2011 International Conference on Advancements in Information Technology
With workshop of ICBMG 2011
IPCSIT vol.20 (2011) © (2011) IACSIT Press, Singapore

Developing a Multilateral Telerehabilitation System for Patient with Diminished Hand Function

Fereshteh Ghasemi [1 +]

IT Department, Payame Noor University, 19395-4697 Tehran, I.R. of IRAN

Abstract. Telerehabilitation or E-rehabilitation is the delivery of rehabilitation services over telecom networks. According to the World Health Organization (WHO), there are about 650 million people with disabilities worldwide; these statistics drive the need for a more applicable Telehealthcare Systems. This paper aims to provide a design description of a novel multilateral telerehabilitation system for Patient with diminished hand function which needs minimum interaction between patient and therapist. The proposed configuration consists of the Central Intelligent System (CIS) including multi-function modules in a homepage for patient in physiotherapy office, and a Hand Rehabilitation System including a Robot, Motion Analysis Module as well as Wireless Sensor Network (WSN) in patient's home. This system works by a diagnostic feedback from a Hand Rehabilitation System to the Central Intelligent System (CIS). Patient fixes sensors on his hand and doing daily activity. Data transmitted by WSN will be analyzed by the Motion Analysis Module in order to diagnose the latest degree of recovery. Information is feed backed automatically to the CIS through network. An appropriate program corresponding to the feed-backed information will be prepared by CIS and transmitted into the robot. After doing exercise by the system, joint angles are measured and send to the CIS again to diagnose the level of patient recovery. Cost of care by this configuration will be reduced significantly. This paper presents a prototype that successfully operates as a multilateral telerehabilitation system.

Keywords: Physiotherapy, Telerehabilitation, Diminished hand function, Hand Rehabilitation System, CIS

1. Introduction

The rapid growth of telecom industry has faced the world with new revolution. Information technology revolution has noticeable impacts on the economic, social, and political development of a country; this impact can be seen in medicine as well. The combination of medicine and information technology has created a new science called Telemedicine and Telehealthcare. By using these new sciences, health care professionals can evaluate, diagnose and treat patients in remote. Telerehabilitation is such an e-Health service too. It delivers rehabilitation services using telecommunication networks by a therapist at a distance location. This new technology has played an important role in healthcare over the last decade. According to the World Health Organization, there are at least 650 million disabled people worldwide and number of them is increasing from year to year. On the other hand, going to the hospital and visiting the therapists are time consuming, difficult, expensive and sometimes may be impossible for the patients; especially for who lives in the depopulated areas.

Robotics researchers have helped to developing Telerehabilitation systems; and till now, some hand rehabilitation systems have been constructed using different types of technologies [1]. Some of them which is set up for tele-care purposes have targeted in bending the hand joints to relieve the tension of the hands. These systems usually consist of a Hand Rehabilitation System for patients and a complete anthropomorphic robot hand system for therapist [2]. The force which is applied to robot hand by therapist would transmit to

+ Corresponding author. Tel: +989132123827
Email Address: f_ghasemy@pnu.ac.ir

patient's hand through a special network. However, therapists have to make an interactive online connection with patients using robotic hand system; also other kind of Telerehabilitation system has been constructed using WSNs; Body area WSNs and gaming have been combined to assist in physiotherapy treatments [3].

The aim of this paper is to propose a novel multilateral telerehabilitation system by a diagnostic feedback from a Hand Rehabilitation System to the Central Intelligent System (CIS) in order to speed up recovery and minimizing interaction between patient and therapist. Cost of care by this configuration will be reduced significantly because the CIS needs to a small office and limited employee. In another word, it provides an appropriate service for low income and low literacy patients at their homes.

2. Novel Hand Telerehabilitation System

In this paper, the author has presents a novel telerehabilitation system by a diagnostic feedback from Hand Rehabilitation System to the Central Intelligent System (CIS). This multilateral system aims to speed up recovery of the hand function by diagnostic feedback and minimizing interaction between patient and therapist. The whole system is divided in to two parts. One part is located in physiotherapy office and the other part can be located in patient's home. Two parts have been illustrated as below:

2.1. Systems in Physiotherapy Office

There is a main configuration consists of the Central Intelligent System (CIS) including multi-function modules in a homepage for a patient in physiotherapy office; these modules are intelligent and have been listed as following:

- Alarm Module:
  This module lets therapist to receive essential alarms from patient or Hand Rehabilitation System. These alarms are received via therapist's mobile phone telling him to check CIS.
- Log Module:
  This module collects the statistics of communications between CIS and hand rehabilitation System. Furthermore it is affected by other modules and processing; and it can store therapist activity.
- Processing Module:
  This main module consists of databases (rehabilitation program) that these databases can be selected and send, corresponding to a net request to Hand Rehabilitation System; this database is updated by therapist as needed.
- Analysis and Reports Module:
  This module allows to analysis generated information placed in Processing Module and Alert Module. Analyzed data is then prepared to report therapist by some graphs. The highlighted graph in the module is the percentage of improvement.

Microsoft's ASP.NET and C# technology has been used to construct the dynamic and interactive CIS and make it easy to manage and maintain. CIS controls Hand Rehabilitation process so this configuration needs a minimum interaction between patient and therapist. By the above illustration, obviously we just need a standard computer with CIS and a high speed available network in physiotherapy office; that is a hope to have a full virtual physiotherapy office in future.

2.2. Systems in Patient's Home

The proposed multilateral configuration consists of Hand Rehabilitation System including a Robot, Motion Analysis Module and body area Wireless Sensor Network (WSN) which are explained as below:

- Robot:
  Robot is a hand rehabilitation device which consists of two parts, a microcontroller, and motion assistance mechanisms for fingers and wrist with 5 DoF (Degree of freedom); One DoF for 4 fingers (flexion of Metacarpophalangeal joints, 0 to 90 degrees/extensions of Metacarpophalangeal joints, 0 to 30 degrees), one DoF for wrist (extension, 0 to 70 degrees/flexion, 0 to 80 degrees). It should be mentioned that we have independent motion assistance for each finger [1]. Because of the complicacy of thumb function, it's not included in this robot; As it is possible to construct thumb motion assistance mechanism with the double parallel-link structure [4].
  Robot or hand rehabilitation device supports one hand of patient; Robots' motors gets appropriate information from a microcontroller and moves targeted joints forcibly. The joint angle is measured

by encoders on motors [1]. Microcontroller can be connected to a laptop or standard PC for sending and receiving data through network. If patient feels pain during the training, he can press emergency stop button; this button simultaneously send alarm to therapist and turn the robot off.

- Body area Wireless Sensor Network:
  WSNs are consisting of sensor nodes that attached to the hands; there is a base station connected directly with a PC and constantly receives and collects hand movements' data from hand sensor nodes; [5]. These data are transmitted to the Motion Analysis module.
- Motion Analysis module:
  This module is a program which written in the java language; it is installed in a PC or Laptop and able to collect hand movements' data from base station and analysis them in order to diagnose the latest degree of recovery. The Module communicates with Processing Module in CIS through network. This program is set in start up of the PC to run promptly even by illiterate patient.

2.3. Whole System Configuration and Operation

This Telerehabilitation system works by a diagnostic feedback from Hand Rehabilitation System to the Central Intelligent System (CIS). Patient should fix sensors on his hands and doing daily activity in a specific time. Data transmitted by WSN will be analyzed by the Motion Analysis Module in order to diagnose the latest degree of recovery; Information can be also feed backed automatically to the CIS by PC through network. An appropriate program corresponding to the feed-backed information will be prepared by CIS and transmitted into the system. Finger and wrist of patient is put in robot and it moves patient's hand joints using local and internal information which is already prepared; after doing appropriate exercise by the robot, joint angle is measured by encoders on motors; afterwards the data is sent to the CIS again to diagnose the level of patient recovery and uploading new rehabilitation program in CIS by therapist. If there is a new condition or if there is not enough information requesting by Hand Rehabilitation System, the CIS send an alarm to the expert to update its information.

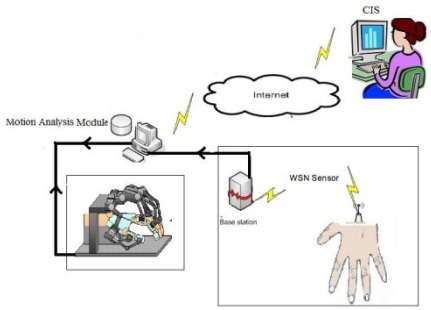

Fig. 1: Multilateral Hand Telerehabilitation System

3. Conclusion and Future Work

The proposed configuration consists of the Central Intelligent System (CIS) including multi-function modules in a homepage for a patient in physiotherapy office, and a Hand Rehabilitation System including a Robot, Motion Analysis Module as well as Wireless Sensor Network (WSN) in patient's home. This multilateral system aims to speed up recovery of the hand function since it has a diagnostic feedback from a Hand Rehabilitation System to the CIS. Using this method allows long-term care and Cost of care by this configuration will be reduced significantly because the CIS needs to a small office and limited employee. Some experiments were carried out with healthy right hands of females and shows the transmitting information is done between CIS and Hand Rehabilitation System successfully and Human hand follow the motion of the robot rehabilitation device very well. This configuration needs a minimum interaction between patient and therapist. In the future, by developing a CIS server, a group of patient would be serviced concurrently and safety parameter of the system can be considered strongly in order to avoiding permanent disabilities. In order to evaluate the effectiveness of the system, the control system can be demonstrated as well.

4. Acknowledgements

The author would like to thanks all persons who helped her for their suggestions in developing project.

5. References

[1] Y. Nishimoto, T. Aoki, T. Mouri, H. Sakaeda, and M. Abe. Development of a Hand Motion Assist Robot for RehabilitationTherapy by Patient Self-Motion Control. *10th International Conference on Rehabilitation Robotics.* Noordwijk, The Netherlands: IEEE. 2007, pp.234-240.

[2] T.Mouri, H.Kawasaki, T.Aoki, Y.Nishimoto, s.Ito, and S.Ueki. Telerehabilitation for Fingers and Wrist Using a Hand Rehabilitation Support System and Robot Hand. *9th International Symposium on Robot Control.* Japan: Nagaragawa Convention Center. 2009, pp.751-756.

[3] K.Kifayat, P.Fergus, S.Cooper and M.Merabti. Body Area Networks for Movement Analysis in Physiotherapy Treatments. *24th International Conference on Advanced Information Networking and Applications Workshops (WAINA).* Perth, WA: IEEE. 2010, pp.866-872.

[4] S.Ito, Y.Ishigure, S.Ueki, J.Mizumoto, Y.nishimoto, M.Abe and H.Kawasaki. A Hand Rehabilitation Support System with Improvements Based on Clinical Practice. *The International Federation of Automatic Control.* Japan: Nagaragawa Convention Center. 2009, pp.829-834.

[5] P.Fergus, K.Kifayat, S.Cooper and M.Merabti. A Framework for Physical Health Improvement using Wireless Sensor Networks and Gaming. *3rd international conference on Pervasive Computing Technology for Health Care.* London: IEEE. 2009, pp.1-4.