing"

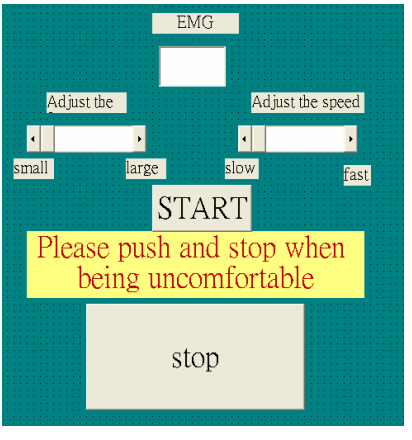

Fig. 6. Screen shot of "Force and speed adjustment"

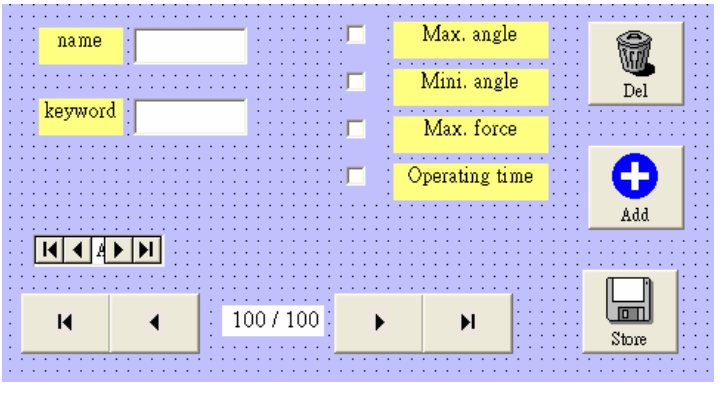

Fig. 7. Screen shot of "Clinical Database"

4 Result

The result of this paper are:

- For the purpose of rehabilitation robotic design, the concept of PMA is introduced to simplify the design procedure.
- Originally we consider in the article the rehabilitation system include feedback and biofeedback.
- For the rehabilitation system, the human-computer interface is designed. This interface consists of three main parts: detect the signal; a control scheme of robotic system combined with multimodal environment based biofeedback system; clinical database.

Acknowledgments

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