Design and Development of Semi Portable Rehabilitation System for Upper-Limb Disability

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***Abstract*: A wearable upper body exoskeleton system with a model based compensation control framework to support robot-aided wrist, fingers and elbow rehabilitation and power assistance tasks. To eliminate the need for EMG and force sensors, we exploit off-the-shelf compensation techniques developed for robot manipulators. Thus target rehabilitation tasks are addressed by using only encoder readings. A proof of concept evaluation was conducted with 5 able-bodied participants. The patient-active rehabilitation task was realized via observer-based user torque estimation, in which resistive forces were adjusted using virtual impedance. In the patient-passive rehabilitation task, the proposed controller enabled precise joint tracking with a maximum positioning error of 0.25 degrees. In the power assistance task, the users' muscular activities were reduced up to 85% while exercising with a 5 [kg] dumbbell. Therefore, the exoskeleton system was regarded as being useful for the target tasks; indicating that it has a potential to promote robot-aided therapy protocols.**

***Keywords*: Exoskeleton Robot, Assistive Robot, SCI, Position Control**

1. Introduction

Lately, compact gadgets have been produced for human appendages because of the advancement of mechanical autonomy. The gadgets are utilized in military, modern and therapeutic orders to build the load bearing limit and help long haul exercises and medicinal recovery. Maturing society is an ordinary and irreversible procedure of human life. Expanding the maturing populace will require more human services specialists. The issue of maturing, yet additionally the high extent of individuals experiencing musculoskeletal and neurological wounds with mishaps through the restorative consideration staff and gear to help treatment. These days, numerous researchers have effectively focused on the improvement of therapeutic recovery gadgets. Specifically, wearable gadgets are a critical advancement for recovery gadget. In any case, patients need quite a while to recuperation their body. An expansive territory of singed wounds showed up will cause scar contracture, and after that causes appendage brokenness, nerve harm, appendage deformation, muscle decay and different issues. The restorative innovation propels, patients extraordinarily expanded survival rate, yet they don't have the initially body.

Early recovery is the way to the achievement of medical procedure. Practically speaking, restoration is definitely not a consistent action so quiet exercises for one to two hours won't have too generous impact, however will result in the weight on patients. Viable recovery is best rehashed a few times each day, each time for five to ten minutes and keep up the joints and muscle action. Robot gadgets for recovery can be partitioned into full-body, upper-appendage, lower-appendage, and so on. The automated gadget is intended to be worn by the client or patient to accomplish synchronized task of the human body and it is likewise an actually difficult. The mechanical structure must be lightweight and the engine torque ought not be excessively little. Instructions to adjust the human-machine cooperation is the most specialized issue in structure. The appendages and recovery gadgets require a perfect control framework if not appropriately controlled, the results can put patients in danger.

The use of remote parameter setting for human services administrations has likewise bit by bit entered the everyday life. In medicinal applications, the remote working framework for recovery can diminish the separation between rehabilitative patients, advisors and have better cooperation with one another. This will expand the comprehension of physical advisors on recuperation of patients with recovery and will build the scope of conceivable applications. A viable recovery program ought not out of the ordinary, restoration is to prepare patients with muscle and joint exercises. These days, the majority of the restoration depends on the recovery designer to help the patients, make appraisal, plan restoration courses, and utilize the restoration hardware in the medical clinic to support patients. In this paper, upper appendage recovery gadget is utilized to enable patients to recoup. Taiwan government center around wellbeing - care and network care, the recovery gadget should be enhanced for restorative treatment to supplant the present specialists deal with one by one with patients and make the gadget compact, lightweight, with the SQL database to give increasingly viable recovery, and to gather the recovery data of every patient such like individual status, demonstrating the

condition of restoration through the visual outline, doctors can utilize this stage for patient follow-up treatment arranging and accomplished by a doctor, while checking various patients, sparing medicinal assets, recovery should be possible anyplace. In the meantime, among sheltered, agreeable and successful working condition are feasible for the body recuperate to a decent state.

In this paper, upper-appendage recovery concentrated on wearable and minimal effort plan. Controller configuration are executed in a Raspberry Pi based installed piece. This paper coordinated Raspberry Pi with miniaturized scale controller (PIC18F4331) so the majority of the framework can do easily flag handling in recovery framework task. In the plan of mechanical structure, 3D printing is utilized to get the key parts by Strong Works 3D programming. So as to accomplish the objective with accuracy control, DC engine work through the twofold circle control with position and speed rule.

2. Proposed system

A. Upper-limb rehabilitation system and 3d printing

This project shows a framework for restoration patients who have upper - appendage hindrance. Patients have diverse state of upper-appendage so we think about that structure a reasonable gadget for all patients is troublesome. A perfect restoration framework needs to join with hand craft and the framework additionally have sufficient for protected, agreeable and effective. This work planned a stage by utilizing Raspberry Pi, which is a control part for recovery framework. The framework additionally associated with specialist database and specialists can without much of a stretch screen tolerant circumstance for recovery with upper-appendage. Also, site is intended for better treatment assignments so specialists can remotely execute the range setting of exoskeleton gadget.

Fig. 1. The refurbish structure for upper limb

This recovery framework is superior to conventional gadget for upper-appendage since this cell phone is with market esteems, having the benefits of little volume, less weight, lower cost and simple to work. Customary recovery gadget is heavier than this paper proposed and this work can bolster remotely social insurance so the proposed framework is advantageous for patients and specialists. Clients and specialists can pick numerous activity models which will be talked about in area B. In the plan of mechanical structure, some key segments are self-planned with 3D printer to satisfy the required restoration activities. We utilize Solid Works programming to configuration key parts for 3D structuring.

B. Micro controller and processing

This part will present advanced control stage and spotlight on PIC18F4331 small scale controller and Raspberry Pi (Fig. 2). We use I2C to interface with PIC18F4331 and Raspberry Pi so the two gadgets can without much of a stretch change every datum and information address so as to control restoration framework. We talk about two sections of Raspberry Pi and PIC18f4331 to acquaint the capacity what with do. In the first place, we use Raspberry Pi to assemble a twofold circle situation, assess speed and information stockpiling with patients. Fig. 2 demonstrate the advanced control and framework combination with Raspberry pi and PIC18F4331. Raspberry Pi bolster twofold circle controller and supply Wi-Fi convention and TCP/IP convention to interface web administration and database. PIC18F4331 is a smaller scale controller which support PWM motion as yield and we can create DC engine or encoder to quantify a few information, for example, engine position, engine speed and voltage. It is anything but difficult to build up our control stage by utilizing I ²C convention among PIC18F4331 and Raspberry Pi so we can without much of a stretch coordinate with recovery framework.

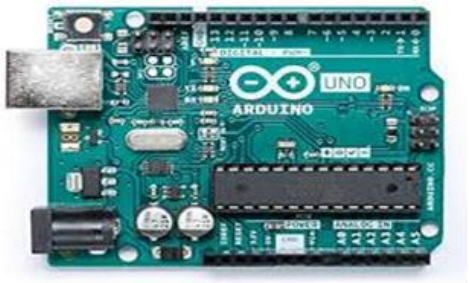

Fig. 2. Microcontroller

PID controller is a typical kind of shut circle control strategy which is generally received in industry control frameworks due to its straightforwardness and adaptability. Contrasted with the other control strategies, PID controller can be tuned without getting the mind boggling model of the procedure to be controlled. The PID control process is performed by figuring the contrast between the set point and the real estimated input esteem at that point limiting the blunder through three control activities: corresponding control, indispensable control and subsidiary control. The fundamental thought of the upper-appendage recovery framework is giving patients an agreeable, sheltered and stable condition and the insights concerning the proposed framework capacity will be talked about in the accompanying. So as to execute PID controller and tune the PID parameters by Ziegler Nichols Controller rule(ZN) to give activity speed and joint edge. Every one of the outcomes will be talked about in segment 3.

3. Experiment and result

Upper-appendage recovery framework backing to patient's recovery and furthermore can be checked by patients without the assistance of physiotherapist. Recovery handling by intelligent site which gave the recovery information such like recovery time, upper-appendage gadget holy messenger, upper-appendage gadget speed.

A. Fixed mode

Mode A is reasonable for the underlying advance of patient recovery, who is soon after medical procedure, damage or joint attachment, etc. In this progression, patients can't ordinary exercises, the scope of movement of joints is little, in this model must be helped by the recovery gadget in patients with joint extending to guarantee joint extensibility and afterward change to the restoration of uninvolved mode later on. The single circle position and speed control framework on model A will be influenced by the stacking which will change edge over the span of working restoration so the patient really works and recuperates can't be balanced out. Task restoration position reaction is influenced by changing in stacking edge so patients can't successfully accomplish the reason for recovery.

B. Inactive mode

The inactive mode is reasonable for the midterm recovery of patients; the patient has an ability of joint augmentation yet at the same time helpless to extend joints as ordinary individuals. This model utilized for preparing patients with joint action, from the activity of the doctor through the patient restoration specialists can modify the recovery parameters of activity speed of development. The reacting to preparing of the joints can be accomplished aloof recovery. At the point when the patient has certain movement capacity, the patient can change to the dynamic method of restoration. The single circle position and speed control framework on model B will be influenced by the stacking which will change point throughout working restoration so the patient really works and recuperates can't be balanced out. Activity restoration position reaction is influenced by changing in stacking edge so patients can't viably accomplish the motivation behind recovery.

C. Dynamic mode

The dynamic mode is reasonable for the last recovery of patients, the patient has a capacity to degree the body and furthermore has great versatility equivalent to sound individuals. In this period, the patient can work the component for itself. Through this model, doctors can set the movement objectives as per the patient's past recovery status as the reason for treatment arranging. Most restoration preparing for the patient is great in light of the fact that as it were when time for patient is flopped in 35 degrees, set the 45 degrees as the objective for patient to accomplish the rehab. Following the three modes restoration handling with upper-appendage gadget can be all around performed and the patient outcome can be too accomplished.

4. Conclusion

In order to promote high performance while ensuring safe operation, the requirements for developing a 7-DOF exoskeleton must be realized and understood both from their technical as well as functional aspects. Additionally, the principles of physiological joints and cable-driven systems can assist in achieving a relatively lightweight, high-performance system. Proximal placement of motors, distal placement of pulley reductions, and open mHMIs are a few features that add to the performance and ease-of-use of the device. Additional characteristics include low inertias, high-stiffness links, and back drivable transmissions without backlash. The design achieves full-workspace ROM, as defined by the ADL study. Until higher power-to-weight ratio motors and structural materials are developed, the state-of-the-art in human strength wearable robotics will remain fixed either to immobile platforms or to full-body support structures, such as powered wheelchairs or lower limb exoskeleton systems. Even within these technological constraints, however, upper limb exoskeletons have much to offer in regard to assistive and rehabilitative services, as well as in high-fidelity virtual simulations and advanced control applications

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